The Sherwin-Williams Company

Summary of Geotechnical Results and Conceptual Geotechnical Engineering Recommendations for The Sherwin-Williams Company Emeryville, CA Manufacturing Facility

June 10, 2005

Technical Memorandum

Technical Memorandum
Results of Preliminary Geotechnical Investigation and Conceptual Geotechnical Engineering Recommendations

This technical memorandum (TM) presents the results of our preliminary geotechnical investigation and provides conceptual geotechnical engineering recommendations for design and construction of the proposed future development at the 8-acre Sherwin-William's facility in Emeryville, CA. The purpose of this TM is to provide Sherwin-Williams with preliminary geotechnical engineering recommendations to facilitate conceptual site development planning with SRM Associates (SRM). The information contained in this TM is considered preliminary, as the primary objective of the investigation was to characterize the overall site geotechnical conditions for planning level evaluations. The recommendations provided herein are based on review of available site data, the results of CDM's preliminary geotechnical investigation, discussions with SRM and Sherwin-Williams representatives, and review of the Parcelization Map, dated May 17, 2004, prepared by ROMA Design Group in association with BKF Engineering.

Purpose and Scope

The purpose of this study was to conduct a preliminary geotechnical investigation to characterize the site subsurface conditions and provide preliminary design recommendations that would be used by SRM to evaluate conceptual design options and perform supporting economic analyses.

Specifically, our scope of work included the following tasks:

- Conduct a preliminary subsurface exploration program consisting of 2 test borings and 6 cone penetration tests (CPTs) at the site;
- Conduct laboratory tests on selected soil samples to assist with classification of soils encountered and determine engineering properties;
- Develop conceptual geotechnical engineering recommendations for foundation design and construction associated with future development as defined herein;
- Present data collected as part of the investigation.
- Prepare this technical memorandum presenting the site characterisitics and CDM's preliminary geotechnical recommendations based on ROMA's Parcelization Map (2004).

Proposed Future Development

The proposed future development plan has not been finalized but based on review of the Parcelization Map, the site will be redeveloped to include a mix of residential and commercial land use with a central open space and links to future greenway or bike trail extensions, refer to Figure 1, Conceptual Site Map. The 8-acre site is subdivided into five parcels using a variety of structure types and height relationships. In general, the development plan includes multi-story structures with podium style parking on the lower levels with provisions for two high rise tower elements ranging in height from 120 feet to 200 feet. A generalized description of the size and intended land use for each of the five parcels is provided below.

- Parcel A: approximately 0.62 acres, mixed residential and commercial use, existing building to remain with structure height up to 50 feet.
- Parcel B: approximately 1.44 acres, mixed residential and commercial use, multi-story structure up to 65 feet in height with podium style parking on lower level, demo existing structures.
- Parcel C: approximately 1.37 acres, mixed residential and commercial use, multi-story structure up to 65 feet in height with podium style parking on lower level, demo existing structures.
- Parcel D: approximately 0.95 acres, mixed residential and commercial use, multi-story structure up to 120 feet in height with podium style parking on lower 3 to 5 levels.
- Parcel E: approximately 1.46 acres, mixed residential and commercial use, multi-story structure up to 65 feet in height including a tower element up to 200 feet high with podium style parking on the lower 3 to 5 levels. The northern portion of this parcel may include a multi-level parking structure up to 65 feet high.

To conduct our analysis and develop our recommendations, CDM made the following design assumptions regarding the proposed development.

- **Multi-level parking structure:** Multi-level parking structures are planned for Parcels B, C, D, and E. For purposes of this study, we have assumed the parking structures will have no below grade parking and up to 6 levels of above grade parking;
- **Mixed-use commercial/residential units:** As currently planned, the site consists of mixed use commercial and residential units with no below grade space and range in height from low rise (up to 2 stories), mid-rise (up to 5 stories), and high rise (over 5 stories). The current development plan indicates that parking will be located beneath the first and upper ground levels beneath each building; and

- **Central parking and asphalt-paved streets**: For purposes of this study, we have assumed that little to no site regrading will be required.

As an overall site consideration, this evaluation is based on the condition that final site grading will be minimal and that the first floor of all structures will be essentially at grade or embedded no more than 5 feet below the existing grade.

Several existing buildings (Buildings No. 1 and 31) along Horton Street are to remain and will be incorporated into the development. The remainder of the existing structures will likely be demolished as part of the new development.

Note that the redevelopment plans for the site are conceptual in nature and other building types may ultimately be considered. Figure 1, Conceptual Site Development Plan, illustrates the proposed conceptual site development plan including proposed building structure heights within each parcel (ROMA, 2004).

Existing Site Conditions

The project site (Site) is located at 1450 Sherwin Ave in Emeryville, CA. The parcel encompasses about 8 acres and is located in an historically industrial neighborhood approximately ¾-mile east of the San Francisco Bay and along Temescal Creek. The site is bounded on the west by Union Pacific Railroad tracks, on the north by Chiron Corporation property, on the east by Horton Avenue and on the south by Sherwin Avenue. The site is an active paint manufacturing facility and is currently occupied by several 1 to 3-story administration and manufacturing structures with multiple aboveground tanks used to manufacture paint products. It is our understanding that all the existing structures at the site are supported on relatively shallow spread footings and that numerous structures have been removed from the site (areas underlying Parcels B and D). However, the foundations for these demolished structures were not removed during demolition and are covered by fill and pavement.

Currently, a significant portion of the site is enclosed by a soil-bentonite and cement-bentonite slurry wall. This impermeable wall is approximately 3 feet thick and extends to an approximate depth of 22 feet depth. Beneath Parcel D, an environmental cap was constructed to encapsulate metals-impacted soils and to reduce potential exposure pathways, surface water infiltration and subsequent contaminant migration. The approximate location of the slurry wall and environmental cap are shown on Figure 2, Boring Location Map. The area of the cap is paved with asphalt and is about 2 to 4 feet higher than the surrounding site grades. The remainder of the site grades range from about El. 10 to El. 20 feet.

A groundwater extraction and treatment system consisting of 13 extraction wells is in operation at the site.

Geotechnical Exploration Program

CDM's geotechnical exploration consisted of drilling two mud rotary borings and six Cone Penetrometer (CPT) soundings up to depths of 100 feet at selected locations across the site. The mud rotary borings and CPT soundings were performed by Gregg Drilling and In-Situ of Martinez, California, on January 28 and 29, 2003. The purpose of the investigation was to characterize the subsurface conditions and determine engineering properties of soils to support development of remedial alternatives and conceptual design planning.

Soil Borings

Two test borings, CDMSB-11 and CDMSB-12, were drilled as part of this investigation. Test boring CDMSB-11 was drilled near the northeastern corner of the property that extends along Horton Street. Test boring CDMSB-12 was drilled near the southwestern corner of the property along Sherwin Avenue. The test borings were located in the field by chaining from existing site features and were monitored in the field by a CDM representative.

Sample collection alternated between a California Modified Split-Spoon Sampler and a Standard Penetration Test (SPT) in general accordance with American Society of Testing Method (ASTM) D1586. Soil samples in the test borings were typically collected at 5-foot intervals over the depth of the boring. Relatively undisturbed samples were collected using a California Modified Split-Spoon Sampler lined with 1-inch brass rings. Generally, the lower 6 rings of the sample were sealed in plastic bags and placed in rigid tubes with resealable end caps for transport to the laboratory. The SPT sampler was unlined and the retained sample material was placed in sealed plastic bags for transport to the laboratory. The drill rig utilized a 140 lb hydraulically driven auto-hammer to drive the sampler 18-inches. The blow count for each six-inch driven interval was recorded and the penetration resistance (N) was determined by adding the second and third 6-inch penetration resistance blow counts.

Water levels in the test borings were estimated from the condition of the samples obtained and by the observed water levels within the borehole at the time of drilling, if any. Both test borings were drilled to a depth of 101.5 feet below ground surface (bgs). At the completion of drilling, each boring was backfilled using Portland cement that was pumped through a 1-inch tremmie pipe to 100 feet bgs. Excess bentonite drilling mud and soil cuttings were collected and placed in 55-gallon drums for characterization and disposal.

In addition to the test borings conducted for this study, CDM reviewed three additional test borings, B11 through B13, which were drilled by others near the project area. The information contained on these logs was incorporated into our evaluation. These borings are located on the adjacent Chiron property, which is to the northeast of the Sherwin-Williams site adjacent to Parcels D and E.

A summary of the subsurface conditions encountered in the explorations is included in Table 1, Summary of Subsurface Explorations. Locations of the test borings

(CDMSB-11 and CDMSB-12 and B11 to B13) and the CPT soundings described in the following section are shown on Figure 2, Site Map. Copies of CDM boring logs, as well as boring logs B11 to B13 prepared by others are included in Appendix A.

Cone Penetrometer Soundings

A total of seven CPTs were planned for this investigation, however, near surface refusal on two attempts, attributed to possible buried foundation footing at location CPT-3, resulted in abandonment of this location. Therefore, a total of six CPTs (CPT-1, CPT-2, and CPT-4 through CPT-7) were conducted to provide information regarding subsurface conditions at the site. A copy of these CPT test data including the interpretation report is included in Appendix B.

Geotechnical Laboratory Testing

Laboratory tests were performed on selected split spoon samples and Shelby tube samples obtained from the test borings CDMSB-11 and CDMSB-12. The following analyses were conducted to characterize material index and strength properties:

- Grain size analyses using ASTM D422,
- Atterberg Limits using ASTM D4318,
- Moisture Content and Dry Unit Weight using ASTM D2216 and D2937, respectively,
- Direct shear tests performed in accordance with ASTM D3080, and
- Consolidation tests using ASTM D2435.

Results of the laboratory tests are summarized in Table 2, and a copy of the laboratory report is included as Appendix C.

Site Geology

The Sherwin-Williams site is located immediately to the east of the former margin of San Francisco Bay and is underlain by a variety of natural and culturally-modified soils.

Soil and Groundwater Conditions

The subsurface conditions encountered in test borings CDMSB-11 and CDMSB-12, B11 to B13, and the CPTs consist of a variety of different soils that CDM defined as follows:

- Layer 1: Silty/clayey gravel with sand
- Layer 2: Black sandy clay
- Layer 3: Clayey sand/ Silty sand
- Layer 4: Sandy clay
- Layer 5: Sand/ Gravelly sand/ Silty Gravel

Layer 1: Soils designated as fill (Layer 1 – silty clayey gravel with sand) were encountered in every test boring and CPT as the topmost Layer. The thickness of this Layer is estimated to be between 4 feet and 22 feet at borings and CPT locations. Layer 1 includes clay, silts, sand and gravel and may contain organic material and debris consisting of glass, concrete or brick fragments. USCS-classification of Layer 1 includes GP, GC, SM, ML, and CL. The SPT and California Modified Split Spoon Sampler N-values measured in the test borings as well as the CPTs indicate a wide range of density and consistency; loose to medium dense in granular soils and medium stiff to very stiff in fine grained soils, respectively.

The presence of debris, including glass and brick fragments, along with interlayed gravel observed in some borings suggests that certain areas are overlain by artificial fill materials. The thickness of artificial fill at these locations is estimated to be on the order of about 7 feet thick. Artificial fill is expected beneath/adjacent to existing and/or abandoned building foundations.

Layer 2: Layer 2 soils consist of mostly fine-grained soils containing organic compounds (Layer 2 – Black sandy clay). Layer 2 is generally described as soft, dark grayish to black, clay with medium to high plasticity with organic odors and varying amounts of silt and sand. The SPT and California Modified Split Spoon Sampler N-values measured in the test borings as well as the CPTs indicate that this stratum is soft. USCS-classification of Layer 2 includes CL and CH. Layer 2 ranges in thickness from 10 to 33 feet at the test boring locations. The bottom of Layer 2 extends to depths ranging from 19 to 43 feet below existing site grades in explorations where this layer was encountered. It appears that the thickness of Layer 2 is variable throughout the site and may be controlled be deposition/erosion along Temescal Creek.

Layer 3: Soils assigned to Layer 3 (Clayey sand/ Silty sand), generally directly underlie Layer 2, however, in some places Layer 3 directly underlies Layer 1. Layer 3 and layer 4 are inter-layered. Layer 3 is generally described as clayey sand, clayey sand with gravel with interbeds of clayey gravel. USCS-classification of Layer 3 includes SC and GC. Layer 3 ranges in thicknesses from 3 feet to greater than 16 feet at the test boring locations. The SPT and California Modified Split Spoon Sampler N-values measured in the test borings as well as the CPTs indicate that this layer is medium dense to dense.

Layer 4: Layer 4 (Sandy clay) generally consists of clay with varying contents of sand, silt and/or gravel with trace organic compounds. The plasticity of this layer is predominantly described as medium to high. USCS-classification of Layer 4 includes CH and CL. Layer 3 and layer 4 are inter-layered. Layer 4 ranges in thickness from 3 to greater than 53 feet thick at the test boring locations. The SPT and California Modified Split Spoon Sampler N-values measured in the test borings as well as the CPTs indicate that this layer is medium stiff to very stiff.

Layer 5: Layer 5 (Sand/ Gravelly sand/ Silty Gravel) generally consists of sand, gravelly sand, and silty gravel. USCS-classification of Layer 5 includes SP, SW and GM. Layer thicknesses range from 5 to 13 feet thick at the test boring locations. The

SPT and California Modified Split Spoon Sampler N-values measured in the test borings as well as the CPTs indicate that this layer is medium dense to very dense.

Groundwater beneath the site varies from depths of 10 to 14 feet below existing ground surface. The extraction well network was operating during this work.

A summary of the subsurface conditions is presented in Table 1. Figure 3, Isopach Map – Base of Layers 1 or 2, illustrates the approximate base or bottom of shallow unsuitable soils. Using this figure, it is possible to estimate the thickness of unsuitable soils (base of Layers 1 and 2) by adding the ground surface elevation (black) contour line to the contour value depicted by the base of Layer 1 or 2 (red) contour line. The sum of these values represents the interpreted thickness of the underlying unsuitable soils.

Assessment of Geologic Hazards

The geologic hazards at the site are attributed to the regional seismicity. Specifically, the seismic hazards include fault surface rupture, liquefaction of saturated granular soils, and ground shaking. The hazard potential associated the seismic potential for the Site is presented below.

Surface Fault Rupture

Based on review of current publications available from the California Geological Survey (CGS), Alquist-Priolo Earthquake Fault Zone map (CGS, 2003) there are no known or identified active or potentially active faults intersecting or trending into the Site (Jennings, 1992; WGCEP, 1996). The nearest known active fault is the Hayward fault, situated approximately 3 miles northeast of the site. Other active regional faults such as the San Andreas, Calaveras, Rodgers Creek – Healdsburg, Concord-Green Valley, San Gregorio, and Greenville faults are located at least 15 miles from the site. Refer to Appendix D for the EQFAULT (EQFAULT, 2000) preliminary listing of active regional faults with estimated moment magnitudes and peak site accelerations values, based on Abrahamson & Silva (1997). Based on review of published information, the potential for fault surface rupture is considered low.

Liquefaction

Liquefaction is a soil behavior phenomenon in which loose saturated granular soils lose their inherent shear strength due to increased pore water pressures as a result of cyclic loading, such as ground shaking during a strong earthquake. While a detailed liquefaction analysis was not conducted for this site, the liquefaction potential for the site ranges from "very high" to "moderate" (CGS, 2003). This determination is generally consistent with site investigation results. However, the continuity of potentially liquefiable zones at the Site was not evaluated as part of this study.

Potential consequences of liquefaction include bearing capacity failure, flotation of lightweight embedded or buried structures, landsliding (lateral spreads and flow slides), and differential settlement. Among these deformation mechanisms, large permanent ground deformations resulting from liquefaction-induced settlement is

considered to be the most significant potential mode of liquefaction-induced ground failure at the Site.

Planned Future Site Remediation

Portions of the site are underlain by impacted soil and groundwater and a variety of remedial approaches are being evaluated. An area approximately 200 feet by 200 feet and located to the north of the existing Building No. 31 and within the area of the raised cap will be remediated (Parcel D). The existing retaining wall surrounding the raised cap will also be removed. Remediation may include removal or in-situ/ex-situ treatment of the contaminated soils to a maximum depth of about 20 feet and replacement as needed with compacted structural fill.

Alternatively, soil-mixing consisting of in-situ mixing of cement-ferrous sulfate slurry with the existing soils to a maximum depth of about 20 feet may be conducted. Soil-mixing, if used, will likely result in a zone of remediated soil with compressive strengths in the range of 100 to 1,000 pound per square inch (psi), depending on final mix design.

It should be noted that future structures supported on shallow foundations that bear on this zone of stabilized soil and extend on to zones of soil not previously treated will require special attention with respect to differential settlement since the mixed soils will be significantly less compressible than the existing, untreated soils present at the site.

Conceptual Geotechnical Design Recommendations

Conceptual geotechnical engineering evaluations have been made as they relate to the proposed future development of the Sherwin-William's Facility in Emeryville, CA. In general, these evaluations have been based on the minimum requirements of the Unified Building Code (UBC) 1997. In addition, recommended design criteria are based on performance tolerances, such as allowable settlement, as understood to relate to similar structures.

Low and Mid Rise Buildings – Conceptual Foundation Design

The proposed low-rise and some of the mid-rise buildings can be supported on spread footings or on mat foundations bearing on suitable foundation bearing soils. Suitable foundation layers consist of Layers 3, 4, or 5 or on structural fill placed after the excavation of unsuitable soils. Unsuitable soils include all of existing Layers 1 and 2 and any loose or disturbed soils present at the subgrade level. As presently understood, no below grade space is anticipated for the proposed buildings, therefore, normal foundation level for the structures will not likely extend into the suitable bearing materials and over excavation and removal of unsuitable soils will be required. Over excavated areas should be backfilled with compacted fill.

Foundations should be designed for maximum net allowable bearing pressures of no more than 5,000 pounds per square foot (psf) for both dead and live loads bearing directly on the existing naturally deposited clayey sand/silty sand, sandy clay, or silty

gravel/gravel and silt stratum soils or on compacted fill placed after the removal of all unsuitable soils. An ultimate bearing pressure for the suitable bearing Layer at the site should be assumed to be no more than 10,000 psf.

All foundations should bear at least 3 feet below any adjacent lowest ground surface. Settlement of these structure, under the anticipated loads and designed as recommended above, is expected to be less than 2 inches with no more than 1 inch of differential settlement across the width of the structure.

Due to the depth of suitable bearing bearings soils, in some areas it may not be economical to support some low and mid-rise structures on shallow spread footings or mat foundations. In these areas it may be more economical to support these structures on deep foundations as described below for high-rise structures.

High Rise Buildings – Conceptual Foundation Design

The proposed high-rise buildings or mid-rise buildings with heavy loads should be supported on deep foundations bearing in the underlying Layer 3, 4 and/or 5 stratums. End driven piles or deep-drilled shafts can be used.

Driven piles consisting of precast prestressed concrete piles are likely to be the most economical pile type. Pile capacities of 100 and 125 tons for 12 and 14-inch square piles, respectively, can be achieved. Piles will develop capacity in both skin friction and end bearing. Piles should be driven to a minimum tip elevation and/or final driving resistance as required to reach the design capacity. Pile lengths should be expected to be about 80 to 100 feet and a load test will be required. Little spoil should be produced during installation of driven piles, thus disposal costs for contaminated soils should be limited. Care should be used when piles are driven in close proximity to adjacent structures or sensitive utilities as excess vibrations may cause damage.

Deep-drilled shafts, bearing in the underlying Layers 3, 4, and 5, can also be used. Drilled shafts will develop capacity in both skin friction and end bearing. Drilled shaft capacities of up to approximately 200 tons can be achieved. Shaft diameters should be expected to range from 2 to 4 feet. Shaft lengths of 80 to 100 feet would be required as shorter shaft lengths will result in less capacity. For conceptual design purposes a 60 foot long, 2-foot diameter shaft should be expected to result in a design capacity of about 80 tons and a 100 foot long, 3-foot diameter shaft should expected to result in a design capacity of 200 tons. Shafts may encounter layers of granular soils (sand and/or gravel) and steel casing or drilling mud may be required to maintain the shaft opening during construction. A significant amount of spoil will result from the drilled shaft construction. Spoils from the upper contaminated layers will require proper disposal. Drilled shafts may be installed adjacent to existing structures. Provided proper construction techniques are used, damage to adjacent structures and/or utilities can be minimized.

Alternatively, it may be feasible and more economic able to support some high-rise structures on an intermediate pile-raft foundation system. Intermediate length piles and a raft, i.e., mat, foundation system can be designed as a composite system to carry

foundation loads. This approach allows for the use of shorter piles since some of the foundation load is carried by the mat/raft. It is unlikely that structures with very high column loads can be supported on a pile raft foundation system, however, structures with 6 to 10 stories may be appropriate.

Lowest Level Floor Slab

The lowest level floor slab may be designed as slabs-on-grade bearing on a minimum of 18-inches of compacted, non-expansive fill. Any existing fill, disturbed, or otherwise unsuitable soils present below the slab level should be removed and replaced with compacted, non-expansive fill. A moisture-proof membrane should be installed below the slab and a 2-inch layer of sand placed between the membrane and the underside of the slab to protect the membrane from damage during construction.

Seismic Design Considerations

For purposes of determining design earthquake forces in accordance with the 1997 Uniform Building Code (UBC), the site may be considered as a "Zone 4" soil site as determined by Figure 16-2 of the UBC 1997. Therefore, in accordance with Table 16-I of the UBC, a Seismic Zone Factor equal to 0.4 should be used. Based on the type of soil encountered in our borings and our recommendations, the site may be considered S_D-Stiff, per Table 16-J of UBC 1997. The site is approximately 3 miles from the Hayward Fault, which is a Type A fault per Table 16-U of UBC 1997. Per Table 16-S and 16-T of the UBC, the near source acceleration (N_a) and velocity (N_v) with respect to the subject site is 1.2 and 1.6, respectively. Per Tables 16-Q and 16-R, the site seismic coefficient of acceleration (C_a) and velocity (C_v) is 0.44 N_a and 0.64 N_v, respectively.

Construction Considerations

Deep Foundation Construction

Installation of deep foundations should be conducted to address the following issues:

- **Potential for contaminant migration during installation of deep foundations through contaminated soils:** Use of precast prestressed piles (e.g., displacement piles) should not require the installation of a casing in areas of shallow impacted soils or groundwater as the piles will displace the surrounding soft plastic ductile soils during driving thus preventing pathways for migration. Flow path development at the pile/soil interface is unlikely because of the resultant relatively high soil/pile interface shear stresses that are induced during driving. In addition, the surface of the piles tend to be relatively smooth and tend not to smear the soil along the pile surface during driving, which in turn reduces "drag down" of soil contamination. Furthermore, the potential for down drag of shallow contaminated soils during installation should be insignificant as the planned remedial action to stabilize these materials in-place will be completed prior to pile installation.

  Displacement piles have been installed at numerous locations throughout the San Francisco Bay Area, through areas of documented soil impacts. Representative

major-construction projects that installed displacement piles through impacted soil include the San Francisco Bay Area Rapid Transit SFO extension and the nearby Shellmound/Bay Street development. These local projects with similar site and soil/groundwater contaminant conditions support this choice of using displacement piles.

In the event that drilled piles are used, then the use of double-cased pile should be evaluated. However, CDM recommends using displacement piles such as prestressed precast concrete piles to prevent the need for casing or other special construction methods. As previously stated, displacement piles also provides the most cost beneficial foundation support for structures requiring deep foundation systems.

- **Driving piles through stabilized soils:** It is our experience that driving piles directly though stabilized soils without pre-drilling can result in damage to the piles, particularly concrete piles. Pre-drilling through stabilized soils using a small caisson drill rig may be required prior to pile driving.

Excavation Support

Removal of contaminated soil located to the north of the existing Building No. 31 and within the area of the raised cap will require an excavation support system due to the proximity of the excavation to adjacent structures and the property limits. As stated previously, excavation and/or in-situ treatment depths of up to 20 feet may be required. Excavation support systems consisting of continuous steel sheeting, soldier piles and lagging, seacant pile walls, or soil-mix walls are considered suitable excavation support systems. In addition, bracing and/or tiebacks may be required. The following is a brief summary of some of the key issues associated with each support system:

- **Continuous Sheeting:** The use of continuous steel sheeting will likely require pre-excavation along the wall alignment to remove obstructions. A vibratory hammer will be used to install the sheeting. Vibrations from a vibratory hammer are not expected to cause damage to adjacent structures but may be a temporary nuisance to adjacent residences/businesses. A steel sheet piling wall will be relatively water tight and thus, reduce site dewatering requirements.

- **Soldier Piles:** Soldier piles can be drilled, or installed into pre-drilled holes. Driven soldier piles can be installed with a vibratory hammer; however, installation using an impact hammer is more common. Provided proper construction methods are used vibrations from an impact hammer are not expected to cause damage to adjacent structures but will likely be a temporary nuisance to adjacent residences/businesses. Soldier piles installed in pre-drilled holes are not expected to result in significant vibrations. The lower portion of the drilled hole should be filled with concrete and the portion of the drilled hole above the lowest excavation level may be backfilled with soil. Some pre-excavation should be expected to remove underground obstructions prior to soldier pile installation. Timber lagging

is typically installed between the soldier piles, however, steel plates may be also be used. A soldier pile and lagging wall system is not considered to be a watertight wall system. Soldier piles that are driven in-place may be extracted once the site has been backfilled. Soldier piles concreted into pre-drilled holes will need to be cut-off and abandoned in place.

- **Seacant Pile Wall:** Seacant pile walls consist of concrete filled, overlapping drilled shafts. A steel section is installed in every other drilled shaft in order to provide sufficient strength to the wall system. Construction of a seacant pile wall system is not expected to result in significant vibrations. Pre-excavation should be expected to remove obstruction located along the wall alignment. A seacant pile wall system is considered to be a watertight wall system. In addition, the top of the wall will need to be cut-off and abandoned in place once the site is backfilled.

- **Soil-Mix Wall:** Soil-mix walls consist of overlapping soil-cement mix columns with a steel section is installed in each or every other column in order to provide sufficient strength to the wall system. Construction of a soil-mix wall system is not expected to result in significant vibrations. Pre-excavation should be expected to remove obstruction located along the wall alignment. A soil-mix wall system is considered to be a watertight wall system. In addition, the top of the wall will need to be cut-off and abandoned in place once the site is backfilled.

- **Bracing/Tiebacks:** Internal bracing and/or tiebacks should be expected to be required for excavation depths over about 15 feet. The actual depth that the excavation can extend without installing bracing will depend on the wall system used. It is not clear at this time if installation of tiebacks below city streets and railroad tracks will be permitted. In addition, installation of tiebacks may be hindered by unknown buried site obstructions. The presence of internal bracing inside the excavation will likely hamper excavation efforts whereas tiebacks allow for a wide-open excavation area.

Compacted Fill

All imported structural fills and backfills shall be predominantly granular, less than 3 inches in any dimensions, free of organic and inorganic debris and other deleterious materials, with less than 35 percent passing the No. 200 sieve. All fill and backfill materials should be observed and tested by the geotechnical engineer prior to their use in order to evaluate the suitability.

Granular structural fill should be placed in layers no thicker than 8 inches, as placed, and compacted with a self-propelled vibratory roller. Each layer of fill should be compacted to at least 95 percent of the maximum dry density as determined by ASTM-D1557. Lift thicknesses should be reduced to 4 inches in confined areas accessible only to hand guided compaction equipment.

Structural fill placed below foundations should extend at least 3 feet beyond the edge of foundations, then outward and downward at a slope of 1 horizontal to 1 vertical (1H:1V).

Closure

The recommendations contained herein are considered suitable for conceptual design level development evaluations associated with the proposed future development of the Sherwin-William's facility in Emeryville, CA as understood at this time and described herein. These recommendations have been prepared in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made. In the event that changes in the design or location of the structures occur, the conclusions and recommendations contained herein should not be considered valid unless verified in writing by CDM.

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Attachments:

Figure 1 -	Site Location Map
Figure 2 -	Site Map
Figure 3 -	Isopach Map – Base of Layers 1 or 2
Table 1 –	Summary of Subsurface Explorations
Table 2 -	Summary of Geotechnical Laboratory Results
Appendix A -	Boring Logs
Appendix B -	Cone Penetrometer Test Results
Appendix C -	Geotechnical Laboratory Test Results
Appendix D -	EQFAULT Summary

Tables

Sherwin-Williams
1450 Sherwin Avenue
Emeryville, California

Table 1
SUMMARY OF SUBSURFACE EXPLORATIONS

Test Boring Number	Approximate Ground Surface EL [1]	Total Drilling Depth (ft)	Layer Thickness (ft)					Approximate Depth to Groundwater (ft) [2]
			Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	
CDMSB-11		101.5	16	11	5 / 10	20 / 20 / >6.5	5 / 5	10
CDMSB-12		101.5	6	21	4 / 5 / >15.5	11/15/2011	13	10
B11		98	7	NE	7 / 2.5 / 4	3 / 8 / 3.5 / 26 / >34	3	NR
B12		81.5	10.5	NE	9	10.5 / >51.5	NE	13
B13		81	4	NE	4 / 11 / >7	8/21/2014	12	14
CPT-1 [3]		100.1	15	12	4 / 7	27 / 26 / >10	3	NR
CPT-2 [3]		100.1	22	10	8 / >24	11 / 19	6	NR
CPT-4 [3]		100.1	20	14	5 / 15	10 / 13 / >15	8	NR
CPT-5 [3]		100.1	5	27	1 / 2 / 9	12 / 21 / >8	4	NR
CPT-6 [3]		100.1	10	33	2 / 6	21 / >28	NE	NR
CPT-7 [3]		100.1	5	14	4 / 5 / 10 / >8	23 / 10 / 6 / 15	NE	NR

Notes:
1. Elevations based on Mean Sea Level (MSL) and are reported in feet.
2. Depth to groundwater is reported at the time of drilling.
3. CPT is an indirect means of investigation. Classification of Layer might be different.

Abbreviations:

NE	Not Encountered
NR	Not Recorded
>	Indicates Layer not fully penetrated
/	Indicates Layer is discontinuous. See test boring logs (Appendix A) for additional information.

Sherwin-Williams
1450 Sherwin Avenue
Emeryville, California

Table 2
SUMMARY OF LABORATORY TEST RESULTS

Test Boring Number	Sample Depth (ft)	Layer No.	Grain Size Analysis [1]			Atterberg Limits [2]			USCS Classification [3]
			Gravel %	Sand %	Fines %	LL (%)	PL (%)	PI (%)	
SB-12	15	2				31	15	16	CL
SB-11	18.5	2				34	15	19	
SB-11	21	2	26.8	52.3	20.9				SM
SB-11	25	2							
SB-12	25	2				46	13	33	
SB-11	27	5				30	14	16	
SB-11	30	5	27.7	61.2	11.1				SP-SM
SB-12	30	5				49	22	27	CL
SB-11	35	4							
SB-12	35	5	43.5	47.0	9.5				SW-SM
SB-11	40	4				36	16	20	
SB-12	40	4							
SB-11	45	4				33	15	18	
SB-12	45	4				33	15	18	
SB-11	55	5							
SB-12	60	4				70	16	54	
SB-11	65	4				39	20	19	CL
SB-12	65	4				47	16	31	
SB-12	70	3							

Notes:

1 Grain size analysis tests were conducted in accordance with ASTM D422.
2 Atterberg Limit tests were performed in accordance with ASTM D4318.
3 USCS classifications were performed in accordance with ASTM D2488.

Abbreviations:

LL Liquid Limit
PL Plastic Limit
PI Plasticity Index
CL Clay
SM Silty Sand
SP Poorly Graded Sand
SW Well Graded Sand

Sherwin-Williams
1450 Sherwin Avenue
Emeryville, California

Table 2
SUMMARY OF LABORATORY TEST RESULTS (continued)

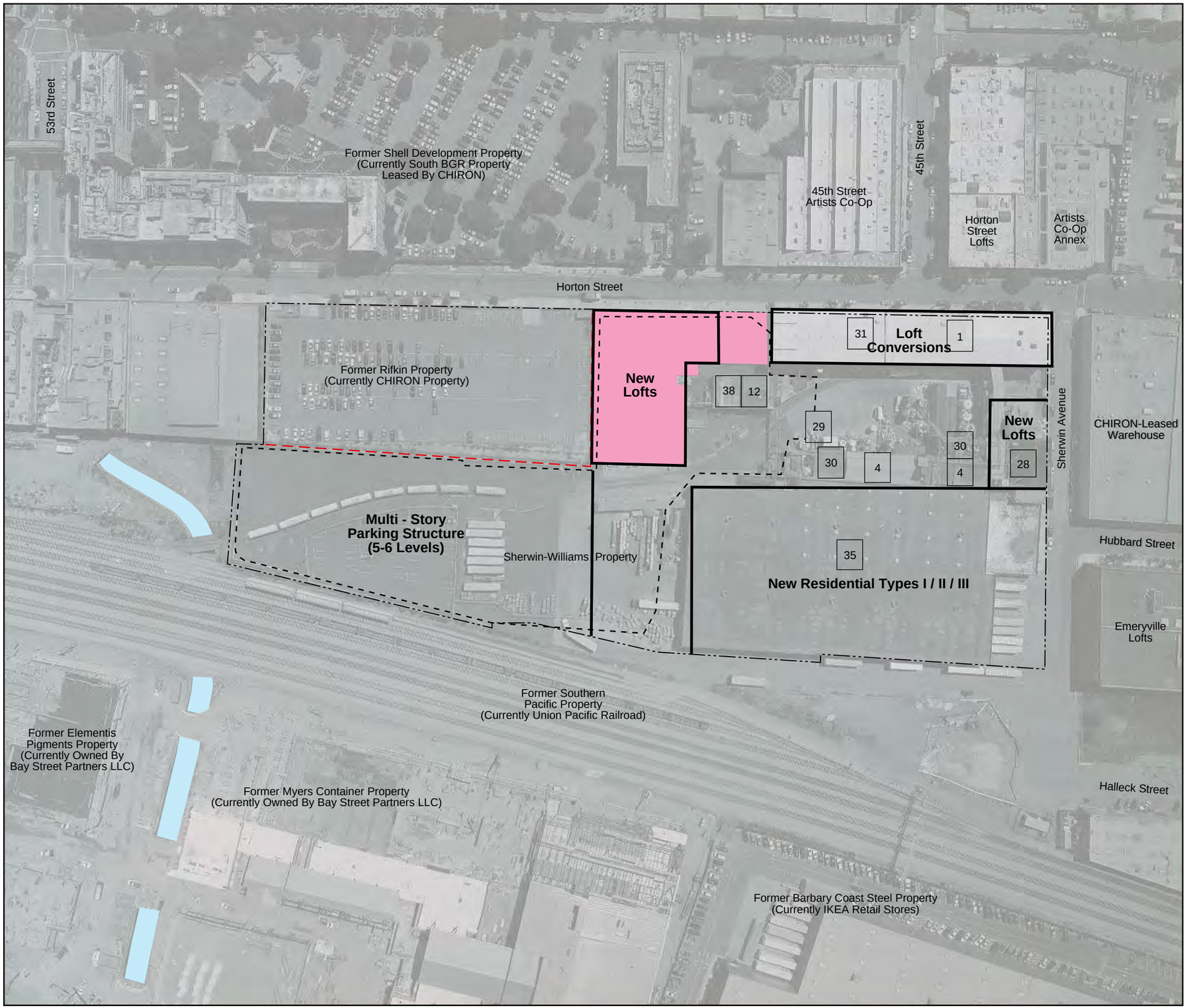
Test Boring Number	Sample Depth (ft)	Layer No.	Moisture Content (%)	Dry Unit Weight (pcf)	Total Unit Weight (pcf)	Consolidation Test [1]			Direct Shear Test [2]	
						PP (ksf)	CC (-)	CR (-)	Phi (deg)	C (psf)
SB-12	15	2							27.7	388
SB-11	18.5	2							23.5	303
SB-11	21	2								
SB-11	25	2	25.0	97.6	122.0					
SB-12	25	2				0.69	0.145	0.020		
SB-11	27	5							30.3	204
SB-11	30	5								
SB-12	30	5							26.0	859
SB-11	35	4	24.2	102.6	127.4	2.0	0.086	0.017		
SB-12	35	5								
SB-11	40	4								
SB-12	40	4	18.5	111.0	131.5	5.0	0.100	0.021		
SB-11	45	4	18.0	113.3	133.7				29.8	298
SB-12	45	4								
SB-11	55	5	16.2	118.9	138.2					
SB-12	60	4	25.8	99.8	125.5					
SB-11	65	4				4.5	0.089	0.021		
SB-12	65	4								
SB-12	70	3	17.5	114.3	134.3					

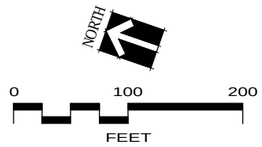
Notes:

1 Consolidation tests were performed in accordance with ASTM D2435
2 Direct shear tests were performed in accordance with ASTM D3080
3 Using CC = cc/(1+e0) with approximation cc = 0.007*(LL-10%)
4 Using approximation CR = 0.2*CC

Abbreviations:

PP Maximum past pressure.
CC Compression Ratio, (C_c/1+e_o)
CR Recompression Ratio, (C_r/1+eo)
Phi Friction Angle.
C Cohesion.





Legend

- Site Boundary
- Approximate Location of Slurry Wall
- Boundary Between S-W and Former Rifkin Property
- 1 — Building Number
- Raised Cap
- Temescal Creek

Figure 1
Conceptual Site Development Plan
Sherwin-Williams Company
Emeryville, California

CDM



N E S W

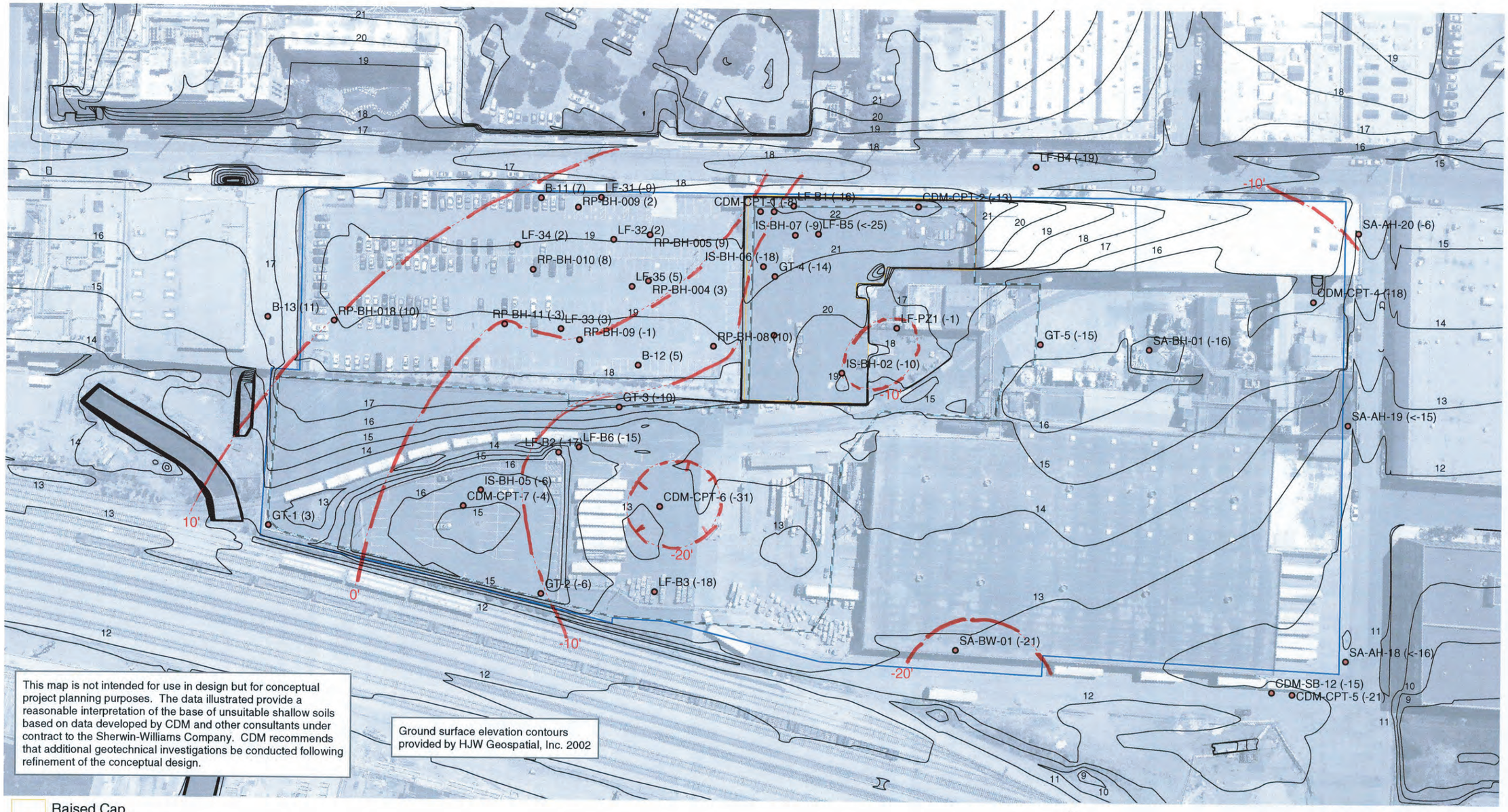
0 25 50 100 150 200 Feet

NAD83 California Stateplane III

Legend

- Extraction Well
- Approx Location Soil Boring By Others
- Approx Location Cone Penetromer Sounding (CDM, 2003)
- Approx Location Mud Rotary Boring (CDM, 2003)
- Temescal Creek
- Raised Cap
- Railroad Track
- Slurry Wall
- Boundary Between S-W and Former Rifkin Property

Figure 2
Boring Location Map
Sherwin-Williams Company
Emeryville, California



Raised Cap
Property Boundary
Slurry Wall
Inferred Elevation of Layers 1 and 2 (Contour Interval 10 Feet)
Ground Surface Elevation Contours (Ft. msl)
GT-1 (2.5)
Selected Soil Borings (Inferred Elev. of the Base of Layer 1 or Layer 2)

100 50 0 100 Feet
NAD83 California Stateplane III

N E S W

Figure 3
Isopach Map - Base of Layers 1 or 2
Sherwin-Williams Company
Emeryville, California

C:\arcgis\Projects\32581_Emeryville\contour_020504.mxd

Appendix A
Boring Logs

Boring Log CDMSB-11

Other Tests	Sample No.	Moisture Content (%)	Dry Density	PID (ppm)	Penetration Resistance (blows / 6 in.)	Depth (feet)	Sample	USCS	Symbol	DESCRIPTION	Elev. (feet)
	SB11-BULK							ML		Asphalt - 2 inches. SANDY SILT WITH GRAVEL, dark brown (10YR3/3), moist, 70% fine grained sand and silt, 25% gravel to 20 cm, and 5% dark gray-brown clay.	
	SB11-5			0.0	6 9 12			ML		SILT, dark brown (10YR3/3), moist, medium stiff, non-plastic, trace gravel to 0.5 cm, minor decayed vegetation.	
				0.0	3 6 6	10				SILTY SAND, dark yellowish-brown (10YR4/4), wet, medium dense, fine grained, 60% sand, 40% silt, some gravel, trace biotite, some gravel slough.	
	SB11-11			0.0	2 5 12			SM			
	SB11-15			0.0	3 3 3			GC		CLAYEY GRAVEL, very dark gray (10YR3/1), wet, 0.5 to 1 cm well rounded clasts.	
	SB11-18.5			0.0	400 lb			CH		CLAY, dark grayish-brown (10YR4/3), wet, mottled with orange-brown, medium to high plasticity.	
	SB11-21			0.0	5 8 8	20		SP		POORLY GRADED SAND WITH GRAVEL, very dark gray (10YR3/1), wet, medium dense, medium to coarse grained sand, 20% fine gravel to 0.5 cm, subangular to angular grains.	
	SB11-25			0.0	2 4 6			CL		CLAY, black (10YR2/1), wet, soft, medium to high plasticity, some gravel slough.	
	SB11-27			0.0	1500 lb			CL SP		GRAVELLY CLAY, dark yellowish-brown (10YR4/4), wet, gravel up to 1 cm. POORLY GRADED SAND WITH GRAVEL, very dark grayish-brown (10YR3/2), wet, medium dense, medium to coarse grained sand, trace gravel, some clay.	
	SB11-30			0.0	6 10 9	30		SW		WELL GRADED SAND, very dark grayish-brown (10YR3/2), wet, medium dense, coarse to medium grained, trace gravel.	
	SB11-35			0.0	4 7 11			CH		CLAY, grayish-brown (2.5YR5/2), moist, medium stiff, low to medium plasticity, medium toughness, stratified layers of brown (7.5YR4/4) oxidized clay, trace black organics, 3 inches of clayey gravel slough at 36.5 feet bgs.	
	SB11-40			0.0	2 3 6	40		CH		As above, medium stiff, no organics, no slough.	
	SB11-45			0.0	13 18 18			CL		GRAVELLY CLAY, gray (2.5Y5/1), moist, stiff, low plasticity, 15% well rounded gravel (chert and siltstone clasts) to 0.5 cm, abundant dark brown oxidation around edges of gravel clasts.	
	SB11-50			0.0	4 5 7	50		CH		CLAY, light olive-brown (2.5Y5/6), moist, medium stiff, medium plasticity, medium toughness, low dilatency.	
	SB11-55			0.0	14 39 38			SP SW		POORLY GRADED SAND, light yellowish-brown (2.5YR6/3), wet, fine to medium grained. WELL GRADED SAND WITH GRAVEL, dark yellowish-brown (10YR4/6), wet, very dense, medium to	

Location: Sherwin-Williams Emeryville
Surface Elevation:
Logged By: H. Young

Drill Rig: D-21
Equipment/Hammer: Mud Rotary/140 lb
Date Completed: 1-28-03

CDM

Sherwin-Williams
Sherwin-Williams Geotechnical Investigation
Emeryville, California

Boring Log CDMSB-11
Project No:

Figure:
1 of 2

BORING LOG SWGEOT.GPJ CDM_BLLV.GDT 4/23/03 REV. 5

Boring Log CDMSB-11

Other Tests	Sample No.	Moisture Content (%)	Dry Density	PID (ppm)	Penetration Resistance (blows / 6 in.)	Depth (feet)	Sample	USCS	Symbol	DESCRIPTION	Elev. (feet)
	SB11-60			0.0	7 11 12			GC		coarse grained, 20% fine gravel (subrounded) to 0.5 cm, subangular grains, quartz and red chert composition. CLAYEY GRAVEL, light yellowish-brown (2.5Y6/3), wet, medium dense, 50% subanular gravel to 4 mm, clay is highly plastic.	
	SB11-65			0.0	7 9 14			CH		CLAY, grayish-brown (2.5Y5/2), moist, medium stiff, medium plasticity, low to medium toughness, mottled with brown (7.5YR4/4) clay, dark brown rootlets to 3 mm.	
	SB11-70			0.0	6 9 11	70		CH		CLAY, as above, moist, stiff, medium plasticity, 5% fine gravel (well rounded, red, light gray, and gray clasts) to 1 cm, dark brown rootlets.	
	SB11-75			0.0	16 24 32			CH		CLAY, light olive brown (2.5Y5/4), moist, very stiff, medium plasticity and toughness, slow dilatency, abundant dark brown rootlets.	
	SB11-80			0.0	4 5 8	80		CL		CLAY, as above, mottled pale olive (5Y6/3) and light olive-brown (2.5Y5/4), moist, stiff, low to medium plasticity, trace fine grained sand, trace white shell fragments.	
	SB11-85			0.0	24 29 35			SC		CLAYEY SAND WITH GRAVEL, dark yellowish-brown (10YR4/6), wet, medium dense, 40% sand, 30% clay, 30% gravel, sand is coarse grained to 3 mm, poorly graded, gravel is well rounded, 0.5 to 3 cm, spherical to oblate clasts, black, light gray, gray, and red.	
	SB11-90			0.0	18 22 24	90		SC		As above, dense, less gravel (15%).	
	SB11-95			0.0	11 15 24			CH		CLAY, light olive-brown (2.5Y5/4), moist, stiff, medium to high plasticity, medium toughness, trace black well rounded gravel to 0.5 cm.	
	SB11-100			0.0	6 12 14	100		CH		As above, very stiff.	
										Total depth 101.5 feet bgs. Borehole abandoned with Portland cement (10-94 lb bags Type I/II cement and 60 gallons of potable water) pumped through a 1-inch tremmie pipe to 100 feet bgs. Bentonite drilling mud and soil cuttings containerized in 55-gallon drums for characterization and disposal.	
						110					

Location: Sherwin-Williams Emeryville
Surface Elevation:
Logged By: H. Young

Drill Rig: D-21
Equipment/Hammer: Mud Rotary/140 lb
Date Completed: 1-28-03

CDM

Sherwin-Williams
Sherwin-Williams Geotechnical Investigation
Emeryville, California

Boring Log CDMSB-11
Project No:

Figure:
2 of 2

BORING LOG SWGEOT.GPJ CDM_BLLV.GDT 4/23/03 REV. 5

Boring Log CDMSB-12

Other Tests	Sample No.	Moisture Content (%)	Dry Density	PID (ppm)	Penetration Resistance (blows / 6 in.)	Depth (feet)	Sample	USCS	Symbol	DESCRIPTION	Elev. (feet)
								GP		Asphalt/concrete-5-inches.	
										GRAVEL, dark yellowish-brown (10YR4/4), moist, loose, angular to subangular clasts to 5 cm, some asphalt.	
	SB12-2.5			0.0			G	CL		CLAY, black (10YR2/1), moist, medium to low plasticity, slight organic odor.	
	SB12-5			0.0	4 3 4			GP		GRAVEL, gray, moist, loose, angular to subangular clasts to 4 cm, 20% clay.	
										CLAY, very dark gray (10YR3/1), moist, soft, high plasticity, high toughness, trace gravel to 0.5 cm, odor like decayed vegetation.	
	SB12-10			0.0	1 1 1	10		CH			
	SB12-15			0.0	1 4 5			CH		CLAY, very dark grayish-brown (10YR3/2), moist, soft, high plasticity and toughness, trace decayed rootlets to 1 cm, strong odor like decayed vegetation.	
	SB12-20			0.0	2 4 6	20		CH		SILTY CLAY, dark gray (10YR4/1), moist, medium stiff, high plasticity, high toughness, mottled with orange-brown clay, trace gravel to 4 mm, well rounded, white and gray clasts.	
	SB12-25			0.0	300 lb			CH		CLAY, grayish-brown (2.5Y5/2), wet, firm, high plasticity, high toughness, trace fine sand.	
								SP		GRAVELLY SAND, dark grayish-brown (2.5Y4/2), wet, medium dense, fine to medium grained, 10% fine gravel to 0.5 cm, subangular to subrounded grains, gray, white, and red clasts.	
	SB12-30			0.0	12 15 17	30		CH		CLAY, grayish-brown (2.5Y5/2) mottled with light olive-brown (2.5Y5/6), moist, stiff, high plasticity, stratified, minor dark brown organics.	
								GM		SILTY GRAVEL, dark yellowish-brown (10YR4/4), wet, medium dense, medium grained sand to medium gravel, 20% silt, well rounded gravel clasts to 2 cm, gray and white clasts, some stratification of clasts, gravel contact at 32.5 feet bgs infered by drill rig chatter.	
	SB12-35			0.0	7 9 16			GM		As above, medium dense.	
	SB12-40			0.0	6 11 13	40		CH		CLAY, light olive-brown (2.5Y5/3), wet, stiff, high plasticity, high toughness, some mottling, 6 inches of gravel slough.	
	SB12-45			0.0	3 5 7			CH		SILTY CLAY, light olive-brown (2.5Y5/3) with stratified layers of yellowish-brown (10YR5/6) clay, moist, medium stiff, medium plasticity low to medium toughness.	
	SB12-50			0.0	6 8 11	50		CH		50 - 50.5 feet bgs: yellow-brown stratification of 2 mm fine grained sand layers.	
								SC		50.5 - 51 feet bgs: trace 3 mm white gravel and shell fragments.	
	SB12-55			0.0	3 4 4			CH		CLAYEY SAND, light olive-brown (2.5Y5/4), wet, loose, fine to coarse grained, trace fine gravel and shell fragments to 0.5 cm, angular to subrounded grains.	
										CLAY, light olive-gray (5Y6/2), moist, medium stiff, high plasticity, medium toughness.	
										55.5 feet bgs: 2-inch clayey sand layer, stratified.	

Location: Sherwin-Williams Emeryville
Surface Elevation:
Logged By: H. Young

Drill Rig: D-21
Equipment/Hammer: Mud Rotary/140 lb
Date Completed: 1-29-03

Sherwin-Williams
Sherwin-Williams Geotechnical Investigation
Emeryville, California

Boring Log CDMSB-12
Project No:

Figure:
1 of 2

CDM

BORING LOG SWGEOT.GPJ CDM_BLLV.GDT 4/23/03 REV. 5

Boring Log CDMSB-12

Other Tests	Sample No.	Moisture Content (%)	Dry Density	PID (ppm)	Penetration Resistance (blows / 6 in.)	Depth (feet)	Sample	USCS	Symbol	DESCRIPTION	Elev. (feet)
	SB12-60			0.0	7 10 12			CH		56 feet bgs: color changes to dark greenish gray (1 FOR GLEY4/1). CLAY, light olive-gray (5Y6/2), wet, medium stiff, high plasticity and toughness, 2% of sample comprises 1-2 mm, black (10YR2/1) round voids and organic fragments.	
	SB12-65			0.0	4 8 9			CH		At 60 - 60.5 feet bgs, trace coarse sand to 4 mm, well rounded, red and white. CLAY, pale olive (5Y6/3), wet, stiff, high plasticity, abundant black (10YR2/2) sand grains to 2 mm, trace gravel to 2 cm, light gray with dark brown and black iron oxide coating, well rounded, siltstone composition.	
	SB12-70			0.0	50 50/4"	70		GC		CLAYEY GRAVEL, yellowish-brown (10YR5/6), wet, very dense, 70% gravel, red and black clasts, 0.5 to 3 cm, well rounded, siltstone composition, high plasticity clay matrix.	
	SB12-75			0.0	8 12 12					SANDY CLAY WITH GRAVEL, moist, very stiff, medium plasticity, 15% fine grained sand, 5% fine gravel to 0.5 cm, gravel is white, light gray, and red chert, well rounded, trace white shell material to 3 mm, thin and soft.	
	NR				27 29 33	80		CH			
	SB12-85A SB12-85B			0.0	29 45 42			CH		CLAY, grayish-brown (2.5Y5/2), wet, firm, high plasticity, minor dark brownish-gray mottling, firm.	
								SC		CLAYEY SAND WITH GRAVEL, grayish-brown (10YR5/2), wet, medium dense, 60% sand, 30% clay/silt, 10% gravel, sand is fine to coarse grained, gravel up to 1 cm, subrounded clasts, black, red, and light gray.	
	SB12-90			0.0	6 8 14	90		ML		SILT, yellowish-brown (10YR5/4), wet, firm, low to medium plasticity, trace fine sand, trace rootlets, <2 mm.	
								SC		CLAYEY SAND, yellowish-brown (10YR5/4), wet, medium dense, fine to medium grained.	
	NR				16 19 24						
	SB12-96.5			0.0	16 27 29			CL		GRAVELLY CLAY, pale olive (5Y6/3), moist, low to medium plasticity, 15% gravel to 0.5 cm, well rounded, black iron oxide around edges.	
								SC		CLAYEY SAND WITH GRAVEL, yellowish brown (10YR5/4), wet, medium dense, 50% fine to coarse grained sand, 30% clay, 20% well rounded gravel to 1 cm, black and gray clasts, abundant black iron oxide around grains.	
	SB12-100			0.0	12 16 22	100		CL		GRAVELLY CLAY, yellowish-brown (10YR5/8), wet, very stiff, low plasticity, gravel to 0.5 cm, white shell fragments.	
										Total depth 101.5 feet bgs. Borehole abandoned with Portland cement (10-94 lb bags Type I/II cement and 60 gallons of potable water) pumped through a 1-inch tremmie pipe to 100 feet bgs. Bentonite drilling mud and soil cuttings containerized in 55-gallon drums for characterization and disposal.	
						110					

Location: Sherwin-Williams Emeryville
Surface Elevation:
Logged By: H. Young

Drill Rig: D-21
Equipment/Hammer: Mud Rotary/140 lb
Date Completed: 1-29-03

Sherwin-Williams
Sherwin-Williams Geotechnical Investigation
Emeryville, California

CDM

Boring Log CDMSB-12
Project No:

Figure:
2 of 2

BORING LOG SWGEOT.GPJ CDM_BLLV.GDT 4/23/03 REV. 5

Boring Logs – Chiron, Geomatrix (1994)

PROJECT: CHIRON CAMPUS EXPANSION PROJECT
Emeryville, California

Log of Boring No. B11

BORING LOCATION: 490799.5N, 1483583.7E

DATE STARTED: 9/29/94 | DATE FINISHED: 9/29/94

DRILLING METHOD: Hollow stem auger/rotary wash

HAMMER WEIGHT: 140 lbs | DROP: 30 inches

SAMPLER: See Explanation, Figure A-1

NOTES:
Logged by: E. Chase
Drilling Equipment: Mobile B-53
Drilling Contractor: RNL Enterprises

Surface Elevation: +14.2 feet

DEPTH (feet)	Sample No.	Sample	Blows/ Foot	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	Unconf. Comp. Str. (psf)
0				2 inches ASPHALT CONCRETE over 5.5 inches CONCRETE			
1-3	1		26	SILTY SAND (SM) Medium dense, dark yellowish brown, dry, fine to medium gravel, some clay [FILL] GMTX-11A PID = 0 ppm -#200 = 16%	---	---	---
4-6	2		22	SANDY CLAY (CL) Stiff, dark brown to black with red [FILL] GMTX-11B PID = 0 ppm	25	93	---
7-9				SANDY CLAY (CL) Stiff, brown			
10-12	3		13	CLAYEY GRAVEL with SAND (GC) Medium dense, dark olive brown, moist, fine to coarse sand Loose, olive green, hydrocarbon odor	---	---	---
13-19	4		2	SANDY CLAY with SILT (CL) Very soft, dark gray, wet	---	---	---
20	5	Shelby	25 - 200 psi		25	102	200
21-24				SILTY SAND (SM) Stiff, olive brown, fine to medium			
25-27	6		44	CLAYEY SAND with GRAVEL (SC) Dense, olive green, fine to coarse	---	---	---
28-30				SANDY CLAY (CL) Medium stiff to stiff, olive green, fine sand			

DRAFT

gt-1-88

Project No. 2803 | Geomatrix Consultants | Figure A-12

PROJECT: CHIRON CAMPUS EXPANSION PROJECT
Emeryville, California

Log of Boring No. B11 (cont'd.)

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/Foot	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content (%)	LABORATORY TESTS Dry Density (pcf)	LABORATORY TESTS Unconf. Comp. Str. (psf)
31	7		41	SANDY CLAY (CL) (continued)	---	---	---
32				CLAYEY SAND with GRAVEL (SC) Dense, mottled yellowish brown, olive brown and light gray, fine to coarse sand, fine gravel			
34							
35	8		20	SANDY CLAY (CL) Stiff, mottled olive brown, gray, and yellowish brown, fine sand			
36				Fine to coarse sand, some gravel	29	95	3900
37							
38							
39							
40	9		19	SILTY CLAY with SAND (CL) Stiff to very stiff, mottled olive gray and rust brown, fine sand	20	105	---
42				SANDY CLAY (CH) Very stiff, light gray with black, fine sand			
44							
45				SANDY CLAY with GRAVEL (CL) Very stiff, mottled olive brown and yellowish brown, fine to coarse sand, fine gravel			
46							
47							
48							
49							
50	10		50				
51					16	118	3850
52				SANDY CLAY (CL) Stiff, dark yellowish brown, fine sand			
53							
54							
55							
56							
57							
58							
59							
60	11		60	CLAYEY SAND with GRAVEL (SC) Very dense, dark olive brown, fine to coarse sand, fine gravel	---	---	---
62							
63							
64							

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gt-2-88

Emeryville, California

Log of Boring No. B11 (cont'd.)

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/Foot	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content (%)	LABORATORY TESTS Dry Density (pcf)	LABORATORY TESTS Unconf. Comp. Str. (psf)
65				SILTY CLAY (CL) Very stiff, light olive, some fine sand			
66							
67							
68				Gravel and sand			
69							
70							
71	12		31		28	96	5300
72							
73							
74							
75				SANDY CLAY (CL) Very stiff, mottled olive brown and yellowish brown, fine to coarse sand			
76							
77							
78							
79							
80	13		20	Mottled light olive and olive brown, some gravel	17	115	---
81							
82							
83							
84							
85							
86							
87							
88							
89							
90							
91	14		44	Olive brown	---	---	---
92				Fine sand, no gravel			
93				SANDY CLAY with GRAVEL (CL) Very dense, olive brown			
94							
95				Bottom of boring at 98.0 feet. Boring drilled using hollow stem augers to 36 feet; approximately 20 gallons of groundwater pumped from hollow stem augers; boring advanced to bottom using rotary wash drilling. Boring backfilled with cement bentonite grout.			
96							
97	15		50/6"		---	---	---
98							

DRAFT

gt-2-88

PROJECT: CHIRON CAMPUS EXPANSION PROJECT
Emeryville, California

Log of Boring No. B12

BORING LOCATION: 490572.6N, 1483467.3E

DATE STARTED: 9/17/94 | DATE FINISHED: 9/17/94

DRILLING METHOD: Hollow stem auger/rotary wash

HAMMER WEIGHT: 140 lbs | DROP: 30 inches

SAMPLER: See Explanation, Figure A-1

NOTES:
Logged by: J. Abitz
Drilling Equipment: CME 550
Drilling Contractor: RNL Enterprises

DRAFT

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/Foot	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content (%)	LABORATORY TESTS Dry Density (pcf)	LABORATORY TESTS Unconf. Comp. Str. (psf)
				Surface Elevation: +15.4 feet			
0				6 inch CONCRETE SLAB			
1	1		11	SANDY SILT (ML) Medium dense, black, moist GMTX-12A PID = 0	---	---	---
2							
3							
4	2		26	GMTX-12B PID = 0	17	98	2200
5							
6							
7							
8							
9							
10	3		19	SILT (ML) Medium dense,dark greenish gray, moist	25	99	---
11				ATD ▽			
12							
13							
14							
15	4		16	SANDY SILT (ML) Medium dense, dark yellowish brown	---	---	---
16							
17							
18				SILT (ML) Dark greenish gray			
19							
20	5		35	Gravel	18	118	---
21				SILTY SAND with GRAVEL (SC) Dense, dark yellowish brown			
22							
23				SILTY SAND (SM) Dense, dark greenish gray, fine sand			
24							
25	6		26	SANDY SILT to SILTY SAND (ML - SM) Medium dense, dark greenish gray	---	---	---
26							
27							
28							
29							
30							

gt-1-88

PROJECT: CHIRON CAMPUS EXPANSION PROJECT
Emeryville, California

Log of Boring No. B12 (cont'd.)

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/ Foot	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content (%)	LABORATORY TESTS Dry Density (pcf)	LABORATORY TESTS Unconf. Comp. Str. (psf)
31	7		52	SANDY CLAY (CL) Very stiff to hard, dark greenish gray	20	110	4900
32							
33							
34							
35				With gravel, dark yellowish brown			
36							
37							
38							
39							
40	8		45		24	101	---
41				SILTY CLAY (CL) Hard, dark greenish gray			
42							
43							
44							
45							
46							
47							
48							
49							
50	9		63		24	103	4400
51							
52							
53							
54							
55				GRAVELLY CLAY with SAND (CL) Hard, dark yellowish brown			
56							
57							
58							
59							
60	10		50/5"		---	---	---
61							
62							
63							
64							

DRAFT

gt-2-88

PROJECT: CHIRON CAMPUS EXPANSION PROJECT
Emeryville, California

Log of Boring No. B12 (cont'd.)

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/ Foot	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content (%)	LABORATORY TESTS Dry Density (pcf)	LABORATORY TESTS Unconf. Comp. Str. (psf)
65				GRAVELLY CLAY with SAND (CL) (continued)			
66							
67							
68							
69							
70							
71				SILTY CLAY (CL) Hard, light yellowish brown			
72							
73							
74							
75							
76							
77							
78							
79							
80	11		59		26	98	---
81							
82				Bottom of boring at 81.5 feet. Boring drilled using hollow stem augers to 25 feet; approximately 1 gallon of groundwater bailed from hollow stem augers; boring advanced to bottom using rotary wash drilling. Boring backfilled with cement bentonite grout.			
83							
84							
85							
86							
87							
88							
89							
90							
91							
92							
93							
94							
95							
96							
97							
98							

DRAFT

gt-2-88

PROJECT: CHIRON CAMPUS EXPANSION PROJECT
Emeryville, California

Log of Boring No. B13

BORING LOCATION: 490826.6N, 1483410.0E

DATE STARTED: 9/16/94 | DATE FINISHED: 9/16/94

DRILLING METHOD: Hollow stem auger/rotary wash

HAMMER WEIGHT: 140 lbs | DROP: 30 inches

SAMPLER: See Explanation, Figure A-1

NOTES:
Logged by: J. Abitz
Drilling Equipment: CME 550
Drilling Contractor: RNL Enterprises

Surface Elevation: +15.4 feet

DEPTH (feet)	Sample No.	Sample	Blows/ Foot	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	Unconf. Comp. Str. (psf)
0				12 inches CONCRETE SLAB			
1	1		28	CLAYEY SILT (ML) Medium dense, very dark brown, trace gravel GMTX-13A PID = 0	18	89	---
4	2		12	CLAYEY SAND (SC) Medium dense, olive brown, trace gravel, moist GMTX-13B PID = 0	---	---	---
8	3		7	CLAYEY SILT (ML - CL) Medium stiff, dark greenish gray ATD ▽	31	89	---
15	4	SHELBY	50-250 psi		---	---	---
16				GRAVELLY SILT (ML) Medium dense, black, grayish green, fine sand, trace calcareous deposits			
20	5	SHELBY	---		22	108	700
25	6		15		19	106	---
28				SANDY CLAY with GRAVEL (CL) Very stiff to hard, greenish gray with dark yellowish brown, fine sand			
30							

DRAFT

gt-1-88

PROJECT: CHIRON CAMPUS EXPANSION PROJECT
Emeryville, California

Log of Boring No. B13 (cont'd.)

DEPTH (feet)	SAMPLES Sample No.	SAMPLES Sample	SAMPLES Blows/Foot	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content (%)	LABORATORY TESTS Dry Density (pcf)	LABORATORY TESTS Unconf. Comp. Str. (psf)
65–74				SANDY CLAY (CL) (continued)			
70–71	12		75		---	---	---
74–81				CLAYEY SAND with GRAVEL (SC) Very dense, dark yellowish brown			
80–81	13		50/4"		---	---	---
81				Bottom of boring at 81.0 feet. Boring drilled using hollow stem augers to 25 feet; approximately 15 gallons of groundwater bailed from hollow stem augers; boring advanced to bottom using rotary wash drilling. Boring backfilled with cement bentonite grout.			

DRAFT

gt-2-88

Appendix B
Cone Penetration Test Results

PRESENTATION OF CONE PENETRATION TEST DATA

SHERWIN WILLIAMS

1450 SHERWIN AVENUE
EMERYVILLE, CALIFORNIA

Prepared for:

CDM

Prepared by:

GREGG IN SITU, INC.
Martinez, California
03-027ma

Prepared on:

February 4, 2003

TABLE OF CONTENTS

1.0 INTRODUCTION

2.0 FIELD EQUIPMENT & PROCEDURES

3.0 CONE PENETRATION TEST DATA & INTERPRETATION

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3.2 INTERPRETED OUTPUT
3.3 PORE PRESSURE DISSIPATION PLOTS

APPENDIX

- Figure 1 Piezocone Figure
- Figure 2 PPDT Correlation Figure
- Figure 3 Soil Classification Chart
- References

ATTACHMENTS

- Interpretation Method
- Computer Diskette with ASCII Files

PRESENTATION OF CONE PENETRATION TEST DATA

1.0 INTRODUCTION

This report presents the results of a Cone Penetration Testing (CPT) program carried out at the Sherwin Williams site located in Emeryville, CA. The work was performed on January 29th, 2003. The scope of work was performed as directed by CDM personnel.

2.0 FIELD EQUIPMENT & PROCEDURES

The Cone Penetration Tests (CPT) were carried out by GREGG IN SITU, INC. of Martinez, CA using an integrated electronic cone system. The CPT soundings were performed in accordance with ASTM standards (D 5778-95). A 20 ton capacity cone was used for all of the soundings (figure 1). This cone has a tip area of 15 cm^2 and friction sleeve area of 225 cm^2. The cone is designed with an equal end area friction sleeve and a tip end area ratio of 0.85.

The cones used during the program recorded the following parameters at 5 cm depth intervals:

- Tip Resistance (qc)
- Sleeve Friction (fs)
- Dynamic Pore Pressure (U)

The above parameters were printed simultaneously on a printer and stored on a computer diskette for future analysis and reference.

The pore water pressure element was located directly behind the cone tip. The pore water pressure element was 5.0 mm thick and consisted of porous plastic. Each of the elements were saturated in silicon oil under vacuum pressure prior to penetration. Pore pressure dissipations were recorded at 5 second intervals when appropriate during pauses in the penetration.

A complete set of baseline readings was taken prior to each sounding to determine temperature shifts and any zero load offsets. Monitoring base line readings ensures that the cone electronics are operating properly.

The cones were pushed using GREGG IN SITU's CPT rig, having a down pressure capacity of approximately 20 tons. Six CPT soundings were performed. The penetration tests were carried to depths of approximately 100 feet below ground surface. Test locations and depths were determined in the field by CDM personnel.

3.0 CONE PENETRATION TEST DATA & INTERPRETATION

The cone penetration test data is presented in graphical form. Penetration depths are referenced to existing ground surface. This data includes CPT logs of measured soil parameters and a computer tabulation of interpreted soil types along with additional geotechnical parameters and pore pressure dissipation data.

The stratigraphic interpretation is based on relationships between cone bearing (qc), sleeve friction (fs), and penetration pore pressure (U). The friction ratio (Rf), which is sleeve friction divided by cone bearing, is a calculated parameter which is used to infer soil behavior type. Generally, cohesive soils (clays) have high friction ratios, low cone bearing and generate large excess pore water pressures. Cohesionless soils (sands) have lower friction ratios, high cone bearing and generate little in the way of excess pore water pressures.

Pore Pressure Dissipation Tests (PPDT's) were taken at various intervals in order to measure hydrostatic water pressures and approximate depth to groundwater table. In addition, the PPDT data can be used to estimate the horizontal permeability (k_h) of the soil. The correlation to permeability is based on the time required for 50 percent of the measured dynamic pore pressure to dissipate (t_{50}). The PPDT correlation figure (figure 2) is provided in the Appendix.

The interpretation of soils encountered on this project was carried out using recent correlations developed by Robertson et al, 1990. It should be noted that it is not always possible to clearly identify a soil type based on qc, fs and U. In these situations, experience and judgement and an assessment of the pore pressure dissipation data should be used to infer the soil behavior type. The soil classification chart (figure 3) used to interpret soil types based on qc and Rf is provided in the Appendix.

Interpreted output requires that depth of water be entered for calculation purposes, where depth to water is unknown an arbitrary depth in excess of 10 feet of the deepest sounding is entered as the groundwater depth.

GREGG IN SITU, INC.
February 4, 2003
03-027ma

CDM
Sherwin Williams
Emeryville, Ca.

We hope the information presented is sufficient for your purposes. We recommend that all data be carefully reviewed by qualified personnel to verify the data and make appropriate recommendations. If you have any questions, please do not hesitate to contact our office at (925) 313-5800.

Sincerely,
GREGG IN SITU, INC.

Mary Walden
Operations Manager

APPENDIX

ELECTRICAL PIEZOCONE

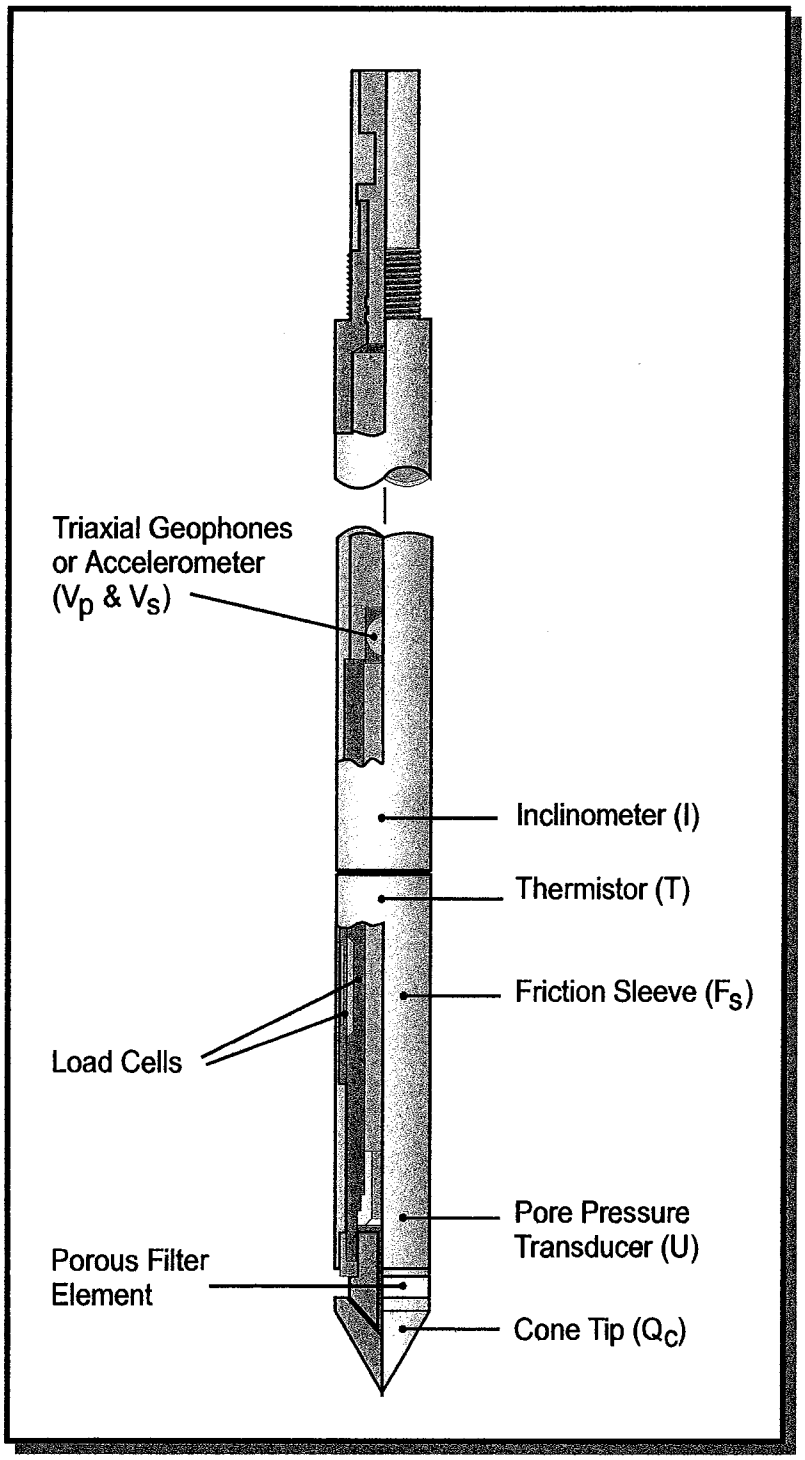
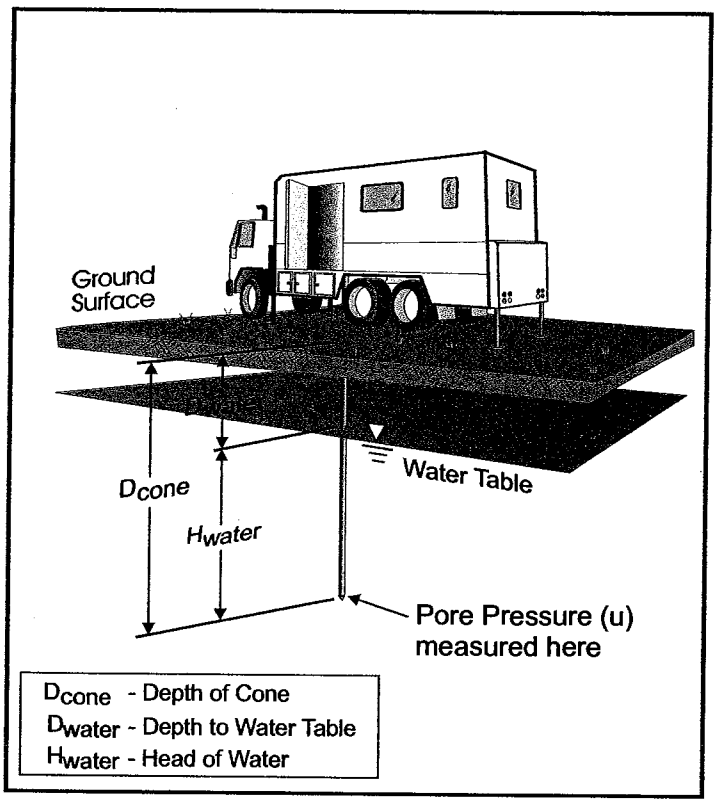
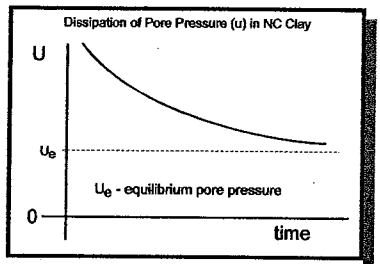
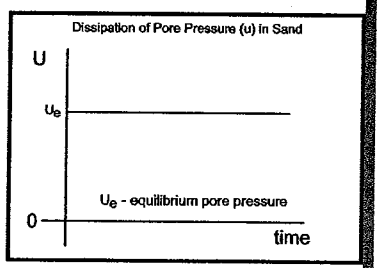


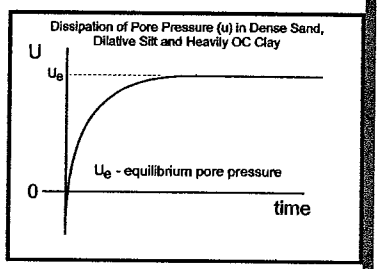
Figure 1

INTERPRETATION PORE PRESSUE DATA AND DISSIPATIONS









Water Table Calculation

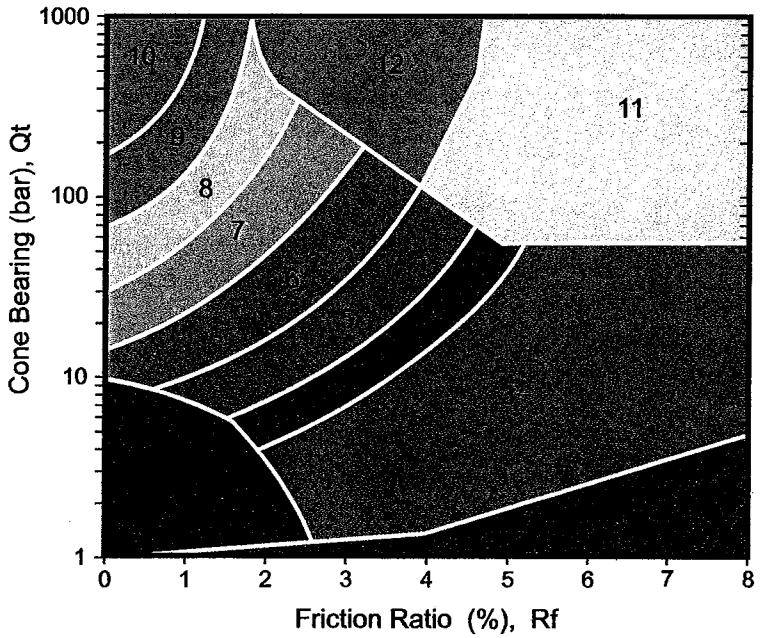
$$D_{water} = D_{cone} - H_{water}$$

where $H_{water} = U_e$ (depth units)

Useful Conversion Factors: 1psi = 0.704m = 2.31 feet (water)
1tsf = 0.958 bar = 13.9 psi
1m = 3.28 feet

Figure 2

SOIL BEHAVIOR TYPE



Zone	Q_t / N	Soil Behaviour Type
1	2	sensitive fine grained
2	1	organic material
3	1	clay
4	1.5	silty clay to clay
5	2	clayey silt to silty clay
6	2.5	sandy silt to clayey silt
7	3	silty sand to sandy silt
8	4	sand to silty sand
9	5	sand
10	6	gravelly sand to sand
11	1	very stiff fine grained *
12	2	sand to clayey sand *

* overconsolidated or cemented

Robertson (1990)

Figure 3

REFERENCES

Robertson, P.K. and Campanella, R.G. and Wightman, A., 1983 "SPT-CPT Correlations", Journal of the Geotechnical Division, ASCE, Vol. 109, No. GT11, Nov., pp. 1449-1460.

Robertson, P.K. and Wride C.E., 1998 "Evaluating Cyclic Liquefaction Potential Using The Cone Penetration Test", Journal of Geotechnical Division, Mar. 1998, pp. 442-459.

Robertson, P.K. and Campanella, R.G., Gillespie, D. and Greig, J., 1986, "Use of Piezometer Cone Data", Proceedings of In Situ 86, ASCE Specialty Conference, Blacksburg, Virginia.

Robertson, P.K. and Campanella, R.G., 1988, "Guidelines for Use, Interpretation and Application of the CPT and CPTU", UBC, Soil Mechanics Series No. 105, Civil Eng. Dept., Vancouver, B.C., V6T 1W5, Canada.

Robertson, P.K., Campanella, R.G., Gillespie, D. and Rice, A., 1986, "Seismic CPT to Measure In Situ Shear Wave Velocity", Journal of Geotechnical Engineering, ASCE, Vol. 112, No. 8, pp. 791-803.

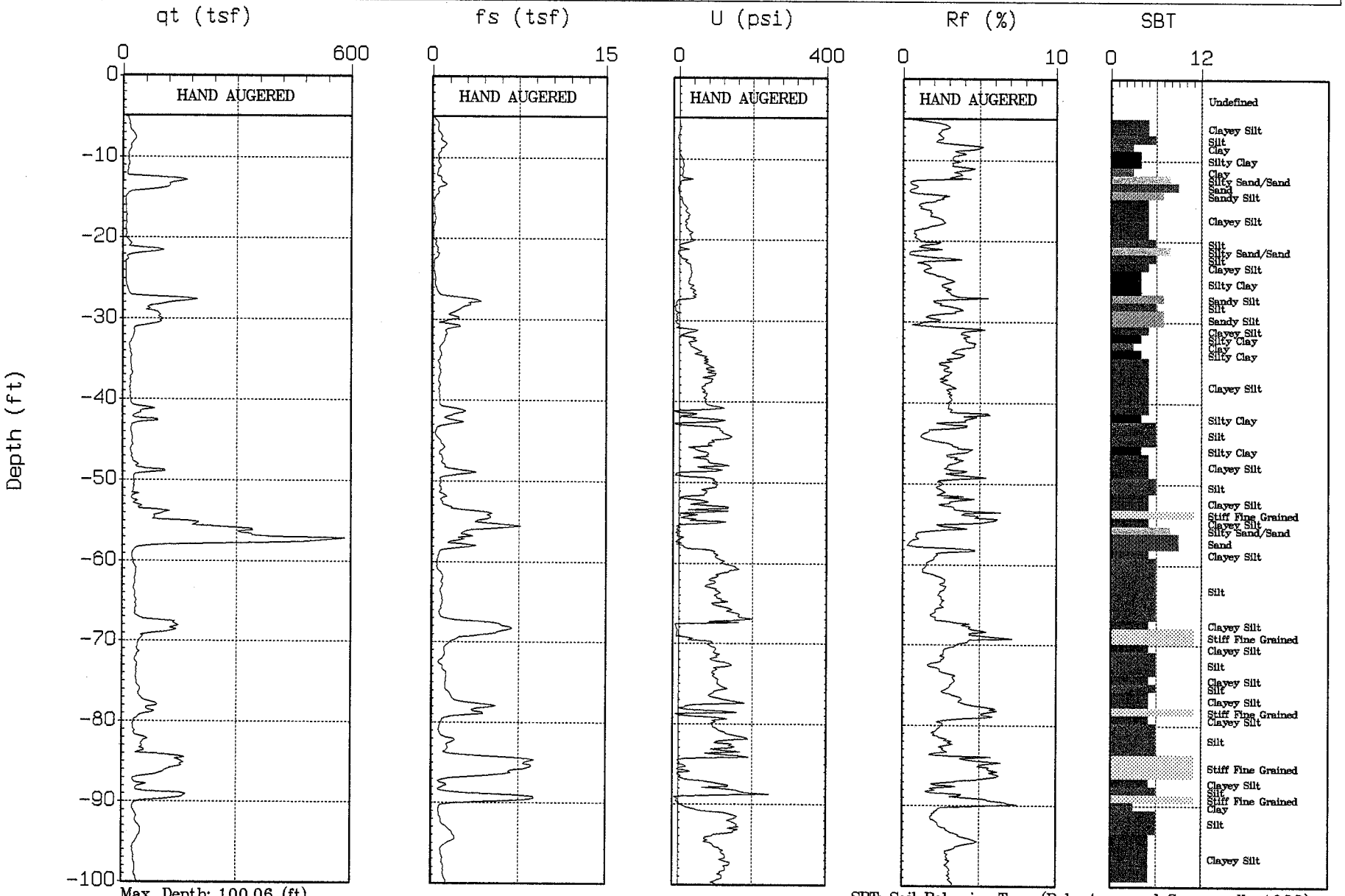
3.1 CPT PLOTS

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-01

Engineer : H. YOUNG
Date : 01:29:03 11:54



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

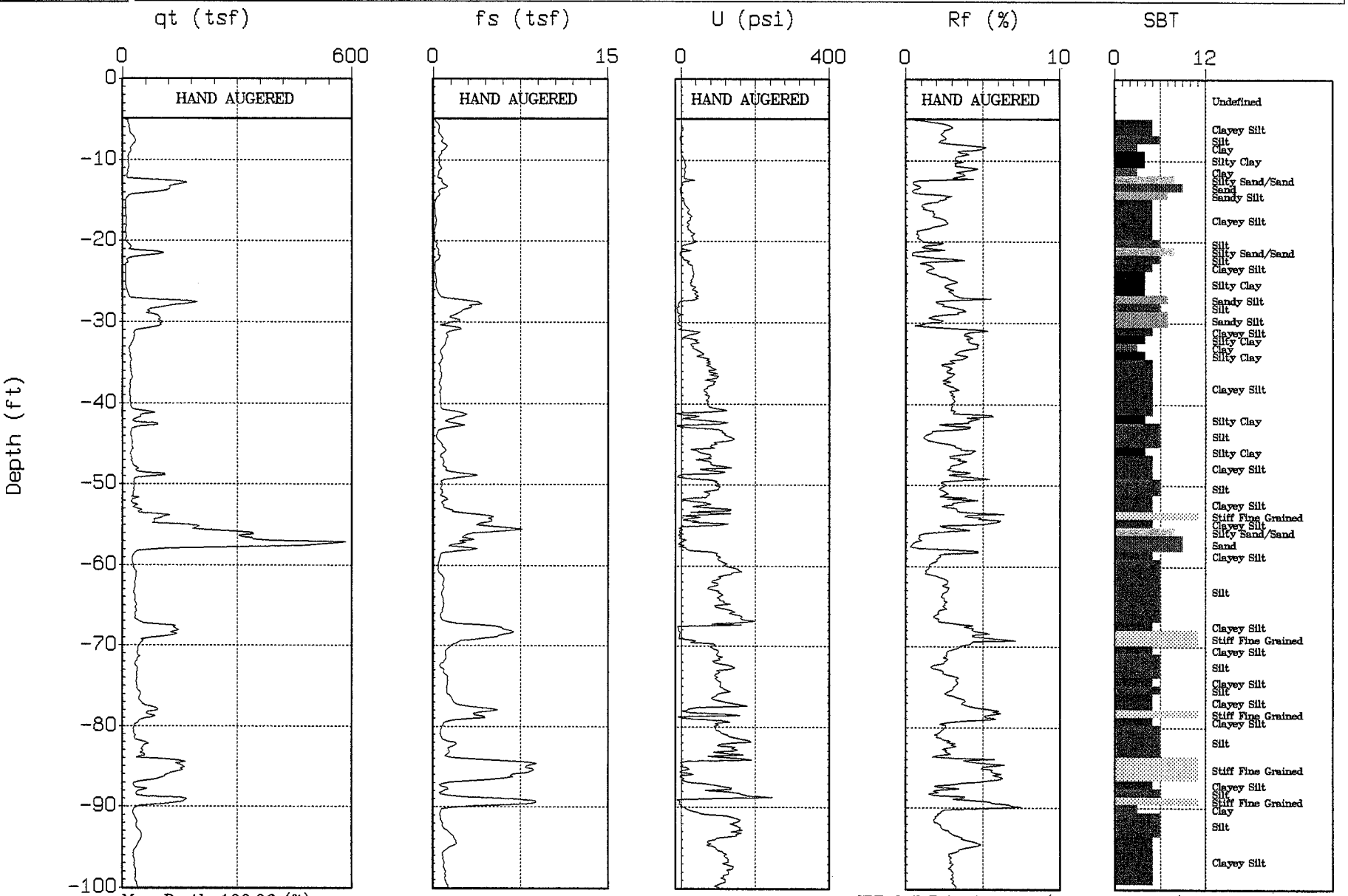
SBT: Soil Behavior Type (Robertson and Campanella 1988)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-01

Engineer : H. YOUNG
Date : 01:29:03 11:54



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

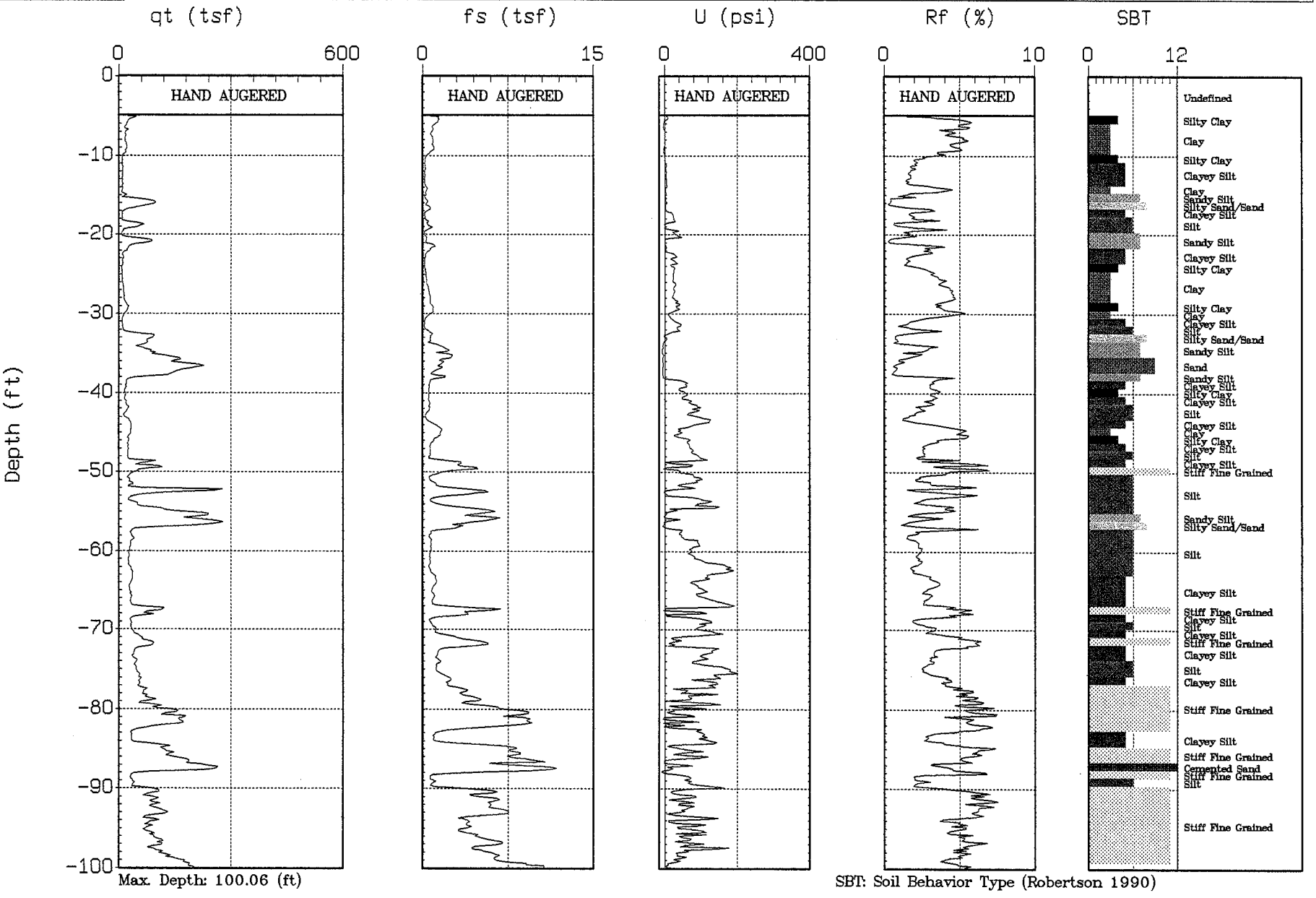
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-02

Engineer : H. YOUNG
Date : 01:29:03 09:33



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

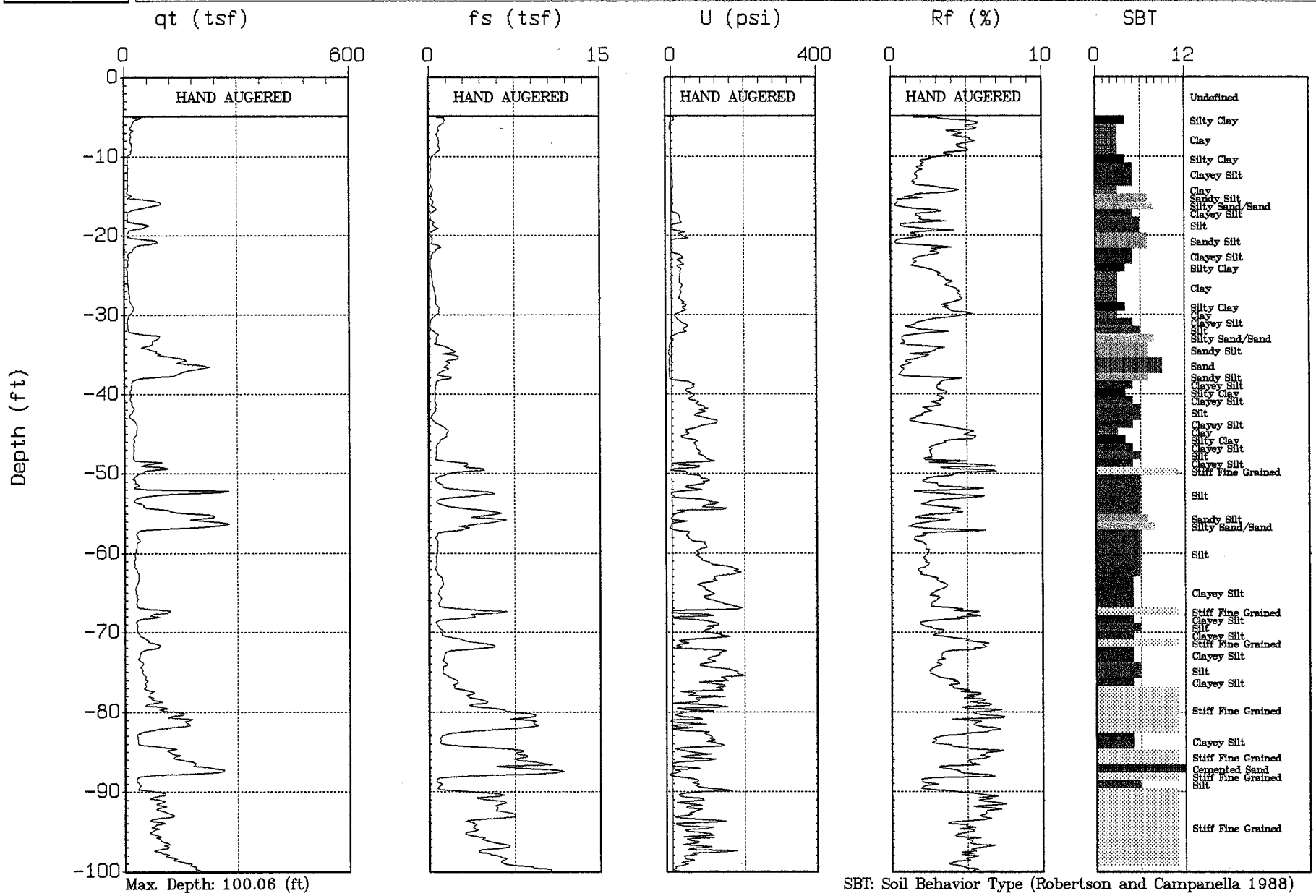
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-02

Engineer : H. YOUNG
Date : 01:29:03 09:33



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

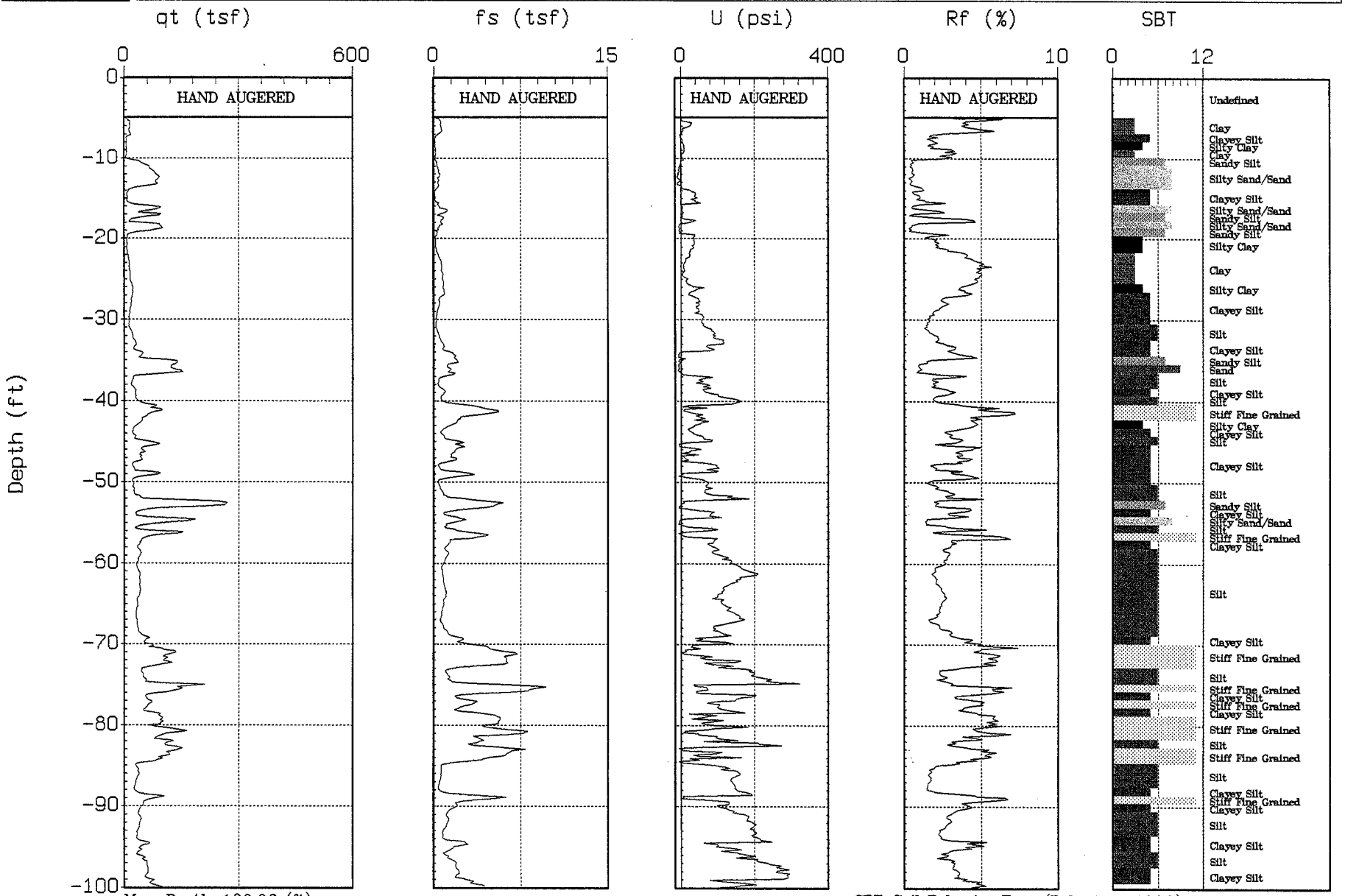
SBT: Soil Behavior Type (Robertson and Campanella 1988)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-04

Engineer : H. YOUNG
Date : 01:28:03 08:29



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

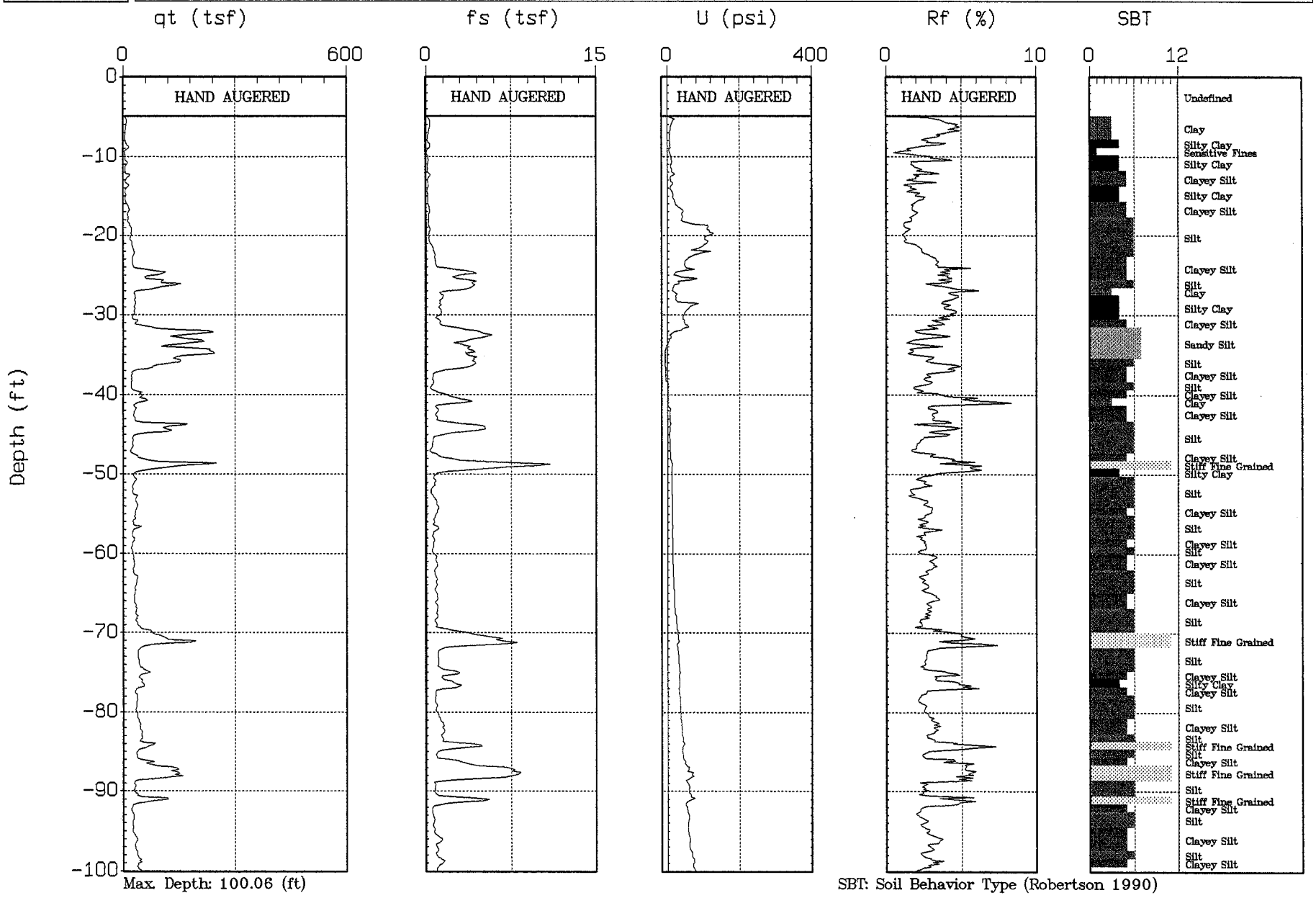
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-05

Engineer : H. YOUNG
Date : 01:28:03 10:52



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

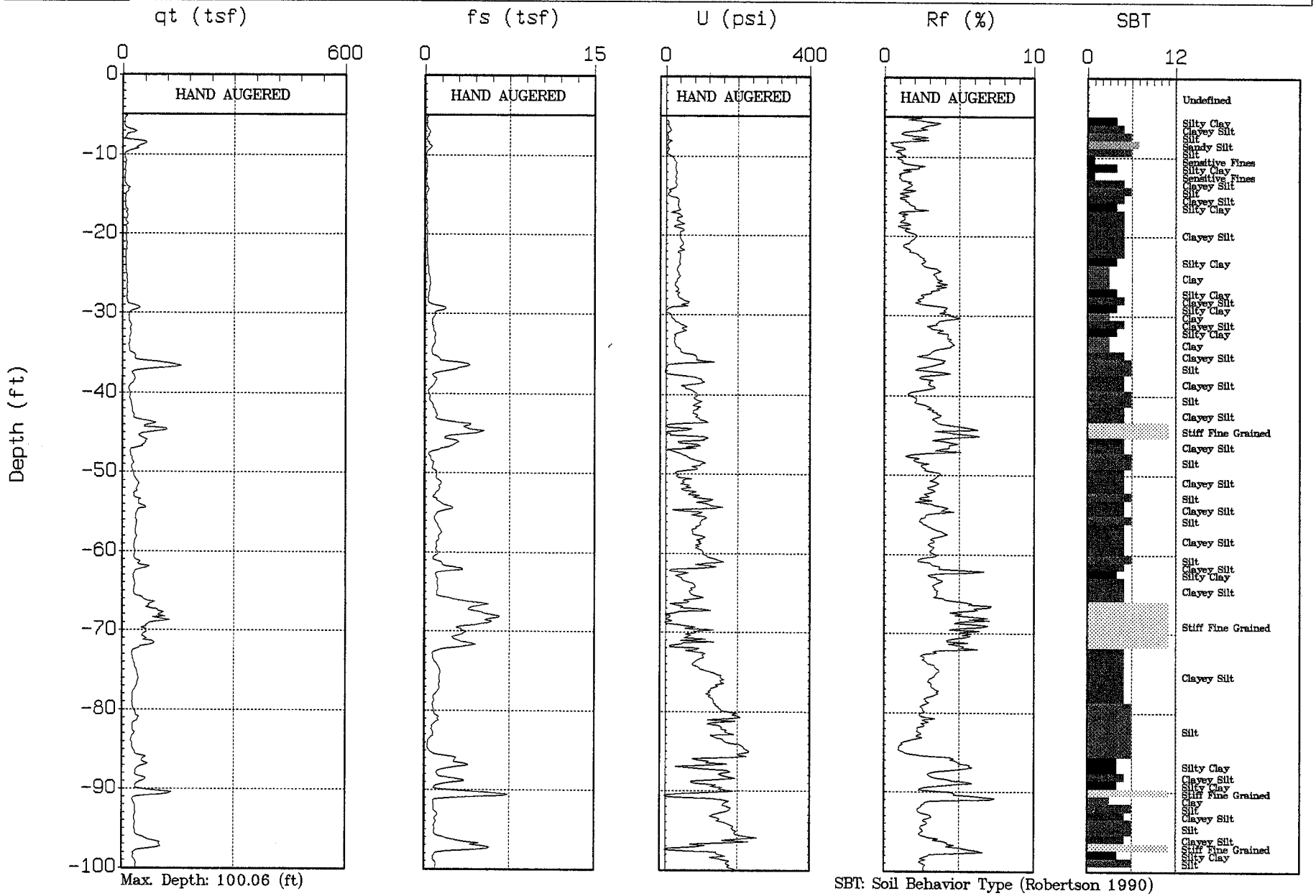
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-06

Engineer : H. YOUNG
Date : 01:28:03 12:49



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

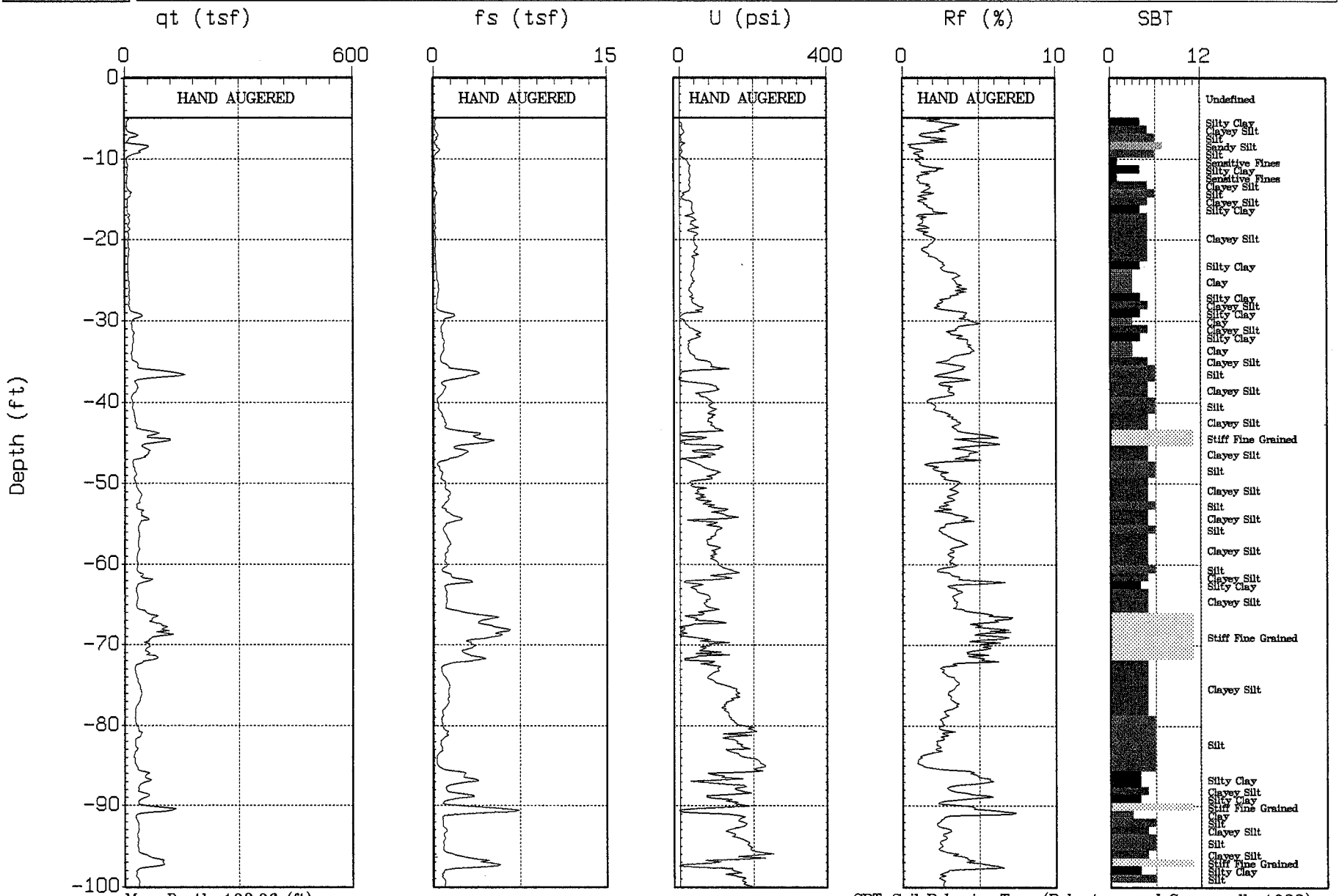
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-06

Engineer : H. YOUNG
Date : 01:28:03 12:49



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

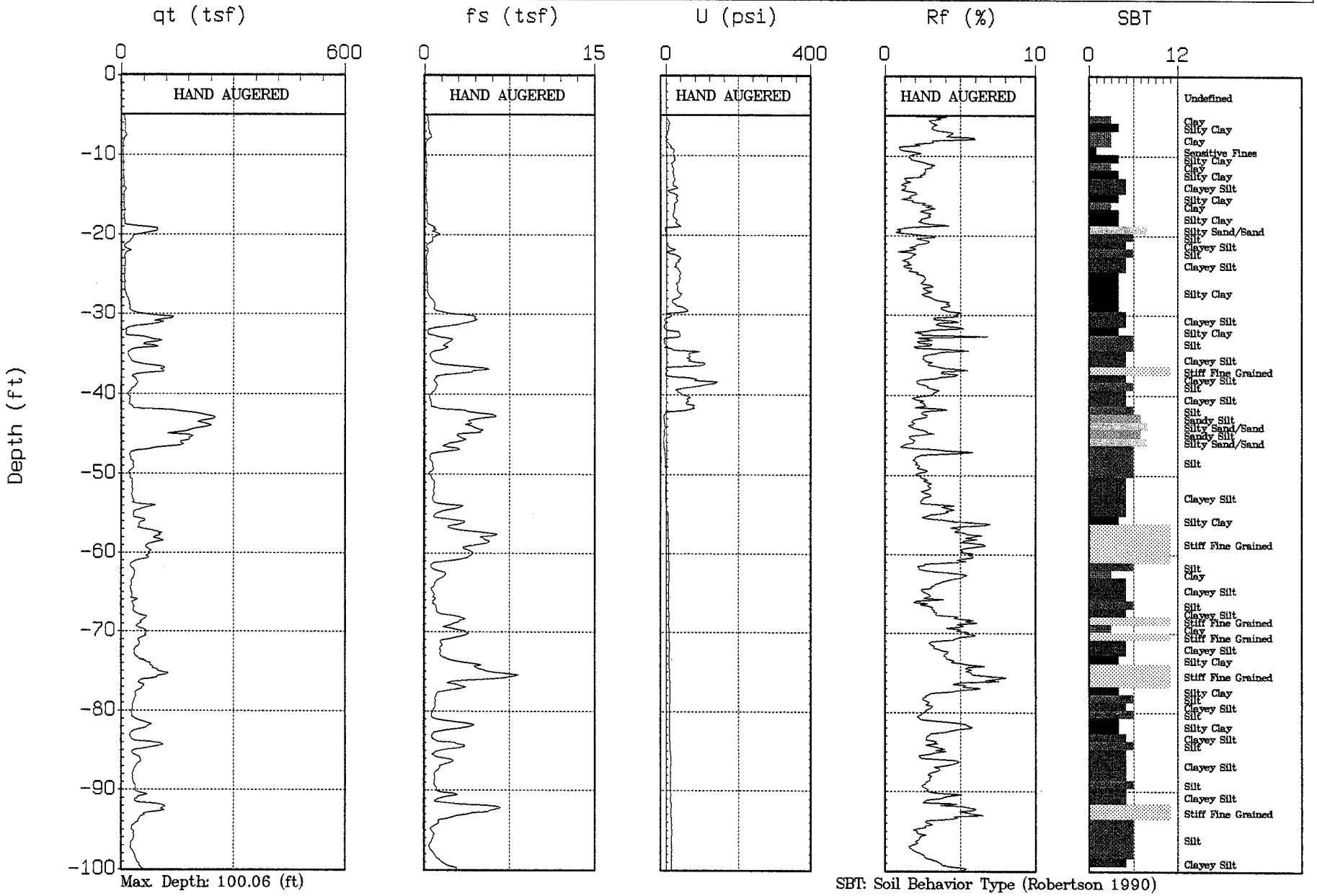
SBT: Soil Behavior Type (Robertson and Campanella 1988)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-07

Engineer : H. YOUNG
Date : 01:28:03 14:52



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

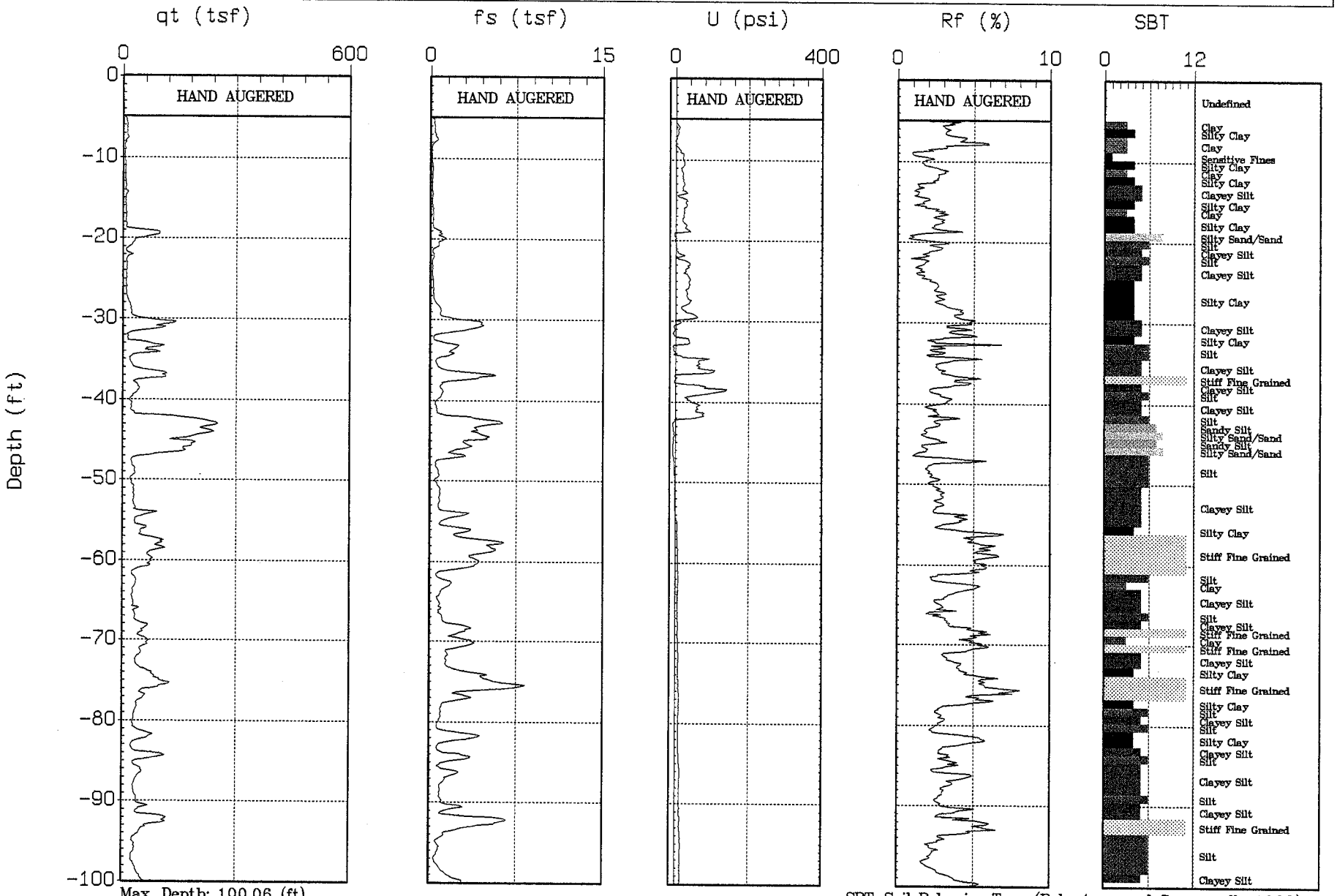
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-07

Engineer : H. YOUNG
Date : 01:28:03 14:52



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

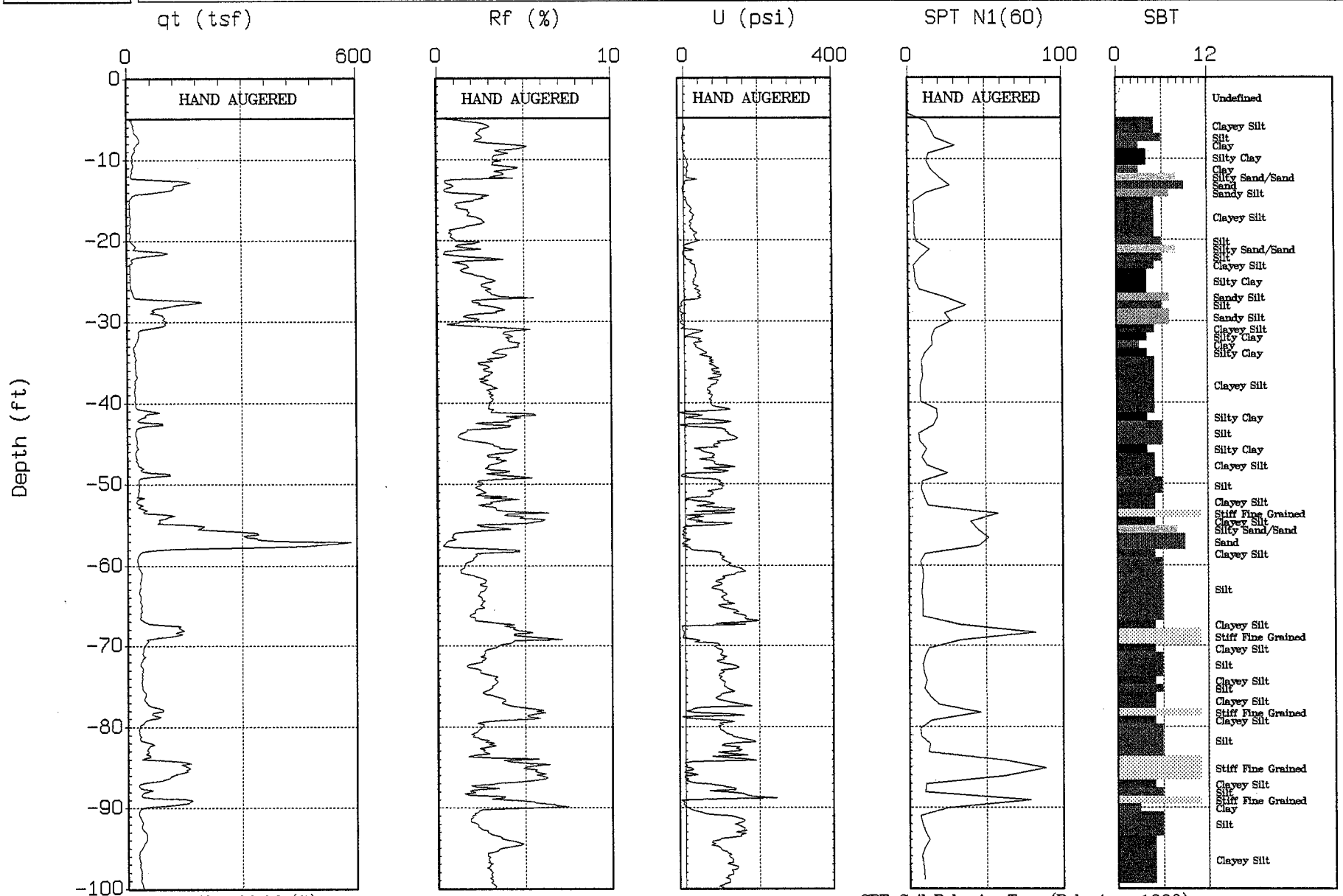
SBT: Soil Behavior Type (Robertson and Campanella 1988)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-01

Engineer : H. YOUNG
Date : 01:29:03 11:54



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

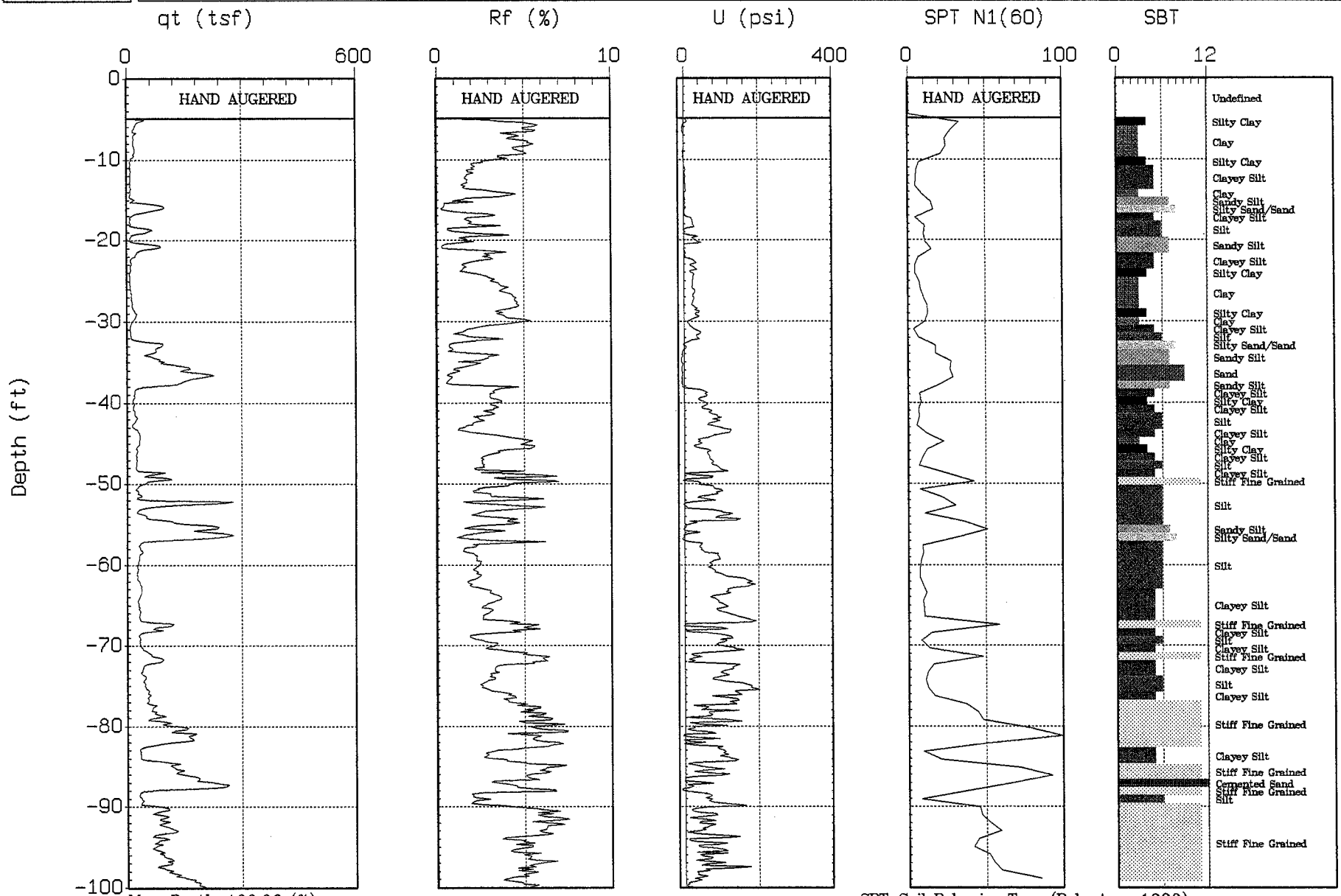
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-02

Engineer : H. YOUNG
Date : 01:29:03 09:33



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

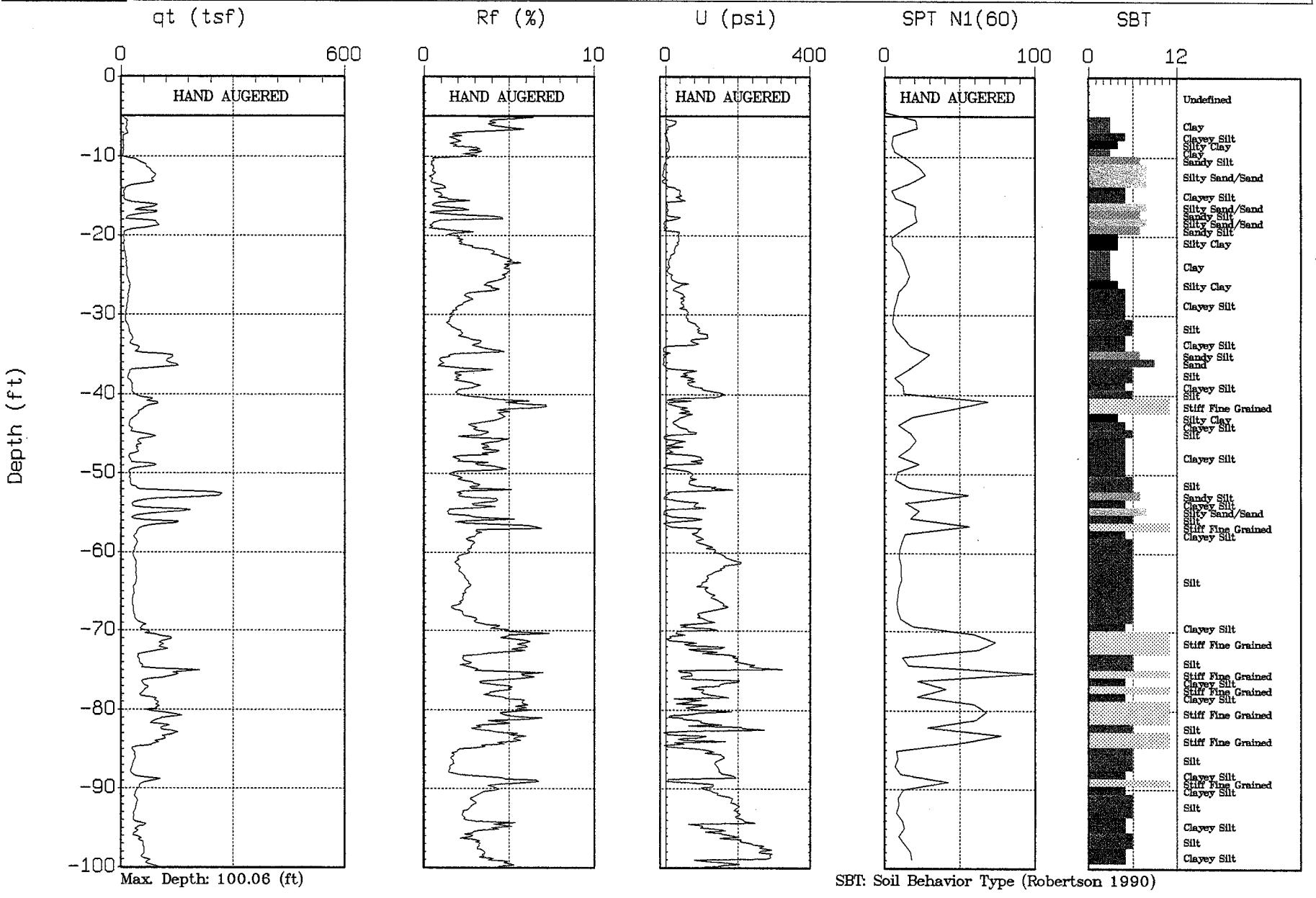
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-04

Engineer : H. YOUNG
Date : 01:28:03 08:29



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

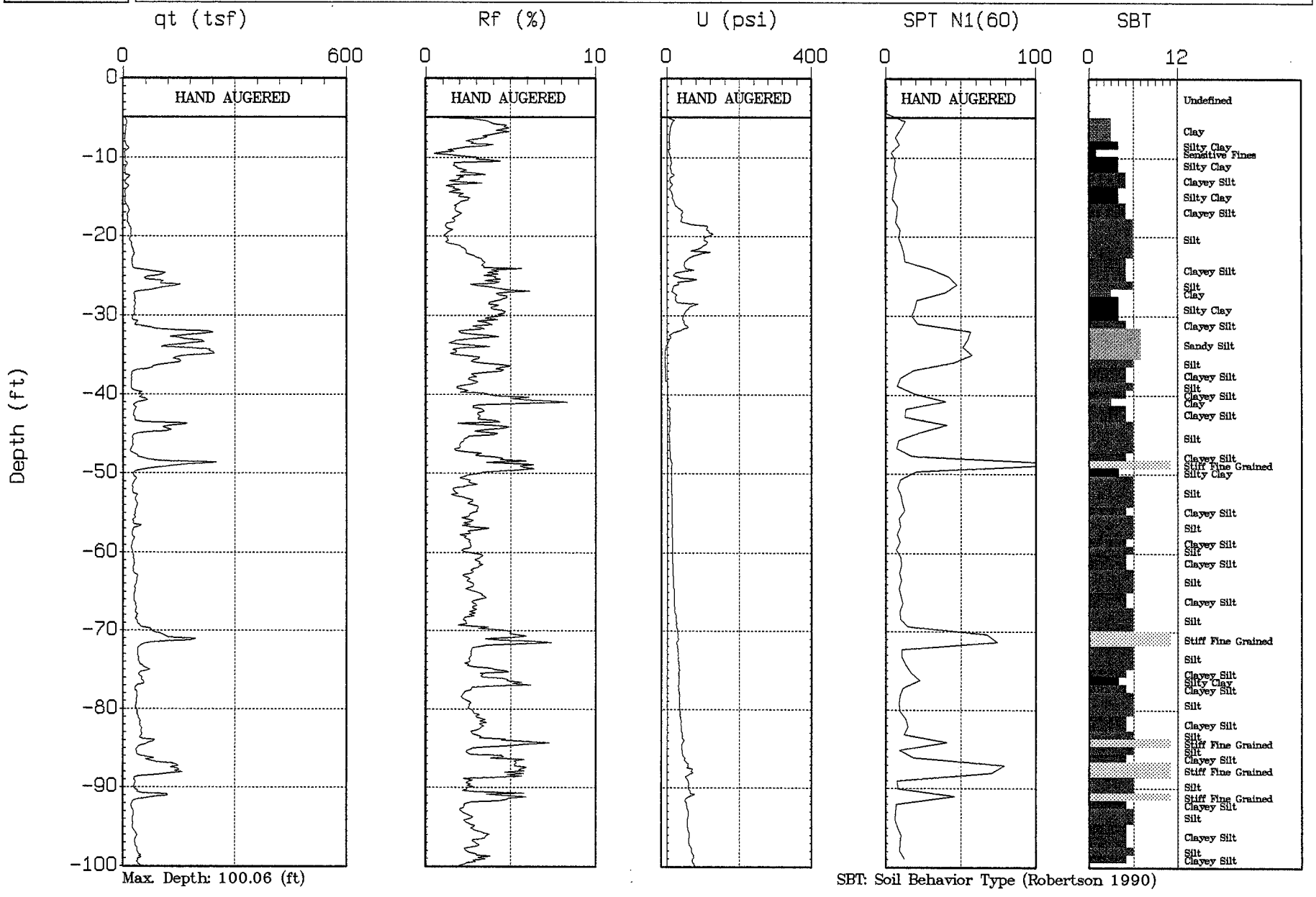
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-05

Engineer : H. YOUNG
Date : 01:28:03 10:52



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

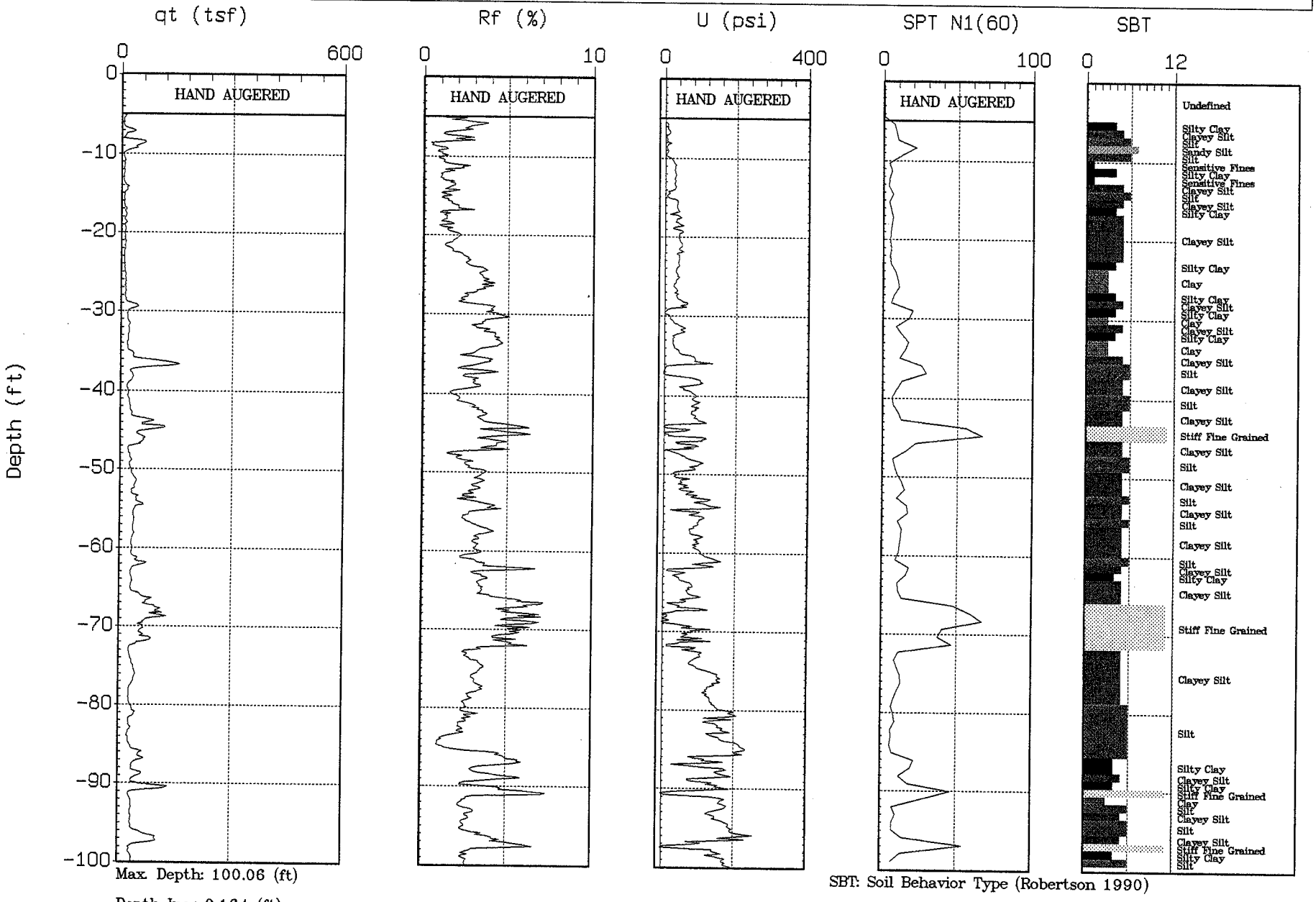
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-06

Engineer : H. YOUNG
Date : 01:28:03 12:49



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

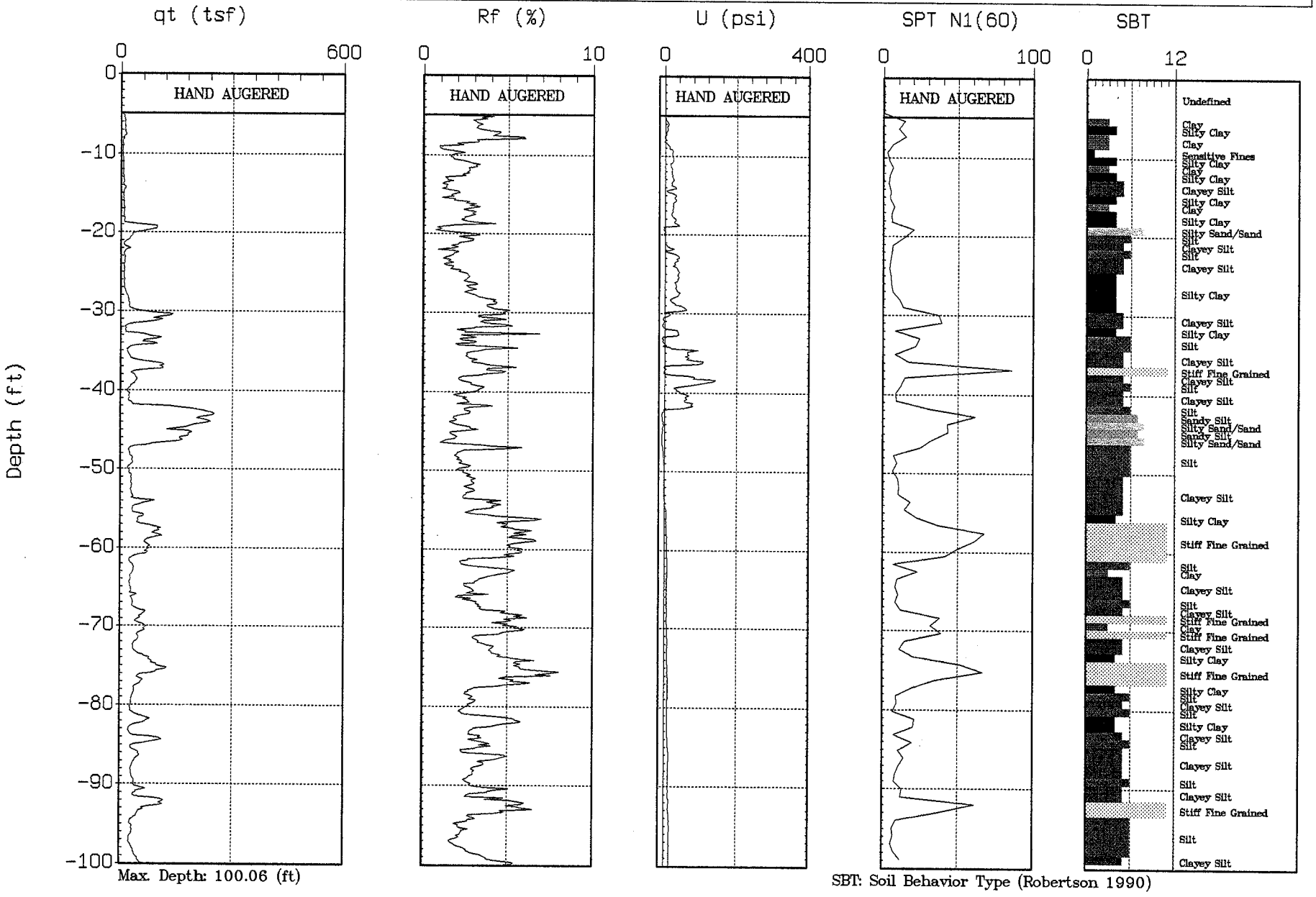
SBT: Soil Behavior Type (Robertson 1990)

GREGG

CDM

Site : SHERWIN WILLIAMS
Location : CPT-07

Engineer : H. YOUNG
Date : 01:28:03 14:52



Max. Depth: 100.06 (ft)

Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

3.2 INTERPRETED OUTPUT

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Run No: 03-0203-1606-1781
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-07
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 14:52
CPT File: 027C07.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 3.35 (ft): 11.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
0.49	0.0	0.00	0.00	0.0	UnDef	124.1	0.03	0.03	0.00	2.00	UnDef	UnDef	UnDef	0.00
1.48	0.0	0.00	0.00	0.0	UnDef	124.1	0.09	0.09	0.00	2.00	UnDef	UnDef	UnDef	0.00
2.46	0.0	0.00	0.00	0.0	UnDef	124.1	0.15	0.15	0.00	2.00	UnDef	UnDef	UnDef	0.00
3.44	0.0	0.00	0.00	0.0	UnDef	124.1	0.21	0.21	0.00	2.00	UnDef	UnDef	UnDef	0.00
4.43	0.0	0.00	0.00	0.0	UnDef	124.1	0.27	0.27	0.00	1.91	UnDef	UnDef	UnDef	0.00
5.41	8.5	0.28	3.33	9.3	3	111.4	0.33	0.33	0.00	1.73	8.2	14.1	0.65	0.12
6.40	9.9	0.33	3.31	15.2	4	114.6	0.39	0.39	0.00	1.60	6.3	10.2	0.76	0.12
7.30	10.8	0.50	4.57	3.4	3	111.4	0.44	0.44	0.00	1.51	10.4	15.7	0.83	0.00
8.20	5.0	0.18	3.55	7.1	3	111.4	0.49	0.49	0.00	1.43	4.8	6.8	0.36	0.00
9.19	3.9	0.05	1.32	39.7	1	79.6	0.54	0.54	0.00	1.37	1.9	2.6	0.27	0.00
10.17	4.2	0.08	1.80	50.1	1	79.6	0.58	0.58	0.00	1.32	2.0	2.6	0.29	0.00
11.15	5.2	0.15	2.90	38.3	3	111.4	0.62	0.62	0.00	1.27	5.0	6.4	0.37	0.00
12.14	4.8	0.12	2.54	44.0	3	111.4	0.68	0.64	0.04	1.25	4.6	5.7	0.33	0.00
13.21	6.1	0.08	1.34	47.5	5	114.6	0.74	0.67	0.07	1.22	2.9	3.6	0.43	0.08
14.27	8.4	0.12	1.47	41.9	5	114.6	0.80	0.70	0.10	1.20	4.0	4.8	0.61	0.09
15.26	5.8	0.09	1.61	67.5	4	114.6	0.86	0.72	0.13	1.18	3.7	4.4	0.40	0.08
16.24	6.5	0.18	2.82	52.8	3	111.4	0.91	0.75	0.16	1.16	6.2	7.2	0.45	0.00
17.22	7.3	0.20	2.74	45.6	4	114.6	0.97	0.77	0.19	1.14	4.7	5.3	0.51	0.09
18.21	7.8	0.22	2.80	66.6	4	114.6	1.02	0.80	0.23	1.12	5.0	5.5	0.54	0.00
19.19	78.7	0.82	1.05	11.7	8	120.9	1.08	0.83	0.26	1.10	18.8	20.7	UnDef	0.18
20.18	34.0	0.90	2.65	-1.4	6	114.6	1.14	0.85	0.29	1.08	13.0	14.1	2.63	0.24
21.16	12.5	0.29	2.33	9.2	5	114.6	1.20	0.88	0.32	1.07	6.0	6.4	0.90	0.11
22.15	14.1	0.21	1.51	41.3	6	114.6	1.25	0.90	0.35	1.05	5.4	5.7	1.03	0.12
23.13	9.3	0.13	1.44	76.0	5	114.6	1.31	0.93	0.38	1.04	4.4	4.6	0.64	0.09
24.11	8.4	0.13	1.58	70.9	5	114.6	1.36	0.96	0.41	1.02	4.0	4.1	0.56	0.09
25.10	7.8	0.19	2.47	85.3	4	114.6	1.42	0.98	0.44	1.01	5.0	5.0	0.51	0.00
26.08	8.3	0.22	2.65	72.4	4	114.6	1.48	1.01	0.47	1.00	5.3	5.3	0.55	0.00
27.07	10.0	0.27	2.70	79.7	4	114.6	1.53	1.03	0.50	0.98	6.4	6.3	0.68	0.09
28.05	17.4	0.63	3.62	54.6	4	114.6	1.59	1.06	0.53	0.97	11.1	10.8	1.26	0.00
29.04	21.8	0.87	4.01	101.7	4	114.6	1.65	1.08	0.56	0.96	13.9	13.3	1.61	0.00

Gregg In Situ, Inc.
Run No: 03-0203-1606-1781
CPT File: 027C07.COR

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60	Su (tsf)	CRR
30.02	83.1	3.26	3.92	28.8	5	114.6	1.70	1.11	0.59	0.95	39.8	37.8	6.51	0.00
31.00	87.8	3.52	4.01	-9.4	5	114.6	1.76	1.13	0.62	0.94	42.0	39.5	6.88	0.00
31.99	13.5	0.43	3.21	39.9	4	114.6	1.82	1.16	0.66	0.93	8.6	8.0	0.94	0.00
32.97	69.7	1.81	2.60	18.3	6	114.6	1.87	1.19	0.69	0.92	26.7	24.5	5.43	0.32
33.96	62.1	1.76	2.83	9.4	6	114.6	1.93	1.21	0.72	0.91	23.8	21.6	4.82	0.37
34.94	18.7	0.54	2.92	155.8	5	114.6	1.98	1.24	0.75	0.90	8.9	8.0	1.34	0.13
35.92	40.3	1.22	3.04	193.6	5	114.6	2.04	1.26	0.78	0.89	19.3	17.2	3.06	0.00
36.91	102.9	4.45	4.33	-1.9	11	130.5	2.10	1.29	0.81	0.88	98.6	86.7	UnDef	0.00
37.89	35.0	1.03	2.94	146.2	5	114.6	2.16	1.32	0.84	0.87	16.8	14.6	2.63	0.39
38.88	36.5	1.01	2.78	192.5	6	114.6	2.22	1.35	0.87	0.86	14.0	12.0	2.74	0.42
39.86	20.6	0.57	2.79	105.7	5	114.6	2.27	1.37	0.90	0.85	9.9	8.4	1.47	0.14
40.85	21.4	0.52	2.45	140.5	5	114.6	2.33	1.40	0.93	0.85	10.2	8.7	1.52	0.14
41.83	95.9	2.53	2.64	102.0	6	114.6	2.39	1.42	0.96	0.84	36.7	30.8	7.48	0.45
42.81	233.7	5.30	2.27	-15.2	7	117.8	2.44	1.45	0.99	0.83	74.6	61.9	UnDef	0.00
43.80	221.0	4.14	1.88	-9.8	8	120.9	2.50	1.48	1.02	0.82	52.9	43.5	UnDef	0.00
44.78	168.7	3.95	2.34	-13.3	7	117.8	2.56	1.51	1.05	0.81	53.9	43.9	UnDef	0.00
45.77	171.7	2.89	1.68	-16.7	8	120.9	2.62	1.54	1.09	0.81	41.1	33.2	UnDef	0.00
46.75	82.5	2.18	2.64	-13.3	6	114.6	2.68	1.56	1.12	0.80	31.6	25.3	6.39	0.45
47.74	23.6	0.49	2.06	-7.8	6	114.6	2.74	1.59	1.15	0.79	9.0	7.2	1.67	0.15
48.72	31.2	0.68	2.19	-4.5	6	114.6	2.79	1.61	1.18	0.79	12.0	9.4	2.28	0.24
49.70	22.1	0.53	2.40	-3.3	6	114.6	2.85	1.64	1.21	0.78	8.5	6.6	1.54	0.14
50.69	26.9	0.75	2.77	-2.6	5	114.6	2.90	1.66	1.24	0.78	12.9	10.0	1.92	0.18
51.67	28.8	0.80	2.77	-2.0	5	114.6	2.96	1.69	1.27	0.77	13.8	10.6	2.06	0.20
52.66	28.1	0.76	2.71	-1.4	5	114.6	3.02	1.72	1.30	0.76	13.5	10.3	2.01	0.19
53.64	50.4	1.82	3.62	-0.3	5	114.6	3.07	1.74	1.33	0.76	24.1	18.3	3.79	0.00
54.63	40.3	1.56	3.87	6.9	5	114.6	3.13	1.77	1.36	0.75	19.3	14.5	2.98	0.00
.61	47.3	2.19	4.62	11.8	4	114.6	3.19	1.79	1.39	0.75	30.2	22.6	3.53	0.00
56.59	52.7	2.63	4.99	11.7	11	130.5	3.25	1.82	1.42	0.74	50.5	37.4	UnDef	0.00
57.58	97.0	5.57	5.75	12.3	11	130.5	3.31	1.86	1.45	0.73	92.9	68.2	UnDef	0.00
58.56	88.7	5.11	5.76	15.2	11	130.5	3.37	1.89	1.49	0.73	84.9	61.8	UnDef	0.00
59.55	73.0	3.86	5.29	15.7	11	130.5	3.44	1.92	1.52	0.72	69.9	50.4	UnDef	0.00
60.53	60.9	3.22	5.29	16.3	11	130.5	3.50	1.96	1.55	0.71	58.3	41.7	UnDef	0.00
61.52	26.4	0.64	2.42	18.0	6	114.6	3.56	1.99	1.58	0.71	10.1	7.2	1.82	0.15
62.42	34.7	1.62	4.68	18.3	3	111.4	3.61	2.01	1.61	0.71	33.3	23.5	2.49	0.00
63.32	29.3	1.20	4.11	16.9	4	114.6	3.67	2.03	1.63	0.70	18.7	13.1	2.05	0.00
64.30	25.6	0.72	2.80	15.6	5	114.6	3.72	2.06	1.66	0.70	12.3	8.6	1.75	0.14
65.29	27.5	0.82	2.99	15.5	5	114.6	3.78	2.08	1.70	0.69	13.1	9.1	1.89	0.15
66.27	33.4	0.83	2.48	16.2	6	114.6	3.83	2.11	1.73	0.69	12.8	8.8	2.37	0.21
67.26	34.3	1.14	3.31	16.5	5	114.6	3.89	2.13	1.76	0.68	16.4	11.3	2.44	0.00
68.24	58.4	3.09	5.29	16.8	11	130.5	3.95	2.16	1.79	0.68	56.0	38.0	UnDef	0.00
69.22	47.6	2.28	4.78	16.7	4	114.6	4.01	2.19	1.82	0.68	30.4	20.5	3.49	0.00
70.21	63.9	3.45	5.39	17.5	11	130.5	4.07	2.22	1.85	0.67	61.2	41.1	UnDef	0.00
71.19	47.2	1.57	3.32	18.8	5	114.6	4.13	2.25	1.88	0.67	22.6	15.1	3.44	0.42
72.18	36.7	1.39	3.78	19.6	5	114.6	4.19	2.28	1.91	0.66	17.6	11.6	2.60	0.00
73.16	43.5	1.84	4.23	19.2	5	114.6	4.25	2.30	1.94	0.66	20.8	13.7	3.14	0.00
74.15	77.6	4.39	5.65	19.4	11	130.5	4.31	2.33	1.97	0.65	74.3	48.6	UnDef	0.00
75.13	108.3	6.75	6.23	20.6	11	130.5	4.37	2.37	2.00	0.65	103.7	67.4	UnDef	0.00
76.11	62.7	3.96	6.33	22.1	11	130.5	4.43	2.40	2.03	0.65	60.0	38.7	UnDef	0.00
77.10	51.7	2.63	5.09	25.0	3	111.4	4.49	2.43	2.06	0.64	49.5	31.8	3.77	0.00
78.08	36.8	0.98	2.66	23.6	6	114.6	4.55	2.45	2.09	0.64	14.1	9.0	2.58	0.22
79.07	31.1	0.91	2.92	22.3	5	114.6	4.61	2.48	2.13	0.64	14.9	9.5	2.12	0.00
80.05	28.3	0.70	2.46	21.4	6	114.6	4.66	2.51	2.16	0.63	10.9	6.9	1.89	0.14

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
81.04	44.7	1.78	3.99	21.8	5	114.6	4.72	2.53	2.19	0.63	21.4	13.5	3.20	0.00
82.02	60.6	3.13	5.16	21.6	11	130.5	4.78	2.56	2.22	0.62	58.1	36.3	UnDef	0.00
83.00	24.6	0.70	2.83	21.5	5	114.6	4.84	2.59	2.25	0.62	11.8	7.3	1.58	0.00
83.99	76.2	2.44	3.20	23.5	6	114.6	4.90	2.62	2.28	0.62	29.2	18.1	5.71	0.00
84.97	42.3	1.45	3.43	25.7	5	114.6	4.95	2.64	2.31	0.62	20.3	12.5	2.99	0.00
85.96	47.4	1.81	3.81	29.6	5	114.6	5.01	2.67	2.34	0.61	22.7	13.9	3.39	0.00
86.94	38.6	1.43	3.70	28.2	5	114.6	5.06	2.69	2.37	0.61	18.5	11.3	2.68	0.00
87.93	30.3	0.90	2.97	26.0	5	114.6	5.12	2.72	2.40	0.61	14.5	8.8	2.01	0.00
88.91	32.5	0.86	2.64	25.8	6	114.6	5.18	2.74	2.43	0.60	12.4	7.5	2.18	0.16
89.89	39.9	1.36	3.42	26.7	5	114.6	5.23	2.77	2.46	0.60	19.1	11.5	2.77	0.00
90.88	46.7	1.61	3.44	27.7	5	114.6	5.29	2.80	2.49	0.60	22.3	13.4	3.31	0.00
91.86	95.4	5.01	5.26	31.0	11	130.5	5.35	2.83	2.52	0.59	91.3	54.3	UnDef	0.00
92.85	76.8	4.10	5.34	30.0	11	130.5	5.41	2.86	2.56	0.59	73.6	43.5	UnDef	0.00
93.83	42.9	1.31	3.06	33.3	5	114.6	5.47	2.89	2.59	0.59	20.5	12.1	2.99	0.26
94.82	29.0	0.63	2.17	34.4	6	114.6	5.53	2.91	2.62	0.59	11.1	6.5	1.88	0.13
95.80	32.1	0.74	2.30	34.0	6	114.6	5.59	2.94	2.65	0.58	12.3	7.2	2.12	0.15
96.78	25.0	0.45	1.81	33.2	6	114.6	5.64	2.97	2.68	0.58	9.6	5.6	1.54	0.11
97.77	31.3	0.73	2.33	33.5	6	114.6	5.70	2.99	2.71	0.58	12.0	6.9	2.04	0.14
98.75	40.5	1.39	3.42	33.0	5	114.6	5.76	3.02	2.74	0.58	19.4	11.2	2.78	0.00

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Run No: 03-0203-1606-1781
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-07
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 14:52
CPT File: 027C07.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 3.35 (ft): 11.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
0.49	1.0E-15	0.00	2.4	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
1.48	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
2.46	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
3.44	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
4.43	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
5.41	5.0E-08	0.04	24.6	3.47	6	14.4	57.8	72.2	41.8	UnDef	UnDef	6.0	UnDef	14.1	28.
6.40	5.0E-07	0.05	24.6	3.45	6	15.6	62.4	78.0	41.7	UnDef	UnDef	6.0	UnDef	10.2	20.
7.30	5.0E-08	0.01	23.7	4.76	1	16.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
8.20	5.0E-08	0.05	9.2	3.93	1	7.0	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
9.19	1.0E-07	0.37	6.3	1.53	4	5.2	20.9	26.1	59.7	UnDef	UnDef	3.0	UnDef	2.6	5.
10.17	1.0E-07	0.43	6.3	2.08	4	5.4	21.6	27.0	64.3	UnDef	UnDef	3.0	UnDef	2.6	5.
11.15	5.0E-08	0.26	7.5	3.30	1	6.5	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
12.14	5.0E-08	0.33	6.4	2.96	4	5.9	23.4	29.3	69.5	UnDef	UnDef	3.0	UnDef	5.7	11.
13.21	5.0E-06	0.26	8.0	1.52	6	7.3	29.2	36.5	53.5	UnDef	UnDef	3.0	UnDef	3.6	7.
14.27	5.0E-06	0.16	10.9	1.63	6	9.8	39.3	49.1	47.4	UnDef	UnDef	3.0	UnDef	4.8	9.
15.26	5.0E-07	0.40	6.9	1.88	4	6.7	26.8	33.5	60.4	UnDef	UnDef	3.0	UnDef	4.4	8.
16.24	5.0E-08	0.26	7.5	3.28	1	7.4	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
17.22	5.0E-07	0.19	8.2	3.16	4	8.1	32.5	40.7	64.1	UnDef	UnDef	3.0	UnDef	5.3	10.
18.21	5.0E-07	0.28	8.4	3.23	1	8.5	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
19.19	5.0E-03	0.00	94.1	1.06	9	84.8	18.0	102.8	11.6	42	62.5	1.0	-0.19	2.6	23.
20.18	5.0E-05	-0.01	38.5	2.75	6	36.0	83.2	119.3	31.1	38	38.0	6.0	-0.20	10.9	25.
21.16	5.0E-06	0.00	12.9	2.57	6	13.0	52.2	65.2	50.1	UnDef	UnDef	6.0	UnDef	6.4	12.
22.15	5.0E-05	0.07	14.2	1.65	6	14.5	58.0	72.5	42.0	32	30.0	6.0	-0.03	5.7	11.
23.13	5.0E-06	0.25	8.6	1.68	6	9.4	37.6	47.0	53.3	UnDef	UnDef	3.0	UnDef	4.6	9.
24.11	5.0E-06	0.26	7.3	1.88	4	8.4	33.5	41.9	58.7	UnDef	UnDef	3.0	UnDef	4.1	8.
25.10	5.0E-07	0.35	6.5	3.02	1	7.7	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
26.08	5.0E-07	0.26	6.8	3.23	1	8.1	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
27.07	5.0E-07	0.23	8.2	3.18	4	9.7	38.7	48.4	64.1	UnDef	UnDef	3.0	UnDef	6.3	12.
28.05	5.0E-07	0.07	14.9	3.99	1	16.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
29.04	5.0E-07	0.13	18.6	4.34	1	20.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
30.02	5.0E-06	0.00	73.4	4.00	6	77.2	117.1	194.3	27.6	UnDef	UnDef	10.0	UnDef	22.9	60.
31.00	5.0E-06	-0.01	75.8	4.09	6	80.6	120.9	201.5	27.5	UnDef	UnDef	10.0	UnDef	23.7	63.
31.99	5.0E-07	0.05	10.1	3.71	1	12.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
32.97	5.0E-05	0.00	57.2	2.67	7	62.6	75.1	137.7	25.4	40	53.9	10.0	-0.24	12.7	37.
33.96	5.0E-05	-0.01	49.7	2.92	6	55.2	91.5	146.8	28.4	38	50.3	6.0	-0.24	13.8	35.
34.94	5.0E-06	0.25	13.5	3.26	4	16.4	65.7	82.2	52.7	UnDef	UnDef	6.0	UnDef	8.0	16.
35.92	5.0E-06	0.14	30.3	3.20	6	35.1	140.3	175.4	37.0	UnDef	UnDef	6.0	UnDef	17.2	34.
36.91	1.0E-15	-0.01	78.0	4.42	6	88.6	144.2	232.8	28.2	42	63.8	1.0	-0.43	54.8	141.
37.89	5.0E-06	0.11	24.9	3.13	6	29.8	119.2	149.0	40.0	UnDef	UnDef	6.0	UnDef	14.6	29.
38.88	5.0E-05	0.15	25.4	2.95	6	30.8	123.0	153.8	38.8	34	33.5	6.0	-0.14	12.0	24.
39.86	5.0E-06	0.13	13.3	3.14	4	17.2	68.8	86.0	52.4	UnDef	UnDef	6.0	UnDef	8.4	16.
40.85	5.0E-06	0.18	13.6	2.75	6	17.7	70.7	88.4	49.9	UnDef	UnDef	6.0	UnDef	8.7	17.
41.83	5.0E-05	0.02	65.6	2.70	7	78.6	80.2	158.8	23.9	40	60.4	10.0	-0.26	14.2	45.
42.81	5.0E-04	-0.01	159.4	2.29	7	189.8	57.1	246.9	13.7	44	85.6	1.0	-0.34	10.5	72.
43.80	5.0E-03	-0.01	147.7	1.90	9	177.8	44.6	222.4	12.5	44	83.8	1.0	-0.30	6.2	49.
44.78	5.0E-04	-0.01	110.2	2.38	7	134.5	64.2	198.6	17.1	42	75.8	1.0	-0.30	11.1	55.
45.77	5.0E-03	-0.01	110.1	1.71	7	135.6	42.7	178.3	14.0	42	76.0	1.0	-0.25	5.8	39.
46.75	5.0E-05	-0.02	51.1	2.73	7	64.6	93.3	157.9	27.1	38	54.8	10.0	-0.24	14.8	40.
47.74	5.0E-05	-0.07	13.1	2.33	6	18.3	73.3	91.6	48.2	32	30.0	6.0	-0.06	7.2	14.
48.72	5.0E-05	-0.05	17.6	2.41	6	24.1	96.3	120.3	42.6	32	30.0	6.0	-0.10	9.4	18.
49.70	5.0E-05	-0.07	11.7	2.76	4	16.9	67.6	84.5	53.2	30	30.0	3.0	-0.07	6.6	13.
50.69	5.0E-06	-0.06	14.4	3.11	4	20.4	81.6	101.9	50.6	UnDef	UnDef	6.0	UnDef	10.0	20.
51.67	5.0E-06	-0.05	15.3	3.08	6	21.6	86.6	108.2	49.2	UnDef	UnDef	6.0	UnDef	10.6	21.
52.66	5.0E-06	-0.05	14.6	3.04	6	21.0	84.0	105.0	49.9	UnDef	UnDef	6.0	UnDef	10.3	20.
53.64	5.0E-06	-0.03	27.2	3.85	6	37.4	149.5	186.9	41.6	UnDef	UnDef	6.0	UnDef	18.3	36.
54.63	5.0E-06	-0.03	21.0	4.20	1	29.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
55.61	5.0E-07	-0.02	24.6	4.95	1	34.6	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
56.59	1.0E-15	-0.02	27.2	5.31	1	38.2	UnDef	UnDef	100.0	36	39.7	1.0	-0.33	UnDef	UnDe
57.58	1.0E-15	-0.01	50.4	5.95	1	69.6	UnDef	UnDef	100.0	38	56.9	1.0	-0.57	UnDef	UnDe
58.56	1.0E-15	-0.01	45.1	5.99	1	63.1	UnDef	UnDef	100.0	38	54.1	1.0	-0.55	UnDef	UnDe
59.55	1.0E-15	-0.01	36.2	5.55	1	51.5	UnDef	UnDef	100.0	38	48.3	1.0	-0.42	UnDef	UnDe
60.53	1.0E-15	-0.02	29.3	5.62	1	42.6	UnDef	UnDef	100.0	36	42.8	1.0	-0.39	UnDef	UnDe
61.52	5.0E-05	-0.04	11.5	2.80	4	18.3	73.2	91.5	53.9	30	30.0	3.0	-0.06	7.2	14.
62.42	5.0E-08	-0.03	15.5	5.22	1	24.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
63.32	5.0E-07	-0.04	12.6	4.70	1	20.1	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
64.30	5.0E-06	-0.05	10.6	3.28	4	17.5	69.9	87.4	58.3	UnDef	UnDef	3.0	UnDef	8.6	17.
65.29	5.0E-06	-0.05	11.4	3.46	4	18.6	74.5	93.1	57.7	UnDef	UnDef	3.0	UnDef	9.1	18.
66.27	5.0E-05	-0.04	14.0	2.80	6	22.5	90.0	112.5	49.5	32	30.0	6.0	-0.09	8.8	17.
67.26	5.0E-06	-0.04	14.3	3.74	1	23.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
68.24	1.0E-15	-0.02	25.2	5.68	1	38.9	UnDef	UnDef	100.0	34	40.2	1.0	-0.36	UnDef	UnDe
69.22	5.0E-07	-0.03	19.9	5.22	1	31.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
70.21	1.0E-15	-0.02	26.9	5.76	1	42.0	UnDef	UnDef	100.0	36	42.4	1.0	-0.39	UnDef	UnDe
71.19	5.0E-06	-0.03	19.1	3.64	4	30.8	123.0	153.8	47.3	UnDef	UnDef	6.0	UnDef	15.1	30.
72.18	5.0E-06	-0.04	14.3	4.27	1	23.8	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
73.16	5.0E-06	-0.03	17.0	4.69	1	28.1	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
74.15	1.0E-15	-0.02	31.4	5.99	1	49.7	UnDef	UnDef	100.0	36	47.2	1.0	-0.46	UnDef	UnDe
75.13	1.0E-15	-0.01	43.9	6.50	1	68.9	UnDef	UnDef	100.0	38	56.6	1.0	-0.66	UnDef	UnDe
76.11	1.0E-15	-0.02	24.2	6.81	1	39.6	UnDef	UnDef	100.0	34	40.7	1.0	-0.56	UnDef	UnDe
77.10	5.0E-08	-0.03	19.4	5.57	1	32.4	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
78.08	5.0E-05	-0.04	13.1	3.03	4	23.0	91.9	114.9	52.2	32	30.0	6.0	-0.09	9.0	18.
79.07	5.0E-06	-0.05	10.7	3.43	1	19.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
80.05	5.0E-05	-0.06	9.4	2.94	4	17.5	70.1	87.6	59.3	30	30.0	3.0	-0.04	6.9	13.

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
81.04	5.0E-06	-0.04	15.8	4.46	1	27.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
82.02	1.0E-15	-0.03	21.8	5.60	1	37.1	UnDef	UnDef	100.0	34	38.8	1.0	-0.32	UnDef	UnDe
83.00	5.0E-06	-0.08	7.6	3.52	1	14.9	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
83.99	5.0E-05	-0.02	27.3	3.42	6	46.1	184.5	230.6	39.7	36	45.1	6.0	-0.20	18.1	36.
84.97	5.0E-06	-0.04	14.1	3.89	1	25.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
85.96	5.0E-06	-0.03	15.9	4.26	1	28.4	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
86.94	5.0E-06	-0.04	12.4	4.26	1	23.0	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
87.93	5.0E-06	-0.06	9.2	3.57	1	18.0	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
88.91	5.0E-05	-0.06	9.9	3.14	4	19.2	76.7	95.9	59.2	30	30.0	3.0	-0.06	7.5	15.
89.89	5.0E-06	-0.05	12.5	3.93	1	23.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
90.88	5.0E-06	-0.04	14.8	3.88	1	27.3	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
91.86	1.0E-15	-0.02	31.9	5.57	1	55.5	UnDef	UnDef	100.0	36	50.4	1.0	-0.40	UnDef	UnDe
92.85	1.0E-15	-0.02	25.0	5.75	1	44.5	UnDef	UnDef	100.0	34	44.0	1.0	-0.37	UnDef	UnDe
93.83	5.0E-06	-0.04	13.0	3.51	4	24.7	98.8	123.5	54.9	UnDef	UnDef	6.0	UnDef	12.1	24.
94.82	5.0E-05	-0.07	8.1	2.69	4	16.6	66.6	83.2	61.8	30	30.0	3.0	-0.02	6.5	13.
95.80	5.0E-05	-0.06	9.0	2.78	4	18.3	73.2	91.5	59.6	30	30.0	3.0	-0.03	7.2	14.
96.78	5.0E-05	-0.09	6.5	2.35	4	14.2	56.7	70.9	65.2	30	30.0	3.0	0.01	5.6	11.
97.77	5.0E-05	-0.07	8.5	2.85	4	17.7	70.7	88.4	61.3	30	30.0	3.0	-0.03	6.9	13.
98.75	5.0E-06	-0.05	11.5	3.99	1	22.8	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Version No: 03-0203-1606-1720
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-06
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 12:49
CPT File: 027C06.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 3.35 (ft): 11.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
0.49	0.0	0.00	0.00	0.0	UnDef	124.1	0.03	0.03	0.00	2.00	UnDef	UnDef	UnDef	0.00
1.48	0.0	0.00	0.00	0.0	UnDef	124.1	0.09	0.09	0.00	2.00	UnDef	UnDef	UnDef	0.00
2.46	0.0	0.00	0.00	0.0	UnDef	124.1	0.15	0.15	0.00	2.00	UnDef	UnDef	UnDef	0.00
3.44	0.0	0.00	0.00	0.0	UnDef	124.1	0.21	0.21	0.00	2.00	UnDef	UnDef	UnDef	0.00
4.43	0.0	0.00	0.00	0.0	UnDef	124.1	0.27	0.27	0.00	1.91	UnDef	UnDef	UnDef	0.00
5.41	6.3	0.16	2.58	7.6	4	114.6	0.33	0.33	0.00	1.73	4.0	6.9	0.48	0.09
6.40	10.8	0.20	1.86	21.6	5	114.6	0.39	0.39	0.00	1.60	5.2	8.3	0.83	0.10
7.30	19.1	0.30	1.58	9.1	6	114.6	0.44	0.44	0.00	1.50	7.3	11.0	1.49	0.10
8.20	40.9	0.26	0.63	16.0	7	117.8	0.49	0.49	0.00	1.42	13.0	18.6	UnDef	0.11
9.19	30.0	0.32	1.07	11.2	7	117.8	0.55	0.55	0.00	1.35	9.6	12.9	UnDef	0.10
10.17	5.3	0.06	1.10	44.2	1	79.6	0.60	0.60	0.00	1.29	2.5	3.3	0.38	0.08
11.15	7.1	0.14	1.90	62.1	5	114.6	0.65	0.64	0.00	1.25	3.4	4.3	0.52	0.09
12.14	6.0	0.07	1.13	64.1	1	79.6	0.70	0.66	0.04	1.23	2.9	3.6	0.43	0.08
13.21	6.0	0.09	1.53	63.8	5	114.6	0.75	0.68	0.07	1.21	2.9	3.5	0.42	0.08
14.27	13.9	0.20	1.43	29.1	6	114.6	0.81	0.71	0.10	1.19	5.3	6.3	1.04	0.13
15.26	6.8	0.09	1.35	60.5	5	114.6	0.87	0.73	0.13	1.17	3.3	3.8	0.48	0.09
16.24	6.8	0.14	2.07	81.1	4	114.6	0.92	0.76	0.16	1.15	4.3	5.0	0.47	0.09
17.22	11.4	0.14	1.22	73.6	5	114.6	0.98	0.78	0.19	1.13	5.5	6.2	0.83	0.10
18.21	10.3	0.13	1.25	83.4	5	114.6	1.04	0.81	0.23	1.11	4.9	5.5	0.74	0.10
19.19	9.0	0.14	1.52	89.7	5	114.6	1.09	0.84	0.26	1.09	4.3	4.7	0.63	0.09
20.18	8.4	0.16	1.95	90.8	5	114.6	1.15	0.86	0.29	1.08	4.0	4.3	0.58	0.09
21.16	9.7	0.14	1.42	101.5	5	114.6	1.20	0.89	0.32	1.06	4.6	4.9	0.68	0.09
22.15	8.6	0.18	2.03	91.1	5	114.6	1.26	0.91	0.35	1.05	4.1	4.3	0.59	0.09
23.13	7.7	0.20	2.60	88.2	4	114.6	1.32	0.94	0.38	1.03	4.9	5.1	0.51	0.00
24.11	8.2	0.27	3.31	75.4	3	111.4	1.37	0.96	0.41	1.02	7.8	8.0	0.54	0.00
25.10	10.0	0.35	3.49	80.9	3	111.4	1.43	0.99	0.44	1.01	9.5	9.6	0.68	0.00
26.08	11.2	0.42	3.74	63.6	3	111.4	1.48	1.01	0.47	0.99	10.7	10.6	0.78	0.00
27.07	11.2	0.33	2.98	76.1	4	114.6	1.54	1.04	0.50	0.98	7.2	7.0	0.77	0.00
28.05	11.3	0.26	2.31	113.2	5	114.6	1.59	1.06	0.53	0.97	5.4	5.2	0.77	0.09
29.04	32.3	1.29	3.98	52.2	4	114.6	1.65	1.09	0.56	0.96	20.6	19.8	2.45	0.40

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
30.02	19.3	0.84	4.34	29.8	3	111.4	1.71	1.11	0.59	0.95	18.5	17.5	1.41	0.00
31.00	19.2	0.64	3.32	90.1	5	114.6	1.76	1.14	0.62	0.94	9.2	8.6	1.40	0.14
31.99	20.7	0.78	3.77	94.8	4	114.6	1.82	1.16	0.66	0.93	13.2	12.3	1.51	0.00
32.97	19.4	0.84	4.35	55.9	3	111.4	1.87	1.19	0.69	0.92	18.6	17.0	1.40	0.00
33.96	17.3	0.69	3.99	72.9	3	111.4	1.93	1.21	0.72	0.91	16.6	15.0	1.23	0.00
34.94	25.9	0.76	2.93	161.1	5	114.6	1.98	1.24	0.75	0.90	12.4	11.2	1.92	0.22
35.92	76.4	2.55	3.34	141.6	6	114.6	2.04	1.26	0.78	0.89	29.3	26.0	5.95	0.00
36.91	86.3	2.31	2.68	0.4	6	114.6	2.10	1.29	0.81	0.88	33.1	29.1	6.74	0.41
37.89	30.8	0.85	2.77	194.6	5	114.6	2.15	1.31	0.84	0.87	14.7	12.8	2.29	0.29
38.88	22.2	0.67	3.02	146.5	5	114.6	2.21	1.34	0.87	0.86	10.6	9.2	1.60	0.16
39.86	18.9	0.34	1.81	189.8	6	114.6	2.27	1.37	0.90	0.86	7.3	6.2	1.33	0.13
40.85	20.9	0.49	2.36	198.1	6	114.6	2.32	1.39	0.93	0.85	8.0	6.8	1.49	0.14
41.83	25.5	0.83	3.25	191.1	5	114.6	2.38	1.42	0.96	0.84	12.2	10.3	1.85	0.19
42.81	31.3	1.09	3.48	211.8	5	114.6	2.44	1.44	0.99	0.83	15.0	12.5	2.31	0.27
43.80	71.0	3.41	4.81	89.6	11	130.5	2.50	1.47	1.02	0.82	68.0	56.1	UnDef	0.00
44.78	86.1	3.99	4.64	74.2	11	130.5	2.56	1.51	1.05	0.82	82.4	67.2	UnDef	0.00
45.77	57.5	2.37	4.13	184.7	5	114.6	2.62	1.53	1.09	0.81	27.5	22.2	4.39	0.00
46.75	40.9	1.65	4.03	109.5	5	114.6	2.68	1.56	1.12	0.80	19.6	15.7	3.06	0.00
47.74	22.5	0.42	1.86	138.8	6	114.6	2.73	1.59	1.15	0.79	8.6	6.8	1.58	0.14
48.72	26.6	0.69	2.59	215.0	6	114.6	2.79	1.61	1.18	0.79	10.2	8.0	1.90	0.18
49.70	26.8	0.91	3.38	99.9	5	114.6	2.85	1.64	1.21	0.78	12.9	10.0	1.92	0.00
50.69	34.7	1.17	3.36	112.5	5	114.6	2.90	1.66	1.24	0.78	16.6	12.9	2.54	0.29
51.67	40.2	1.25	3.11	140.3	5	114.6	2.96	1.69	1.27	0.77	19.2	14.8	2.98	0.40
52.66	32.4	0.88	2.73	201.8	6	114.6	3.02	1.71	1.30	0.76	12.4	9.5	2.35	0.24
53.64	44.9	1.46	3.25	273.7	5	114.6	3.07	1.74	1.33	0.76	21.5	16.3	3.35	0.00
54.63	47.0	1.71	3.64	171.8	5	114.6	3.13	1.77	1.36	0.75	22.5	16.9	3.51	0.00
55.61	35.4	0.88	2.48	236.7	6	114.6	3.18	1.79	1.39	0.75	13.6	10.1	2.58	0.28
56.59	36.3	1.17	3.23	192.1	5	114.6	3.24	1.82	1.42	0.74	17.4	12.9	2.64	0.29
57.58	35.6	1.31	3.67	205.3	5	114.6	3.30	1.84	1.45	0.74	17.1	12.6	2.59	0.00
58.56	33.6	1.06	3.16	208.9	5	114.6	3.35	1.87	1.49	0.73	16.1	11.8	2.42	0.24
59.55	32.0	1.03	3.21	224.0	5	114.6	3.41	1.89	1.52	0.73	15.3	11.1	2.29	0.22
60.53	32.5	0.87	2.69	307.9	6	114.6	3.47	1.92	1.55	0.72	12.4	9.0	2.32	0.22
61.52	52.6	2.01	3.82	219.8	5	114.6	3.52	1.95	1.58	0.72	25.2	18.1	3.93	0.00
62.42	36.9	1.68	4.56	86.4	4	114.6	3.57	1.97	1.61	0.71	23.5	16.8	2.66	0.00
63.32	30.0	1.08	3.60	119.2	5	114.6	3.63	1.99	1.63	0.71	14.4	10.2	2.11	0.00
64.30	32.5	1.10	3.38	172.5	5	114.6	3.68	2.02	1.66	0.70	15.6	11.0	2.31	0.00
65.29	35.1	1.29	3.66	186.5	5	114.6	3.74	2.04	1.70	0.70	16.8	11.8	2.51	0.00
66.27	69.5	4.19	6.03	101.5	11	130.5	3.80	2.07	1.73	0.69	66.6	46.2	UnDef	0.00
67.26	85.0	4.38	5.15	127.3	11	130.5	3.86	2.11	1.76	0.69	81.4	56.1	UnDef	0.00
68.24	104.5	6.01	5.75	16.2	11	130.5	3.93	2.14	1.79	0.68	100.1	68.4	UnDef	0.00
69.22	67.9	4.01	5.90	142.1	11	130.5	3.99	2.17	1.82	0.68	65.0	44.1	UnDef	0.00
70.21	59.3	3.14	5.30	152.7	11	130.5	4.06	2.21	1.85	0.67	56.8	38.2	UnDef	0.00
71.19	71.1	3.36	4.73	149.2	11	130.5	4.12	2.24	1.88	0.67	68.1	45.5	UnDef	0.00
72.18	43.5	1.88	4.32	168.8	4	114.6	4.18	2.27	1.91	0.66	27.8	18.4	3.15	0.00
73.16	26.8	0.71	2.63	221.1	5	114.6	4.24	2.30	1.94	0.66	12.8	8.5	1.81	0.14
74.15	31.9	1.07	3.36	193.6	5	114.6	4.29	2.32	1.97	0.66	15.3	10.0	2.21	0.00
75.13	39.1	1.32	3.39	312.1	5	114.6	4.35	2.35	2.00	0.65	18.7	12.2	2.78	0.00
76.11	42.2	1.28	3.03	353.0	5	114.6	4.41	2.37	2.03	0.65	20.2	13.1	3.02	0.30
77.10	35.6	1.21	3.41	296.4	5	114.6	4.46	2.40	2.06	0.65	17.0	11.0	2.49	0.00
78.08	27.6	0.82	2.95	285.3	5	114.6	4.52	2.42	2.09	0.64	13.2	8.5	1.85	0.00
79.07	27.0	0.71	2.64	320.7	5	114.6	4.58	2.45	2.13	0.64	12.9	8.3	1.80	0.14
80.05	32.4	0.82	2.51	407.7	6	114.6	4.63	2.48	2.16	0.64	12.4	7.9	2.23	0.18

Gregg In Situ, Inc.
Run No: 03-0203-1606-1720
CPT File: 027C06.COR

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
81.04	39.4	1.09	2.76	359.6	6	114.6	4.69	2.50	2.19	0.63	15.1	9.5	2.78	0.25
82.02	27.1	0.62	2.30	361.8	6	114.6	4.74	2.53	2.22	0.63	10.4	6.5	1.79	0.13
83.00	29.4	0.64	2.17	352.3	6	114.6	4.80	2.55	2.25	0.63	11.3	7.1	1.97	0.15
83.99	24.7	0.27	1.09	436.1	6	114.6	4.86	2.58	2.28	0.62	9.5	5.9	1.59	0.12
84.97	30.0	0.49	1.63	503.1	6	114.6	4.91	2.60	2.31	0.62	11.5	7.1	2.00	0.15
85.96	52.6	2.46	4.68	301.3	4	114.6	4.97	2.63	2.34	0.62	33.6	20.7	3.81	0.00
86.94	53.6	2.83	5.27	249.2	11	130.5	5.03	2.66	2.37	0.61	51.4	31.5	UnDef	0.00
87.93	37.2	1.23	3.31	385.6	5	114.6	5.09	2.69	2.40	0.61	17.8	10.9	2.56	0.00
88.91	51.5	2.42	4.69	242.9	4	114.6	5.15	2.71	2.43	0.61	32.9	20.0	3.71	0.00
89.89	65.5	2.67	4.08	305.1	5	114.6	5.20	2.74	2.46	0.60	31.3	18.9	4.82	0.00
90.88	63.7	3.84	6.04	189.7	11	130.5	5.26	2.77	2.49	0.60	61.0	36.6	UnDef	0.00
91.86	32.5	0.77	2.38	387.9	6	114.6	5.32	2.80	2.52	0.60	12.4	7.4	2.17	0.16
92.85	34.7	0.98	2.81	333.7	6	114.6	5.38	2.82	2.56	0.60	13.3	7.9	2.35	0.18
93.83	33.6	0.90	2.68	363.1	6	114.6	5.44	2.85	2.59	0.59	12.9	7.6	2.25	0.17
94.82	33.8	0.82	2.44	434.3	6	114.6	5.49	2.88	2.62	0.59	12.9	7.6	2.26	0.17
95.80	45.6	1.48	3.25	471.2	5	114.6	5.55	2.90	2.65	0.59	21.8	12.8	3.20	0.00
96.78	94.8	4.43	4.67	245.4	11	130.5	5.61	2.93	2.68	0.58	90.8	53.0	UnDef	0.00
97.77	46.1	2.29	4.97	250.9	3	111.4	5.67	2.96	2.71	0.58	44.2	25.7	3.24	0.00
98.75	31.8	0.81	2.54	361.3	6	114.6	5.72	2.98	2.74	0.58	12.2	7.0	2.08	0.15

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Run No: 03-0203-1606-1720
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-06
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 12:49
CPT File: 027C06.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 3.35 (ft): 11.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
0.49	1.0E-15	0.00	2.4	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
1.48	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
2.46	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
3.44	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
4.43	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
5.41	5.0E-07	0.04	17.8	2.72	6	10.6	42.6	53.2	44.2	UnDef	UnDef	6.0	UnDef	6.9	13.
6.40	5.0E-06	0.06	26.6	1.93	6	16.9	46.5	63.4	32.5	UnDef	UnDef	6.0	UnDef	7.0	15.
7.30	5.0E-05	0.02	42.3	1.62	7	28.1	28.3	56.4	23.8	38	30.9	6.0	-0.15	5.0	16.
8.20	5.0E-04	0.01	81.7	0.63	9	56.9	7.8	64.7	9.5	42	51.1	1.0	-0.13	1.5	20.
9.19	5.0E-04	0.01	53.4	1.09	7	39.5	19.5	59.0	17.4	40	40.7	1.0	-0.13	3.4	16.
10.17	1.0E-07	0.29	7.8	1.25	6	6.7	26.7	33.4	51.6	UnDef	UnDef	3.0	UnDef	3.3	6.
11.15	5.0E-06	0.30	10.1	2.09	6	8.7	34.8	43.5	52.5	UnDef	UnDef	3.0	UnDef	4.3	8.
12.14	1.0E-07	0.37	8.1	1.28	6	7.3	29.1	36.4	51.1	UnDef	UnDef	3.0	UnDef	3.6	7.
13.21	5.0E-06	0.37	7.7	1.75	4	7.1	28.5	35.6	56.3	UnDef	UnDef	3.0	UnDef	3.5	7.
14.27	5.0E-05	0.06	18.5	1.52	6	16.1	64.5	80.7	36.0	32	30.0	6.0	-0.05	6.3	12.
15.26	5.0E-06	0.29	8.1	1.54	6	7.8	31.2	39.0	53.4	UnDef	UnDef	3.0	UnDef	3.8	7.
16.24	5.0E-07	0.40	7.7	2.39	4	7.6	30.5	38.1	61.0	UnDef	UnDef	3.0	UnDef	5.0	10.
17.22	5.0E-06	0.20	13.3	1.33	6	12.6	50.4	63.0	40.7	UnDef	UnDef	6.0	UnDef	6.2	12.
18.21	5.0E-06	0.26	11.4	1.39	6	11.2	44.6	55.8	44.4	UnDef	UnDef	3.0	UnDef	5.5	10.
19.19	5.0E-06	0.32	9.5	1.73	6	9.7	38.6	48.3	51.2	UnDef	UnDef	3.0	UnDef	4.7	9.
20.18	5.0E-06	0.35	8.4	2.26	4	8.9	35.4	44.3	58.0	UnDef	UnDef	3.0	UnDef	4.3	8.
21.16	5.0E-06	0.34	9.5	1.62	6	10.1	40.2	50.3	50.2	UnDef	UnDef	3.0	UnDef	4.9	9.
22.15	5.0E-06	0.34	8.1	2.37	4	8.9	35.4	44.3	59.7	UnDef	UnDef	3.0	UnDef	4.3	8.
23.13	5.0E-07	0.37	6.8	3.13	1	7.8	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
24.11	5.0E-08	0.29	7.1	3.98	1	8.1	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
25.10	5.0E-08	0.24	8.6	4.07	1	9.8	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
26.08	5.0E-08	0.16	9.6	4.31	1	10.9	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
27.07	5.0E-07	0.19	9.3	3.45	1	10.8	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
28.05	5.0E-06	0.31	9.1	2.69	4	10.7	42.8	53.5	58.8	UnDef	UnDef	3.0	UnDef	5.2	10.
29.04	5.0E-07	0.03	28.2	4.19	6	30.3	121.3	151.7	42.3	UnDef	UnDef	6.0	UnDef	19.8	39.

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
30.02	5.0E-08	0.02	15.8	4.76	1	17.9	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
31.00	5.0E-06	0.13	15.3	3.66	4	17.6	70.5	88.1	51.9	UnDef	UnDef	6.0	UnDef	8.6	17.
31.99	5.0E-07	0.12	16.3	4.13	1	18.8	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
32.97	5.0E-08	0.06	14.7	4.82	1	17.4	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
33.96	5.0E-08	0.10	12.7	4.49	1	15.4	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
34.94	5.0E-06	0.18	19.4	3.17	6	22.8	91.2	114.0	44.8	UnDef	UnDef	6.0	UnDef	11.2	22.
35.92	5.0E-05	0.05	58.9	3.44	6	66.5	108.9	175.4	28.2	40	55.6	10.0	-0.29	16.5	42.
36.91	5.0E-05	-0.01	65.4	2.74	7	74.4	77.7	152.1	24.1	40	58.8	10.0	-0.27	13.7	42.
37.89	5.0E-06	0.18	21.8	2.97	6	26.3	105.0	131.3	41.7	UnDef	UnDef	6.0	UnDef	12.8	25.
38.88	5.0E-06	0.19	14.9	3.35	4	18.8	75.1	93.9	51.0	UnDef	UnDef	6.0	UnDef	9.2	18.
39.86	5.0E-05	0.30	12.2	2.05	6	15.9	63.5	79.3	47.9	30	30.0	3.0	0.00	6.2	12.
40.85	5.0E-05	0.28	13.4	2.66	6	17.4	69.5	86.9	49.7	32	30.0	6.0	-0.03	6.8	13.
41.83	5.0E-06	0.22	16.3	3.58	4	21.0	83.9	104.9	50.2	UnDef	UnDef	6.0	UnDef	10.3	20.
42.81	5.0E-06	0.19	20.0	3.77	4	25.5	101.9	127.4	47.0	UnDef	UnDef	6.0	UnDef	12.5	24.
43.80	1.0E-15	0.03	46.5	4.98	6	57.3	229.1	286.4	36.9	38	51.3	1.0	-0.40	56.1	112.
44.78	1.0E-15	0.02	55.5	4.78	6	68.6	226.6	295.2	33.7	40	56.5	1.0	-0.41	62.0	129.
45.77	5.0E-06	0.09	35.8	4.32	6	45.4	181.7	227.1	38.8	UnDef	UnDef	6.0	UnDef	22.2	44.
46.75	5.0E-06	0.06	24.5	4.31	4	32.0	128.1	160.1	45.3	UnDef	UnDef	6.0	UnDef	15.7	31.
47.74	5.0E-05	0.16	12.4	2.12	6	17.4	69.8	87.2	48.0	30	30.0	3.0	-0.02	6.8	13.
48.72	5.0E-05	0.23	14.8	2.89	6	20.5	82.0	102.5	48.9	32	30.0	6.0	-0.06	8.0	16.
49.70	5.0E-06	0.08	14.7	3.78	1	20.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
50.69	5.0E-06	0.07	19.1	3.67	4	26.3	105.3	131.7	47.4	UnDef	UnDef	6.0	UnDef	12.9	25.
51.67	5.0E-06	0.08	22.0	3.36	6	30.2	121.0	151.2	43.3	UnDef	UnDef	6.0	UnDef	14.8	29.
52.66	5.0E-05	0.17	17.1	3.01	6	24.2	96.8	121.1	46.5	32	30.0	6.0	-0.09	9.5	19.
53.64	5.0E-06	0.17	24.0	3.49	6	33.3	133.3	166.6	42.3	UnDef	UnDef	6.0	UnDef	16.3	32.
54.63	5.0E-06	0.09	24.9	3.90	6	34.6	138.5	173.2	43.4	UnDef	UnDef	6.0	UnDef	16.9	33.
.61	5.0E-05	0.19	18.0	2.72	6	25.9	103.7	129.6	44.0	32	30.0	6.0	-0.08	10.1	20.
56.59	5.0E-06	0.14	18.2	3.55	4	26.4	105.4	131.8	47.8	UnDef	UnDef	6.0	UnDef	12.9	25.
57.58	5.0E-06	0.15	17.5	4.05	1	25.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
58.56	5.0E-06	0.17	16.2	3.51	4	24.0	96.1	120.1	50.1	UnDef	UnDef	6.0	UnDef	11.8	23.
59.55	5.0E-06	0.19	15.1	3.59	4	22.8	91.1	113.8	51.9	UnDef	UnDef	6.0	UnDef	11.1	22.
60.53	5.0E-05	0.28	15.1	3.01	6	22.9	91.7	114.7	49.0	32	30.0	6.0	-0.06	9.0	18.
61.52	5.0E-06	0.11	25.2	4.10	6	36.9	147.7	184.6	43.9	UnDef	UnDef	6.0	UnDef	18.1	36.
62.42	5.0E-07	0.03	16.9	5.05	1	25.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
63.32	5.0E-06	0.08	13.2	4.10	1	20.8	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
64.30	5.0E-06	0.13	14.3	3.81	1	22.4	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
65.29	5.0E-06	0.13	15.4	4.10	1	24.1	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
66.27	1.0E-15	0.02	31.7	6.38	1	47.2	UnDef	UnDef	100.0	36	45.8	1.0	-0.52	UnDef	UnDe
67.26	1.0E-15	0.03	38.5	5.40	1	57.3	UnDef	UnDef	100.0	38	51.3	1.0	-0.41	UnDef	UnDe
68.24	1.0E-15	-0.01	47.0	5.97	1	69.9	UnDef	UnDef	100.0	38	57.0	1.0	-0.55	UnDef	UnDe
69.22	1.0E-15	0.04	29.4	6.27	1	45.1	UnDef	UnDef	100.0	36	44.4	1.0	-0.47	UnDef	UnDe
70.21	1.0E-15	0.05	25.0	5.69	1	39.1	UnDef	UnDef	100.0	34	40.3	1.0	-0.34	UnDef	UnDe
71.19	1.0E-15	0.04	29.9	5.02	1	46.5	UnDef	UnDef	100.0	36	45.3	1.0	-0.31	UnDef	UnDe
72.18	5.0E-07	0.09	17.3	4.78	1	28.3	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
73.16	5.0E-06	0.22	9.8	3.13	4	17.3	69.3	86.6	59.4	UnDef	UnDef	3.0	UnDef	8.5	17.
74.15	5.0E-06	0.15	11.9	3.88	1	20.5	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
75.13	5.0E-06	0.22	14.8	3.81	1	25.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
76.11	5.0E-06	0.24	15.9	3.38	4	26.8	107.1	133.9	49.8	UnDef	UnDef	6.0	UnDef	13.1	26.
77.10	5.0E-06	0.23	13.0	3.90	1	22.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
78.08	5.0E-06	0.29	9.5	3.53	1	17.4	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
79.07	5.0E-06	0.35	9.2	3.18	4	16.9	67.6	84.5	61.3	UnDef	UnDef	3.0	UnDef	8.3	16.
80.05	5.0E-05	0.38	11.2	2.93	4	20.2	80.7	100.9	55.1	30	30.0	3.0	0.00	7.9	15.

Gregg In Situ, Inc.
Run No: 03-0203-1606-1720
CPT File: 027C06.COR

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
81.04	5.0E-05	0.26	13.9	3.13	4	24.4	97.5	121.8	51.5	32	30.0	6.0	-0.05	9.5	19.
82.02	5.0E-05	0.41	8.9	2.79	4	16.7	66.8	83.5	60.0	30	30.0	3.0	0.04	6.5	13.
83.00	5.0E-05	0.36	9.6	2.60	4	18.0	72.1	90.1	56.8	30	30.0	3.0	0.02	7.1	14.
83.99	5.0E-05	0.57	7.7	1.36	6	15.1	60.2	75.3	53.0	30	30.0	3.0	0.12	5.9	11.
84.97	5.0E-05	0.53	9.6	1.95	6	18.2	72.7	90.9	52.6	30	30.0	3.0	0.07	7.1	14.
85.96	5.0E-07	0.15	18.1	5.16	1	31.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
86.94	1.0E-15	0.11	18.3	5.81	1	32.2	UnDef	UnDef	100.0	32	34.8	1.0	-0.27	UnDef	UnDe
87.93	5.0E-06	0.30	11.9	3.83	1	22.2	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
88.91	5.0E-07	0.11	17.1	5.21	1	30.6	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
89.89	5.0E-06	0.12	22.0	4.44	1	38.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
90.88	1.0E-15	0.06	21.1	6.58	1	37.4	UnDef	UnDef	100.0	34	39.1	1.0	-0.43	UnDef	UnDe
91.86	5.0E-05	0.35	9.7	2.84	4	19.0	76.0	95.0	58.1	30	30.0	3.0	0.02	7.4	14.
92.85	5.0E-05	0.27	10.4	3.33	4	20.2	80.9	101.1	59.1	30	30.0	3.0	-0.02	7.9	15.
93.83	5.0E-05	0.31	9.9	3.20	4	19.5	77.9	97.4	59.6	30	30.0	3.0	0.00	7.6	15.
94.82	5.0E-05	0.39	9.8	2.91	4	19.5	77.9	97.4	58.2	30	30.0	3.0	0.02	7.6	15.
95.80	5.0E-06	0.30	13.8	3.70	1	26.2	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
96.78	1.0E-15	0.06	30.4	4.96	1	54.2	UnDef	UnDef	100.0	36	49.7	1.0	-0.31	UnDef	UnDe
97.77	5.0E-08	0.13	13.7	5.67	1	26.2	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
98.75	5.0E-05	0.33	8.7	3.10	4	18.0	72.0	90.0	62.2	30	30.0	3.0	0.02	7.0	14.

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Job No: 03-0203-1606-1660
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-05
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 10:52
CPT File: 027C05.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 1.83 (ft): 6.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
0.49	0.0	0.00	0.00	0.0	UnDef	124.1	0.03	0.03	0.00	2.00	UnDef	UnDef	UnDef	0.00
1.48	0.0	0.00	0.00	0.0	UnDef	124.1	0.09	0.09	0.00	2.00	UnDef	UnDef	UnDef	0.00
2.46	0.0	0.00	0.00	0.0	UnDef	124.1	0.15	0.15	0.00	2.00	UnDef	UnDef	UnDef	0.00
3.44	0.0	0.00	0.00	0.0	UnDef	124.1	0.21	0.21	0.00	2.00	UnDef	UnDef	UnDef	0.00
4.43	0.0	0.00	0.00	0.0	UnDef	124.1	0.27	0.27	0.00	1.91	UnDef	UnDef	UnDef	0.00
5.41	7.7	0.29	3.72	33.1	3	111.4	0.33	0.33	0.00	1.73	7.4	12.8	0.59	0.11
6.40	6.2	0.28	4.56	20.5	3	111.4	0.39	0.38	0.01	1.63	5.9	9.7	0.46	0.00
7.30	4.2	0.14	3.40	16.7	3	111.4	0.44	0.40	0.04	1.59	4.1	6.4	0.30	0.00
8.20	7.4	0.22	2.92	16.5	4	114.6	0.49	0.42	0.07	1.54	4.8	7.3	0.56	0.10
9.19	6.9	0.10	1.46	14.3	5	114.6	0.55	0.45	0.10	1.50	3.3	4.9	0.51	0.09
10.17	5.6	0.16	2.79	24.9	3	111.4	0.60	0.47	0.13	1.46	5.3	7.8	0.40	0.09
11.15	7.0	0.13	1.86	24.1	5	114.6	0.66	0.50	0.16	1.42	3.4	4.8	0.51	0.09
12.14	10.1	0.22	2.22	31.5	5	114.6	0.71	0.52	0.19	1.39	4.8	6.7	0.75	0.11
13.21	8.9	0.15	1.75	25.2	5	114.6	0.77	0.55	0.22	1.35	4.2	5.7	0.65	0.10
14.27	5.9	0.11	1.77	26.5	4	114.6	0.84	0.58	0.26	1.32	3.8	5.0	0.41	0.09
15.26	5.3	0.12	2.22	40.1	4	114.6	0.89	0.60	0.29	1.29	3.4	4.3	0.35	0.08
16.24	12.5	0.22	1.74	70.0	5	114.6	0.95	0.63	0.32	1.26	6.0	7.6	0.92	0.12
17.22	12.5	0.23	1.85	94.9	5	114.6	1.00	0.65	0.35	1.24	6.0	7.4	0.92	0.12
18.21	13.6	0.19	1.39	136.1	6	114.6	1.06	0.68	0.38	1.21	5.2	6.3	1.00	0.13
19.19	20.8	0.28	1.34	265.0	6	114.6	1.12	0.71	0.41	1.19	8.0	9.5	1.57	0.10
20.18	19.3	0.23	1.19	249.2	6	114.6	1.17	0.73	0.44	1.17	7.4	8.6	1.45	0.10
21.16	23.6	0.46	1.94	227.4	6	114.6	1.23	0.76	0.47	1.15	9.1	10.4	1.79	0.15
22.15	27.4	0.70	2.57	197.4	6	114.6	1.29	0.78	0.50	1.13	10.5	11.9	2.09	0.24
23.13	23.7	0.79	3.33	118.1	5	114.6	1.34	0.81	0.53	1.11	11.3	12.6	1.79	0.28
24.11	56.7	2.25	3.97	112.7	5	114.6	1.40	0.83	0.57	1.10	27.2	29.7	4.42	0.00
25.10	81.5	3.17	3.89	97.4	5	114.6	1.46	0.86	0.60	1.08	39.0	42.1	6.41	0.00
26.08	115.7	4.13	3.56	55.2	6	114.6	1.51	0.88	0.63	1.06	44.3	47.1	9.14	0.00
27.07	39.4	1.92	4.89	45.1	3	111.4	1.57	0.91	0.66	1.05	37.7	39.6	3.03	0.00
28.05	31.2	1.30	4.18	81.1	4	114.6	1.62	0.93	0.69	1.03	20.0	20.6	2.37	0.45
29.04	29.7	1.24	4.17	138.8	4	114.6	1.68	0.96	0.72	1.02	18.9	19.3	2.24	0.38

Gregg In Situ, Inc.
Run No: 03-0203-1606-1660
CPT File: 027C05.COR

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60	Su (tsf)	CRR
30.02	26.6	1.12	4.20	104.6	4	114.6	1.74	0.99	0.75	1.01	17.0	17.1	1.99	0.00
31.00	44.4	1.43	3.23	117.2	5	114.6	1.79	1.01	0.78	0.99	21.3	21.2	3.41	0.00
31.99	179.8	4.43	2.46	56.1	7	117.8	1.85	1.04	0.81	0.98	57.4	56.4	UnDef	0.00
32.97	176.4	4.05	2.29	15.2	7	117.8	1.91	1.07	0.84	0.97	56.3	54.6	UnDef	0.00
33.96	167.9	3.63	2.16	-7.7	7	117.8	1.97	1.09	0.87	0.96	53.6	51.3	UnDef	0.00
34.94	190.3	3.94	2.07	-14.2	7	117.8	2.02	1.12	0.90	0.95	60.7	57.4	UnDef	0.00
35.92	125.8	4.18	3.32	-14.0	6	114.6	2.08	1.15	0.93	0.93	48.2	45.0	9.90	0.00
36.91	41.8	1.71	4.09	-11.5	5	114.6	2.14	1.17	0.97	0.92	20.0	18.5	3.17	0.00
37.89	21.7	0.60	2.76	-8.2	5	114.6	2.19	1.20	1.00	0.91	10.4	9.5	1.56	0.17
38.88	21.5	0.48	2.24	3.7	6	114.6	2.25	1.22	1.03	0.90	8.2	7.5	1.54	0.16
39.86	44.3	1.61	3.64	4.6	5	114.6	2.31	1.25	1.06	0.90	21.2	19.0	3.36	0.00
40.85	46.5	2.80	6.01	4.6	3	111.4	2.36	1.27	1.09	0.89	44.5	39.5	3.53	0.00
41.83	31.0	0.96	3.08	15.1	5	114.6	2.42	1.30	1.12	0.88	14.9	13.0	2.29	0.30
42.81	30.0	0.98	3.28	16.2	5	114.6	2.47	1.32	1.15	0.87	14.4	12.5	2.20	0.27
43.80	123.1	4.27	3.47	16.7	6	114.6	2.53	1.35	1.18	0.86	47.1	40.6	9.64	0.00
44.78	67.3	2.24	3.33	13.4	6	114.6	2.59	1.38	1.21	0.85	25.8	22.0	5.18	0.00
45.77	25.2	0.55	2.19	15.3	6	114.6	2.64	1.40	1.24	0.84	9.7	8.2	1.81	0.19
46.75	21.6	0.42	1.94	16.5	6	114.6	2.70	1.43	1.27	0.84	8.3	6.9	1.51	0.14
47.74	43.6	1.67	3.82	19.3	5	114.6	2.76	1.45	1.30	0.83	20.9	17.3	3.27	0.00
48.72	159.6	8.07	5.06	28.3	11	130.5	2.82	1.48	1.33	0.82	152.8	125.6	UnDef	0.00
49.70	38.6	1.80	4.67	26.8	4	114.6	2.88	1.51	1.36	0.81	24.7	20.1	2.86	0.00
50.69	30.9	0.72	2.34	27.7	6	114.6	2.93	1.54	1.40	0.81	11.8	9.5	2.23	0.25
51.67	24.5	0.51	2.06	27.4	6	114.6	2.99	1.56	1.43	0.80	9.4	7.5	1.72	0.16
52.66	31.9	0.60	1.87	28.8	6	114.6	3.05	1.59	1.46	0.79	12.2	9.7	2.31	0.26
53.64	35.2	0.95	2.71	29.2	6	114.6	3.10	1.61	1.49	0.79	13.5	10.6	2.56	0.31
54.63	32.5	0.94	2.89	29.5	5	114.6	3.16	1.64	1.52	0.78	15.5	12.1	2.35	0.26
55.61	28.6	0.70	2.46	30.9	6	114.6	3.21	1.67	1.55	0.77	10.9	8.5	2.03	0.20
56.59	32.7	0.87	2.66	31.5	6	114.6	3.27	1.69	1.58	0.77	12.5	9.6	2.35	0.25
57.58	25.2	0.59	2.36	31.2	6	114.6	3.33	1.72	1.61	0.76	9.6	7.4	1.75	0.16
58.56	25.0	0.64	2.55	32.3	5	114.6	3.38	1.74	1.64	0.76	12.0	9.1	1.73	0.15
59.55	23.0	0.55	2.41	32.4	6	114.6	3.44	1.77	1.67	0.75	8.8	6.6	1.57	0.14
60.53	27.4	0.86	3.13	33.2	5	114.6	3.50	1.79	1.70	0.75	13.1	9.8	1.92	0.17
61.52	28.2	0.87	3.10	34.5	5	114.6	3.55	1.82	1.73	0.74	13.5	10.0	1.97	0.18
62.42	29.5	0.75	2.54	35.7	6	114.6	3.60	1.84	1.76	0.74	11.3	8.3	2.07	0.19
63.32	36.4	0.89	2.45	38.4	6	114.6	3.66	1.87	1.79	0.73	13.9	10.2	2.62	0.29
64.30	31.6	0.83	2.63	40.9	6	114.6	3.71	1.89	1.82	0.73	12.1	8.8	2.23	0.21
65.29	29.3	0.96	3.26	43.6	5	114.6	3.77	1.92	1.85	0.72	14.1	10.1	2.05	0.00
66.27	30.8	0.89	2.88	44.9	5	114.6	3.83	1.94	1.88	0.72	14.8	10.6	2.16	0.20
67.26	33.8	0.94	2.78	47.8	6	114.6	3.88	1.97	1.91	0.71	12.9	9.2	2.39	0.23
68.24	35.3	0.85	2.40	56.0	6	114.6	3.94	1.99	1.94	0.71	13.5	9.6	2.51	0.25
69.22	47.6	1.29	2.70	59.7	6	114.6	3.99	2.02	1.97	0.70	18.2	12.8	3.49	0.00
70.21	92.7	4.73	5.11	66.5	11	130.5	4.05	2.05	2.00	0.70	88.7	62.0	UnDef	0.00
71.19	124.2	6.16	4.96	65.8	11	130.5	4.12	2.08	2.04	0.69	119.0	82.4	UnDef	0.00
72.18	40.8	1.20	2.94	66.5	6	114.6	4.18	2.11	2.07	0.69	15.6	10.8	2.93	0.32
73.16	39.7	1.03	2.60	70.8	6	114.6	4.24	2.14	2.10	0.68	15.2	10.4	2.83	0.30
74.15	46.5	1.18	2.53	73.8	6	114.6	4.29	2.16	2.13	0.68	17.8	12.1	3.38	0.42
75.13	54.5	2.21	4.05	76.0	5	114.6	4.35	2.19	2.16	0.68	26.1	17.6	4.01	0.00
76.11	50.2	2.21	4.41	77.2	5	114.6	4.40	2.22	2.19	0.67	24.0	16.2	3.66	0.00
77.10	37.4	1.54	4.13	73.3	4	114.6	4.46	2.24	2.22	0.67	23.9	16.0	2.64	0.00
78.08	36.2	0.79	2.17	78.4	6	114.6	4.52	2.27	2.25	0.66	13.9	9.2	2.54	0.23
79.07	34.7	0.86	2.48	80.0	6	114.6	4.57	2.29	2.28	0.66	13.3	8.8	2.41	0.21
80.05	35.8	0.95	2.65	81.4	6	114.6	4.63	2.32	2.31	0.66	13.7	9.0	2.49	0.22

Gregg In Situ, Inc.
Run No: 03-0203-1606-1660
CPT File: 027C05.COR

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
81.04	41.4	1.30	3.15	85.6	5	114.6	4.69	2.34	2.34	0.65	19.8	13.0	2.94	0.30
82.02	45.9	1.50	3.27	89.9	5	114.6	4.74	2.37	2.37	0.65	22.0	14.3	3.29	0.37
83.00	48.6	1.39	2.86	94.8	6	114.6	4.80	2.40	2.40	0.65	18.6	12.0	3.50	0.42
83.99	65.3	3.47	5.31	100.7	11	130.5	4.86	2.42	2.44	0.64	62.5	40.1	UnDef	0.00
84.97	38.5	1.23	3.21	94.5	5	114.6	4.92	2.45	2.47	0.64	18.4	11.8	2.68	0.00
85.96	53.0	2.18	4.11	105.4	5	114.6	4.98	2.48	2.50	0.64	25.4	16.1	3.84	0.00
86.94	118.7	6.37	5.36	128.4	11	130.5	5.04	2.51	2.53	0.63	113.7	71.8	UnDef	0.00
87.93	134.6	7.20	5.35	152.5	11	130.5	5.10	2.54	2.56	0.63	128.9	80.9	UnDef	0.00
88.91	32.2	1.06	3.31	128.7	5	114.6	5.16	2.57	2.59	0.62	15.4	9.6	2.16	0.00
89.89	30.9	0.75	2.43	138.5	6	114.6	5.22	2.60	2.62	0.62	11.9	7.4	2.06	0.16
90.88	78.0	3.58	4.59	146.0	11	130.5	5.28	2.63	2.65	0.62	74.7	46.1	UnDef	0.00
91.86	25.2	0.82	3.26	120.6	5	114.6	5.34	2.66	2.68	0.61	12.1	7.4	1.59	0.00
92.85	25.6	0.55	2.13	132.9	6	114.6	5.39	2.68	2.71	0.61	9.8	6.0	1.62	0.12
93.83	25.4	0.63	2.50	131.3	6	114.6	5.45	2.71	2.74	0.61	9.7	5.9	1.60	0.00
94.82	25.7	0.69	2.68	130.3	5	114.6	5.51	2.73	2.77	0.60	12.3	7.4	1.62	0.00
95.80	34.0	1.16	3.41	139.7	5	114.6	5.56	2.76	2.80	0.60	16.3	9.8	2.27	0.00
96.78	31.3	0.93	2.98	138.4	5	114.6	5.62	2.79	2.83	0.60	15.0	9.0	2.05	0.00
97.77	37.1	0.92	2.49	155.0	6	114.6	5.68	2.81	2.87	0.60	14.2	8.5	2.51	0.20
98.75	42.9	1.35	3.16	165.7	5	114.6	5.73	2.84	2.90	0.59	20.5	12.2	2.97	0.00

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Run No: 03-0203-1606-1660
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-05
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 10:52
CPT File: 027C05.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 1.83 (ft): 6.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
0.49	1.0E-15	0.00	2.4	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
1.48	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
2.46	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
3.44	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
4.43	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
5.41	5.0E-08	0.14	22.1	3.89	6	13.0	52.1	65.2	45.5	UnDef	UnDef	6.0	UnDef	12.8	25.
6.40	5.0E-08	0.11	15.5	4.87	1	9.9	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
7.30	5.0E-08	0.13	9.6	3.79	1	6.6	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
8.20	5.0E-07	0.06	16.6	3.12	6	11.2	45.0	56.2	47.7	UnDef	UnDef	6.0	UnDef	7.3	14.
9.19	5.0E-06	0.06	14.2	1.59	6	10.1	40.2	50.3	41.5	UnDef	UnDef	6.0	UnDef	4.9	9.
10.17	5.0E-08	0.13	10.5	3.13	4	7.9	31.8	39.7	57.7	UnDef	UnDef	3.0	UnDef	7.8	15.
11.15	5.0E-06	0.09	12.8	2.05	6	9.8	39.1	48.8	46.8	UnDef	UnDef	6.0	UnDef	4.8	9.
12.14	5.0E-06	0.08	18.0	2.38	6	13.7	54.8	68.5	42.1	UnDef	UnDef	6.0	UnDef	6.7	13.
13.21	5.0E-06	0.07	14.7	1.91	6	11.7	46.8	58.5	43.1	UnDef	UnDef	6.0	UnDef	5.7	11.
14.27	5.0E-07	0.11	8.8	2.06	4	7.7	30.6	38.3	55.4	UnDef	UnDef	3.0	UnDef	5.0	10.
15.26	5.0E-07	0.22	7.3	2.67	4	6.7	26.6	33.3	64.3	UnDef	UnDef	3.0	UnDef	4.3	8.
16.24	5.0E-06	0.16	18.4	1.88	6	15.4	61.8	77.2	38.5	UnDef	UnDef	6.0	UnDef	7.6	15.
17.22	5.0E-06	0.23	17.5	2.01	6	15.1	60.4	75.5	40.3	UnDef	UnDef	6.0	UnDef	7.4	14.
18.21	5.0E-05	0.31	18.4	1.51	6	16.1	64.3	80.4	36.0	32	30.0	6.0	-0.02	6.3	12.
19.19	5.0E-05	0.40	27.9	1.42	7	24.2	39.9	64.1	28.3	36	30.0	6.0	-0.04	6.0	15.
20.18	5.0E-05	0.41	24.8	1.26	7	22.1	39.3	61.4	29.0	34	30.0	6.0	-0.02	5.8	14.
21.16	5.0E-05	0.30	29.6	2.05	7	26.6	64.4	90.9	31.5	36	30.0	6.0	-0.10	8.3	18.
22.15	5.0E-05	0.22	33.4	2.69	6	30.3	90.6	120.9	33.1	36	33.1	6.0	-0.15	10.5	22.
23.13	5.0E-06	0.14	27.6	3.53	6	25.8	103.0	128.8	40.0	UnDef	UnDef	6.0	UnDef	12.6	25.
24.11	5.0E-06	0.05	66.4	4.07	6	60.8	108.8	169.6	29.0	UnDef	UnDef	10.0	UnDef	19.9	49.
25.10	5.0E-06	0.03	93.2	3.96	12	86.1	UnDef	UnDef	0.0	UnDef	UnDef	10.0	UnDef	UnDef	UnDe
26.08	5.0E-05	0.01	129.1	3.61	12	120.4	UnDef	UnDef	0.0	44	72.6	10.0	-0.42	UnDef	UnDe
27.07	5.0E-08	0.02	41.6	5.09	6	40.4	161.7	202.1	39.0	UnDef	UnDef	6.0	UnDef	39.6	79.
28.05	5.0E-07	0.06	31.7	4.40	6	31.6	126.5	158.2	41.1	UnDef	UnDef	6.0	UnDef	20.6	41.
29.04	5.0E-07	0.13	29.1	4.42	6	29.6	118.5	148.1	42.6	UnDef	UnDef	6.0	UnDef	19.3	38.

Gregg In Situ, Inc.
Run No: 03-0203-1606-1660
CPT File: 027C05.COR

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
30.02	5.0E-07	0.10	25.2	4.49	1	26.2	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
31.00	5.0E-06	0.07	42.2	3.36	6	43.2	120.1	163.3	32.5	UnDef	UnDef	6.0	UnDef	18.0	39.
31.99	5.0E-04	0.01	171.5	2.49	7	172.8	53.8	226.6	13.9	44	82.9	1.0	-0.36	9.8	66.
32.97	5.0E-04	0.00	163.8	2.32	7	167.2	49.6	216.8	13.6	44	82.0	1.0	-0.34	9.1	63.
33.96	5.0E-04	-0.01	151.9	2.19	7	157.2	46.7	203.9	13.6	44	80.2	1.0	-0.32	8.6	59.
34.94	5.0E-04	-0.01	168.2	2.09	9	176.0	43.6	219.6	12.4	44	83.5	1.0	-0.33	8.1	65.
35.92	5.0E-05	-0.01	108.0	3.37	7	115.0	87.4	202.4	21.2	42	71.3	10.0	-0.38	16.7	61.
36.91	5.0E-06	-0.03	33.8	4.31	6	37.8	151.0	188.8	39.6	UnDef	UnDef	6.0	UnDef	18.5	37.
37.89	5.0E-06	-0.06	16.3	3.07	6	19.4	77.6	97.0	47.8	UnDef	UnDef	6.0	UnDef	9.5	19.
38.88	5.0E-05	-0.05	15.8	2.51	6	19.0	76.2	95.2	45.4	32	30.0	6.0	-0.09	7.5	14.
39.86	5.0E-06	-0.02	33.7	3.84	6	38.8	155.3	194.1	37.9	UnDef	UnDef	6.0	UnDef	19.0	38.
40.85	5.0E-08	-0.02	34.7	6.33	1	40.3	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
41.83	5.0E-06	-0.02	22.0	3.34	6	26.7	106.6	133.3	43.2	UnDef	UnDef	6.0	UnDef	13.0	26.
42.81	5.0E-06	-0.02	20.8	3.57	6	25.5	102.0	127.6	45.3	UnDef	UnDef	6.0	UnDef	12.5	25.
43.80	5.0E-05	-0.01	89.3	3.54	7	103.7	103.7	207.3	23.7	42	68.3	10.0	-0.37	18.5	59.
44.78	5.0E-05	-0.01	47.1	3.46	6	56.2	133.3	189.5	31.4	38	50.7	6.0	-0.27	17.3	39.
45.77	5.0E-05	-0.03	16.1	2.45	6	20.8	83.4	104.2	44.7	32	30.0	6.0	-0.09	8.2	16.
46.75	5.0E-05	-0.04	13.3	2.22	6	17.7	70.8	88.6	47.3	32	30.0	6.0	-0.06	6.9	13.
47.74	5.0E-06	-0.02	28.1	4.08	6	35.4	141.7	177.1	41.9	UnDef	UnDef	6.0	UnDef	17.3	34.
48.72	1.0E-15	0.00	105.8	5.15	11	128.3	UnDef	UnDef	0.0	42	74.4	1.0	-0.58	UnDef	UnDe
49.70	5.0E-07	-0.01	23.7	5.05	1	30.8	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
50.69	5.0E-05	-0.02	18.2	2.58	6	24.4	97.5	121.8	43.1	32	30.0	6.0	-0.11	9.5	19.
51.67	5.0E-05	-0.03	13.8	2.35	6	19.2	76.8	96.1	47.3	32	30.0	6.0	-0.07	7.5	15.
52.66	5.0E-05	-0.02	18.2	2.07	6	24.8	99.1	123.8	40.0	32	30.0	6.0	-0.08	9.7	19.
53.64	5.0E-05	-0.02	19.9	2.97	6	27.1	108.3	135.4	43.4	34	30.0	6.0	-0.13	10.6	21.
54.63	5.0E-06	-0.02	17.9	3.20	6	24.8	99.3	124.1	46.6	UnDef	UnDef	6.0	UnDef	12.1	24.
.61	5.0E-05	-0.02	15.2	2.77	6	21.7	86.7	108.4	47.6	32	30.0	6.0	-0.09	8.5	17.
56.59	5.0E-05	-0.02	17.4	2.96	6	24.6	98.3	122.9	45.9	32	30.0	6.0	-0.12	9.6	19.
57.58	5.0E-05	-0.03	12.7	2.72	6	18.8	75.2	94.1	51.2	32	30.0	6.0	-0.07	7.4	14.
58.56	5.0E-06	-0.03	12.4	2.95	4	18.5	74.1	92.6	53.0	UnDef	UnDef	3.0	UnDef	9.1	18.
59.55	5.0E-05	-0.03	11.1	2.83	4	17.0	67.8	84.8	54.9	30	30.0	3.0	-0.06	6.6	13.
60.53	5.0E-06	-0.03	13.4	3.59	4	20.1	80.2	100.3	54.6	UnDef	UnDef	6.0	UnDef	9.8	19.
61.52	5.0E-06	-0.03	13.5	3.54	4	20.4	81.8	102.2	54.0	UnDef	UnDef	6.0	UnDef	10.0	20.
62.42	5.0E-05	-0.02	14.0	2.90	6	21.3	85.0	106.3	50.0	32	30.0	6.0	-0.09	8.3	16.
63.32	5.0E-05	-0.02	17.5	2.72	6	26.1	104.2	130.3	44.5	32	30.0	6.0	-0.11	10.2	20.
64.30	5.0E-05	-0.02	14.8	2.98	6	22.5	90.0	112.5	49.4	32	30.0	6.0	-0.10	8.8	17.
65.29	5.0E-06	-0.02	13.3	3.74	1	20.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
66.27	5.0E-06	-0.02	13.9	3.29	4	21.6	86.6	108.2	52.2	UnDef	UnDef	6.0	UnDef	10.6	21.
67.26	5.0E-05	-0.01	15.2	3.15	4	23.6	94.2	117.8	49.6	32	30.0	6.0	-0.11	9.2	18.
68.24	5.0E-05	-0.01	15.7	2.70	6	24.4	97.8	122.2	46.6	32	30.0	6.0	-0.09	9.6	19.
69.22	5.0E-05	0.00	21.6	2.95	6	32.8	131.2	164.0	41.7	34	35.3	6.0	-0.14	12.8	25.
70.21	1.0E-15	0.00	43.2	5.34	1	63.3	UnDef	UnDef	100.0	38	54.2	1.0	-0.43	UnDef	UnDe
71.19	1.0E-15	0.00	57.7	5.13	6	84.2	302.8	387.0	34.3	40	62.4	1.0	-0.46	79.0	161.
72.18	5.0E-05	0.00	17.3	3.27	6	27.5	110.0	137.5	47.5	32	30.3	6.0	-0.13	10.8	21.
73.16	5.0E-05	0.00	16.6	2.92	6	26.5	106.1	132.7	46.7	32	30.0	6.0	-0.11	10.4	20.
74.15	5.0E-05	0.00	19.5	2.79	6	30.9	123.7	154.7	42.8	34	33.6	6.0	-0.12	12.1	24.
75.13	5.0E-06	0.00	22.9	4.40	1	36.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
76.11	5.0E-06	0.00	20.7	4.83	1	33.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
77.10	5.0E-07	0.00	14.7	4.69	1	24.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
78.08	5.0E-05	0.01	14.0	2.48	6	23.5	94.2	117.7	47.7	32	30.0	6.0	-0.07	9.2	18.
79.07	5.0E-05	0.01	13.1	2.86	4	22.4	89.7	112.1	51.2	32	30.0	6.0	-0.07	8.8	17.
80.05	5.0E-05	0.01	13.4	3.05	4	23.0	92.0	115.0	51.8	32	30.0	6.0	-0.08	9.0	18.

Gregg In Situ, Inc.
Run No: 03-0203-1606-1660
CPT File: 027C05.COR

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
81.04	5.0E-06	0.01	15.7	3.55	4	26.5	105.9	132.3	50.9	UnDef	UnDef	6.0	UnDef	13.0	25.
82.02	5.0E-06	0.01	17.4	3.65	4	29.2	116.7	145.9	49.2	UnDef	UnDef	6.0	UnDef	14.3	28.
83.00	5.0E-05	0.01	18.3	3.17	6	30.7	123.0	153.7	46.0	32	33.5	6.0	-0.13	12.0	24.
83.99	1.0E-15	0.01	24.9	5.74	1	41.0	UnDef	UnDef	100.0	34	41.7	1.0	-0.36	UnDef	UnDe
84.97	5.0E-06	0.01	13.7	3.68	1	24.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
85.96	5.0E-06	0.02	19.3	4.54	1	32.9	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
86.94	1.0E-15	0.01	45.3	5.60	1	73.3	UnDef	UnDef	100.0	38	58.4	1.0	-0.47	UnDef	UnDe
87.93	1.0E-15	0.02	50.9	5.56	6	82.6	330.4	413.1	37.3	38	61.8	1.0	-0.49	80.9	161.
88.91	5.0E-06	0.05	10.5	3.94	1	19.6	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
89.89	5.0E-05	0.07	9.9	2.92	4	18.8	75.1	93.9	58.1	30	30.0	3.0	-0.03	7.4	14.
90.88	1.0E-15	0.03	27.7	4.92	1	47.1	UnDef	UnDef	100.0	36	45.7	1.0	-0.29	UnDef	UnDe
91.86	5.0E-06	0.05	7.5	4.13	1	15.2	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
92.85	5.0E-05	0.07	7.5	2.70	4	15.3	61.2	76.5	63.7	30	30.0	3.0	0.01	6.0	12.
93.83	5.0E-05	0.07	7.4	3.18	1	15.1	UnDef	UnDef	100.0	30	30.0	3.0	0.00	UnDef	UnDe
94.82	5.0E-06	0.06	7.4	3.42	1	15.2	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
95.80	5.0E-06	0.05	10.3	4.08	1	20.0	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
96.78	5.0E-06	0.06	9.2	3.63	1	18.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
97.77	5.0E-05	0.06	11.2	2.94	4	21.6	86.6	108.2	55.3	30	30.0	3.0	-0.05	8.5	16.
98.75	5.0E-06	0.06	13.1	3.64	1	24.9	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
n No: 03-0203-1606-1605
ob No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-04
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 08:29
CPT File: 027C04.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 2.44 (ft): 8.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
0.49	0.0	0.00	0.00	0.0	UnDef	124.1	0.03	0.03	0.00	2.00	UnDef	UnDef	UnDef	0.00
1.48	0.0	0.00	0.00	0.0	UnDef	124.1	0.09	0.09	0.00	2.00	UnDef	UnDef	UnDef	0.00
2.46	0.0	0.00	0.00	0.0	UnDef	124.1	0.15	0.15	0.00	2.00	UnDef	UnDef	UnDef	0.00
3.44	0.0	0.00	0.00	0.0	UnDef	124.1	0.21	0.21	0.00	2.00	UnDef	UnDef	UnDef	0.00
).43	0.0	0.00	0.00	0.0	UnDef	124.1	0.27	0.27	0.00	1.91	UnDef	UnDef	UnDef	0.00
5.41	12.4	0.53	4.30	34.6	3	111.4	0.33	0.33	0.00	1.73	11.9	20.6	0.96	0.19
6.40	13.9	0.60	4.34	16.0	3	111.4	0.39	0.39	0.00	1.61	13.3	21.4	1.08	0.20
7.30	8.2	0.14	1.74	1.6	5	114.6	0.44	0.44	0.00	1.51	3.9	5.9	0.62	0.10
8.20	5.2	0.10	1.82	15.8	4	114.6	0.49	0.48	0.01	1.44	3.3	4.8	0.38	0.08
9.19	5.3	0.16	2.95	13.9	3	111.4	0.55	0.51	0.04	1.40	5.0	7.1	0.38	0.08
10.17	25.6	0.15	0.59	6.5	7	117.8	0.60	0.53	0.07	1.37	8.2	11.2	UnDef	0.09
11.15	67.8	0.33	0.49	-10.2	8	120.9	0.66	0.56	0.10	1.33	16.2	21.6	UnDef	0.14
12.14	86.8	0.43	0.49	-16.9	8	120.9	0.72	0.59	0.13	1.30	20.8	27.0	UnDef	0.21
13.21	61.5	0.33	0.54	-5.9	8	120.9	0.78	0.62	0.16	1.27	14.7	18.7	UnDef	0.13
14.27	7.7	0.07	0.84	80.5	5	114.6	0.85	0.65	0.20	1.24	3.7	4.6	0.55	0.09
15.26	12.1	0.17	1.41	79.1	5	114.6	0.90	0.68	0.23	1.21	5.8	7.1	0.90	0.11
16.24	71.3	0.76	1.06	8.0	8	120.9	0.96	0.70	0.26	1.19	17.1	20.3	UnDef	0.17
17.22	53.5	0.62	1.17	22.9	7	117.8	1.02	0.73	0.29	1.17	17.1	20.0	UnDef	0.13
18.21	77.0	0.53	0.69	11.5	8	120.9	1.08	0.76	0.32	1.15	18.4	21.1	UnDef	0.16
19.19	33.4	0.24	0.73	22.6	7	117.8	1.14	0.79	0.35	1.13	10.7	12.0	UnDef	0.10
20.18	6.4	0.12	1.90	80.5	4	114.6	1.20	0.82	0.38	1.11	4.1	4.5	0.42	0.08
21.16	6.8	0.18	2.67	67.7	4	114.6	1.25	0.84	0.41	1.09	4.4	4.8	0.45	0.00
22.15	9.8	0.41	4.19	46.2	3	111.4	1.31	0.87	0.44	1.07	9.4	10.1	0.68	0.00
23.13	12.5	0.63	5.02	20.3	3	111.4	1.36	0.89	0.47	1.06	12.0	12.7	0.89	0.00
24.11	14.3	0.70	4.89	15.2	3	111.4	1.42	0.91	0.50	1.05	13.7	14.3	1.03	0.00
25.10	16.4	0.76	4.64	34.0	3	111.4	1.47	0.94	0.53	1.03	15.7	16.2	1.20	0.00
26.08	21.6	0.82	3.79	88.2	4	114.6	1.53	0.96	0.56	1.02	13.8	14.1	1.61	0.20
27.07	19.4	0.64	3.30	78.7	5	114.6	1.58	0.99	0.60	1.01	9.3	9.3	1.42	0.16
28.05	17.0	0.44	2.58	106.3	5	114.6	1.64	1.01	0.63	0.99	8.2	8.1	1.23	0.13
29.04	13.6	0.26	1.93	115.3	5	114.6	1.70	1.04	0.66	0.98	6.5	6.4	0.95	0.11

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
30.02	11.6	0.18	1.58	136.3	5	114.6	1.75	1.07	0.69	0.97	5.6	5.4	0.79	0.10
31.00	14.5	0.21	1.47	173.0	6	114.6	1.81	1.09	0.72	0.96	5.6	5.3	1.02	0.11
31.99	21.5	0.45	2.08	218.6	6	114.6	1.87	1.12	0.75	0.95	8.2	7.8	1.57	0.17
32.97	27.7	0.75	2.69	216.4	5	114.6	1.92	1.14	0.78	0.94	13.3	12.4	2.06	0.27
33.96	39.4	1.36	3.44	60.2	5	114.6	1.98	1.17	0.81	0.93	18.9	17.5	3.00	0.00
34.94	102.0	1.79	1.76	-4.9	7	117.8	2.04	1.19	0.84	0.91	32.6	29.8	UnDef	0.30
35.92	133.2	1.26	0.95	-12.7	9	124.1	2.10	1.22	0.87	0.90	25.5	23.1	UnDef	0.31
36.91	44.5	1.00	2.25	91.5	6	114.6	2.15	1.25	0.90	0.89	17.1	15.2	3.39	0.28
37.89	19.9	0.40	2.01	148.0	6	114.6	2.21	1.28	0.93	0.88	7.6	6.8	1.42	0.14
38.88	29.0	0.82	2.81	179.9	5	114.6	2.27	1.30	0.96	0.88	13.9	12.2	2.14	0.26
39.86	38.1	0.92	2.41	332.5	6	114.6	2.32	1.33	0.99	0.87	14.6	12.7	2.87	0.00
40.85	83.6	4.47	5.35	51.2	11	130.5	2.38	1.36	1.03	0.86	80.1	68.7	UnDef	0.00
41.83	55.3	3.07	5.56	110.0	11	130.5	2.45	1.39	1.06	0.85	53.0	44.9	UnDef	0.00
42.81	34.4	1.55	4.51	107.3	4	114.6	2.51	1.42	1.09	0.84	21.9	18.4	2.55	0.00
43.80	23.3	0.69	2.97	77.2	5	114.6	2.56	1.45	1.12	0.83	11.2	9.3	1.66	0.16
44.78	53.6	1.62	3.03	115.7	6	114.6	2.62	1.47	1.15	0.82	20.5	16.9	4.08	0.00
45.77	53.6	2.08	3.88	45.2	5	114.6	2.68	1.50	1.18	0.82	25.7	21.0	4.08	0.00
46.75	42.7	1.64	3.84	34.7	5	114.6	2.73	1.52	1.21	0.81	20.5	16.6	3.20	0.00
47.74	24.2	0.63	2.60	164.7	5	114.6	2.79	1.55	1.24	0.80	11.6	9.3	1.71	0.16
48.72	59.3	2.08	3.50	102.2	5	114.6	2.85	1.58	1.27	0.80	28.4	22.6	4.52	0.00
49.70	23.0	0.62	2.71	131.0	5	114.6	2.90	1.60	1.30	0.79	11.0	8.7	1.61	0.15
50.69	23.4	0.56	2.39	159.3	6	114.6	2.96	1.63	1.33	0.78	9.0	7.0	1.63	0.15
51.67	54.6	1.63	2.98	258.6	6	114.6	3.02	1.65	1.36	0.78	20.9	16.3	4.13	0.00
52.66	225.0	5.10	2.27	2.1	7	117.8	3.07	1.68	1.39	0.77	71.8	55.4	UnDef	0.00
53.64	38.0	1.43	3.76	156.9	5	114.6	3.13	1.70	1.43	0.77	18.2	13.9	2.79	0.35
54.63	125.0	1.96	1.57	42.5	8	120.9	3.19	1.73	1.46	0.76	29.9	22.7	UnDef	0.34
55.61	59.0	1.58	2.67	107.2	6	114.6	3.25	1.76	1.49	0.75	22.6	17.0	4.46	0.00
56.59	78.4	3.59	4.58	80.3	11	130.5	3.31	1.79	1.52	0.75	75.1	56.1	UnDef	0.00
57.58	38.2	1.16	3.04	197.5	5	114.6	3.37	1.82	1.55	0.74	18.3	13.6	2.79	0.33
58.56	40.6	1.12	2.76	223.4	6	114.6	3.42	1.84	1.58	0.74	15.6	11.5	2.98	0.37
59.55	34.7	0.92	2.65	304.3	6	114.6	3.48	1.87	1.61	0.73	13.3	9.7	2.50	0.26
60.53	34.1	0.69	2.02	394.5	6	114.6	3.54	1.90	1.64	0.73	13.0	9.5	2.44	0.24
61.52	39.3	0.77	1.97	410.1	6	114.6	3.59	1.92	1.67	0.72	15.0	10.9	2.85	0.33
62.42	39.4	0.85	2.15	308.2	6	114.6	3.64	1.94	1.70	0.72	15.1	10.8	2.86	0.33
63.32	40.4	1.00	2.47	257.9	6	114.6	3.70	1.97	1.73	0.71	15.5	11.0	2.94	0.34
64.30	34.6	0.89	2.59	237.3	6	114.6	3.75	1.99	1.76	0.71	13.2	9.4	2.46	0.24
65.29	32.8	0.76	2.31	286.1	6	114.6	3.81	2.02	1.79	0.70	12.5	8.8	2.32	0.21
66.27	29.8	0.63	2.12	347.5	6	114.6	3.86	2.05	1.82	0.70	11.4	8.0	2.08	0.18
67.26	32.6	0.63	1.92	307.8	6	114.6	3.92	2.07	1.85	0.69	12.5	8.7	2.29	0.21
68.24	37.0	1.02	2.77	230.0	6	114.6	3.98	2.10	1.88	0.69	14.2	9.8	2.64	0.26
69.22	55.1	2.09	3.79	187.5	5	114.6	4.03	2.12	1.91	0.69	26.4	18.1	4.09	0.00
70.21	77.5	4.20	5.42	112.4	11	130.5	4.09	2.15	1.94	0.68	74.2	50.6	UnDef	0.00
71.19	118.3	6.52	5.51	78.7	11	130.5	4.16	2.19	1.97	0.68	113.3	76.7	UnDef	0.00
72.18	104.5	5.80	5.55	257.9	11	130.5	4.22	2.22	2.00	0.67	100.0	67.2	UnDef	0.00
73.16	48.0	1.32	2.75	402.8	6	114.6	4.28	2.25	2.03	0.67	18.4	12.3	3.49	0.44
74.15	52.6	1.33	2.54	518.6	6	114.6	4.34	2.27	2.07	0.66	20.1	13.4	3.86	0.00
75.13	152.3	7.48	4.91	232.0	11	130.5	4.40	2.30	2.10	0.66	145.9	96.1	UnDef	0.00
76.11	80.7	4.11	5.09	271.3	11	130.5	4.46	2.34	2.13	0.65	77.3	50.6	UnDef	0.00
77.10	65.2	3.09	4.74	256.4	11	130.5	4.53	2.37	2.16	0.65	62.5	40.6	UnDef	0.00
78.08	63.8	2.70	4.23	255.7	5	114.6	4.59	2.40	2.19	0.65	30.5	19.7	4.74	0.00
79.07	96.2	5.55	5.77	173.6	11	130.5	4.65	2.43	2.22	0.64	92.1	59.1	UnDef	0.00
80.05	98.9	5.15	5.21	219.4	11	130.5	4.71	2.46	2.25	0.64	94.7	60.3	UnDef	0.00

Gregg In Situ, Inc.
Run No: 03-0203-1606-1605
CPT File: 027C04.COR

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
81.04	113.9	6.12	5.37	117.5	11	130.5	4.78	2.50	2.28	0.63	109.1	69.1	UnDef	0.00
82.02	108.4	3.70	3.41	391.0	6	114.6	4.84	2.53	2.31	0.63	41.5	26.1	8.29	0.00
83.00	132.3	6.58	4.97	105.6	11	130.5	4.90	2.56	2.34	0.63	126.7	79.2	UnDef	0.00
83.99	96.2	4.65	4.83	123.1	11	130.5	4.96	2.59	2.37	0.62	92.1	57.3	UnDef	0.00
84.97	33.6	0.80	2.39	195.3	6	114.6	5.02	2.62	2.40	0.62	12.9	8.0	2.29	0.18
85.96	36.2	0.60	1.66	353.0	6	114.6	5.08	2.64	2.43	0.62	13.9	8.5	2.49	0.20
86.94	29.9	0.48	1.60	321.2	6	114.6	5.13	2.67	2.46	0.61	11.4	7.0	1.98	0.15
87.93	29.1	0.60	2.08	369.9	6	114.6	5.19	2.70	2.50	0.61	11.1	6.8	1.91	0.14
88.91	75.5	4.18	5.54	160.3	11	130.5	5.25	2.73	2.53	0.61	72.3	43.8	UnDef	0.00
89.89	44.7	1.78	3.99	274.0	5	114.6	5.31	2.75	2.56	0.60	21.4	12.9	3.15	0.00
90.88	38.0	1.13	2.97	375.5	5	114.6	5.37	2.78	2.59	0.60	18.2	10.9	2.61	0.21
91.86	40.8	1.17	2.88	440.3	6	114.6	5.42	2.81	2.62	0.60	15.6	9.3	2.83	0.24
92.85	35.1	0.83	2.37	453.7	6	114.6	5.48	2.83	2.65	0.59	13.5	8.0	2.37	0.18
93.83	35.9	1.14	3.17	488.8	5	114.6	5.54	2.86	2.68	0.59	17.2	10.2	2.43	0.00
94.82	50.0	2.14	4.27	255.6	5	114.6	5.59	2.88	2.71	0.59	23.9	14.1	3.55	0.00
95.80	39.9	1.04	2.60	365.0	6	114.6	5.65	2.91	2.74	0.59	15.3	9.0	2.74	0.22
96.78	55.2	1.75	3.16	526.5	6	114.6	5.71	2.93	2.77	0.58	21.1	12.3	3.96	0.44
97.77	61.0	2.05	3.36	628.9	5	114.6	5.76	2.96	2.80	0.58	29.2	17.0	4.42	0.00
98.75	62.3	2.41	3.86	513.4	5	114.6	5.82	2.99	2.83	0.58	29.8	17.3	4.52	0.00

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Run No: 03-0203-1606-1605
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-04
Engineer: H. YOUNG
CPT Date: 03/28/01
CPT Time: 08:29
CPT File: 027C04.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 2.44 (ft): 8.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
0.49	1.0E-15	0.00	2.4	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
1.48	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
2.46	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
3.44	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
4.43	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
5.41	5.0E-08	0.09	36.2	4.42	6	21.0	84.1	105.1	38.9	UnDef	UnDef	6.0	UnDef	20.6	41.
6.40	5.0E-08	0.04	35.0	4.46	6	21.9	87.6	109.5	39.6	UnDef	UnDef	6.0	UnDef	21.4	42.
7.30	5.0E-06	0.01	17.7	1.84	6	12.1	48.4	60.5	39.0	UnDef	UnDef	6.0	UnDef	5.9	11.
8.20	5.0E-07	0.10	9.8	2.01	6	7.4	29.5	36.8	52.5	UnDef	UnDef	3.0	UnDef	4.8	9.
9.19	5.0E-08	0.08	9.3	3.29	4	7.2	28.9	36.2	61.6	UnDef	UnDef	3.0	UnDef	7.1	14.
10.17	5.0E-04	0.01	46.7	0.61	9	34.2	11.9	46.2	14.7	38	36.5	1.0	-0.07	2.2	13.
11.15	5.0E-03	-0.01	119.4	0.49	9	88.5	0.0	88.5	5.0	42	63.8	1.0	-0.14	0.0	21.
12.14	5.0E-03	-0.01	145.6	0.49	9	110.5	0.0	110.5	4.3	44	70.1	1.0	-0.16	0.0	27.
13.21	5.0E-03	-0.01	97.5	0.55	9	76.2	5.1	81.4	7.4	42	59.5	1.0	-0.13	0.8	19.
14.27	5.0E-06	0.34	10.6	0.95	6	9.4	37.5	46.9	41.7	UnDef	UnDef	3.0	UnDef	4.6	9.
15.26	5.0E-06	0.20	16.6	1.52	6	14.4	57.7	72.1	37.9	UnDef	UnDef	6.0	UnDef	7.1	14.
16.24	5.0E-03	0.00	99.7	1.08	9	83.1	16.4	99.5	11.2	42	62.0	1.0	-0.19	2.3	22.
17.22	5.0E-04	0.01	71.6	1.19	7	61.2	22.1	83.3	14.9	40	53.2	1.0	-0.17	4.0	23.
18.21	5.0E-03	0.00	99.8	0.70	9	86.4	8.7	95.1	8.4	42	63.1	1.0	-0.15	1.3	22.
19.19	5.0E-04	0.01	40.9	0.75	7	36.8	18.7	55.4	17.6	38	38.6	1.0	-0.08	3.2	15.
20.18	5.0E-07	0.41	6.4	2.34	4	6.9	27.8	34.7	65.7	UnDef	UnDef	3.0	UnDef	4.5	9.
21.16	5.0E-07	0.30	6.6	3.26	1	7.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
22.15	5.0E-08	0.12	9.8	4.83	1	10.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
23.13	5.0E-08	0.01	12.5	5.64	1	13.0	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
24.11	5.0E-08	0.00	14.1	5.43	1	14.6	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
25.10	5.0E-08	0.04	15.9	5.10	1	16.6	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
26.08	5.0E-07	0.11	20.9	4.08	4	21.6	86.3	107.9	47.4	UnDef	UnDef	6.0	UnDef	14.1	28.
27.07	5.0E-06	0.10	18.0	3.60	4	19.1	76.3	95.4	48.3	UnDef	UnDef	6.0	UnDef	9.3	18.
28.05	5.0E-06	0.17	15.2	2.85	6	16.6	66.2	82.8	48.1	UnDef	UnDef	6.0	UnDef	8.1	16.
29.04	5.0E-06	0.25	11.5	2.20	6	13.1	52.3	65.4	50.3	UnDef	UnDef	3.0	UnDef	6.4	12.

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
30.02	5.0E-06	0.36	9.3	1.86	6	11.0	44.2	55.2	52.7	UnDef	UnDef	3.0	UnDef	5.4	10.
31.00	5.0E-05	0.37	11.6	1.68	6	13.6	54.3	67.9	46.3	30	30.0	3.0	0.03	5.3	10.
31.99	5.0E-05	0.31	17.6	2.27	6	19.9	79.5	99.4	41.9	32	30.0	6.0	-0.05	7.8	15.
32.97	5.0E-06	0.23	22.6	2.89	6	25.4	101.5	126.9	40.6	UnDef	UnDef	6.0	UnDef	12.4	24.
33.96	5.0E-06	0.03	32.1	3.62	6	35.7	142.8	178.5	37.9	UnDef	UnDef	6.0	UnDef	17.5	34.
34.94	5.0E-04	-0.01	83.7	1.80	7	91.3	42.8	134.1	17.0	42	64.7	1.0	-0.23	7.4	37.
35.92	5.0E-02	-0.01	107.1	0.96	9	117.8	17.5	135.4	9.9	42	72.0	1.0	-0.19	2.0	25.
36.91	5.0E-05	0.05	33.9	2.36	6	38.9	90.2	129.2	31.2	36	40.2	6.0	-0.16	11.8	27.
37.89	5.0E-05	0.21	13.9	2.26	6	17.3	69.0	86.3	46.6	32	30.0	6.0	-0.03	6.8	13.
38.88	5.0E-06	0.17	20.5	3.05	6	24.9	99.4	124.3	43.2	UnDef	UnDef	6.0	UnDef	12.2	24.
39.86	5.0E-05	0.26	27.0	2.57	6	32.4	129.5	161.9	35.9	36	35.0	6.0	-0.11	12.7	25.
40.85	1.0E-15	0.01	59.8	5.51	6	70.2	278.8	349.0	34.9	40	57.1	1.0	-0.52	68.6	137.
41.83	1.0E-15	0.04	38.0	5.82	1	45.9	UnDef	UnDef	100.0	38	44.9	1.0	-0.46	UnDef	UnDe
42.81	5.0E-07	0.07	22.4	4.86	1	28.2	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
43.80	5.0E-06	0.06	14.4	3.34	4	19.0	75.9	94.9	51.8	UnDef	UnDef	6.0	UnDef	9.3	18.
44.78	5.0E-05	0.05	34.6	3.18	6	43.2	167.3	210.5	34.8	38	43.2	6.0	-0.21	16.7	33.
45.77	5.0E-06	0.00	34.0	4.08	6	42.9	171.5	214.4	38.7	UnDef	UnDef	6.0	UnDef	21.0	42.
46.75	5.0E-06	0.00	26.3	4.10	6	33.9	135.6	169.5	43.2	UnDef	UnDef	6.0	UnDef	16.6	33.
47.74	5.0E-06	0.18	13.8	2.94	4	19.0	76.1	95.1	50.6	UnDef	UnDef	6.0	UnDef	9.3	18.
48.72	5.0E-06	0.03	35.8	3.68	6	46.2	185.0	231.2	36.3	UnDef	UnDef	6.0	UnDef	22.6	45.
49.70	5.0E-06	0.14	12.6	3.10	4	17.8	71.3	89.1	53.5	UnDef	UnDef	6.0	UnDef	8.7	17.
50.69	5.0E-05	0.18	12.6	2.74	4	18.0	71.8	89.8	51.6	32	30.0	6.0	-0.04	7.0	14.
51.67	5.0E-05	0.13	31.2	3.16	6	41.6	166.3	207.8	36.3	36	42.1	6.0	-0.18	16.3	32.
52.66	5.0E-04	-0.01	132.2	2.30	7	169.9	63.3	233.3	15.2	44	82.5	1.0	-0.32	11.3	66.
53.64	5.0E-06	0.10	20.4	4.10	4	28.5	113.8	142.3	47.9	UnDef	UnDef	6.0	UnDef	13.9	27.
54.63	5.0E-03	0.00	70.3	1.61	7	92.9	47.8	140.7	17.7	40	65.2	1.0	-0.20	6.1	28.
55.61	5.0E-05	0.03	31.7	2.83	6	43.5	162.5	206.0	34.5	36	43.4	6.0	-0.18	16.6	33.
56.59	1.0E-15	0.01	42.0	4.78	6	57.3	229.4	286.7	37.8	38	51.3	1.0	-0.36	56.1	112.
57.58	5.0E-06	0.13	19.1	3.33	6	27.7	110.9	138.6	45.8	UnDef	UnDef	6.0	UnDef	13.6	27.
58.56	5.0E-05	0.14	20.2	3.01	6	29.3	117.1	146.4	43.3	34	32.1	6.0	-0.11	11.5	22.
59.55	5.0E-05	0.25	16.7	2.95	6	24.9	99.4	124.3	46.6	32	30.0	6.0	-0.07	9.7	19.
60.53	5.0E-05	0.35	16.1	2.26	6	24.2	96.8	121.0	43.5	32	30.0	6.0	-0.03	9.5	19.
61.52	5.0E-05	0.31	18.6	2.16	6	27.7	110.9	138.6	40.2	32	30.5	6.0	-0.05	10.9	21.
62.42	5.0E-05	0.22	18.4	2.37	6	27.6	110.5	138.1	41.6	32	30.4	6.0	-0.07	10.8	21.
63.32	5.0E-05	0.17	18.6	2.72	6	28.2	112.7	140.9	43.3	32	31.0	6.0	-0.09	11.0	22.
64.30	5.0E-05	0.18	15.4	2.90	6	23.9	95.8	119.7	48.0	32	30.0	6.0	-0.07	9.4	18.
65.29	5.0E-05	0.25	14.3	2.61	6	22.6	90.2	112.8	48.0	32	30.0	6.0	-0.04	8.8	17.
66.27	5.0E-05	0.35	12.7	2.43	6	20.4	81.6	102.0	49.5	32	30.0	6.0	-0.01	8.0	16.
67.26	5.0E-05	0.27	13.8	2.19	6	22.2	88.7	110.8	46.1	32	30.0	6.0	-0.02	8.7	17.
68.24	5.0E-05	0.16	15.7	3.11	6	25.0	99.9	124.9	48.7	32	30.0	6.0	-0.08	9.8	19.
69.22	5.0E-06	0.08	24.1	4.09	6	37.0	148.1	185.2	44.7	UnDef	UnDef	6.0	UnDef	18.1	36.
70.21	1.0E-15	0.02	34.1	5.72	1	51.7	UnDef	UnDef	100.0	38	48.4	1.0	-0.43	UnDef	UnDe
71.19	1.0E-15	0.00	52.2	5.71	1	78.3	UnDef	UnDef	100.0	40	60.3	1.0	-0.53	UnDef	UnDe
72.18	1.0E-15	0.06	45.2	5.79	1	68.6	UnDef	UnDef	100.0	38	56.5	1.0	-0.49	UnDef	UnDe
73.16	5.0E-05	0.24	19.4	3.02	6	31.3	125.2	156.5	44.0	34	34.0	6.0	-0.09	12.3	24.
74.15	5.0E-05	0.29	21.2	2.77	6	34.1	136.5	170.7	41.1	34	36.5	6.0	-0.09	13.4	26.
75.13	1.0E-15	0.03	64.2	5.05	6	98.2	275.7	373.9	32.6	40	66.8	1.0	-0.46	82.3	178.
76.11	1.0E-15	0.08	32.6	5.39	1	51.7	UnDef	UnDef	100.0	36	48.4	1.0	-0.36	UnDef	UnDe
77.10	1.0E-15	0.10	25.6	5.10	1	41.5	UnDef	UnDef	100.0	36	42.0	1.0	-0.28	UnDef	UnDe
78.08	5.0E-06	0.10	24.7	4.55	1	40.3	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
79.07	1.0E-15	0.03	37.7	6.06	1	60.4	UnDef	UnDef	100.0	38	52.8	1.0	-0.50	UnDef	UnDe
80.05	1.0E-15	0.05	38.2	5.47	1	61.6	UnDef	UnDef	100.0	38	53.4	1.0	-0.41	UnDef	UnDe

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
81.04	1.0E-15	0.01	43.7	5.61	1	70.6	UnDef	UnDef	100.0	38	57.3	1.0	-0.47	UnDef	UnDe
82.02	5.0E-05	0.10	41.0	3.57	6	66.8	221.9	288.7	33.8	38	55.7	6.0	-0.24	24.2	50.
83.00	1.0E-15	0.01	49.8	5.17	6	81.0	323.9	404.8	36.5	38	61.2	1.0	-0.43	79.2	158.
83.99	1.0E-15	0.02	35.2	5.09	1	58.5	UnDef	UnDef	100.0	38	51.9	1.0	-0.36	UnDef	UnDe
84.97	5.0E-05	0.13	10.9	2.81	4	20.3	81.3	101.6	55.1	30	30.0	3.0	-0.03	8.0	15.
85.96	5.0E-05	0.28	11.8	1.93	6	21.8	87.1	108.9	47.9	30	30.0	3.0	0.00	8.5	17.
86.94	5.0E-05	0.31	9.3	1.94	6	17.9	71.6	89.5	53.4	30	30.0	3.0	0.03	7.0	14.
87.93	5.0E-05	0.38	8.9	2.53	4	17.3	69.4	86.7	58.4	30	30.0	3.0	0.04	6.8	13.
88.91	1.0E-15	0.04	25.8	5.95	1	44.7	UnDef	UnDef	100.0	36	44.2	1.0	-0.39	UnDef	UnDe
89.89	5.0E-06	0.15	14.3	4.53	1	26.4	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
90.88	5.0E-06	0.28	11.7	3.46	4	22.3	89.2	111.5	56.9	UnDef	UnDef	3.0	UnDef	10.9	21.
91.86	5.0E-05	0.31	12.6	3.32	4	23.8	95.2	119.0	54.6	32	30.0	6.0	-0.03	9.3	18.
92.85	5.0E-05	0.39	10.5	2.81	4	20.4	81.7	102.2	56.1	30	30.0	3.0	0.01	8.0	16.
93.83	5.0E-06	0.41	10.6	3.75	1	20.8	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
94.82	5.0E-06	0.12	15.4	4.81	1	28.8	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
95.80	5.0E-05	0.25	11.8	3.03	4	22.9	91.5	114.4	54.6	30	30.0	3.0	-0.03	9.0	17.
96.78	5.0E-05	0.28	16.9	3.53	4	31.5	126.2	157.7	49.3	32	34.2	6.0	-0.09	12.3	24.
97.77	5.0E-06	0.30	18.7	3.71	4	34.7	138.8	173.6	48.0	UnDef	UnDef	6.0	UnDef	17.0	34.
98.75	5.0E-06	0.23	18.9	4.26	1	35.3	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe

Interpretation Output - Release 1.00.19e

Job No: 03-0203-1606-1545
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-02
Engineer: H. YOUNG
CPT Date: 03/29/01
CPT Time: 09:33
CPT File: 027C02.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 4.57 (ft): 15.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
0.49	0.0	0.00	0.00	0.0	UnDef	124.1	0.03	0.03	0.00	2.00	UnDef	UnDef	UnDef	0.00
1.48	0.0	0.00	0.00	0.0	UnDef	124.1	0.09	0.09	0.00	2.00	UnDef	UnDef	UnDef	0.00
2.46	0.0	0.00	0.00	0.0	UnDef	124.1	0.15	0.15	0.00	2.00	UnDef	UnDef	UnDef	0.00
3.44	0.0	0.00	0.00	0.0	UnDef	124.1	0.21	0.21	0.00	2.00	UnDef	UnDef	UnDef	0.00
4.43	0.0	0.00	0.00	0.0	UnDef	124.1	0.27	0.27	0.00	1.91	UnDef	UnDef	UnDef	0.00
5.41	29.8	1.31	4.40	7.8	4	114.6	0.33	0.33	0.00	1.73	19.1	33.0	2.36	0.00
6.40	18.1	0.86	4.75	-5.6	3	111.4	0.39	0.39	0.00	1.60	17.4	27.8	1.42	0.35
7.30	16.5	0.76	4.58	0.6	3	111.4	0.44	0.44	0.00	1.51	15.8	23.9	1.29	0.25
8.20	17.7	0.87	4.91	-0.1	3	111.4	0.49	0.49	0.00	1.43	16.9	24.2	1.37	0.00
9.19	18.2	0.82	4.49	-3.8	3	111.4	0.54	0.54	0.00	1.36	17.5	23.7	1.42	0.24
10.17	8.9	0.25	2.76	-1.2	4	114.6	0.60	0.60	0.00	1.29	5.7	7.3	0.66	0.10
11.15	8.5	0.17	1.98	5.2	5	114.6	0.66	0.66	0.00	1.23	4.1	5.0	0.63	0.09
12.14	8.8	0.15	1.69	7.2	5	114.6	0.71	0.71	0.00	1.18	4.2	5.0	0.65	0.09
13.21	8.4	0.15	1.74	9.1	5	114.6	0.77	0.77	0.00	1.14	4.0	4.6	0.61	0.09
14.27	8.5	0.29	3.41	6.0	3	111.4	0.83	0.83	0.00	1.09	8.2	8.9	0.62	0.00
15.26	43.0	0.25	0.59	4.4	7	117.8	0.89	0.88	0.01	1.06	13.7	14.6	UnDef	0.10
16.24	65.3	0.44	0.67	5.9	8	120.9	0.95	0.91	0.04	1.05	15.6	16.4	UnDef	0.13
17.22	9.0	0.21	2.33	36.8	5	114.6	1.01	0.94	0.07	1.03	4.3	4.5	0.64	0.09
18.21	27.7	0.31	1.11	42.7	6	114.6	1.06	0.96	0.10	1.02	10.6	10.8	2.13	0.10
19.19	26.4	0.45	1.72	27.4	6	114.6	1.12	0.99	0.13	1.01	10.1	10.2	2.02	0.16
20.18	33.4	0.22	0.65	56.4	7	117.8	1.18	1.02	0.16	0.99	10.7	10.6	UnDef	0.09
21.16	48.4	0.64	1.32	3.9	7	117.8	1.24	1.04	0.19	0.98	15.4	15.1	UnDef	0.13
22.15	14.1	0.39	2.78	28.4	5	114.6	1.29	1.07	0.22	0.97	6.8	6.5	1.03	0.11
23.13	9.6	0.15	1.54	60.6	5	114.6	1.35	1.10	0.25	0.96	4.6	4.4	0.66	0.09
24.11	7.1	0.16	2.27	52.1	4	114.6	1.41	1.12	0.28	0.94	4.5	4.3	0.46	0.08
25.10	7.7	0.26	3.39	53.8	3	111.4	1.46	1.15	0.32	0.93	7.4	6.9	0.50	0.00
26.08	9.1	0.36	3.89	60.0	3	111.4	1.52	1.17	0.35	0.92	8.8	8.1	0.61	0.00
27.07	11.3	0.51	4.46	58.0	3	111.4	1.57	1.19	0.38	0.92	10.9	9.9	0.78	0.00
28.05	14.0	0.61	4.34	62.0	3	111.4	1.63	1.22	0.41	0.91	13.4	12.2	0.99	0.00
29.04	22.2	0.82	3.71	82.1	4	114.6	1.68	1.24	0.44	0.90	14.2	12.7	1.64	0.00

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
30.02	12.7	0.58	4.56	32.6	3	111.4	1.74	1.27	0.47	0.89	12.1	10.8	0.87	0.00
31.00	7.9	0.13	1.65	77.2	5	114.6	1.79	1.29	0.50	0.88	3.8	3.3	0.49	0.08
31.99	19.3	0.40	2.07	66.4	6	114.6	1.85	1.32	0.53	0.87	7.4	6.4	1.39	0.13
32.97	85.2	0.66	0.78	2.6	8	120.9	1.91	1.35	0.56	0.86	20.4	17.6	UnDef	0.15
33.96	63.9	1.39	2.17	-11.0	7	117.8	1.97	1.37	0.59	0.85	20.4	17.4	UnDef	0.26
34.94	102.1	2.15	2.10	-13.6	7	117.8	2.02	1.40	0.62	0.85	32.6	27.5	UnDef	0.35
35.92	167.5	1.75	1.04	-13.7	9	124.1	2.08	1.43	0.65	0.84	32.1	26.8	UnDef	0.44
36.91	182.3	1.28	0.70	-13.1	9	124.1	2.14	1.46	0.68	0.83	34.9	28.9	UnDef	0.43
37.89	73.5	1.23	1.67	8.9	7	117.8	2.20	1.49	0.71	0.82	23.5	19.2	UnDef	0.21
38.88	18.3	0.56	3.09	128.4	5	114.6	2.26	1.51	0.75	0.81	8.8	7.1	1.28	0.00
39.86	15.6	0.52	3.36	119.9	4	114.6	2.32	1.54	0.78	0.81	9.9	8.0	1.06	0.00
40.85	16.9	0.53	3.14	143.1	5	114.6	2.37	1.57	0.81	0.80	8.1	6.5	1.16	0.00
41.83	22.4	0.54	2.43	204.0	6	114.6	2.43	1.59	0.84	0.79	8.6	6.8	1.60	0.14
42.81	17.0	0.26	1.55	202.4	6	114.6	2.49	1.62	0.87	0.79	6.5	5.1	1.16	0.11
43.80	30.9	0.94	3.02	216.5	5	114.6	2.54	1.64	0.90	0.78	14.8	11.6	2.27	0.23
44.78	30.5	1.57	5.17	88.8	3	111.4	2.60	1.67	0.93	0.77	29.2	22.6	2.23	0.00
45.77	24.2	1.01	4.15	128.3	4	114.6	2.65	1.69	0.96	0.77	15.5	11.9	1.73	0.00
46.75	24.0	0.63	2.62	162.9	5	114.6	2.71	1.72	0.99	0.76	11.5	8.8	1.70	0.15
47.74	23.2	0.57	2.47	201.4	6	114.6	2.77	1.74	1.02	0.76	8.9	6.7	1.64	0.14
48.72	68.5	2.81	4.11	130.8	5	114.6	2.82	1.77	1.05	0.75	32.8	24.7	5.26	0.00
49.70	59.5	3.02	5.08	74.9	11	130.5	2.88	1.80	1.08	0.75	57.0	42.5	UnDef	0.00
50.69	25.8	0.63	2.45	205.8	6	114.6	2.94	1.83	1.11	0.74	9.9	7.3	1.83	0.16
51.67	77.4	1.96	2.53	120.3	6	114.6	3.00	1.85	1.15	0.73	29.6	21.8	5.95	0.00
52.66	108.2	3.84	3.55	32.8	6	114.6	3.06	1.88	1.18	0.73	41.4	30.2	8.41	0.00
53.64	37.2	0.98	2.62	239.5	6	114.6	3.11	1.91	1.21	0.72	14.3	10.3	2.73	0.29
54.63	128.1	4.83	3.77	135.9	6	114.6	3.17	1.93	1.24	0.72	49.1	35.3	10.00	0.00
55.61	223.8	5.32	2.38	20.0	7	117.8	3.23	1.96	1.27	0.71	71.4	51.1	UnDef	0.00
56.59	184.8	3.29	1.78	-0.2	8	120.9	3.28	1.99	1.30	0.71	44.2	31.4	UnDef	0.00
57.58	32.8	0.74	2.24	101.6	6	114.6	3.34	2.01	1.33	0.70	12.6	8.9	2.36	0.21
58.56	34.5	0.67	1.95	180.3	6	114.6	3.40	2.04	1.36	0.70	13.2	9.3	2.49	0.23
59.55	28.8	0.68	2.37	178.9	6	114.6	3.46	2.06	1.39	0.70	11.0	7.7	2.03	0.17
60.53	26.3	0.57	2.19	183.2	6	114.6	3.51	2.09	1.42	0.69	10.1	7.0	1.82	0.15
61.52	26.4	0.57	2.14	334.1	6	114.6	3.57	2.12	1.45	0.69	10.1	7.0	1.83	0.15
62.42	34.5	0.68	1.98	386.7	6	114.6	3.62	2.14	1.48	0.68	13.2	9.0	2.47	0.22
63.32	35.6	1.09	3.07	251.8	5	114.6	3.67	2.16	1.51	0.68	17.1	11.6	2.56	0.23
64.30	29.1	0.98	3.37	202.2	5	114.6	3.73	2.19	1.54	0.68	14.0	9.4	2.03	0.00
65.29	30.3	0.87	2.86	230.7	5	114.6	3.78	2.21	1.57	0.67	14.5	9.8	2.12	0.17
66.27	31.1	0.83	2.68	326.9	6	114.6	3.84	2.24	1.60	0.67	11.9	8.0	2.18	0.18
67.26	87.1	4.28	4.91	179.7	11	130.5	3.90	2.27	1.63	0.66	83.4	55.4	UnDef	0.00
68.24	52.4	2.21	4.21	147.0	5	114.6	3.96	2.30	1.66	0.66	25.1	16.5	3.87	0.00
69.22	31.6	0.78	2.47	253.3	6	114.6	4.02	2.32	1.69	0.66	12.1	7.9	2.20	0.18
70.21	39.3	1.32	3.37	279.9	5	114.6	4.07	2.35	1.72	0.65	18.8	12.3	2.82	0.26
71.19	71.3	4.12	5.78	68.0	11	130.5	4.13	2.38	1.75	0.65	68.3	44.2	UnDef	0.00
72.18	60.4	3.01	4.98	210.1	11	130.5	4.20	2.41	1.79	0.64	57.8	37.2	UnDef	0.00
73.16	38.1	1.23	3.24	257.1	5	114.6	4.26	2.44	1.82	0.64	18.2	11.7	2.71	0.24
74.15	44.6	1.32	2.96	233.3	6	114.6	4.32	2.47	1.85	0.64	17.1	10.9	3.22	0.33
75.13	48.8	1.33	2.73	401.4	6	114.6	4.37	2.49	1.88	0.63	18.7	11.8	3.55	0.40
76.11	54.9	2.25	4.09	296.4	5	114.6	4.43	2.52	1.91	0.63	26.3	16.6	4.04	0.00
77.10	59.8	2.82	4.71	238.3	4	114.6	4.48	2.55	1.94	0.63	38.2	23.9	4.43	0.00
78.08	69.0	3.83	5.56	173.2	11	130.5	4.54	2.58	1.97	0.62	66.1	41.2	UnDef	0.00
79.07	82.1	4.52	5.50	161.3	11	130.5	4.61	2.61	2.00	0.62	78.6	48.7	UnDef	0.00
80.05	128.3	7.97	6.21	86.6	11	130.5	4.67	2.64	2.03	0.62	122.9	75.6	UnDef	0.00

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
81.04	160.3	8.67	5.41	96.4	11	130.5	4.74	2.68	2.06	0.61	153.5	93.8	UnDef	0.00
82.02	106.7	6.70	6.28	70.2	11	130.5	4.80	2.71	2.09	0.61	102.2	62.1	UnDef	0.00
83.00	32.9	1.19	3.63	236.3	5	114.6	4.86	2.74	2.12	0.60	15.7	9.5	2.24	0.00
83.99	55.3	2.15	3.89	245.0	5	114.6	4.92	2.76	2.15	0.60	26.5	15.9	4.03	0.00
84.97	126.5	7.91	6.25	115.2	11	130.5	4.98	2.79	2.18	0.60	121.2	72.5	UnDef	0.00
85.96	153.9	8.46	5.50	124.4	11	130.5	5.04	2.83	2.22	0.59	147.4	87.6	UnDef	0.00
86.94	224.3	9.11	4.06	52.4	12	120.9	5.10	2.86	2.25	0.59	107.4	63.5	UnDef	0.00
87.93	101.6	5.09	5.01	38.5	11	130.5	5.17	2.89	2.28	0.59	97.3	57.2	UnDef	0.00
88.91	35.3	0.79	2.24	154.0	6	114.6	5.23	2.92	2.31	0.59	13.5	7.9	2.40	0.18
89.89	73.4	3.45	4.70	197.0	11	130.5	5.29	2.95	2.34	0.58	70.3	40.9	UnDef	0.00
90.88	85.3	5.44	6.38	114.3	11	130.5	5.35	2.98	2.37	0.58	81.7	47.3	UnDef	0.00
91.86	91.6	5.93	6.47	136.8	11	130.5	5.42	3.02	2.40	0.58	87.7	50.5	UnDef	0.00
92.85	114.3	7.01	6.14	89.5	11	130.5	5.48	3.05	2.43	0.57	109.4	62.7	UnDef	0.00
93.83	82.1	3.78	4.60	155.8	11	130.5	5.54	3.08	2.46	0.57	78.7	44.8	UnDef	0.00
94.82	74.3	3.69	4.97	174.0	11	130.5	5.61	3.12	2.49	0.57	71.2	40.3	UnDef	0.00
95.80	91.4	4.56	4.99	160.1	11	130.5	5.67	3.15	2.52	0.56	87.5	49.3	UnDef	0.00
96.78	108.7	6.24	5.74	138.4	11	130.5	5.74	3.18	2.55	0.56	104.1	58.3	UnDef	0.00
97.77	102.1	5.26	5.15	184.6	11	130.5	5.80	3.22	2.58	0.56	97.8	54.5	UnDef	0.00
98.75	152.2	6.60	4.34	89.0	11	130.5	5.87	3.25	2.61	0.55	145.8	80.9	UnDef	0.00

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Run No: 03-0203-1606-1545
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-02
Engineer: H. YOUNG
CPT Date: 03/29/01
CPT Time: 09:33
CPT File: 027C02.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 4.57 (ft): 15.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
0.49	1.0E-15	0.00	2.4	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
1.48	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
2.46	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
3.44	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
4.43	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
5.41	5.0E-07	0.01	88.5	4.45	11	50.6	UnDef	UnDef	0.0	UnDef	UnDef	10.0	UnDef	UnDef	UnDe
6.40	5.0E-08	-0.01	45.6	4.85	6	28.4	113.7	142.2	36.8	UnDef	UnDef	6.0	UnDef	27.8	55.
7.30	5.0E-08	0.00	36.6	4.70	6	24.4	97.5	121.9	39.7	UnDef	UnDef	6.0	UnDef	23.9	47.
8.20	5.0E-08	0.00	35.1	5.05	1	24.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
9.19	5.0E-08	-0.01	32.5	4.63	6	24.2	96.8	121.0	41.4	UnDef	UnDef	6.0	UnDef	23.7	47.
10.17	5.0E-07	0.00	13.8	2.96	4	11.3	45.0	56.3	50.6	UnDef	UnDef	6.0	UnDef	7.3	14.
11.15	5.0E-06	0.02	12.0	2.14	6	10.3	41.2	51.5	48.9	UnDef	UnDef	3.0	UnDef	5.0	10.
12.14	5.0E-06	0.03	11.4	1.83	6	10.2	40.9	51.1	48.0	UnDef	UnDef	3.0	UnDef	5.0	10.
13.21	5.0E-06	0.04	9.8	1.92	6	9.3	37.3	46.7	51.8	UnDef	UnDef	3.0	UnDef	4.6	9.
14.27	5.0E-08	0.02	9.2	3.78	1	9.1	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
15.26	5.0E-04	0.00	47.8	0.60	9	44.8	14.9	59.7	14.3	38	44.3	1.0	-0.08	2.7	17.
16.24	5.0E-03	0.00	70.7	0.68	9	67.0	13.2	80.2	11.2	40	55.8	1.0	-0.12	1.9	18.
17.22	5.0E-06	0.13	8.6	2.62	4	9.1	36.5	45.6	59.9	UnDef	UnDef	3.0	UnDef	4.5	8.
18.21	5.0E-05	0.05	27.6	1.15	7	27.6	36.8	64.4	26.4	36	30.4	6.0	-0.07	6.0	16.
19.19	5.0E-05	0.03	25.5	1.79	7	26.0	69.5	95.5	32.3	34	30.0	6.0	-0.10	8.5	18.
20.18	5.0E-04	0.05	31.7	0.68	7	32.5	21.9	54.3	20.1	36	35.0	1.0	-0.04	3.6	14.
21.16	5.0E-04	0.00	45.2	1.35	7	46.3	35.2	81.6	21.2	38	45.2	1.0	-0.14	5.6	20.
22.15	5.0E-06	0.05	12.0	3.06	4	13.4	53.5	66.9	54.3	UnDef	UnDef	3.0	UnDef	6.5	13.
23.13	5.0E-06	0.20	7.6	1.79	4	9.0	36.1	45.1	57.2	UnDef	UnDef	3.0	UnDef	4.4	8.
24.11	5.0E-07	0.23	5.1	2.83	4	6.6	26.3	32.9	75.3	UnDef	UnDef	1.5	UnDef	4.3	8.
25.10	5.0E-08	0.22	5.5	4.18	1	7.1	UnDef	UnDef	100.0	UnDef	UnDef	1.5	UnDef	UnDef	UnDe
26.08	5.0E-08	0.20	6.5	4.67	1	8.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
27.07	5.0E-08	0.15	8.2	5.18	1	10.2	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
28.05	5.0E-08	0.12	10.2	4.90	1	12.4	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
29.04	5.0E-07	0.10	16.5	4.01	1	19.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
30.02	5.0E-08	0.05	8.6	5.28	1	11.0	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
31.00	5.0E-06	0.31	4.7	2.13	4	6.8	27.2	34.0	72.7	UnDef	UnDef	1.5	UnDef	3.3	6.
31.99	5.0E-05	0.09	13.2	2.29	6	16.4	65.6	82.0	47.8	32	30.0	6.0	-0.05	6.4	12.
32.97	5.0E-03	-0.01	61.9	0.80	9	71.9	21.0	92.9	13.5	40	57.8	1.0	-0.12	2.9	20.
33.96	5.0E-04	-0.02	45.1	2.24	7	53.4	71.4	124.8	26.4	38	49.3	1.0	-0.19	9.7	27.
34.94	5.0E-04	-0.01	71.4	2.14	7	84.4	58.7	143.1	20.4	40	62.4	1.0	-0.24	9.5	37.
35.92	5.0E-02	-0.01	115.8	1.06	9	137.1	20.5	157.6	9.9	42	76.3	1.0	-0.21	2.4	29.
36.91	5.0E-02	-0.01	123.4	0.71	9	147.7	8.4	156.0	7.0	42	78.4	1.0	-0.18	1.0	29.
37.89	5.0E-04	-0.01	47.9	1.72	7	59.0	53.2	112.2	22.8	38	52.1	1.0	-0.17	8.1	27.
38.88	5.0E-06	0.20	10.6	3.52	1	14.5	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
39.86	5.0E-07	0.22	8.6	3.94	1	12.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
40.85	5.0E-06	0.25	9.3	3.65	1	13.2	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
41.83	5.0E-05	0.28	12.6	2.72	4	17.4	69.6	87.0	51.5	30	30.0	6.0	-0.03	6.8	13.
42.81	5.0E-05	0.38	8.9	1.81	6	13.1	52.2	65.3	53.3	30	30.0	3.0	0.05	5.1	10.
43.80	5.0E-06	0.21	17.3	3.30	6	23.6	94.5	118.1	47.7	UnDef	UnDef	6.0	UnDef	11.6	23.
44.78	5.0E-08	0.07	16.7	5.65	1	23.1	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
45.77	5.0E-07	0.14	12.7	4.66	1	18.2	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
46.75	5.0E-06	0.19	12.4	2.95	4	17.9	71.7	89.6	53.0	UnDef	UnDef	3.0	UnDef	8.8	17.
47.74	5.0E-05	0.26	11.7	2.81	4	17.2	68.9	86.1	53.5	30	30.0	3.0	-0.02	6.7	13.
48.72	5.0E-06	0.05	37.1	4.28	6	50.4	201.6	252.0	38.0	UnDef	UnDef	6.0	UnDef	24.7	49.
49.70	1.0E-15	0.02	31.5	5.34	1	43.4	UnDef	UnDef	100.0	36	43.3	1.0	-0.36	UnDef	UnDe
50.69	5.0E-05	0.23	12.5	2.76	4	18.7	74.7	93.4	51.8	30	30.0	6.0	-0.03	7.3	14.
51.67	5.0E-05	0.04	40.1	2.63	6	55.6	112.0	167.6	30.0	38	50.4	6.0	-0.20	15.6	37.
52.66	5.0E-05	0.00	55.9	3.65	6	77.2	150.5	227.7	29.8	40	59.9	10.0	-0.31	21.3	51.
53.64	5.0E-05	0.18	17.9	2.86	6	26.4	105.6	132.0	44.8	32	30.0	6.0	-0.09	10.3	20.
54.63	5.0E-05	0.02	64.7	3.87	6	90.2	154.5	244.7	28.6	40	64.3	10.0	-0.34	23.0	58.
55.61	5.0E-04	0.00	112.6	2.41	7	156.5	74.1	230.6	17.0	42	80.1	1.0	-0.31	12.8	63.
56.59	5.0E-03	-0.01	91.4	1.81	7	128.3	54.7	182.9	16.2	42	74.4	1.0	-0.24	7.2	38.
57.58	5.0E-05	0.06	14.6	2.50	6	22.6	90.5	113.1	46.9	32	30.0	6.0	-0.07	8.9	17.
58.56	5.0E-05	0.14	15.3	2.16	6	23.7	94.6	118.3	44.0	32	30.0	6.0	-0.05	9.3	18.
59.55	5.0E-05	0.17	12.3	2.69	4	19.6	78.5	98.1	51.8	30	30.0	3.0	-0.04	7.7	15.
60.53	5.0E-05	0.19	10.9	2.53	4	17.8	71.1	88.8	53.6	30	30.0	3.0	-0.02	7.0	13.
61.52	5.0E-05	0.39	10.8	2.48	4	17.8	71.1	88.9	53.4	30	30.0	3.0	0.02	7.0	13.
62.42	5.0E-05	0.34	14.4	2.21	6	23.1	92.4	115.5	45.4	32	30.0	6.0	-0.02	9.0	18.
63.32	5.0E-06	0.20	14.8	3.42	4	23.7	94.8	118.5	51.6	UnDef	UnDef	6.0	UnDef	11.6	23.
64.30	5.0E-06	0.19	11.6	3.87	1	19.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
65.29	5.0E-06	0.21	12.0	3.26	4	19.9	79.7	99.7	55.4	UnDef	UnDef	3.0	UnDef	9.8	19.
66.27	5.0E-05	0.32	12.2	3.06	4	20.3	81.4	101.7	54.0	30	30.0	3.0	-0.02	8.0	15.
67.26	1.0E-15	0.05	36.7	5.14	1	56.6	UnDef	UnDef	100.0	38	51.0	1.0	-0.36	UnDef	UnDe
68.24	5.0E-06	0.06	21.1	4.55	1	33.8	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
69.22	5.0E-05	0.23	11.8	2.83	4	20.2	81.0	101.2	53.4	30	30.0	3.0	-0.03	7.9	15.
70.21	5.0E-06	0.20	15.0	3.75	4	25.1	100.4	125.5	52.8	UnDef	UnDef	6.0	UnDef	12.3	24.
71.19	1.0E-15	0.01	28.2	6.13	1	45.2	UnDef	UnDef	100.0	36	44.5	1.0	-0.45	UnDef	UnDe
72.18	1.0E-15	0.09	23.3	5.36	1	38.0	UnDef	UnDef	100.0	34	39.6	1.0	-0.28	UnDef	UnDe
73.16	5.0E-06	0.18	13.8	3.65	4	23.8	95.4	119.2	54.0	UnDef	UnDef	6.0	UnDef	11.7	23.
74.15	5.0E-05	0.13	16.3	3.28	6	27.8	111.1	138.9	48.8	32	30.6	6.0	-0.10	10.9	21.
75.13	5.0E-05	0.24	17.8	3.00	6	30.2	121.0	151.2	45.6	32	33.0	6.0	-0.08	11.8	23.
76.11	5.0E-06	0.15	20.0	4.45	1	33.9	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
77.10	5.0E-07	0.10	21.7	5.09	1	36.7	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
78.08	1.0E-15	0.05	25.0	5.95	1	42.1	UnDef	UnDef	100.0	34	42.5	1.0	-0.37	UnDef	UnDe
79.07	1.0E-15	0.04	29.7	5.83	1	49.7	UnDef	UnDef	100.0	36	47.3	1.0	-0.40	UnDef	UnDe
80.05	1.0E-15	0.01	46.8	6.45	1	77.2	UnDef	UnDef	100.0	38	59.9	1.0	-0.66	UnDef	UnDe

epth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
81.04	1.0E-15	0.01	58.1	5.58	6	95.9	383.5	479.4	35.5	40	66.1	1.0	-0.53	93.8	187.
82.02	1.0E-15	0.00	37.6	6.58	1	63.5	UnDef	UnDef	100.0	38	54.2	1.0	-0.63	UnDef	UnDe
83.00	5.0E-06	0.19	10.2	4.26	1	19.4	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
83.99	5.0E-06	0.11	18.2	4.27	1	32.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
84.97	1.0E-15	0.01	43.5	6.51	1	74.1	UnDef	UnDef	100.0	38	58.7	1.0	-0.65	UnDef	UnDe
85.96	1.0E-15	0.01	52.6	5.69	1	89.6	UnDef	UnDef	100.0	40	64.1	1.0	-0.52	UnDef	UnDe
86.94	1.0E-15	0.00	76.7	4.16	6	129.8	196.6	326.4	27.6	40	74.8	1.0	-0.40	38.4	101.
87.93	1.0E-15	-0.01	33.4	5.28	1	58.5	UnDef	UnDef	100.0	36	51.9	1.0	-0.37	UnDef	UnDe
88.91	5.0E-05	0.08	10.3	2.62	4	20.2	80.8	101.0	55.4	30	30.0	3.0	-0.03	7.9	15.
89.89	1.0E-15	0.06	23.1	5.06	1	41.8	UnDef	UnDef	100.0	34	42.3	1.0	-0.26	UnDef	UnDe
90.88	1.0E-15	0.02	26.8	6.80	1	48.4	UnDef	UnDef	100.0	36	46.4	1.0	-0.58	UnDef	UnDe
91.86	1.0E-15	0.02	28.6	6.88	1	51.6	UnDef	UnDef	100.0	36	48.3	1.0	-0.62	UnDef	UnDe
92.85	1.0E-15	0.00	35.7	6.45	1	64.0	UnDef	UnDef	100.0	38	54.5	1.0	-0.58	UnDef	UnDe
93.83	1.0E-15	0.03	24.8	4.93	1	45.8	UnDef	UnDef	100.0	34	44.9	1.0	-0.27	UnDef	UnDe
94.82	1.0E-15	0.04	22.1	5.37	1	41.2	UnDef	UnDef	100.0	34	41.9	1.0	-0.28	UnDef	UnDe
95.80	1.0E-15	0.03	27.2	5.32	1	50.4	UnDef	UnDef	100.0	36	47.6	1.0	-0.32	UnDef	UnDe
96.78	1.0E-15	0.02	32.3	6.06	1	59.6	UnDef	UnDef	100.0	36	52.4	1.0	-0.47	UnDef	UnDe
97.77	1.0E-15	0.03	30.0	5.46	1	55.7	UnDef	UnDef	100.0	36	50.5	1.0	-0.36	UnDef	UnDe
98.75	1.0E-15	0.00	45.0	4.51	6	82.6	330.5	413.1	35.9	38	61.8	1.0	-0.35	80.9	161.

Gregg In Situ, Inc.
Interpretation Output - Release 1.00.19e
Run No: 03-0203-1606-1479
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-01
Engineer: H. YOUNG
CPT Date: 03/29/01
CPT Time: 11:54
CPT File: 027C01.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 4.57 (ft): 15.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
0.49	0.0	0.00	0.00	0.0	UnDef	124.1	0.03	0.03	0.00	2.00	UnDef	UnDef	UnDef	0.00
1.48	0.0	0.00	0.00	0.0	UnDef	124.1	0.09	0.09	0.00	2.00	UnDef	UnDef	UnDef	0.00
2.46	0.0	0.00	0.00	0.0	UnDef	124.1	0.15	0.15	0.00	2.00	UnDef	UnDef	UnDef	0.00
3.44	0.0	0.00	0.00	0.0	UnDef	124.1	0.21	0.21	0.00	2.00	UnDef	UnDef	UnDef	0.00
4.43	0.0	0.00	0.00	0.0	UnDef	124.1	0.27	0.27	0.00	1.91	UnDef	UnDef	UnDef	0.00
5.41	14.8	0.35	2.34	1.3	5	114.6	0.33	0.33	0.00	1.73	7.1	12.2	1.15	0.10
6.40	19.8	0.49	2.46	1.7	5	114.6	0.39	0.39	0.00	1.60	9.5	15.2	1.55	0.12
7.30	31.3	0.75	2.41	-5.4	6	114.6	0.44	0.44	0.00	1.50	12.0	18.0	2.47	0.14
8.20	24.4	1.03	4.21	-1.5	4	114.6	0.49	0.49	0.00	1.42	15.6	22.2	1.91	0.40
9.19	16.9	0.60	3.58	2.2	4	114.6	0.55	0.55	0.00	1.35	10.8	14.6	1.31	0.21
10.17	14.8	0.49	3.29	21.1	4	114.6	0.61	0.61	0.00	1.28	9.5	12.1	1.14	0.16
11.15	13.7	0.55	3.99	22.4	3	111.4	0.66	0.66	0.00	1.23	13.1	16.2	1.04	0.00
12.14	46.7	0.54	1.15	29.4	7	117.8	0.72	0.72	0.00	1.18	14.9	17.6	UnDef	0.12
13.21	132.5	0.85	0.65	-0.6	9	124.1	0.78	0.78	0.00	1.13	25.4	28.7	UnDef	0.37
14.27	32.6	0.40	1.23	1.1	7	117.8	0.85	0.85	0.00	1.09	10.4	11.3	UnDef	0.11
15.26	7.1	0.11	1.54	21.5	5	114.6	0.90	0.90	0.01	1.06	3.4	3.6	0.49	0.08
16.24	7.7	0.13	1.62	46.1	5	114.6	0.96	0.92	0.04	1.04	3.7	3.9	0.54	0.09
17.22	8.9	0.21	2.36	50.8	5	114.6	1.02	0.95	0.07	1.03	4.2	4.4	0.63	0.09
18.21	8.1	0.14	1.68	44.2	5	114.6	1.07	0.97	0.10	1.01	3.9	4.0	0.57	0.09
19.19	8.2	0.07	0.79	71.1	5	114.6	1.13	1.00	0.13	1.00	3.9	3.9	0.57	0.09
20.18	14.1	0.21	1.47	48.8	6	114.6	1.19	1.02	0.16	0.99	5.4	5.3	1.03	0.11
21.16	59.5	0.39	0.66	11.7	8	120.9	1.24	1.05	0.19	0.98	14.2	13.9	UnDef	0.12
22.15	21.8	0.38	1.74	20.1	6	114.6	1.30	1.08	0.22	0.96	8.4	8.1	1.64	0.18
23.13	7.4	0.12	1.57	64.8	5	114.6	1.36	1.10	0.25	0.95	3.5	3.3	0.48	0.08
24.11	7.3	0.16	2.16	72.7	4	114.6	1.42	1.13	0.28	0.94	4.7	4.4	0.47	0.08
25.10	7.9	0.23	2.89	64.2	4	114.6	1.47	1.16	0.32	0.93	5.0	4.7	0.51	0.00
26.08	11.9	0.35	2.97	83.8	4	114.6	1.53	1.18	0.35	0.92	7.6	7.0	0.83	0.00
27.07	82.6	2.00	2.43	59.6	7	117.8	1.59	1.21	0.38	0.91	26.4	24.0	UnDef	0.33
28.05	108.2	3.16	2.92	-21.7	6	114.6	1.64	1.23	0.41	0.90	41.5	37.3	8.53	0.00
29.04	82.7	1.87	2.26	-15.5	7	117.8	1.70	1.26	0.44	0.89	26.4	23.5	UnDef	0.31

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60 (blows/ft)	Su (tsf)	CRR
30.02	97.7	1.52	1.56	-12.2	7	117.8	1.76	1.29	0.47	0.88	31.2	27.5	UnDef	0.26
31.00	40.8	1.66	4.07	47.7	5	114.6	1.81	1.31	0.50	0.87	19.6	17.1	3.12	0.00
31.99	27.3	1.13	4.13	63.6	4	114.6	1.87	1.34	0.53	0.86	17.4	15.1	2.03	0.00
32.97	18.6	0.81	4.36	76.9	3	111.4	1.93	1.37	0.56	0.86	17.8	15.2	1.33	0.00
33.96	19.3	0.69	3.57	133.0	4	114.6	1.98	1.39	0.59	0.85	12.3	10.4	1.38	0.00
34.94	20.4	0.56	2.76	168.3	5	114.6	2.04	1.42	0.62	0.84	9.8	8.2	1.47	0.14
35.92	21.1	0.61	2.88	190.5	5	114.6	2.09	1.44	0.65	0.83	10.1	8.4	1.52	0.14
36.91	22.3	0.60	2.68	201.1	5	114.6	2.15	1.47	0.68	0.83	10.7	8.8	1.61	0.15
37.89	19.0	0.57	3.00	164.7	5	114.6	2.21	1.49	0.71	0.82	9.1	7.4	1.34	0.12
38.88	18.9	0.57	3.03	162.2	5	114.6	2.26	1.52	0.75	0.81	9.0	7.3	1.33	0.12
39.86	20.1	0.61	3.03	163.8	5	114.6	2.32	1.54	0.78	0.80	9.6	7.8	1.43	0.13
40.85	47.5	1.67	3.51	146.6	5	114.6	2.38	1.57	0.81	0.80	22.7	18.2	3.61	0.00
41.83	36.6	1.65	4.51	129.7	4	114.6	2.43	1.60	0.84	0.79	23.4	18.5	2.73	0.00
42.81	53.0	1.57	2.97	120.8	6	114.6	2.49	1.62	0.87	0.79	20.3	15.9	4.04	0.00
43.80	21.5	0.29	1.35	286.5	6	114.6	2.55	1.65	0.90	0.78	8.2	6.4	1.51	0.13
44.78	24.2	0.59	2.45	229.0	6	114.6	2.60	1.67	0.93	0.77	9.3	7.2	1.73	0.15
45.77	23.0	0.90	3.90	127.8	4	114.6	2.66	1.70	0.96	0.77	14.7	11.3	1.63	0.00
46.75	22.6	0.76	3.35	164.0	5	114.6	2.72	1.72	0.99	0.76	10.8	8.3	1.59	0.00
47.74	32.0	0.95	2.96	208.7	5	114.6	2.77	1.75	1.02	0.76	15.3	11.6	2.34	0.23
48.72	69.5	2.57	3.70	83.2	5	114.6	2.83	1.78	1.05	0.75	33.3	25.0	5.33	0.00
49.70	28.9	0.74	2.55	216.6	6	114.6	2.88	1.80	1.08	0.75	11.1	8.2	2.08	0.19
50.69	28.4	0.69	2.44	190.5	6	114.6	2.94	1.83	1.11	0.74	10.9	8.1	2.04	0.18
51.67	27.6	0.90	3.27	94.5	5	114.6	3.00	1.85	1.15	0.73	13.2	9.7	1.97	0.00
52.66	35.4	1.06	3.00	197.5	5	114.6	3.05	1.88	1.18	0.73	16.9	12.4	2.58	0.27
53.64	83.0	3.73	4.49	120.8	11	130.5	3.11	1.91	1.21	0.72	79.5	57.6	UnDef	0.00
54.63	115.8	4.53	3.91	118.4	5	114.6	3.17	1.94	1.24	0.72	55.4	39.8	9.01	0.00
55.61	262.4	5.44	2.07	-7.8	8	120.9	3.23	1.96	1.27	0.71	62.8	44.8	UnDef	0.00
56.59	379.4	2.76	0.73	-0.6	9	124.1	3.29	1.99	1.30	0.71	72.7	51.5	UnDef	0.00
57.58	334.3	2.43	0.73	14.6	9	124.1	3.35	2.02	1.33	0.70	64.0	45.0	UnDef	0.00
58.56	29.9	0.82	2.73	219.7	5	114.6	3.41	2.05	1.36	0.70	14.3	10.0	2.12	0.18
59.55	26.1	0.44	1.70	262.6	6	114.6	3.47	2.08	1.39	0.69	10.0	6.9	1.81	0.14
60.53	31.9	0.44	1.38	339.5	6	114.6	3.52	2.10	1.42	0.69	12.2	8.4	2.27	0.20
61.52	34.1	0.83	2.44	225.8	6	114.6	3.58	2.13	1.45	0.69	13.1	9.0	2.44	0.22
62.42	32.1	0.83	2.60	200.6	6	114.6	3.63	2.15	1.48	0.68	12.3	8.4	2.27	0.19
63.32	30.0	0.74	2.45	235.0	6	114.6	3.68	2.18	1.51	0.68	11.5	7.8	2.10	0.17
64.30	32.6	0.82	2.52	254.3	6	114.6	3.74	2.20	1.54	0.67	12.5	8.4	2.31	0.20
65.29	34.5	0.80	2.32	263.9	6	114.6	3.80	2.23	1.57	0.67	13.2	8.9	2.46	0.21
66.27	32.6	0.64	1.97	355.3	6	114.6	3.85	2.25	1.60	0.67	12.5	8.3	2.30	0.19
67.26	83.7	3.19	3.81	224.5	5	114.6	3.91	2.28	1.63	0.66	40.1	26.6	6.39	0.00
68.24	135.9	6.32	4.65	-12.0	11	130.5	3.97	2.31	1.66	0.66	130.1	85.7	UnDef	0.00
69.22	62.2	3.26	5.24	62.5	11	130.5	4.03	2.34	1.69	0.65	59.6	38.9	UnDef	0.00
70.21	41.1	1.29	3.14	206.5	5	114.6	4.10	2.37	1.72	0.65	19.7	12.8	2.96	0.29
71.19	39.6	1.03	2.61	232.3	6	114.6	4.15	2.40	1.75	0.65	15.2	9.8	2.83	0.26
72.18	34.4	0.70	2.02	263.7	6	114.6	4.21	2.42	1.79	0.64	13.2	8.5	2.41	0.20
73.16	37.5	0.94	2.51	235.8	6	114.6	4.26	2.45	1.82	0.64	14.4	9.2	2.66	0.23
74.15	36.2	1.20	3.31	229.8	5	114.6	4.32	2.47	1.85	0.64	17.3	11.0	2.55	0.00
75.13	38.2	1.14	2.97	264.3	5	114.6	4.38	2.50	1.88	0.63	18.3	11.6	2.71	0.23
76.11	44.5	1.40	3.13	213.4	5	114.6	4.43	2.53	1.91	0.63	21.3	13.4	3.21	0.32
77.10	54.9	2.23	4.07	283.7	5	114.6	4.49	2.55	1.94	0.63	26.3	16.4	4.03	0.00
78.08	77.6	4.39	5.66	128.1	11	130.5	4.55	2.58	1.97	0.62	74.3	46.3	UnDef	0.00
79.07	57.6	2.59	4.50	137.9	5	114.6	4.61	2.61	2.00	0.62	27.6	17.1	4.24	0.00
80.05	29.5	0.72	2.44	218.0	6	114.6	4.67	2.64	2.03	0.62	11.3	7.0	1.99	0.15

Depth (ft)	AvgQt (tsf)	AvgFs (tsf)	AvgRf (%)	AvgUd (ft)	SBT	U.Wt. pcf	TStress (tsf)	EStress (tsf)	Ueq (tsf)	Cn	N60 (blows/ft)	(N1)60	Su (tsf)	CRR
81.04	30.2	0.64	2.11	298.4	6	114.6	4.72	2.66	2.06	0.61	11.6	7.1	2.04	0.15
82.02	53.2	1.58	2.96	329.5	6	114.6	4.78	2.69	2.09	0.61	20.4	12.4	3.88	0.45
83.00	51.2	1.28	2.51	308.6	6	114.6	4.84	2.71	2.12	0.61	19.6	11.9	3.71	0.41
83.99	91.4	3.75	4.11	215.2	5	114.6	4.89	2.74	2.15	0.60	43.8	26.5	6.92	0.00
84.97	152.6	8.36	5.48	14.7	11	130.5	4.95	2.77	2.18	0.60	146.1	87.8	UnDef	0.00
85.96	118.3	7.05	5.96	19.7	11	130.5	5.02	2.80	2.22	0.60	113.3	67.7	UnDef	0.00
86.94	45.4	1.83	4.03	115.2	5	114.6	5.08	2.83	2.25	0.59	21.7	12.9	3.22	0.00
87.93	43.4	0.89	2.06	298.1	6	114.6	5.13	2.86	2.28	0.59	16.6	9.8	3.06	0.26
88.91	124.3	5.60	4.50	195.1	11	130.5	5.19	2.89	2.31	0.59	119.0	70.1	UnDef	0.00
89.89	60.7	3.62	5.96	15.9	11	130.5	5.26	2.92	2.34	0.59	58.1	34.0	UnDef	0.00
90.88	29.4	0.59	1.99	217.7	6	114.6	5.32	2.95	2.37	0.58	11.3	6.6	1.93	0.13
91.86	35.8	0.74	2.07	342.4	6	114.6	5.37	2.97	2.40	0.58	13.7	7.9	2.43	0.18
92.85	42.6	1.18	2.77	355.1	6	114.6	5.43	3.00	2.43	0.58	16.3	9.4	2.97	0.24
93.83	46.8	1.82	3.89	230.8	5	114.6	5.49	3.03	2.46	0.57	22.4	12.9	3.31	0.00
94.82	36.5	1.50	4.13	199.3	4	114.6	5.54	3.05	2.49	0.57	23.3	13.3	2.47	0.00
95.80	28.0	0.81	2.89	271.5	5	114.6	5.60	3.08	2.52	0.57	13.4	7.6	1.79	0.00
96.78	30.4	0.89	2.92	290.3	5	114.6	5.66	3.10	2.55	0.57	14.6	8.3	1.98	0.00
97.77	32.8	0.97	2.95	300.0	5	114.6	5.71	3.13	2.58	0.57	15.7	8.9	2.16	0.00
98.75	33.3	1.01	3.02	264.5	5	114.6	5.77	3.15	2.61	0.56	16.0	9.0	2.20	0.00

Interpretation Output - Release 1.00.19e

Run No: 03-0203-1606-1479
Job No: 97-100
Client: CDM
Project: CPT SITE INVESTIGATION
Site: SHERWIN WILLIAMS
Location: CPT-01
Engineer: H. YOUNG
CPT Date: 03/29/01
CPT Time: 11:54
CPT File: 027C01.COR
Northing (m): 0.000
Easting (m): 0.000
Elevation (m): 0.000

Water Table (m): 4.57 (ft): 15.0
Su Nkt used: 12.50
Averaging Increment (m): 0.30
Phi Method : Robertson and Campanella, 1983
Dr Method : Jamiolkowski - All Sands
State Parameter M: 1.20
Used Unit Weights Assigned to Soil Zones
Values of 1.0E9 or UnDef are printed for parameters that are not valid for the material type (SBT)

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
0.49	1.0E-15	0.00	2.4	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
1.48	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
2.46	1.0E-15	0.00	0.1	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
3.44	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
4.43	1.0E-15	0.00	0.0	0.10	1	0.2	UnDef	UnDef	100.0	UnDef	UnDef	1.0	UnDef	UnDef	UnDe
5.41	5.0E-06	0.00	43.3	2.40	7	25.0	38.9	63.9	27.8	UnDef	UnDef	6.0	UnDef	7.5	19.
6.40	5.0E-06	0.00	49.7	2.51	7	31.0	41.6	72.6	26.5	UnDef	UnDef	6.0	UnDef	8.5	23.
7.30	5.0E-05	-0.01	69.9	2.44	7	46.1	38.4	84.5	22.0	40	45.1	10.0	-0.25	7.2	25.
8.20	5.0E-07	0.00	48.5	4.29	6	34.0	117.0	151.0	34.0	UnDef	UnDef	6.0	UnDef	20.9	43.
9.19	5.0E-07	0.00	29.8	3.70	6	22.3	89.3	111.6	39.4	UnDef	UnDef	6.0	UnDef	14.6	29.
10.17	5.0E-07	0.05	23.4	3.43	6	18.6	74.5	93.1	42.5	UnDef	UnDef	6.0	UnDef	12.1	24.
11.15	5.0E-08	0.05	19.7	4.20	1	16.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
12.14	5.0E-04	0.02	64.1	1.17	7	54.0	22.1	76.1	15.9	40	49.6	1.0	-0.16	3.9	21.
13.21	5.0E-02	0.00	168.3	0.65	9	146.5	0.0	146.5	4.6	44	78.2	1.0	-0.20	0.0	28.
14.27	5.0E-04	0.00	37.5	1.26	7	34.7	31.8	66.5	22.9	38	36.9	1.0	-0.11	4.8	16.
15.26	5.0E-06	0.11	6.9	1.76	4	7.3	29.2	36.6	59.4	UnDef	UnDef	3.0	UnDef	3.6	7.
16.24	5.0E-06	0.21	7.4	1.85	4	7.9	31.6	39.5	58.4	UnDef	UnDef	3.0	UnDef	3.9	7.
17.22	5.0E-06	0.19	8.3	2.67	4	8.9	35.6	44.5	61.0	UnDef	UnDef	3.0	UnDef	4.4	8.
18.21	5.0E-06	0.18	7.3	1.94	4	8.1	32.3	40.4	59.4	UnDef	UnDef	3.0	UnDef	4.0	7.
19.19	5.0E-06	0.29	7.1	0.92	6	8.0	32.2	40.2	50.4	UnDef	UnDef	3.0	UnDef	3.9	7.
20.18	5.0E-05	0.11	12.6	1.61	6	13.6	54.4	68.0	44.1	30	30.0	6.0	-0.01	5.3	10.
21.16	5.0E-03	0.00	55.3	0.68	9	56.7	16.8	73.5	13.5	40	51.0	1.0	-0.10	2.3	16.
22.15	5.0E-05	0.02	19.0	1.85	6	20.6	82.3	102.8	37.7	32	30.0	6.0	-0.08	8.1	16.
23.13	5.0E-06	0.30	5.4	1.92	4	6.8	27.4	34.2	67.1	UnDef	UnDef	1.5	UnDef	3.3	6.
24.11	5.0E-07	0.33	5.2	2.68	4	6.8	27.0	33.8	73.5	UnDef	UnDef	1.5	UnDef	4.4	8.
25.10	5.0E-07	0.26	5.5	3.56	1	7.2	UnDef	UnDef	100.0	UnDef	UnDef	1.5	UnDef	UnDef	UnDe
26.08	5.0E-07	0.22	8.8	3.40	1	10.7	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
27.07	5.0E-04	0.02	67.0	2.47	7	73.5	65.5	139.0	22.6	40	58.5	1.0	-0.25	10.0	34.
28.05	5.0E-05	-0.01	86.3	2.96	7	95.3	78.5	173.8	21.9	42	65.9	10.0	-0.32	14.7	52.
29.04	5.0E-04	-0.01	64.2	2.31	7	72.1	62.2	134.3	22.3	40	57.9	1.0	-0.24	9.6	33.

Depth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
30.02	5.0E-04	-0.01	74.5	1.59	7	84.2	39.6	123.9	17.0	40	62.4	1.0	-0.21	6.9	34.
31.00	5.0E-06	0.03	29.7	4.26	6	34.8	139.4	174.2	41.7	UnDef	UnDef	6.0	UnDef	17.1	34.
31.99	5.0E-07	0.06	19.0	4.43	1	23.1	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
32.97	5.0E-08	0.11	12.2	4.87	1	15.6	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
33.96	5.0E-07	0.21	12.4	3.98	1	16.0	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
34.94	5.0E-06	0.25	13.0	3.07	4	16.8	67.2	84.1	52.6	UnDef	UnDef	6.0	UnDef	8.2	16.
35.92	5.0E-06	0.28	13.2	3.20	4	17.2	68.9	86.2	52.9	UnDef	UnDef	6.0	UnDef	8.4	16.
36.91	5.0E-06	0.28	13.8	2.96	4	18.0	72.2	90.2	50.8	UnDef	UnDef	6.0	UnDef	8.8	17.
37.89	5.0E-06	0.26	11.2	3.39	4	15.2	60.9	76.1	57.5	UnDef	UnDef	3.0	UnDef	7.4	14.
38.88	5.0E-06	0.26	10.9	3.44	4	15.0	59.9	74.9	58.4	UnDef	UnDef	3.0	UnDef	7.3	14.
39.86	5.0E-06	0.24	11.5	3.42	4	15.9	63.4	79.3	57.1	UnDef	UnDef	3.0	UnDef	7.8	15.
40.85	5.0E-06	0.08	28.7	3.69	6	37.1	148.4	185.5	40.0	UnDef	UnDef	6.0	UnDef	18.2	36.
41.83	5.0E-07	0.09	21.4	4.83	1	28.3	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
42.81	5.0E-05	0.06	31.2	3.11	6	40.7	162.9	203.6	36.1	36	41.5	6.0	-0.19	15.9	31.
43.80	5.0E-05	0.43	11.5	1.53	6	16.4	65.4	81.8	45.4	30	30.0	3.0	0.04	6.4	12.
44.78	5.0E-05	0.29	12.9	2.75	6	18.3	73.2	91.5	51.0	32	30.0	6.0	-0.03	7.2	14.
45.77	5.0E-07	0.15	12.0	4.41	1	17.3	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
46.75	5.0E-06	0.21	11.6	3.81	1	16.9	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
47.74	5.0E-06	0.19	16.7	3.24	6	23.7	94.8	118.5	48.1	UnDef	UnDef	6.0	UnDef	11.6	23.
48.72	5.0E-06	0.02	37.5	3.86	6	51.0	204.1	255.1	36.3	UnDef	UnDef	6.0	UnDef	25.0	49.
49.70	5.0E-05	0.22	14.4	2.83	6	21.0	84.2	105.2	49.1	32	30.0	6.0	-0.06	8.2	16.
50.69	5.0E-05	0.19	13.9	2.72	6	20.6	82.3	102.8	49.2	32	30.0	6.0	-0.05	8.1	16.
51.67	5.0E-06	0.07	13.3	3.67	1	19.9	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
52.66	5.0E-06	0.15	17.2	3.28	6	25.3	101.0	126.3	47.7	UnDef	UnDef	6.0	UnDef	12.4	24.
53.64	1.0E-15	0.03	41.9	4.66	6	58.8	235.3	294.1	37.5	38	52.1	1.0	-0.34	57.6	115.
54.63	5.0E-06	0.02	58.1	4.02	6	81.4	175.2	256.6	30.6	UnDef	UnDef	10.0	UnDef	29.7	69.
55.61	5.0E-03	-0.01	131.9	2.10	7	183.2	60.7	243.9	14.3	44	84.6	1.0	-0.30	8.3	53.
56.59	5.0E-02	0.00	188.7	0.73	9	263.0	0.0	263.0	4.6	44	95.0	1.0	-0.22	0.0	51.
57.58	5.0E-02	0.00	163.5	0.73	9	230.0	2.5	232.4	5.4	44	91.1	1.0	-0.20	0.3	45.
58.56	5.0E-06	0.21	12.9	3.08	4	20.4	81.7	102.1	52.8	UnDef	UnDef	6.0	UnDef	10.0	20.
59.55	5.0E-05	0.30	10.9	1.96	6	17.7	70.9	88.6	49.8	30	30.0	3.0	0.02	6.9	13.
60.53	5.0E-05	0.32	13.5	1.55	6	21.5	86.2	107.7	42.1	32	30.0	6.0	0.01	8.4	16.
61.52	5.0E-05	0.18	14.3	2.72	6	22.9	91.6	114.4	48.6	32	30.0	6.0	-0.06	9.0	17.
62.42	5.0E-05	0.17	13.2	2.93	4	21.4	85.5	106.9	51.5	32	30.0	6.0	-0.05	8.4	16.
63.32	5.0E-05	0.22	12.1	2.80	4	19.9	79.5	99.4	52.7	30	30.0	3.0	-0.03	7.8	15.
64.30	5.0E-05	0.22	13.1	2.85	4	21.5	86.1	107.6	51.2	32	30.0	6.0	-0.04	8.4	16.
65.29	5.0E-05	0.22	13.8	2.61	6	22.6	90.5	113.1	48.8	32	30.0	6.0	-0.04	8.9	17.
66.27	5.0E-05	0.33	12.8	2.23	6	21.3	85.0	106.3	48.2	32	30.0	6.0	-0.01	8.3	16.
67.26	5.0E-06	0.07	35.0	3.99	6	54.3	217.1	271.4	37.9	UnDef	UnDef	6.0	UnDef	26.6	53.
68.24	1.0E-15	-0.02	57.1	4.79	6	87.5	273.1	360.6	33.4	40	63.5	1.0	-0.42	77.1	162.
69.22	1.0E-15	0.00	24.8	5.60	1	39.8	UnDef	UnDef	100.0	34	40.9	1.0	-0.34	UnDef	UnDe
70.21	5.0E-06	0.13	15.6	3.48	4	26.1	104.4	130.5	50.7	UnDef	UnDef	6.0	UnDef	12.8	25.
71.19	5.0E-05	0.16	14.8	2.91	6	25.0	100.0	125.0	49.0	32	30.0	6.0	-0.07	9.8	19.
72.18	5.0E-05	0.21	12.5	2.30	6	21.6	86.5	108.1	49.2	30	30.0	3.0	-0.02	8.5	16.
73.16	5.0E-05	0.17	13.6	2.83	6	23.4	93.8	117.2	50.4	32	30.0	6.0	-0.06	9.2	18.
74.15	5.0E-06	0.17	12.9	3.75	1	22.5	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
75.13	5.0E-06	0.19	13.5	3.36	4	23.6	94.6	118.2	53.2	UnDef	UnDef	6.0	UnDef	11.6	23.
76.11	5.0E-06	0.12	15.9	3.48	4	27.4	109.6	137.0	50.3	UnDef	UnDef	6.0	UnDef	13.4	26.
77.10	5.0E-06	0.14	19.7	4.43	1	33.6	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
78.08	1.0E-15	0.03	28.3	6.01	1	47.3	UnDef	UnDef	100.0	36	45.8	1.0	-0.42	UnDef	UnDe
79.07	5.0E-06	0.04	20.3	4.89	1	34.9	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
80.05	5.0E-05	0.19	9.4	2.89	4	17.8	71.1	88.9	59.1	30	30.0	3.0	-0.01	7.0	13.

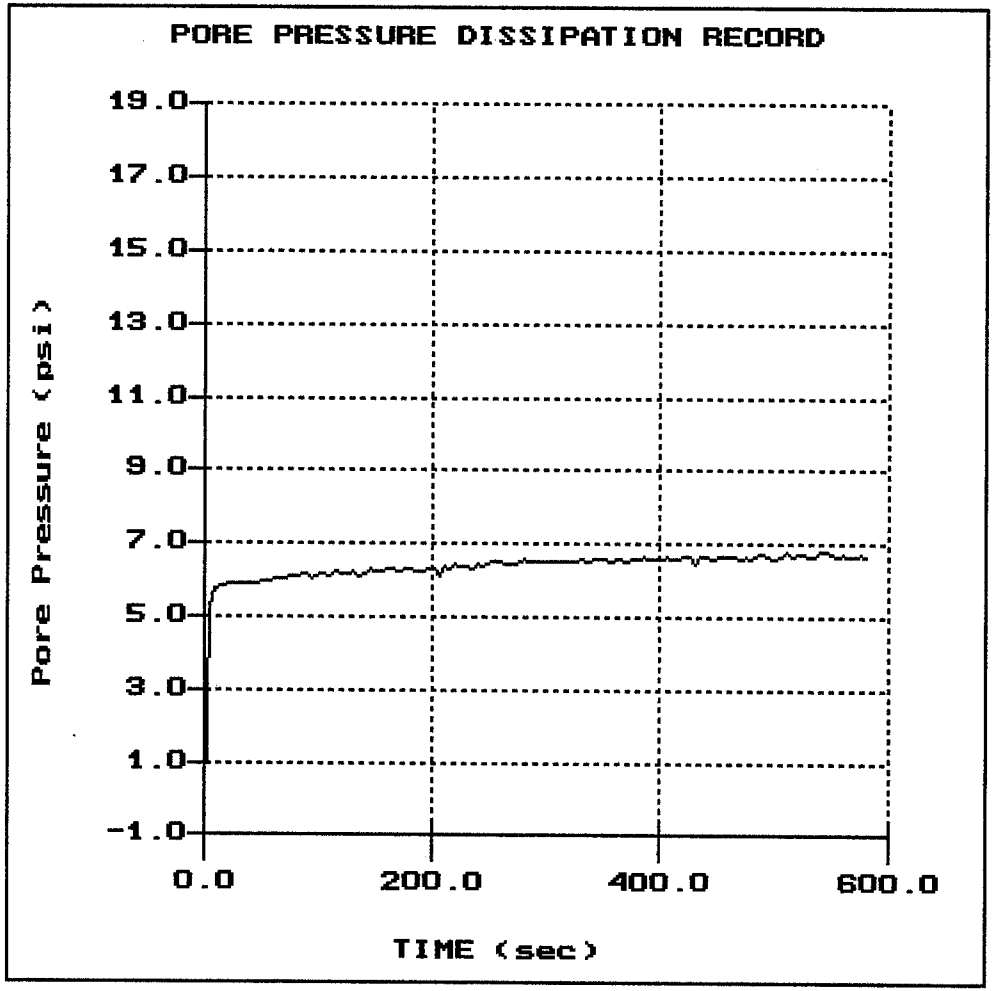
pth (ft)	k (cm/s)	Bq	Qtn	Rfn	SBTn	Qc1N	DeltaQc1N	Qc1Ncs	Fc (%)	Phi (Deg)	Dr (%)	OCR	State Param	Del(n1)60	(N1)60c
81.04	5.0E-05	0.29	9.6	2.50	4	18.1	72.4	90.5	56.4	30	30.0	3.0	0.01	7.1	14.
82.02	5.0E-05	0.17	18.0	3.25	6	31.8	127.1	158.9	46.6	32	34.4	6.0	-0.11	12.4	24.
83.00	5.0E-05	0.16	17.1	2.77	6	30.4	121.8	152.2	45.2	32	33.2	6.0	-0.08	11.9	23.
83.99	5.0E-06	0.05	31.6	4.34	6	54.1	216.3	270.4	40.9	UnDef	UnDef	6.0	UnDef	26.5	52.
84.97	1.0E-15	-0.01	53.3	5.66	1	89.7	UnDef	UnDef	100.0	40	64.2	1.0	-0.53	UnDef	UnDe
85.96	1.0E-15	-0.01	40.4	6.22	1	69.2	UnDef	UnDef	100.0	38	56.7	1.0	-0.57	UnDef	UnDe
86.94	5.0E-06	0.03	14.2	4.54	1	26.4	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
87.93	5.0E-05	0.18	13.4	2.34	6	25.1	100.5	125.6	47.8	32	30.0	6.0	-0.04	9.8	19.
88.91	1.0E-15	0.03	41.3	4.70	6	71.6	286.4	358.0	37.8	38	57.7	1.0	-0.34	70.1	140.
89.89	1.0E-15	-0.03	19.0	6.52	1	34.8	UnDef	UnDef	100.0	32	37.0	1.0	-0.41	UnDef	UnDe
90.88	5.0E-05	0.18	8.2	2.43	4	16.8	67.1	83.8	59.8	30	30.0	3.0	0.02	6.6	13.
91.86	5.0E-05	0.27	10.2	2.43	4	20.3	81.2	101.5	54.4	30	30.0	3.0	0.01	7.9	15.
92.85	5.0E-05	0.23	12.4	3.18	4	24.0	96.2	120.2	54.3	30	30.0	3.0	-0.04	9.4	18.
93.83	5.0E-06	0.11	13.7	4.41	1	26.3	UnDef	UnDef	100.0	UnDef	UnDef	6.0	UnDef	UnDef	UnDe
94.82	5.0E-07	0.12	10.1	4.87	1	20.4	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
95.80	5.0E-06	0.27	7.3	3.61	1	15.6	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
96.78	5.0E-06	0.26	8.0	3.59	1	16.9	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
97.77	5.0E-06	0.25	8.6	3.58	1	18.1	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe
98.75	5.0E-06	0.20	8.7	3.65	1	18.4	UnDef	UnDef	100.0	UnDef	UnDef	3.0	UnDef	UnDef	UnDe

3.3 PORE PRESSURE DISSIPATION PLOTS

CDM

Site: SHERWIN WILLIAMS
Location: CPT-01

Engineer: H. YOUNG
Date:01:29:03 11:54

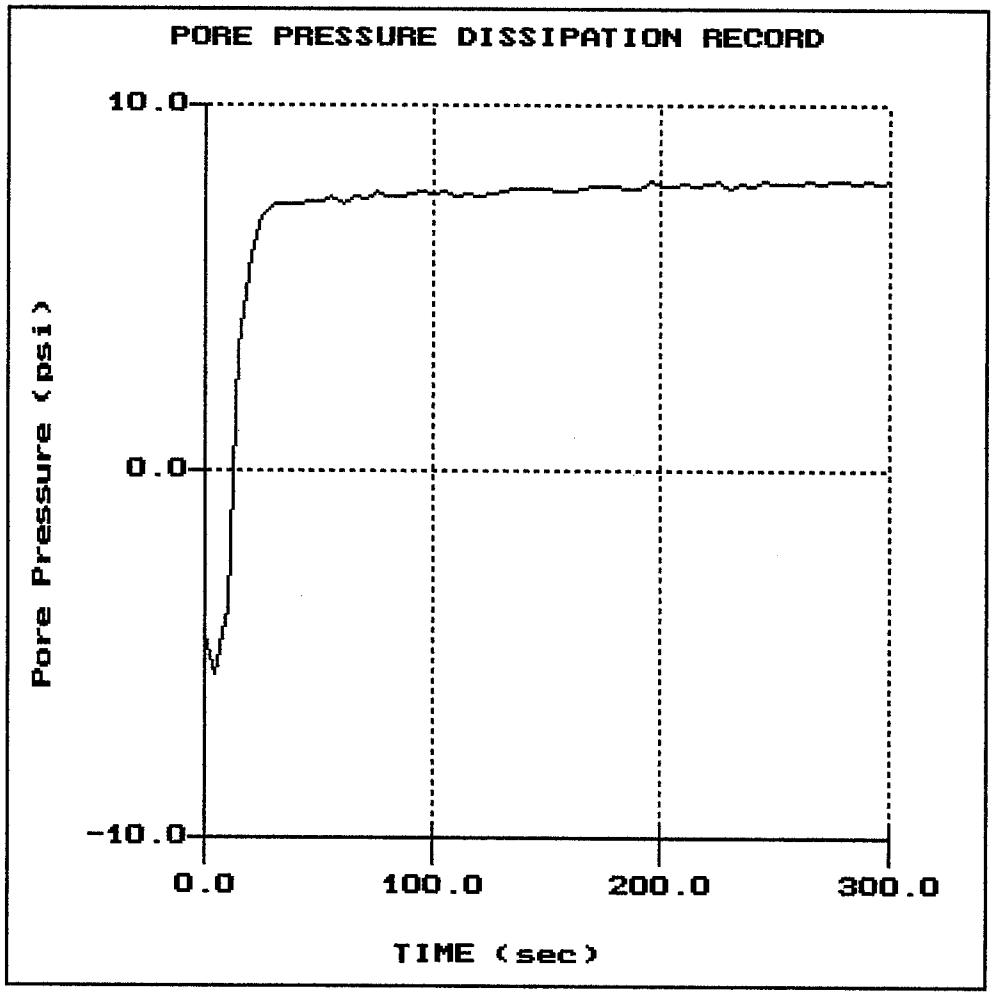


File: 027C01.PPC
Depth (m): 9.30
(ft): 30.51
Duration : 580.0s
U-min: -0.61 0.0s
U-max: 6.77 545.0s

CDM

Site: SHERWIN WILLIAMS
Location: CPT-02

Engineer: H. YOUNG
Date:01:29:03 09:33

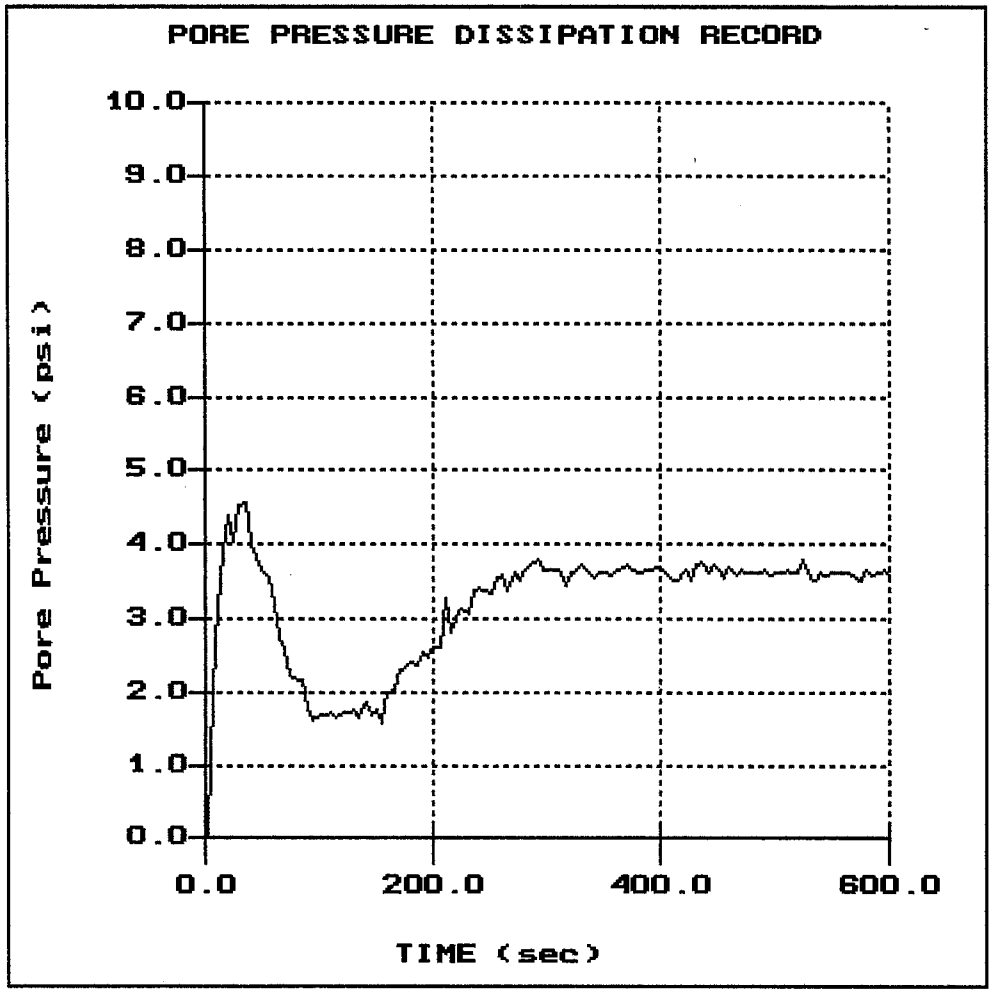


File: 027C02.PPC
Depth (m): 10.30
(ft): 33.79
Duration : 300.0s
U-min: -5.59 5.0s
U-max: 7.93 300.0s

CDM

Site: SHERWIN WILLIAMS
Location: CPT-04

Engineer: H. YOUNG
Date:01:28:03 08:29

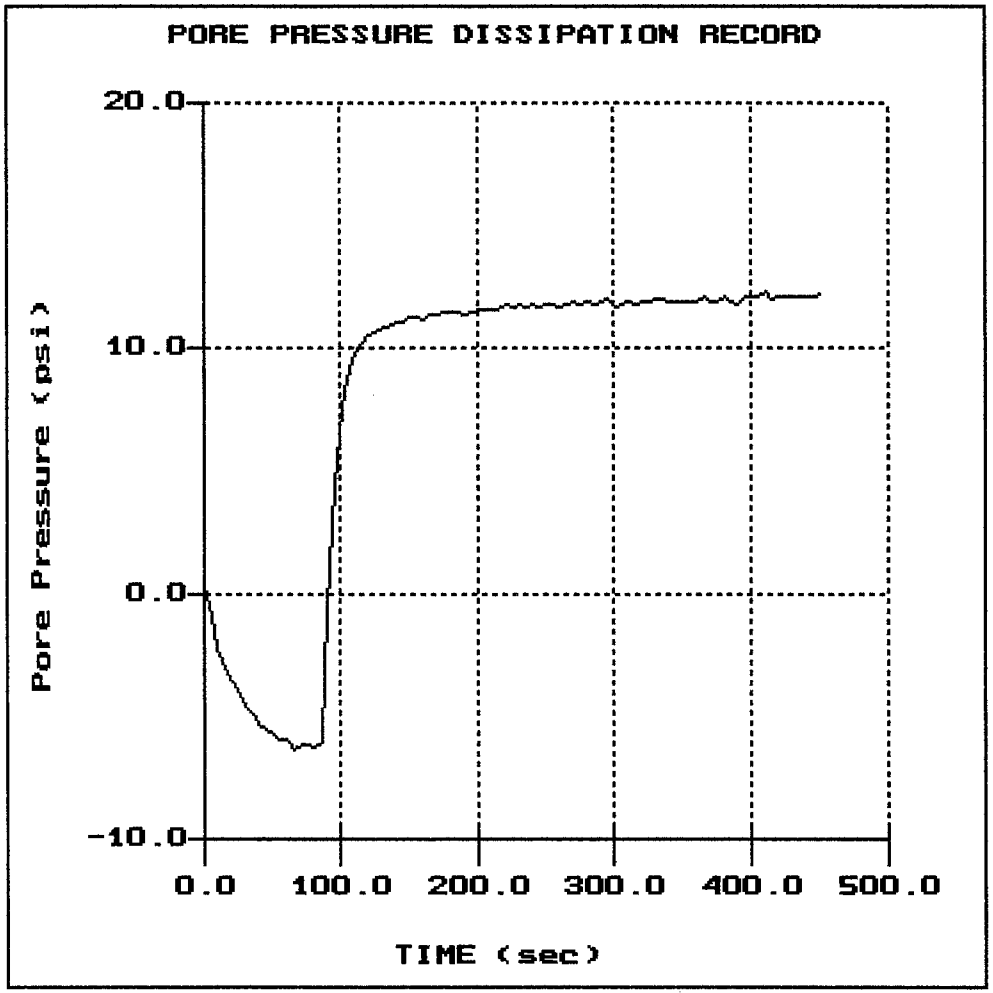


File: 027C04.PPC
Depth (m): 4.85
(ft): 15.91
Duration : 600.0s
U-min: -4.41 0.0s
U-max: 4.54 35.0s

CDM

Site: SHERWIN WILLIAMS
Location: CPT-05

Engineer: H. YOUNG
Date:01:28:03 10:52



File: 027C05.PPC
Depth (m): 10.25
(ft): 33.63
Duration : 450.0s
U-min: -6.35 65.0s
U-max: 12.27 410.0s

GREGG IN SITU CPT Interpretations as of July 31, 2002 (Release 1.20c)

GREGG IN SITU's interpretation routine provides a tabular output of geotechnical parameters based on current published CPT correlations and is subject to change to reflect the current state of practice. The interpreted values are not considered valid for all soil types. The interpretations are presented only as a guide for geotechnical use and should be carefully scrutinized for consideration in any geotechnical design. Reference to current literature is strongly recommended. GREGG IN SITU, Inc. and GREGG DRILLING & TESTING Inc. do not warranty the correctness or the applicability of any of the geotechnical parameters interpreted by the program and can not assume liability for any use of the results in any design or review. Representative hand calculations should be made for any parameter that is critical for design purposes. The end user of the interpreted output should also be fully aware of the techniques and the limitations of any method used in this program. The purpose of this document is to inform the user as to which methods were used and what the appropriate papers and/or publications are for further reference.

The CPT interpretations are based on values of tip, sleeve friction and pore pressure averaged over a user specified interval (e.g. 0.20m). Note that q_t is the recorded tip value, q_c, corrected for pore pressure effects. Since all GREGG IN SITU cones have equal end area friction sleeves, pore pressure corrections to sleeve friction, Fs, are not required.

The tip correction is: $q_t = q_c + (1-a) \bullet u_2$

where: q_t is the corrected tip resistance
q_c is the recorded tip resistance
u_2 is the recorded dynamic pore pressure behind the tip (u_2 position)
a is the Net Area Ratio for the cone (typically 0.85 for GREGG IN SITU cones)

The total stress calculations are based on soil unit weights that have been assigned to the Soil Behavior Type zones, from a user defined unit weight profile or by using a single value throughout the profile. Effective vertical overburden stresses are calculated based on a hydrostatic distribution of equilibrium pore pressures below the water table or from a user defined equilibrium pore pressure profile (this can be obtained from CPT dissipation tests). For over water projects the effects of the column of water have been taken in to account as has the appropriate unit weight of water. How this is done depends on where the instruments were zeroed (i.e. on deck or at mud line).

Details regarding the interpretation methods for all of the interpreted parameters are provided in Table 1. The appropriate references cited in Table 1 are listed in Table 2. Where methods are based on charts or techniques that are too complex to describe in this summary the user should reference to the cited references.

The estimated Soil Behavior Types (normalized and non-normalized) are based on the charts developed by Robertson and Campanella shown in Figures 1 and 2.

Where the results of a calculation/interpretation are declared *'invalid'* the value will be represented by the text strings "-9999" or "-9999.0". Invalid results will occur because of (and not limited to) one or a combination of:

1. Invalid or undefined CPT data (e.g. drilled out section or data gap).

2. Where the interpretation method is inappropriate, for example, drained parameters in an undrained material (and vice versa).

3. Where interpretation input values are beyond the range of the referenced charts or specified limitations of the interpretation method.

4. Where pre-requisite or intermediate interpretation calculations are invalid.

The parameters selected for output from the program are often specific to a particular project. As such, not all of the interpreted parameters listed in Table 1 may be included in the output files delivered with this report.

Table 1
CPT Interpretation Methods

Interpreted Parameter	Description	Equation	Ref
Depth	Mid Layer Depth *(where interpretations are done at each point then Mid Layer Depth = Recorded Depth)*	*Depth (Layer Top) + Depth (Layer Bottom) / 2.0*	
Elevation	Elevation of Mid Layer based on sounding collar elevation supplied by client	Elevation = Collar Elevation - Depth	
Avgqc	Averaged recorded tip value (q_c)	$Avgqc = \frac{1}{n}\sum_{i=1}^{n} q_c$ *n=1 when interpretations are done at each point*	
Avgqt	Averaged corrected tip (q_t) where: $q_t = q_c + (1-a) \bullet u$	$Avgqt = \frac{1}{n}\sum_{i=1}^{n} q_t$ *n=1 when interpretations are done at each point*	
Avgfs	Averaged sleeve friction (f_s)	$Avgfs = \frac{1}{n}\sum_{i=1}^{n} fs$ *n=1 when interpretations are done at each point*	
AvgRf	Averaged friction ratio (Rf) where friction ratio is defined as: $Rf = 100\% \bullet \frac{fs}{qt}$	$AvgRf = 100\% \bullet \frac{Avgfs}{Avgqt}$ *n=1 when interpretations are done at each point*	
Avgu	Averaged dynamic pore pressure *(u)*	$Avgu = \frac{1}{n}\sum_{i=1}^{n} u_i$ *n=1 when interpretations are done at each point*	
AvgRes	Averaged Resistivity (this data is not always available since it is a specialized test requiring an additional module)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} RESISTIVITY_i$ *n=1 when interpretations are done at each point*	
AvgUVIF	Averaged UVIF ultra-violet induced fluorescence (this data is not always available since it is a specialized test requiring an additional module)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} UVIF_i$ *n=1 when interpretations are done at each point*	
AvgTemp	Averaged Temperature (this data is not always available since it is a specialized test)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} TEMPERATURE_i$ *n=1 when interpretations are done at each point*	
AvgGamma	Averaged Gamma Counts (this data is not always available since it is a specialized test requiring an additional module)	$Avgu = \frac{1}{n}\sum_{i=1}^{n} GAMMA_i$ *n=1 when interpretations are done at each point*	
SBT	Soil Behavior Type as defined by Robertson and Campanella	See Figure 1	2, 5
U.Wt.	Unit Weight of soil determined from one of the following user selectable options: 1) uniform value 2) value assigned to each SBT zone 3) user supplied unit weight profile	See references	5
T. Stress σ_v	Total vertical overburden stress at Mid Layer Depth. *A layer is defined as the averaging interval specified by the user. For data interpreted at each point the Mid Layer Depth is the same as the recorded depth.*	$TStress = \sum_{i=1}^{n} \gamma_i h_i$ *where* γ_i is layer unit weight h_i is layer thickness	

CPT Interpretations

Interpreted Parameter	Description	Equation	Ref
E. Stress σ_v'	Effective vertical overburden stress at Mid Layer Depth	$Estress = Tstress - u_{eq}$	
Ueq	Equilibrium pore pressure determined from one of the following user selectable options: 1) hydrostatic from water table depth 2) user supplied profile	For hydrostatic option: $u_{eq} = \gamma_w \bullet (D - D_{wt})$ where u_{eq} is equilibrium pore pressure γ_w is unit weight of water D is the current depth D_{wt} is the depth to the water table	
Cn	SPT N_{60} overburden correction factor	$Cn=(\sigma_v')^{-0.5}$ where σ_v' *is in tsf* $0.5 < C_n < 2.0$	
N_{60}	SPT N value at 60% energy calculated from qt/N ratios assigned to each SBT zone. This method has abrupt N value changes at zone boundaries.	*See Figure 1*	4, 5
N_{60} (Ic)	SPTN Value at 60% energy. This method is a slight modification of the Jefferies and Davies technique whereby the qt/N ratio varies across soil classification zones based on the Ic parameter. This techniques is limited to zones 2 through 7 on the normalized Soil Behavior Type Chart	*See Figure 1*	5, 8
$(N_1)_{60}$	SPT N_{60} value corrected for overburden pressure	$(N_1)_{60} = Cn \bullet N_{60}$	4
$\Delta(N_1)_{60}$	Equivalent Clean Sand Correction to $(N_1)_{60}$	$\Delta(N_1)_{60} = \frac{K_{SPT}}{1 - K_{SPT}} \bullet (N_1)_{60}$ Where: K_{SPT} is defined as: 0.0 for FC < 5% 0.0167 • (FC - 5) for 5% < FC < 35% 0.5 for FC > 35% FC - Fines Content in %	4
$(N_1)_{60cs}$	Equivalent Clean Sand $(N_1)_{60}$	$(N1)_{60cs} = (N1)_{60} + \Delta(N1)_{60}$	4
Su	Undrained shear strength - N_{kt} is user selectable	$Su = \frac{qt - \sigma_v}{N_{kt}}$	1, 5
k	Coefficient of permeability (assigned to each SBT zone)		5
Bq	Pore pressure parameter	$Bq = \frac{\Delta u}{qt - \sigma_v}$ *where:* $\Delta u = u - u_{eq}$ *and u = dynamic pore pressure* *u_{eq} = equilibrium pore pressure*	1, 5
Q_t	Normalized q_t for Soil Behavior Type classification as defined by Robertson, 1990	$Qt = \frac{qt - \sigma_v}{\sigma_v'}$	2, 5
F_r	Normalized Friction Ratio for Soil Behavior Type classification as defined by Robertson, 1990	$Fr = 100\% \bullet \frac{fs}{qt - \sigma_v}$	2, 5
SBTn	Normalized Soil Behavior Type as defined by Robertson and Campanella	See Figure 2	2, 5

CPT Interpretations

Interpreted Parameter	Description	Equation	Ref
q_{c1}	q_t normalized for overburden stress used for seismic analysis	$q_{c1} = q_t \bullet (Pa/\sigma_v')^{0.5}$ where: Pa = atm. Pressure q_t is in MPa	3
q_{c1N}	q_{c1} in dimensionless form used for seismic analysis	$q_{c1N} = q_{c1} / Pa$ where: Pa = atm. pressure	3
K_c	Equivalent clean sand correction for q_{c1N}	*$K_c = 1.0$ for $I_c \leq 1.64$* *$K_c = f(I_c)$ for $I_c > 1.64$ (see reference)* *$K_c = 1.0$ for $1.64 < I_c < 2.36$ and $Fc < 0.5\%$*	3
q_{c1Ncs}	Clean Sand equivalent q_{c1N}	$q_{c1Ncs} = q_{c1N} \bullet K_c$	3
I_c	Soil index for estimating grain characteristics	$Ic = [(3.47 - \log_{10}Q)^2 + (\log_{10} Fr + 1.22)^2]^{0.5}$ *Where:* $Q = \left(\frac{qt - \sigma_v}{P_{a2}}\right)\left(\frac{P_a}{\sigma_v'}\right)^n$ *And* *Fr is in percent* *P_a = atmospheric pressure* *P_{a2} = atmospheric pressure* *n varies from 0.5 to 1.0 and is selected in an iterative manner based on the resulting I_c*	3, 8
FC	Apparent fines content (%)	*$FC=1.75(Ic^{3.25}) - 3.7$* *$FC=100$ for $Ic > 3.5$* *$FC=0$ for $Ic < 1.26$* *$FC = 5\%$ if $1.64 < Ic < 2.6$ AND $F_r<0.5$*	3
Ic Zone	This parameter is the Soil Behavior Type zone based on the Ic parameter (valid for zones 2 through 7 on SBTn chart)	Ic < 1.31 Zone = 7 1.31 < Ic < 2.05 Zone = 6 2.05 < Ic < 2.60 Zone = 5 2.60 < Ic < 2.95 Zone = 4 2.95 < Ic < 3.60 Zone = 3 Ic > 3.60 Zone = 2	3
PHI ϕ	Friction Angle determined from one of the following user selectable options: a) Campanella and Robertson b) Durgunoglu and Mitchel c) Janbu	See reference	5
Dr	Relative Density determined from one of the following user selectable options: a) Ticino Sand b) Hokksund Sand c) Schmertmann 1976 d) Jamiolkowski - All Sands	See reference	5
OCR	Over Consolidation Ratio – 2 methods available	a) Based on Schmertmann's method involving a plot of $S_u/\sigma_v' / (S_u/\sigma_v')_{NC}$ and OCR b) Based on $OCR = K \bullet \left(\frac{qt - \sigma_v}{\sigma_v'}\right)$ where an average value of k=0.3 is used	5
State Parameter	The state parameter is used to describe whether a soil is contractive (SP is positive) or dilative (SP is negative) at large strains based on the work by Been and Jefferies	See reference	9, 7, 5

CPT Interpretations

Interpreted Parameter	Description	Equation	Ref
CRR	Cyclic Resistance Ratio (for M=7.5)	*For* $(q_{c1N})_{cs} < 160$: $CRR = 93 \bullet \left(\frac{(q_{c1N})cs}{1000}\right)^3 + 0.08$ *For* $(q_{c1N})_{cs} < 50$: $CRR = 0.833 \bullet \left(\frac{(q_{c1N})cs}{1000}\right)^3 + 0.05$	5
Youngs Modulus E	Youngs Modulus based on the work by Baldi. There are three types of sands considered in this technique. The user selects the approriate type for the site from: a) OC Sands b) Aged NC Sands c) Recent NC Sands Each sand type has a family of curves that depend on mean normal stress. The program calculates mean normal stress and linearly interpolates between the two extremes provided in Baldi's chart.	Mean normal stress is evaluated from: $\sigma'_m = \frac{1}{3} \bullet (\sigma'_v + \sigma'_h + \sigma'_h)$ where σ_v'= vertical effective stress σ_h'= horizontal effective stress and $\sigma_h = K_o * \sigma_v'$ with Ko assumed to be 0.5	5
K_o	Coefficient of lateral earth pressure at rest.	$K_o = 0.1 \bullet \left(\frac{q_t - \sigma_{v0}}{\sigma'_v}\right)$	5

Savannah River Site Specific Parameters

Interpreted Parameter	Description	Equation	Ref
Ic	Ic based on normalized data at the Savannah River Site; developed by Frank Syms and SGS	$Ic = [(1.95 - \log_{10}Q)^2 + (\log_{10} Fr + 1.78)^2]^{0.5}$ *Where: Q is the normalized tip resistance And Fr is the normalized friction ratio*	10
FC	Fines content based on the normalized Savannah River Site Ic parameter; developed by Frank Syms and SGS	$FC = (5.31 * (I_c)^{2.31}) + 9.61$ For FC > 100 and q_t < 15 tsf the material is flagged as a soft zone	10
FC	Fines Content directly from non-normalized data at the Savannah River Site; developed by Frank Syms and SGS	$FC = [(3.58 - \log_{10}(qtsf))^2 + (1.43 + \log_{10}(Rf))^2]^{1.8}$ For FC > 100 and q_t < 15 tsf the material is flagged as a soft zone *Where: qtsf is the non-normalized tip resistance in tsf Rf is the non-normalized friction ratio*	11

Figure 1
Non-Normalized Behavior Type Classification Chart

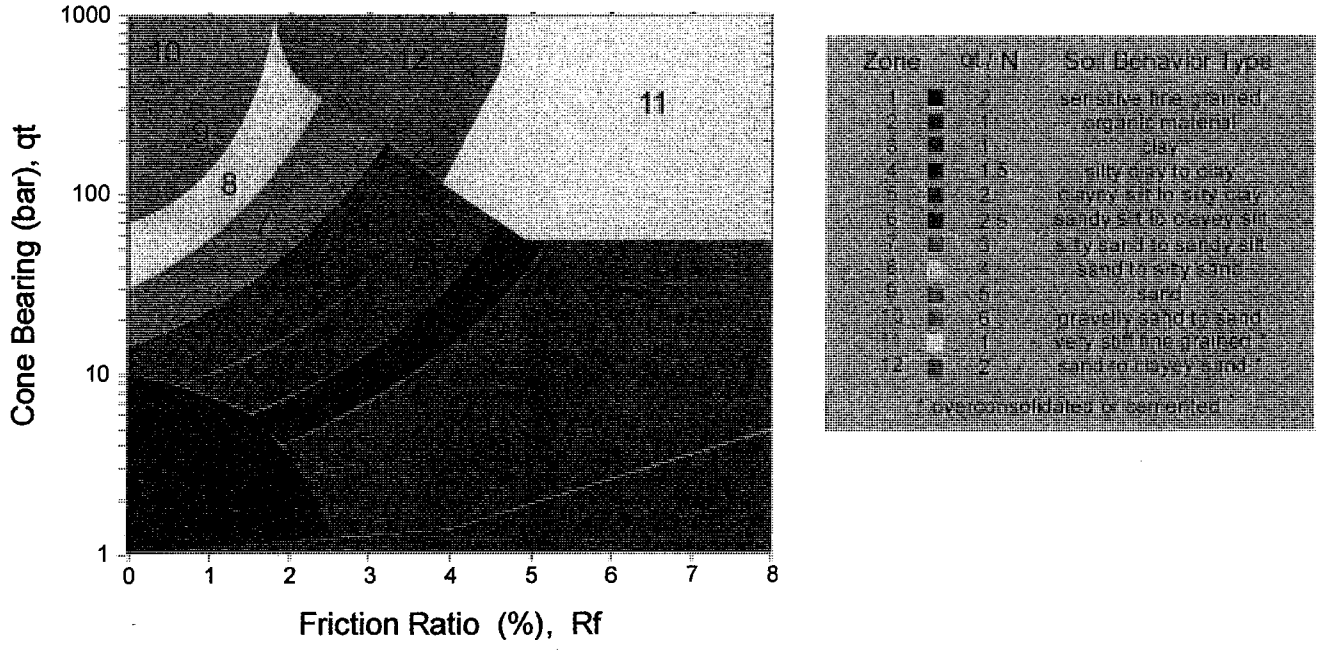
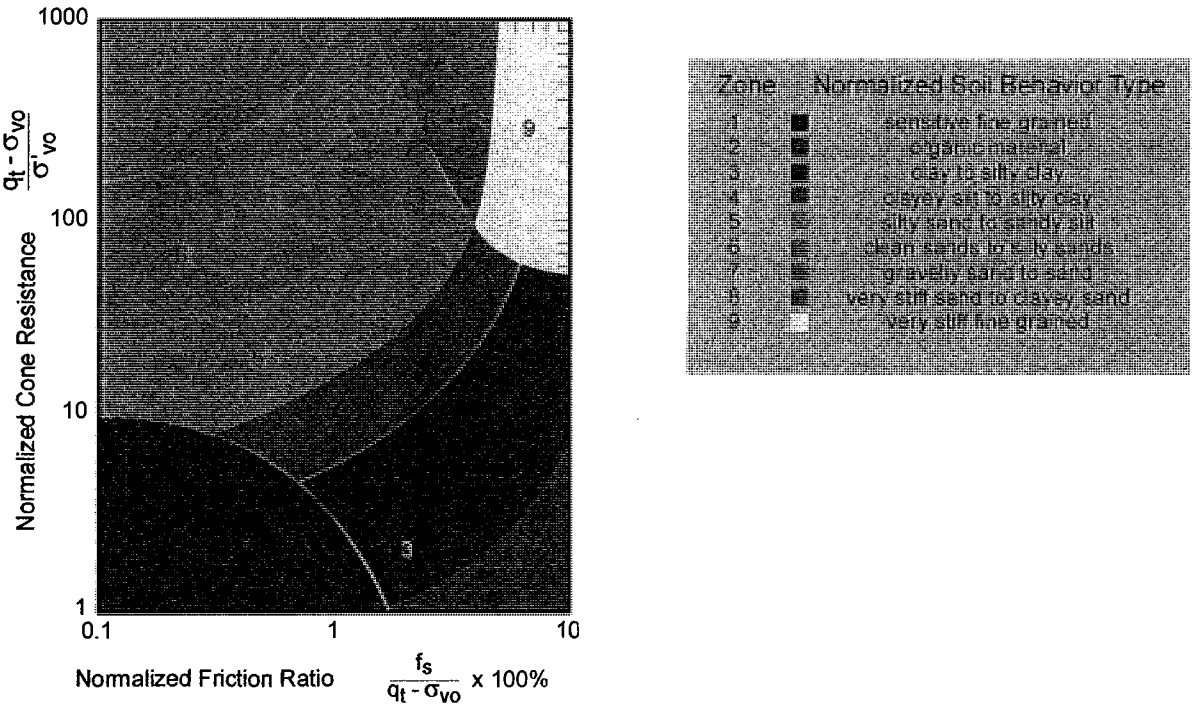


Figure 2
Normalized Behavior Type Classification Chart



GREGG

Table 2
References

No.	References
1	Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986, "Use of Piezometer Cone Data", Proceedings of InSitu 86, ASCE Specialty Conference, Blacksburg, Virginia.
2	Robertson, P.K., 1990, "Soil Classification Using the Cone Penetration Test", Canadian Geotechnical Journal, Volume 27.
3	Robertson, P.K. and Fear, C.E., 1998, "Evaluating cyclic liquefaction potential using the cone penetration test", Canadian Geotechnical Journal, 35: 442-459.
4	Robertson, P.K. and Wride, C.E., 1998, "Cyclic Liquefaction and its Evaluation Based on SPT and CPT", NCEER Workshop Paper, January 22, 1997
5	Lunne, T., Robertson, P.K. and Powell, J. J. M., 1997, " Cone Penetration Testing in Geotechnical Practice," Blackie Academic and Professional.
6	GREGG IN SITU Internal Report
7	Plewes, H.D., Davies, M.P. and Jefferies, M.G., 1992, "CPT Based Screening Procedure for Evaluating Liquefaction Susceptibility", 45th Canadian Geotechnical Conference, Toronto, Ontario, October 1992.
8	Jefferies, M.G. and Davies, M.P., 1993. "Use of CPTu to Estimate equivalent N_{60}", Geotechnical Testing Journal, 16(4): 458-467.
9	Been, K. and Jefferies, M.P., 1985, "A state parameter for sands", Geotechnique, 35(2), 99-112.
10	Frank Syms, Bechtel Corp (Savannah River Site), 2001, "CPTU Fines Content Determination", Calculation No. K-CIC-G-00065 Revision 0.
11	Frank Syms, Bechtel Corp (Savannah River Site) – personal communication

Appendix C
Geotechnical Laboratory Test Results

SMITH-EMERY COMPANY
The Full Service Independent Testing Laboratory, Established 1904

Hunters Point Shipyard, Bldg. 114
P. O. Box 880550
San Francisco, California 94188
(415) 330-3000 Fax (415) 330-3030

791 East Washington Blvd.
Los Angeles, California 90021-3043
(213) 749-3411
Fax (213) 746-7228

GEOSERVICES DIVISION
MAR 1 3 2003

March 11, 2003

SECo File No. 2058
SECo Report No. 03-135

One Walnut Creek Center
100 Pringle Avenue, Sulte 300
Walnut Creek, California 94596

Attn: Mr. Michael Gray

Re: CDM Project No. 13452-35952-TK16.Design
Sherwin-Williams SB-11 and SB-12

SUBJECT: REPORT OF TESTS

TEST STANDARDS: ASTM D2216 (Moisture Content), ASTM D2937 (Dry Unit Weight), ASTM D4318 (Atterberg Limits), ASTM D422 (Sieve Analysis), ASTM D3080 (Direct Shear Test), and ASTM D2435 (Consolidation Test)

SOURCE: Soil boring samples from the Sherwin-Williams Geotechnical Investigation were submitted to our laboratory by your representative on February 6, 2003.

REPORT OF TESTS

In compliance with the request of your authorized representative, we have conducted the subject tests, as per your requirements for the above referenced project. Test results for the moisture content, dry unit weight, and Atterberg Limits are presented on the following table. The Sieve Analysis, Atterberg Limits, Direct Shear, and Consolidation test results/graphs are attached.

Respectfully submitted,
SMITH-EMERY COMPANY

Patrick Morrison

PATRICK MORRISON, R.G. #7174
Registered Geologist
Geoservices Division Manager, SF

Attachments: Sieve Analysis, Atterberg Limits, Direct Shear, and Consolidation test results/graphs

Cc: 2-Addressee

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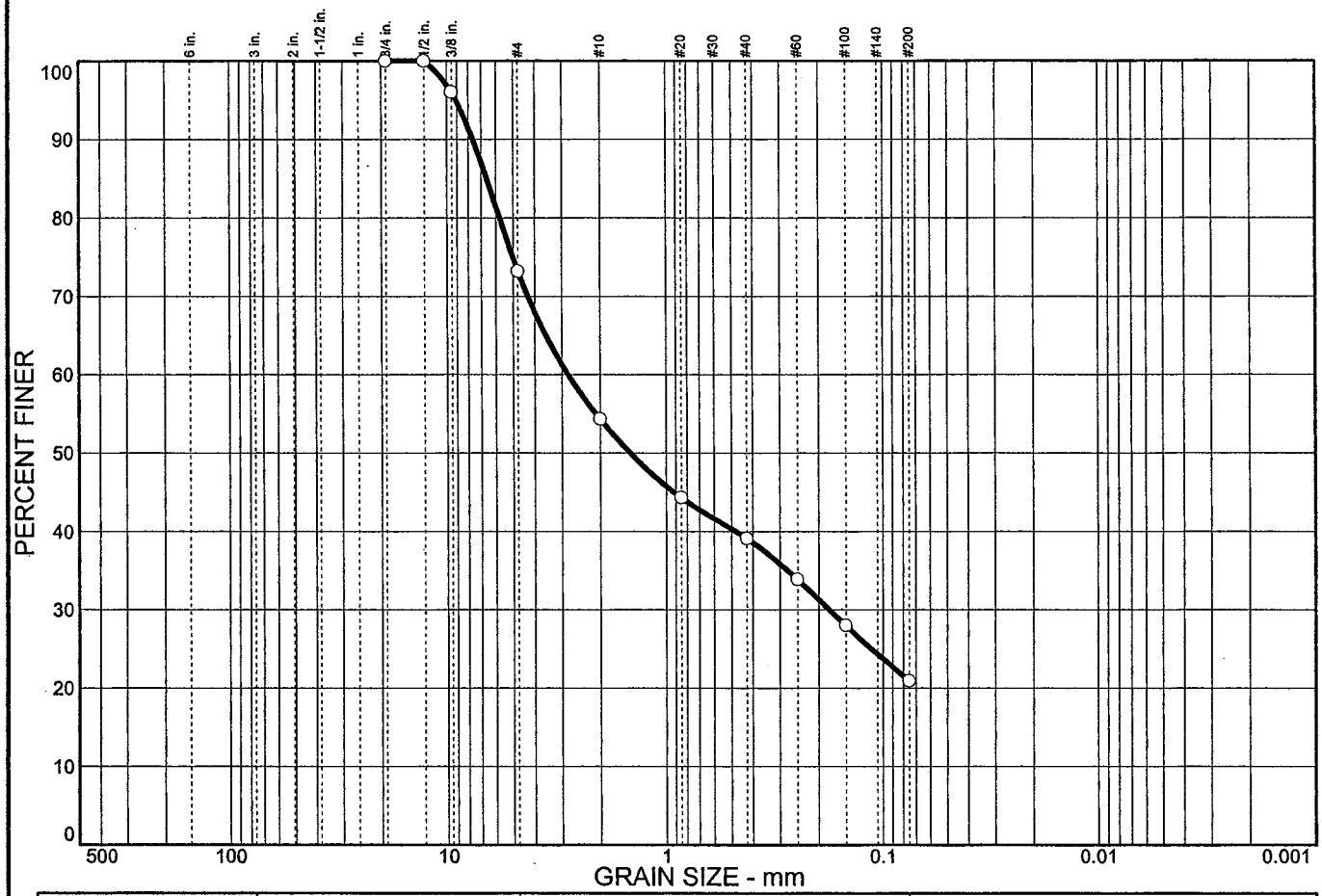
Re: CDM Project No. 13452-35952-TK16.Design
Sherwin Williams SB-11 and SB-12

REPORT OF TESTS

Boring No.	Depth (ft)	Dry Unit Weight (pcf)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Reports/Graphs Attached
SB-11	18.5	--	--	34	15	19	Plasticity Chart, Direct Shear
SB-11	21	--	--	--	--	--	Sieve Analysis
SB-11	25	97.6	25.0	--	--	--	--
SB-11	27	--	--	30	14	16	Plasticity Chart, Direct Shear
SB-11	30	--	--	--	--	--	Sieve Analysis
SB-11	35	102.6	24.2	--	--	--	Consolidation
SB-11	40			36	16	20	Plasticity Chart
SB-11	45	113.3	18.0	33	15	18	Plasticity Chart, Direct Shear
SB-11	55	118.9	16.2	--	--	--	--
SB-11	65	--	--	39	20	19	Plasticity Chart, Consolidation
SB-12	15	--	--	31	15	16	Plasticity Chart, Direct Shear
SB-12	25	--	--	46	13	33	Plasticity Chart, Consolidation
SB-12	30	--	--	49	22	27	Plasticity Chart, Direct Shear
SB-12	35	--	--	--	--	--	Sieve Analysis
SB-12	40	111.0	18.5	--	--	--	Consolidation
SB-12	45	--	--	33	15	18	Plasticity Chart
SB-12	60	99.8	25.8	70	16	54	Plasticity Chart
SB-12	65	--	--	47	16	31	Plasticity Chart
SB-12	70	114.3	17.5	--	--	--	--

SIEVE ANALYSIS RESULTS / GRAPHS

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	26.8	18.9	15.2	18.2	20.9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.50 in.	100.0		
.375 in.	96.0		
#4	73.2		
#10	54.3		
#20	44.3		
#40	39.1		
#60	33.9		
#100	28.0		
#200	20.9		

* (no specification provided)

Soil Description

Gray clayey gravelly Sand

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 6.60 D_{60}= 2.82 D_{50}= 1.46
D_{30}= 0.179 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

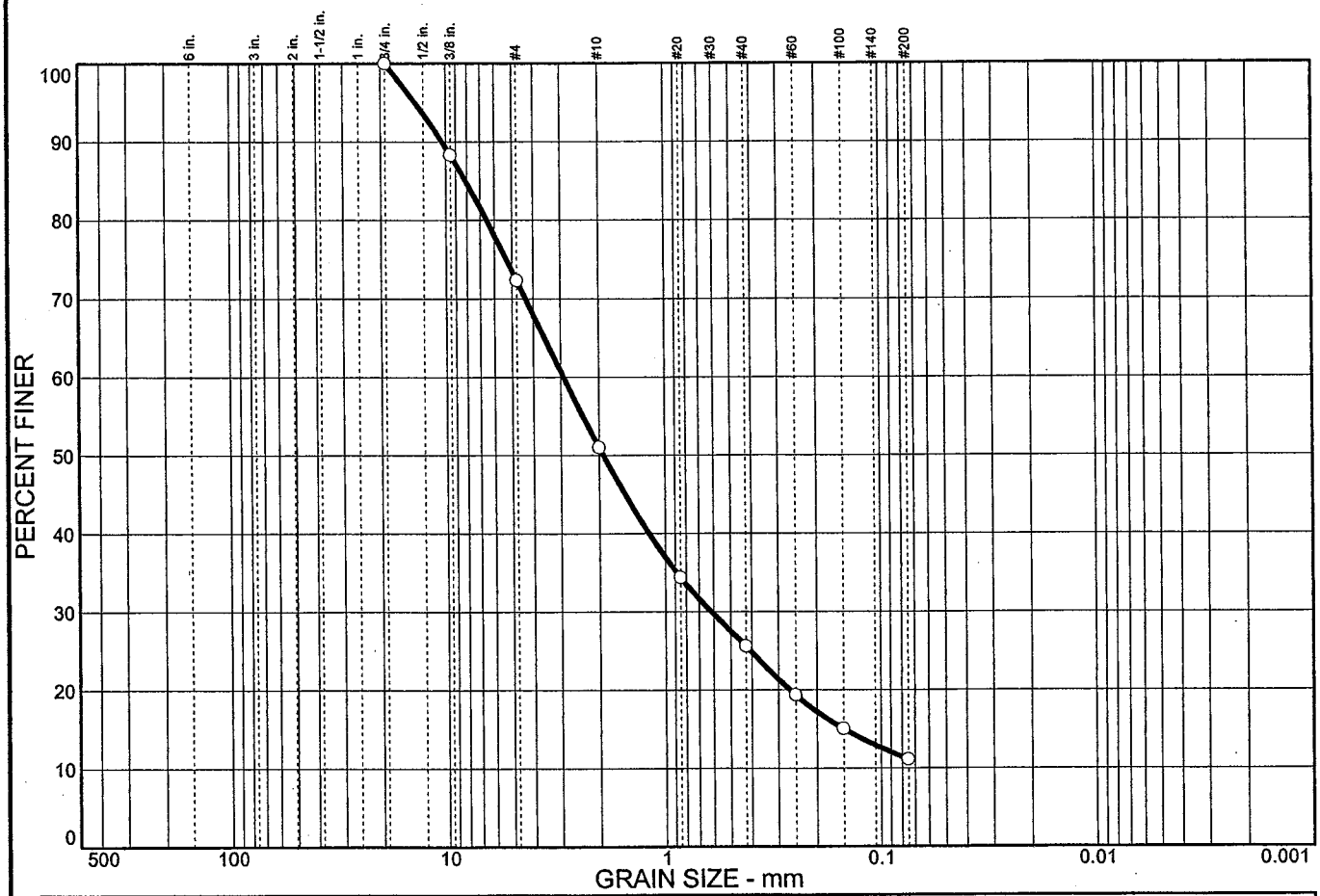
Sample No.: SB-11 **Source of Sample:** CDM-Sherwin Williams **Date:** 2-24-03
Location: **Elev./Depth:** 21

Smith-Emery Company

Client: CDM Inc.
Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No: 2058-2 **Plate** 1

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	27.7	21.3	25.4	14.5	11.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	100.0		
.375 in.	88.3		
#4	72.3		
#10	51.0		
#20	34.4		
#40	25.6		
#60	19.3		
#100	15.0		
#200	11.1		

* (no specification provided)

Soil Description

Brown gravelly Sand with silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 8.12 D_{60}= 2.91 D_{50}= 1.91
D_{30}= 0.614 D_{15}= 0.150 D_{10}=
C_u= C_c=

Classification

USCS= SP-SM AASHTO=

Remarks

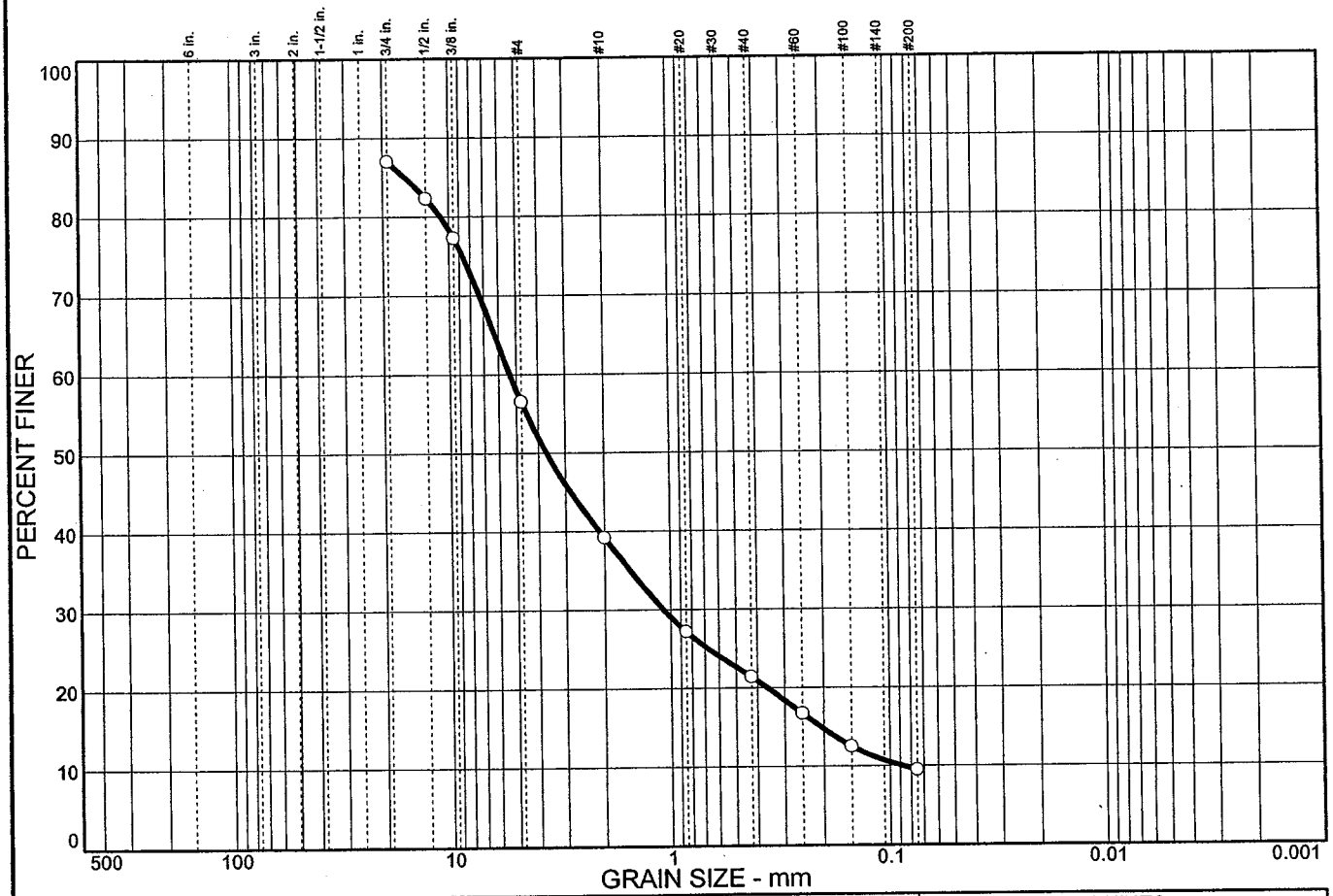
Sample No.: SB-11 **Source of Sample:** CDM-Sherwin Williams **Date:** 2-24-03
Location: **Elev./Depth:** 30

Smith-Emery Company

Client: CDM Inc.
Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No: 2058-2 **Plate** 2

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
		30.5	17.3	17.8	11.9	9.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75 in.	87.0		
.50 in.	82.3		
.375 in.	77.3		
#4	56.5		
#10	39.2		
#20	27.2		
#40	21.4		
#60	16.7		
#100	12.5		
#200	9.5		

* (no specification provided)

Soil Description

Brown gravelly Sand with silt

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 15.8 D_{60}= 5.34 D_{50}= 3.66
D_{30}= 1.08 D_{15}= 0.207 D_{10}= 0.0874
C_u= 61.12 C_c= 2.48

Classification

USCS= SW-SM AASHTO=

Remarks

Sample No.: SB-12 **Source of Sample:** CDM-Sherwin Williams **Date:** 2-24-03
Location: **Elev./Depth:** 35

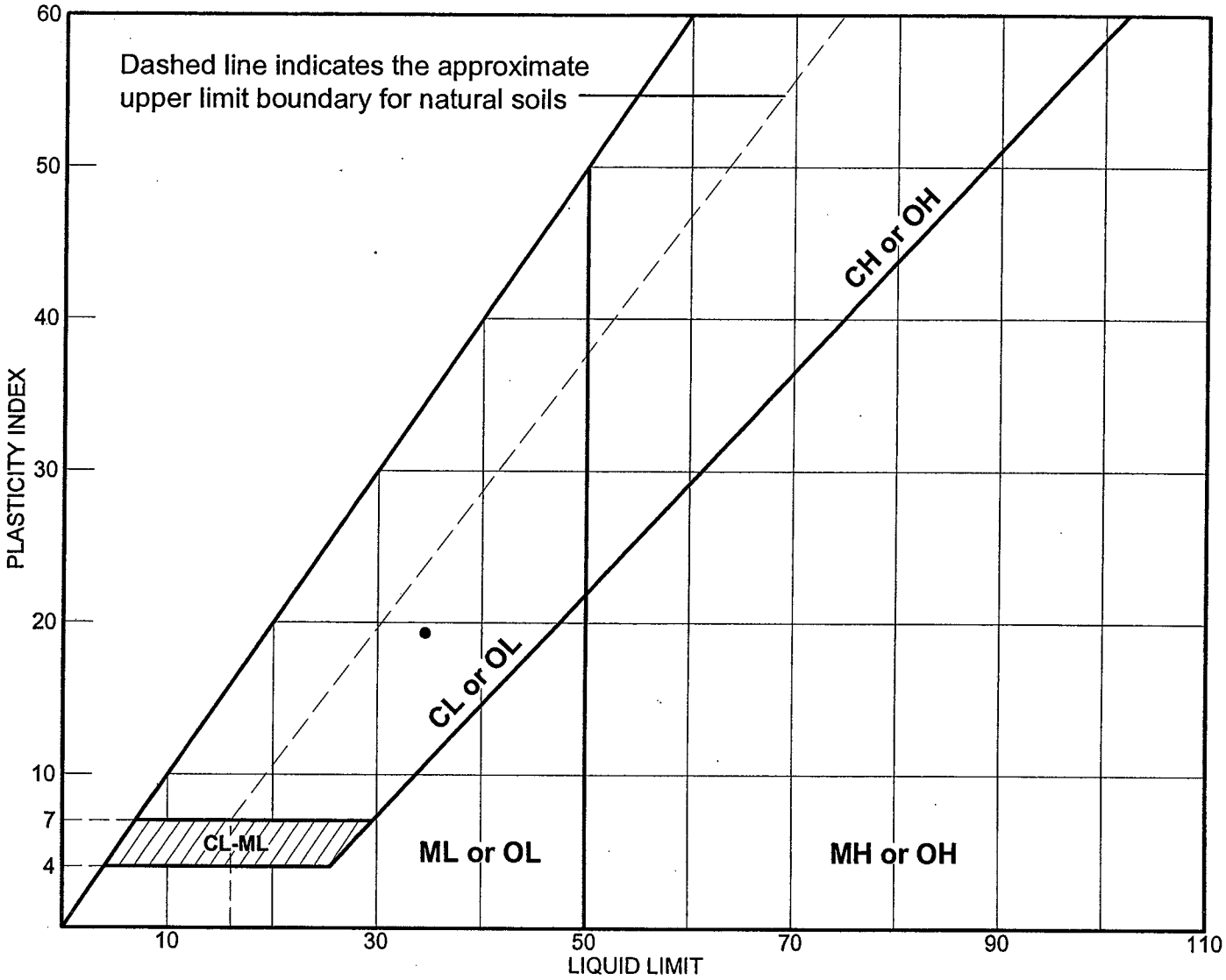
Smith-Emery Company

Client: CDM Inc.
Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No: 2058-2 **Plate** 3

ATTERBERG LIMITS PLASTICITY CHARTS

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	CDM-Sherwin Williams	SB-11	18.5		15.3	34.6	19.3	

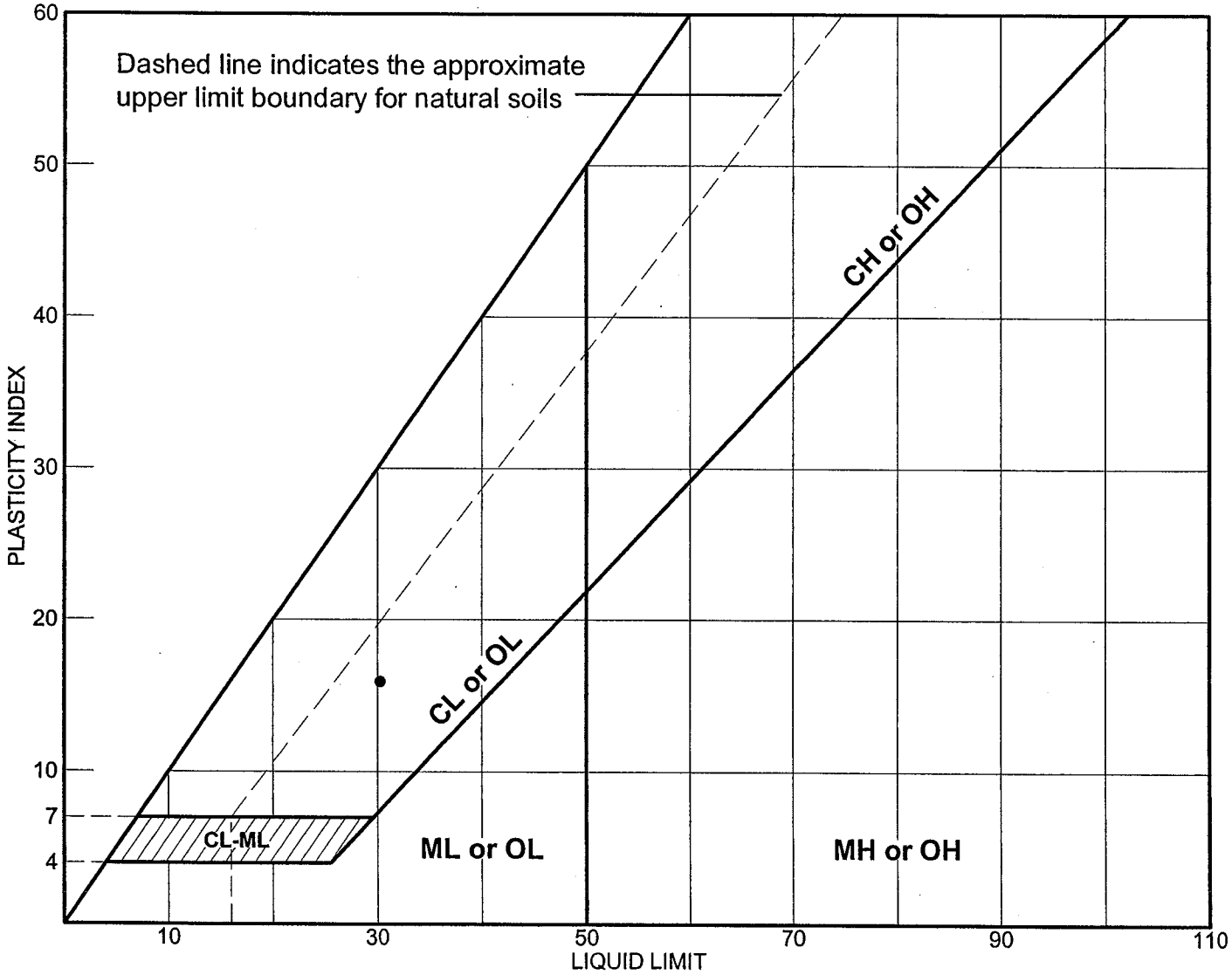
Smith-Emery Company

Client: CDM Inc.

Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No.: 2058-2 **Plate** 4

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	CDM-Sherwin Williams	SB-11	27		14.4	30.3	15.9	

Smith-Emery Company

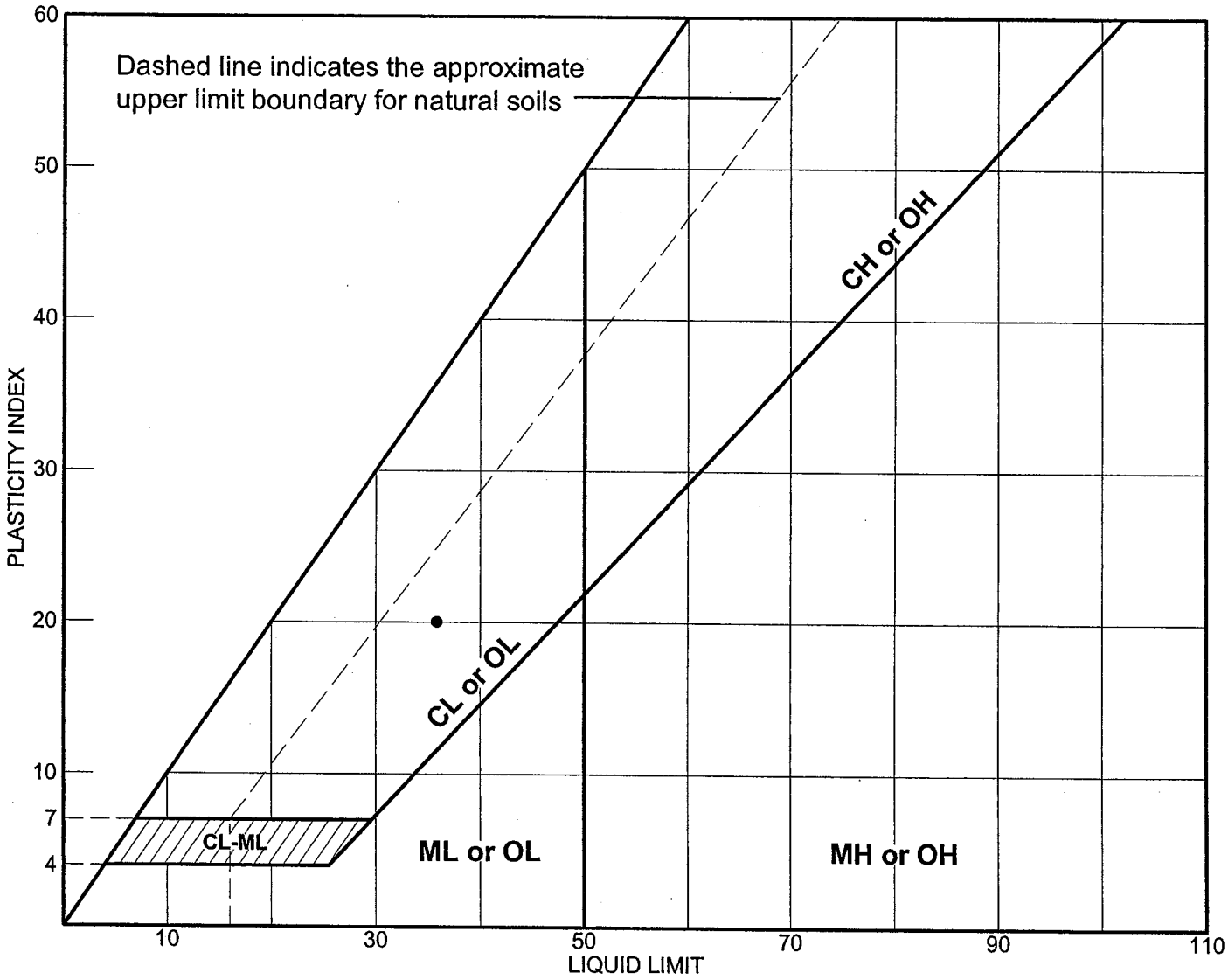
Client: CDM Inc.

Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No.: 2058-2

Plate 5

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	CDM-Sherwin Williams	SB-11	40		15.9	35.9	20.0	

Smith-Emery Company

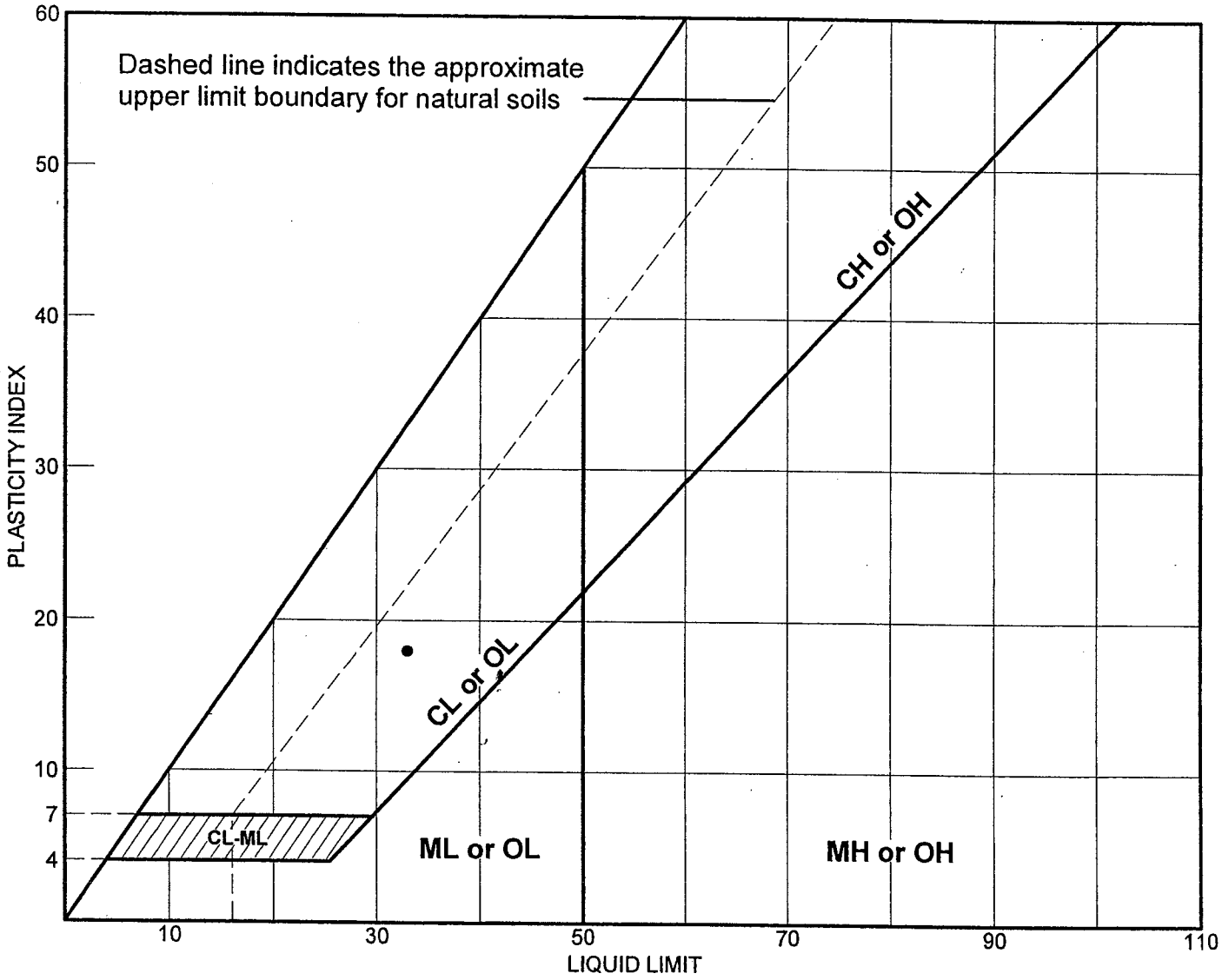
Client: CDM Inc.

Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No.: 2058-2

Plate 6

LIQUID AND PLASTIC LIMITS TEST REPORT



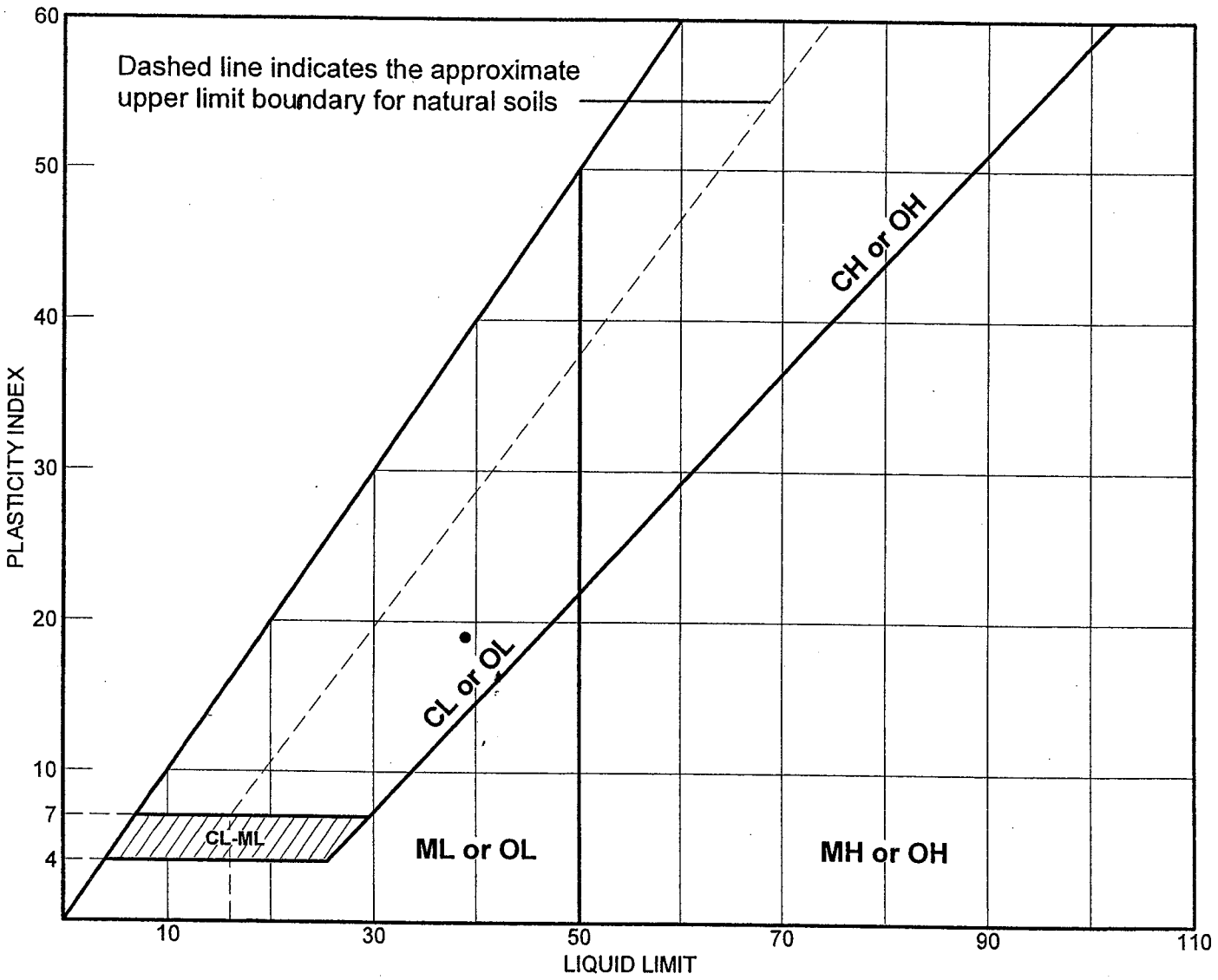
SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	Sherwin	SB11-45	45 ft.		15	33	18	CL

Smith-Emery Company

Client: SHERWIN WILLIAMS
Project: 13452-35952-TK16.DESIGN
Project No.: 2058-2

Plate 7

LIQUID AND PLASTIC LIMITS TEST REPORT

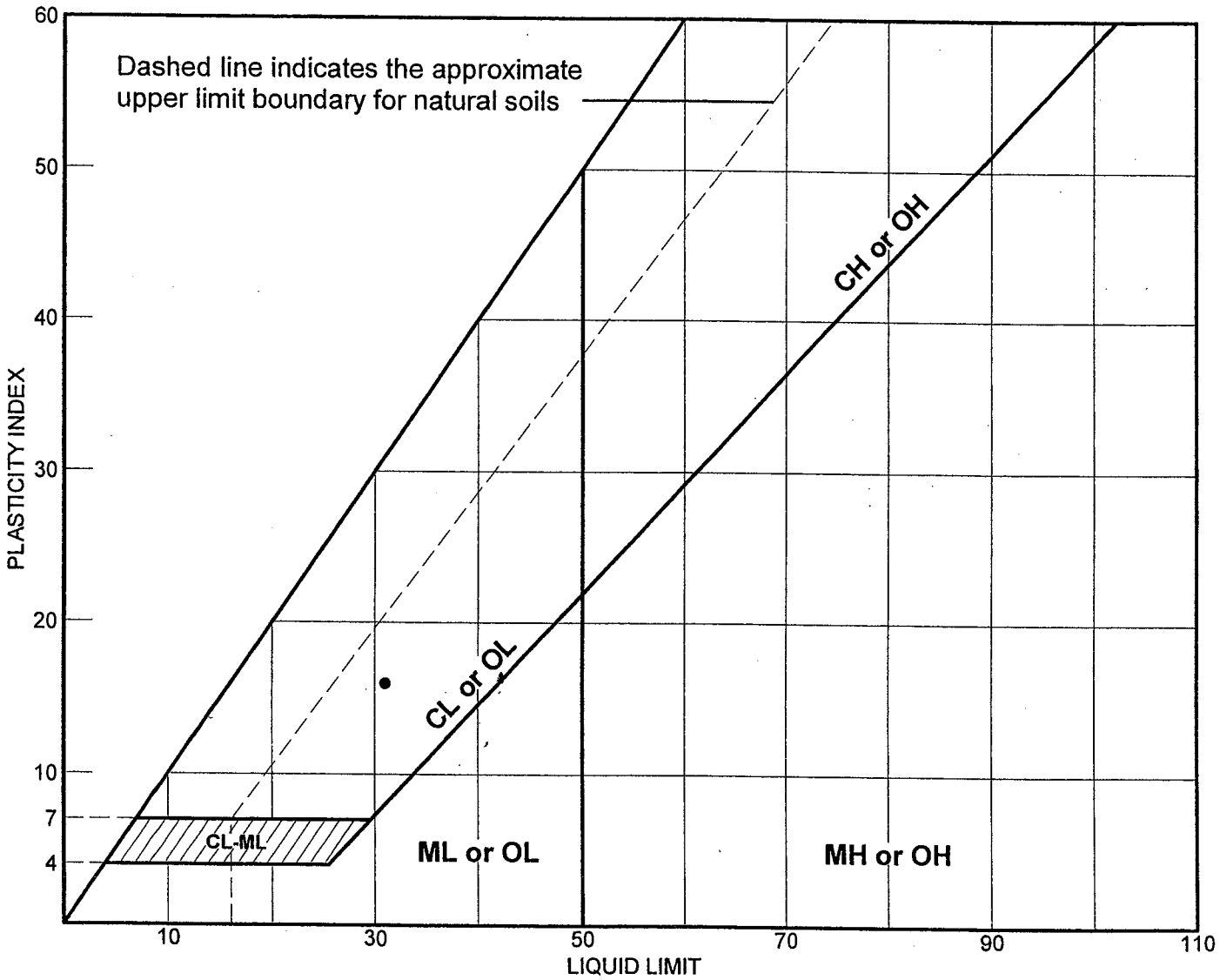


SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	Sherwin	SB11-65	65 ft.		20	39	19	CL

Smith-Emery Company

Client: SHERWIN WILLIAMS
Project: 13452-35952-TK16.DESIGN
Project No.: 2058-2
Plate 8

LIQUID AND PLASTIC LIMITS TEST REPORT

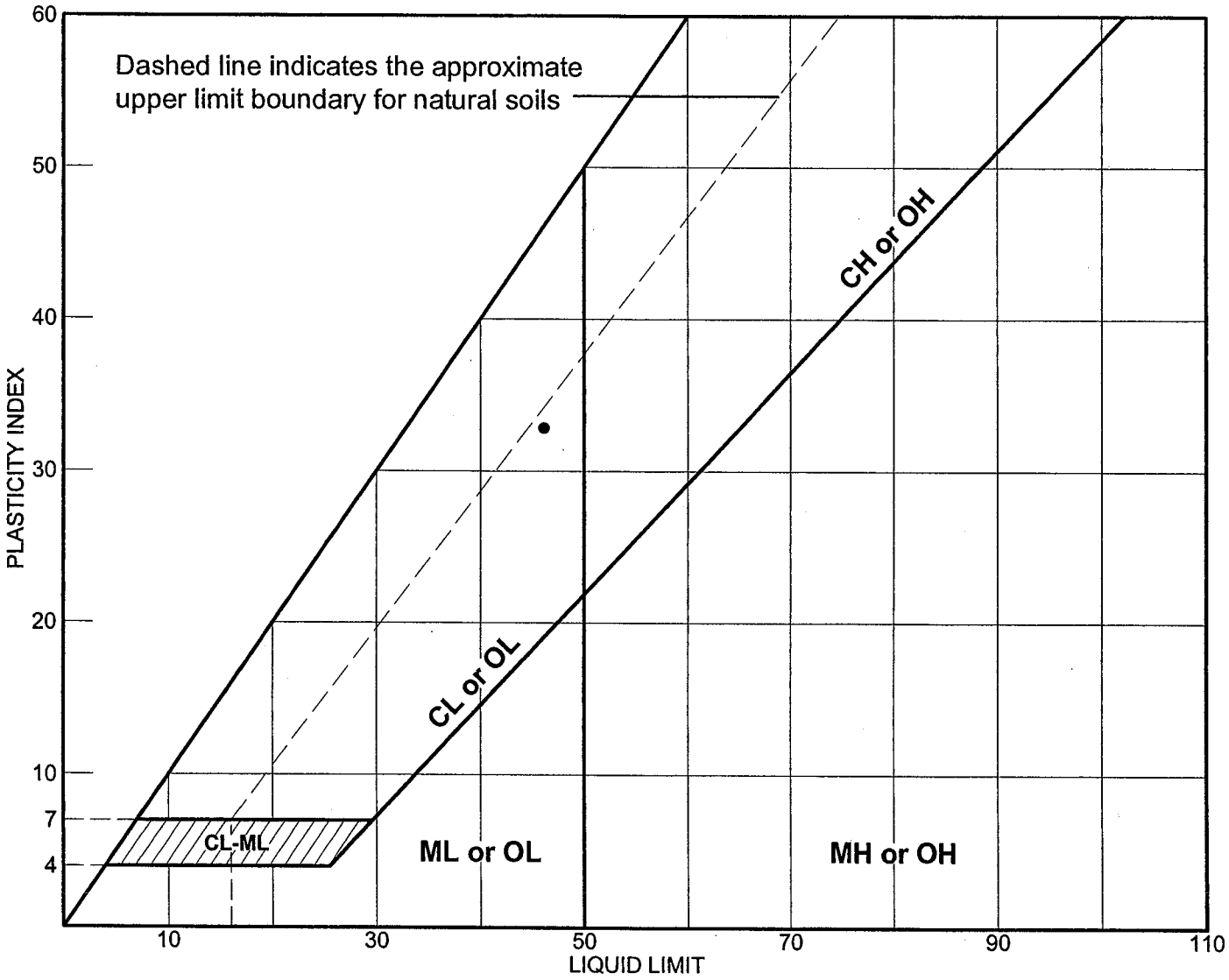


SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	Sherwin	SB12-15	15 ft.		15	31	16	CL

Smith-Emery Company

Client: SHERWIN WILLIAMS
Project: 13452-35952-TK16.DESIGN
Project No.: 2058-2

LIQUID AND PLASTIC LIMITS TEST REPORT



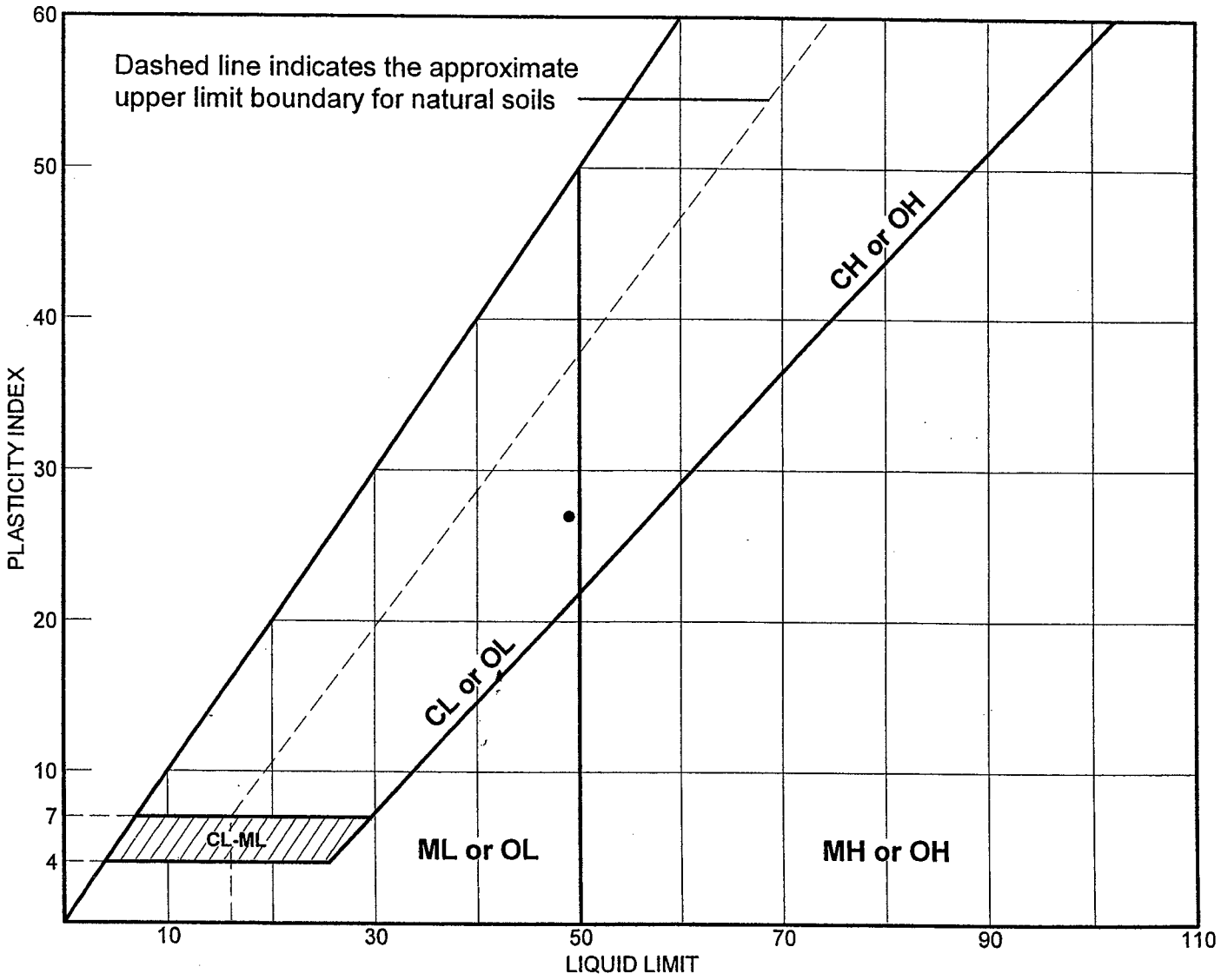
SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	CDM-Sherwin Williams	SB-12	25		13.4	46.2	32.8	

Smith-Emery Company

Client: CDM Inc.
Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No.: 2058-2 **Plate** 10

LIQUID AND PLASTIC LIMITS TEST REPORT



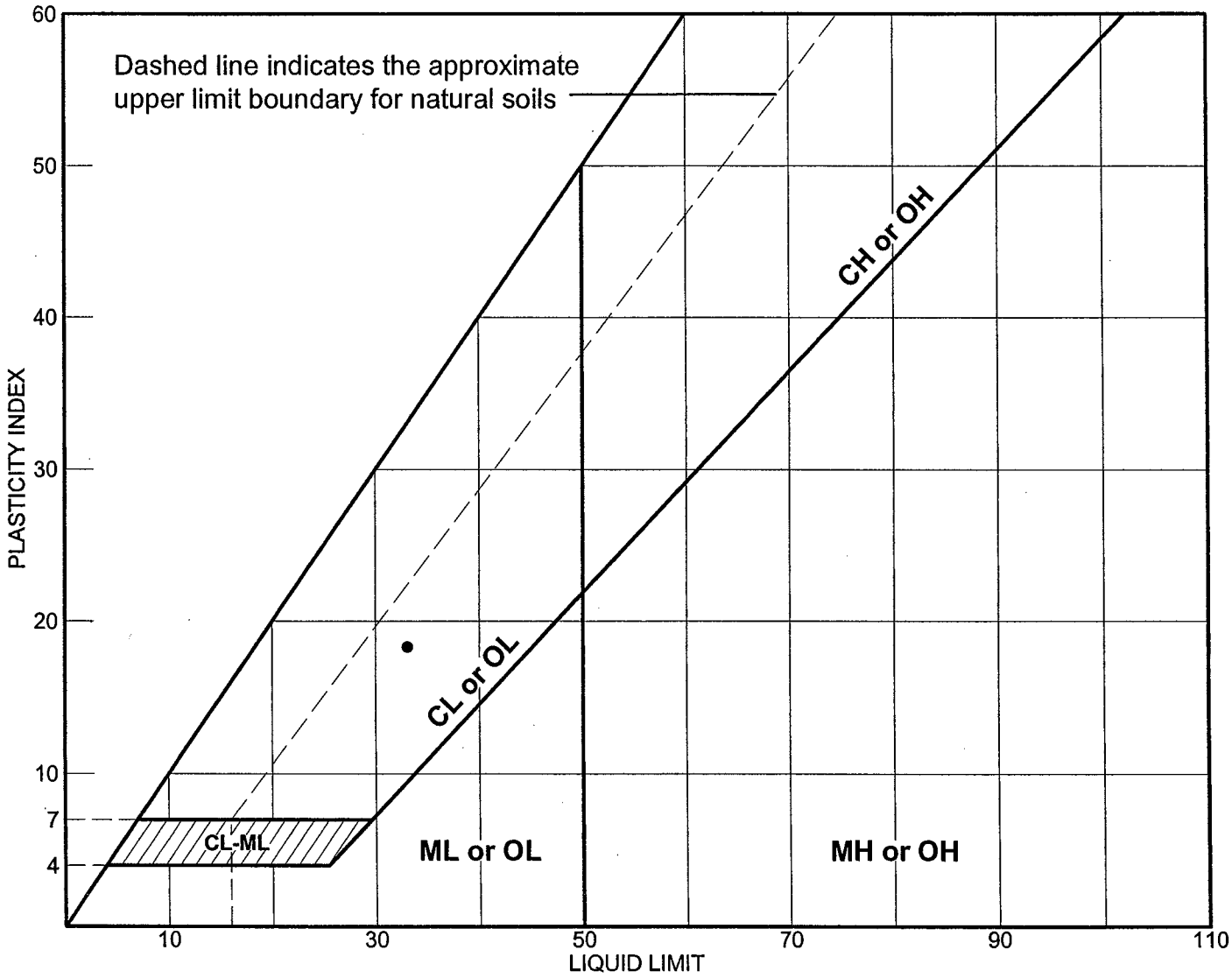
SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	Sherwin	SB12-30	30 ft.		22	49	27	CL

Smith-Emery Company

Client: SHERWIN WILLIAMS
Project: 13452-35952-TK16.DESIGN

Project No.: 2058-2 **Plate** 11

LIQUID AND PLASTIC LIMITS TEST REPORT



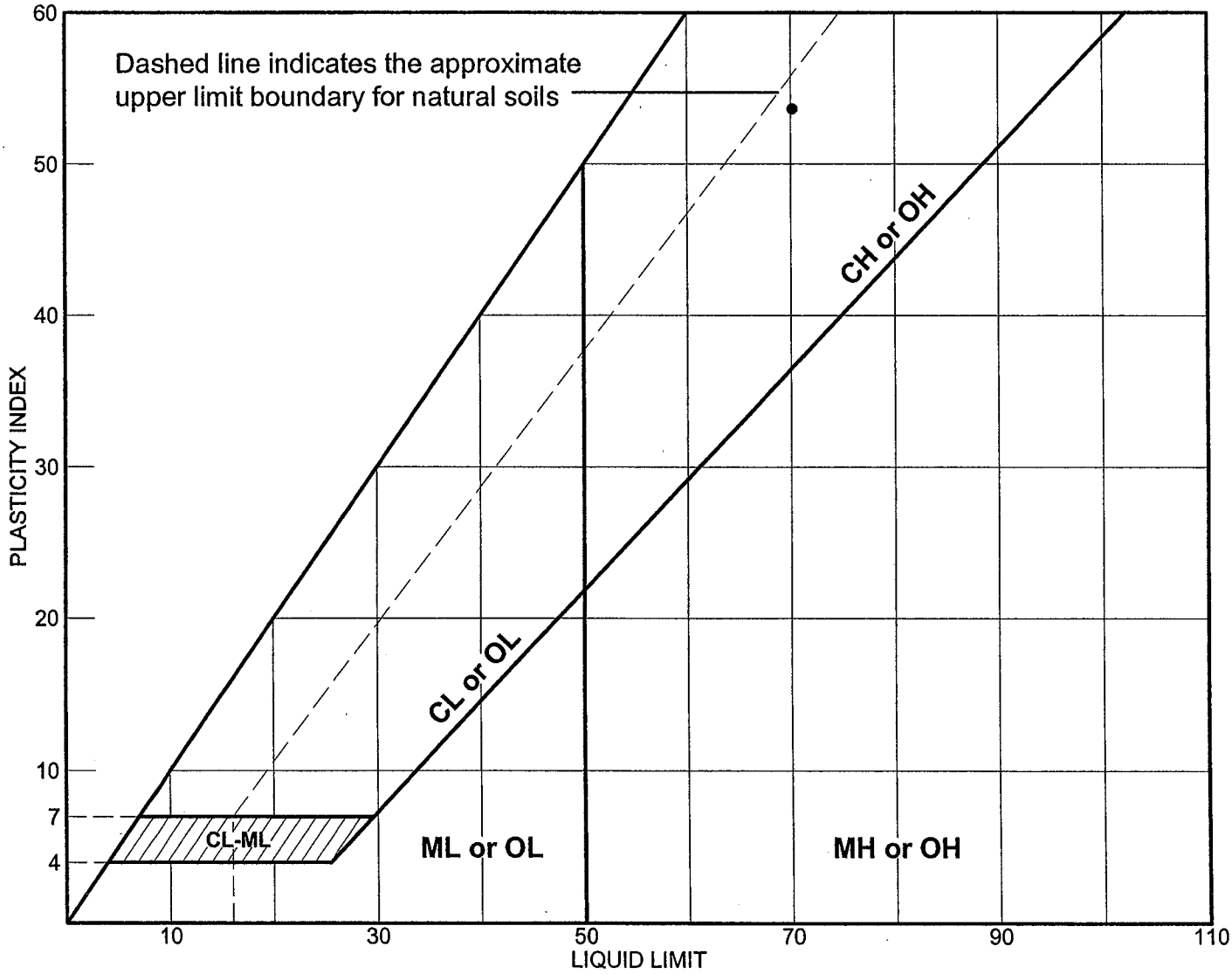
SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	CDM-Sherwin Williams	SB-12	45		14.8	33.1	18.3	

Smith-Emery Company

Client: CDM Inc.
Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No.: 2058-2 **Plate** 12

LIQUID AND PLASTIC LIMITS TEST REPORT



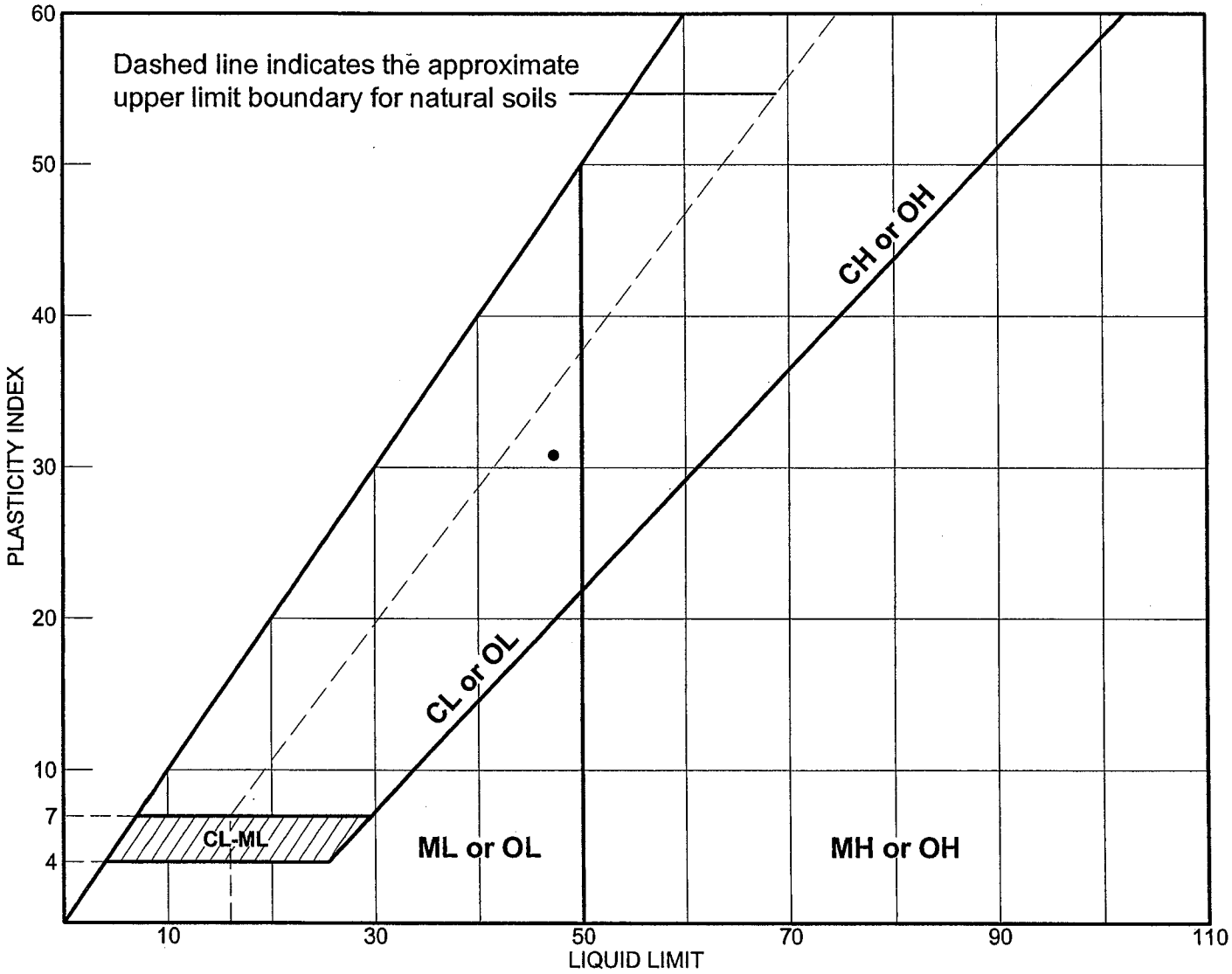
SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	CDM-Sherwin Williams	SB-12	60		16.6	70.2	53.6	

Smith-Emery Company

Client: CDM Inc.
Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No.: 2058-2 **Plate** 13

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA								
SYMBOL	SOURCE	SAMPLE NO.	DEPTH (ft.)	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	CDM-Sherwin Williams	SB-12	65		16.5	47.3	30.8	

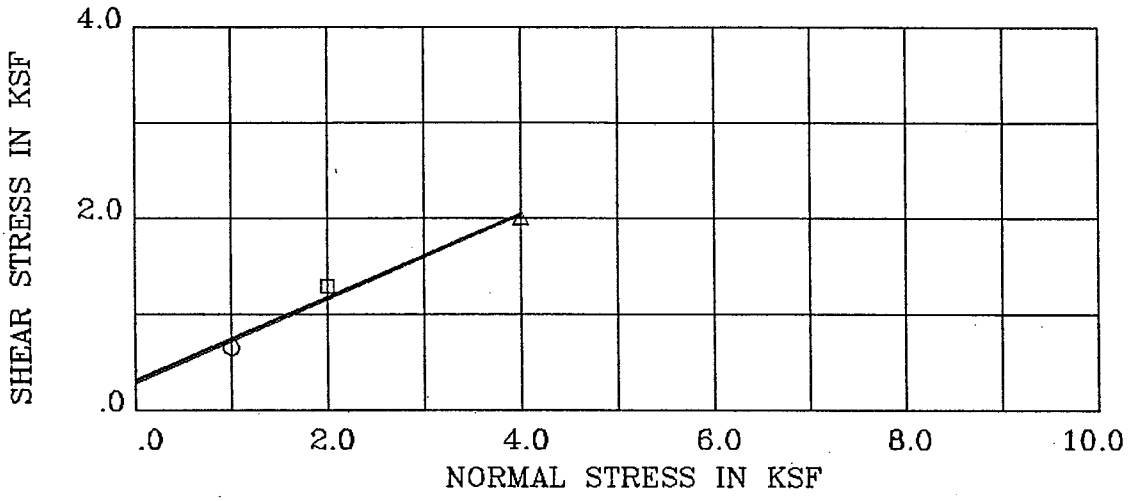
Smith-Emery Company

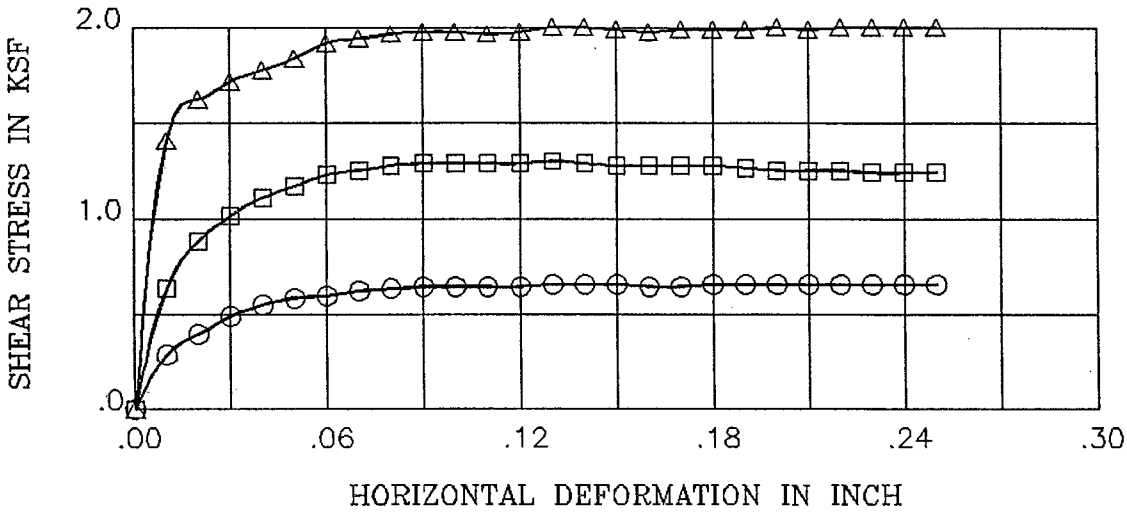
Client: CDM Inc.

Project: Sherwin Williams (CDM Project No. 13452-35952-TK16.Design)

Project No.: 2058-2 **Plate** 14

DIRECT SHEAR TESTS



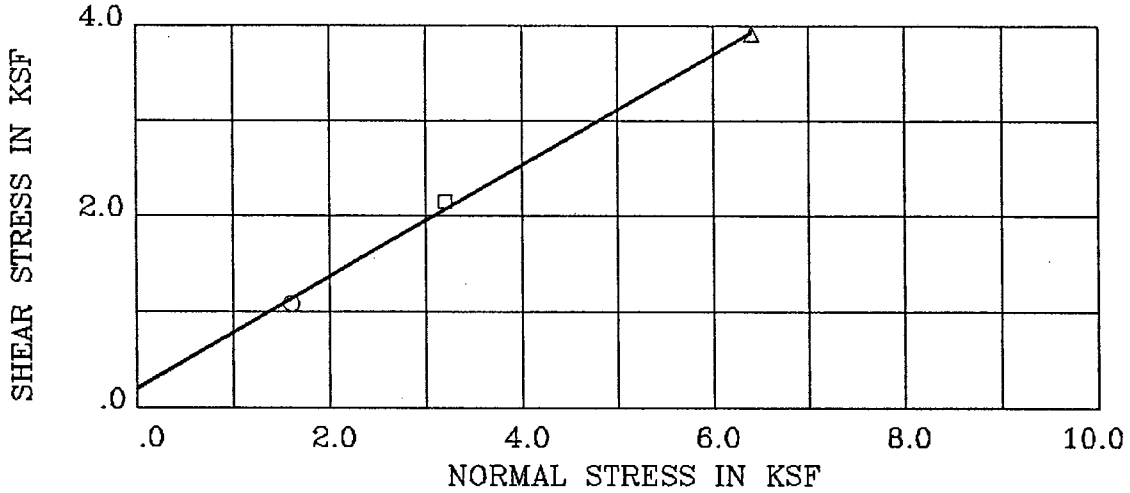


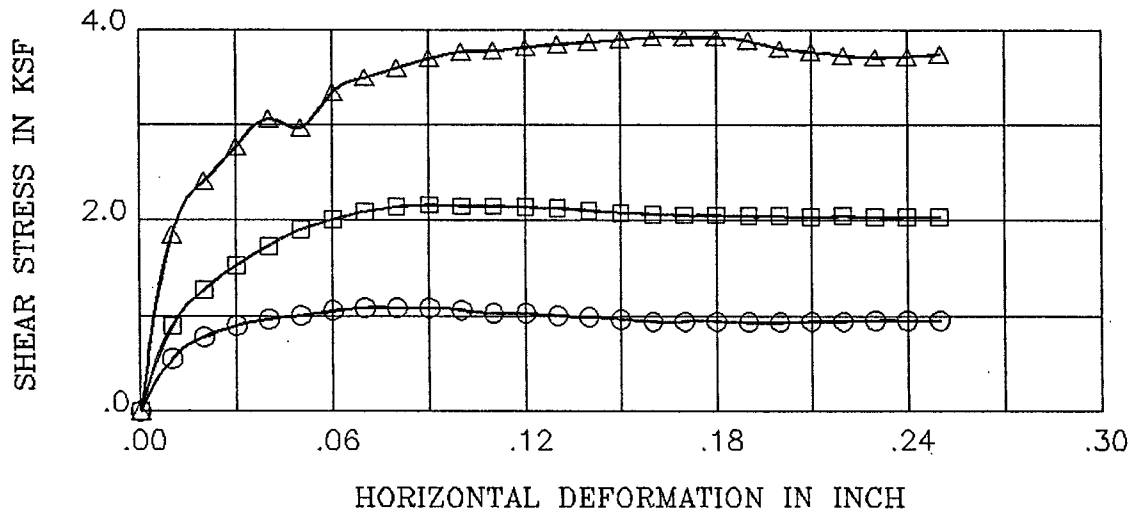
BORING/SAMPLE : SB11-18.5/ DEPTH (ft) : 18.5
DESCRIPTION : GRAY CLAYEY SILT
STRENGTH INTERCEPT (C) : .303 KSF
FRICTION ANGLE (PHI) : 23.5 DEG
(PEAK STRENGTH)

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	VOID RATIO	NORMAL STRESS (ksf)	PEAK SHEAR (ksf)	RESIDUAL SHEAR (ksf)
○	25.8	102.5	.644	1.00	.66	.65
□	25.0	103.8	.623	2.00	1.30	1.24
△	27.3	100.7	.673	4.00	2.00	1.98

Remark : INUNDATED

Project No.2058-2	Project Name:S.WILLIAMS 13452-35952-TK16.DESIGN
Smith-Emery Company	DIRECT SHEAR TEST Plate No.: 15



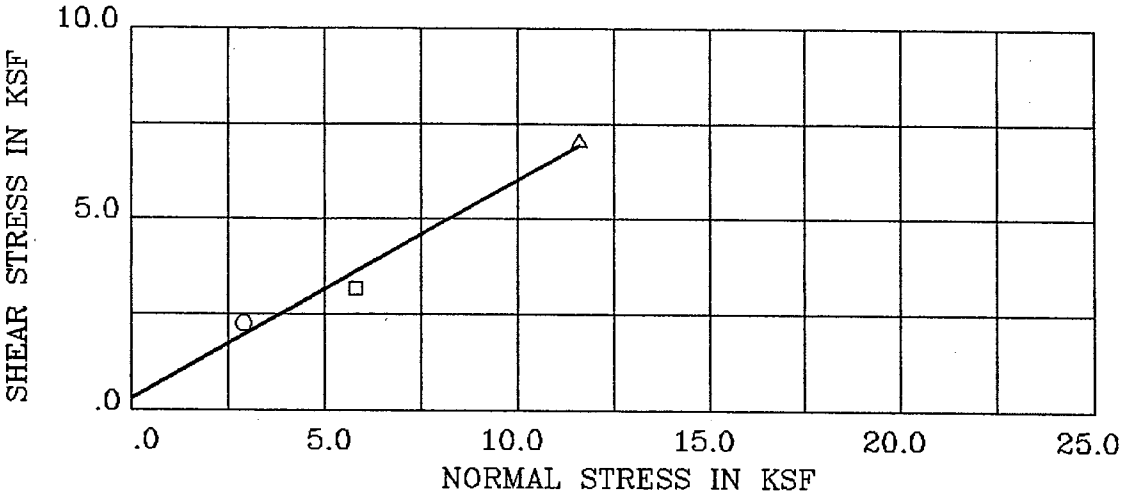


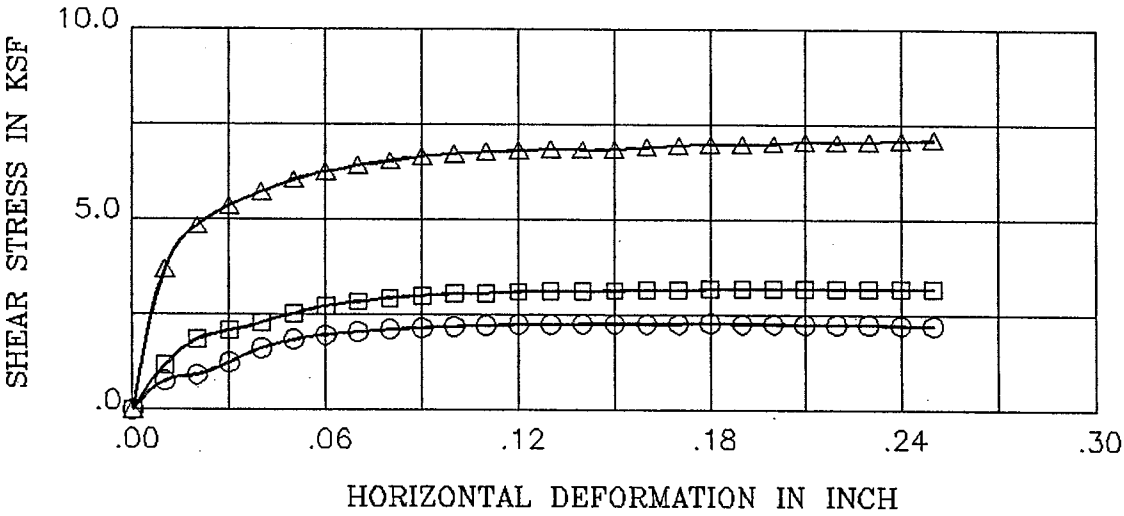
BORING/SAMPLE : SB11-27 / DEPTH (ft) : 27.0
DESCRIPTION : BROWN CLAYEY SAND
STRENGTH INTERCEPT (C) : .204 KSF
FRICTION ANGLE (PHI) : 30.3 DEG
(PEAK STRENGTH)

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	VOID RATIO	NORMAL STRESS (ksf)	PEAK SHEAR (ksf)	RESIDUAL SHEAR (ksf)
○	19.8	103.6	.626	1.60	1.09	.93
□	19.9	103.8	.623	3.20	2.15	2.02
△	20.8	104.5	.612	6.40	3.92	3.70

Remark : INUNDATED

Project No.2058-2	Project Name:S.WILLIAMS 13452-35952-TK16.DESIGN
Smith-Emery Company	DIRECT SHEAR TEST Plate No.: 16



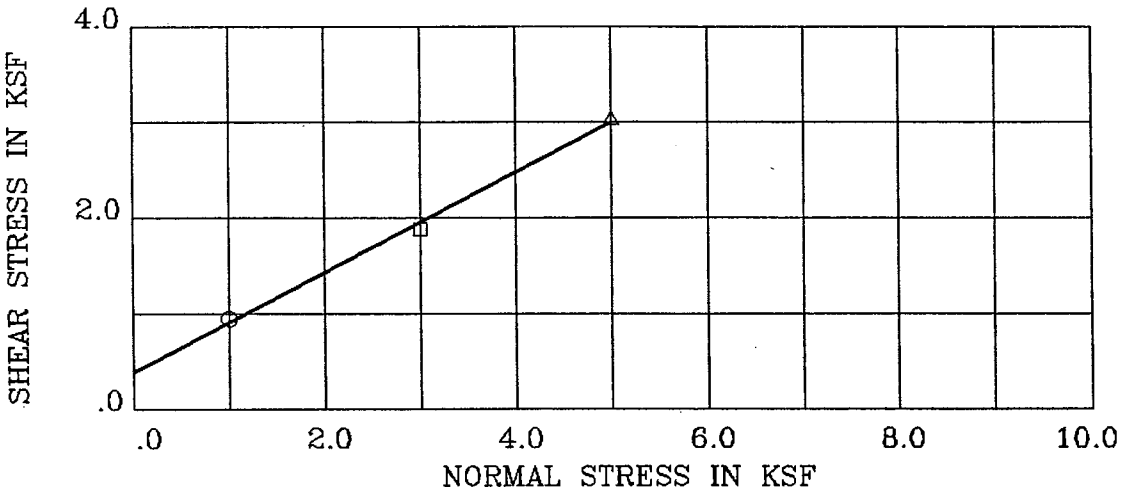


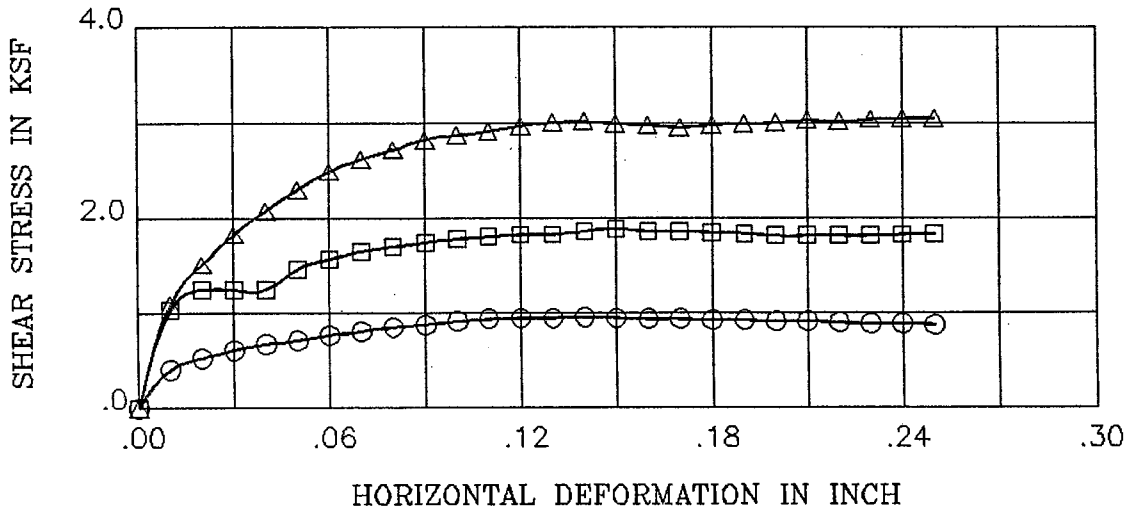
BORING/SAMPLE : SB11-45 / DEPTH (ft) : 45.0
DESCRIPTION : BROWN SILTY CLAY WITH GRAVEL
STRENGTH INTERCEPT (C) : .298 KSF
FRICTION ANGLE (PHI) : 29.8 DEG
(PEAK STRENGTH)

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	VOID RATIO	NORMAL STRESS (ksf)	PEAK SHEAR (ksf)	RESIDUAL SHEAR (ksf)
○	20.2	108.7	.550	2.90	2.26	2.20
□	19.8	110.0	.532	5.80	3.17	3.15
△	14.2	121.1	.391	11.60	7.09	7.09

Remark : INUNDATED

Project No.2058-2	Project Name:S.WILLIAMS 13452-35952-TK16.DESIGN
Smith-Emery Company	DIRECT SHEAR TEST Plate No.: 17



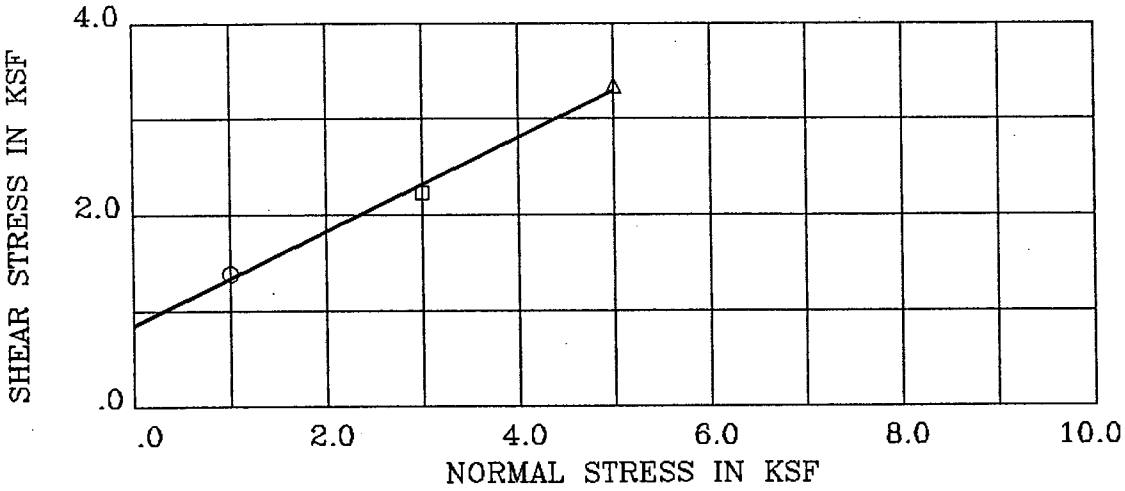


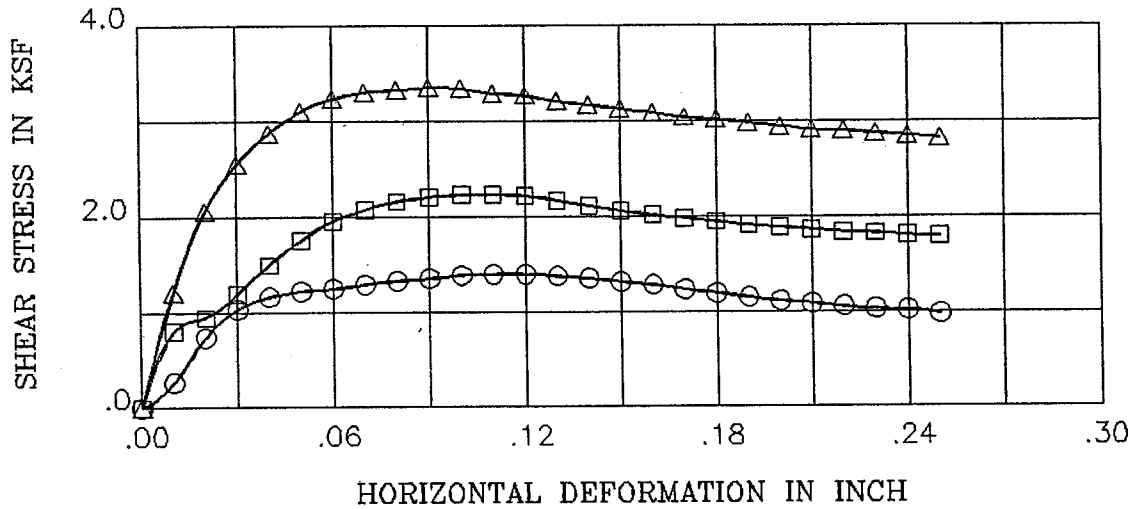
BORING/SAMPLE : SB12-15 / DEPTH (ft) : 15.0
DESCRIPTION : BROWN SILTY CLAY
STRENGTH INTERCEPT (C) : .388 KSF
FRICTION ANGLE (PHI) : 27.7 DEG
(PEAK STRENGTH)

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	VOID RATIO	NORMAL STRESS (ksf)	PEAK SHEAR (ksf)	RESIDUAL SHEAR (ksf)
○	20.9	107.2	.572	1.00	.95	.87
□	21.7	106.7	.579	3.00	1.88	1.81
△	20.9	107.7	.565	5.00	3.05	3.05

Remark : INUNDATED

Project No.2058-2	Project Name:S.WILLIAMS 13452-35952-TK16.DESIGN
Smith-Emery Company	DIRECT SHEAR TEST Plate No.: 18





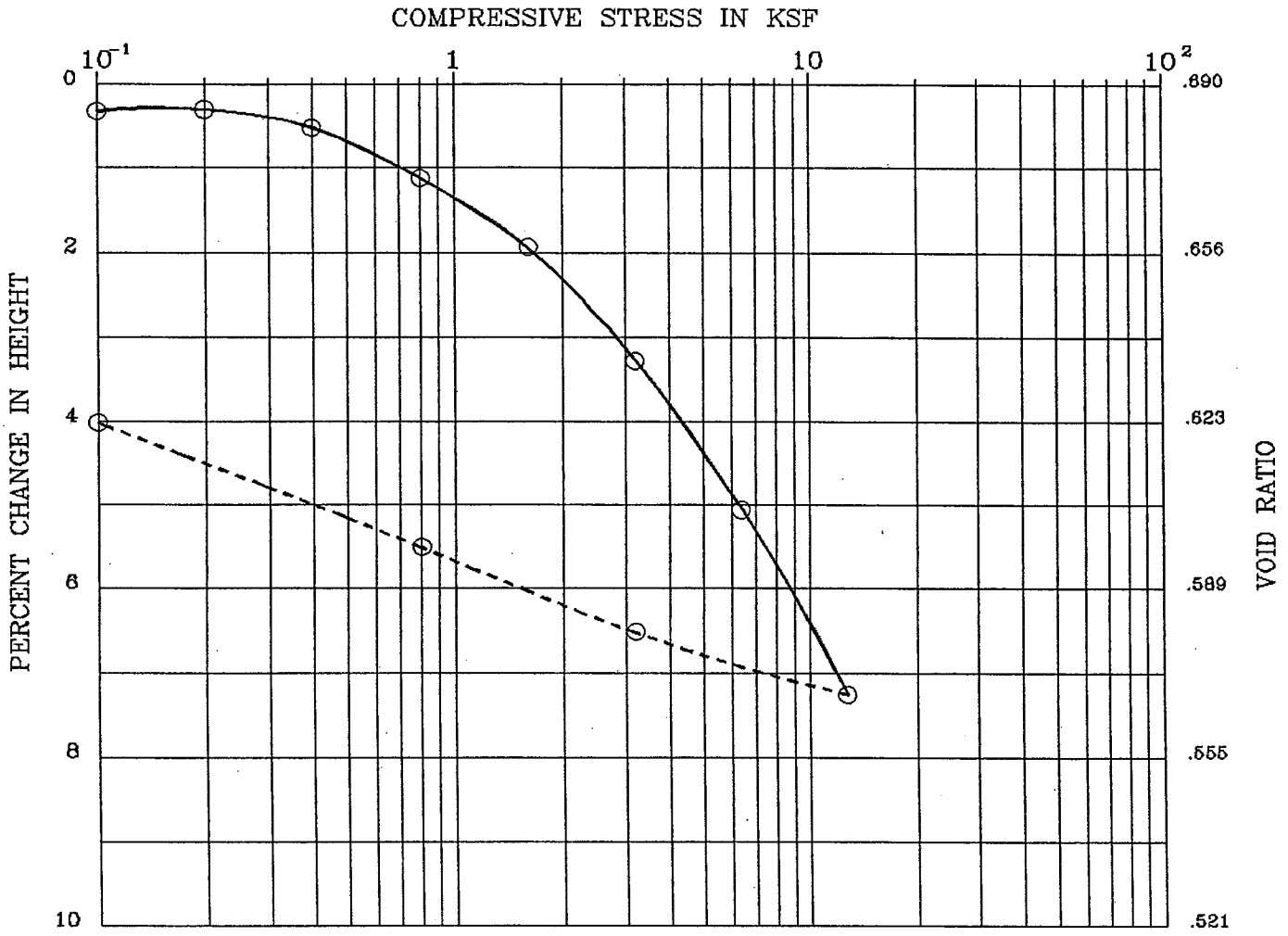
BORING/SAMPLE : SB12-30 / DEPTH (ft) : 30.0
DESCRIPTION : BROWN SILTY CLAY
STRENGTH INTERCEPT (C) : .859 KSF
FRICTION ANGLE (PHI) : 26.0 DEG
(PEAK STRENGTH)

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	VOID RATIO	NORMAL STRESS (ksf)	PEAK SHEAR (ksf)	RESIDUAL SHEAR (ksf)
○	24.8	102.0	.651	1.00	1.39	.98
□	22.9	104.3	.616	3.00	2.23	1.79
△	22.5	105.1	.603	5.00	3.35	2.82

Remark : INUNDATED

Project No.2058-2	Project Name:S.WILLIAMS 13452-35952-TK16.DESIGN
Smith-Emery Company	DIRECT SHEAR TEST Plate No.: 19

CONSOLIDATION TESTS

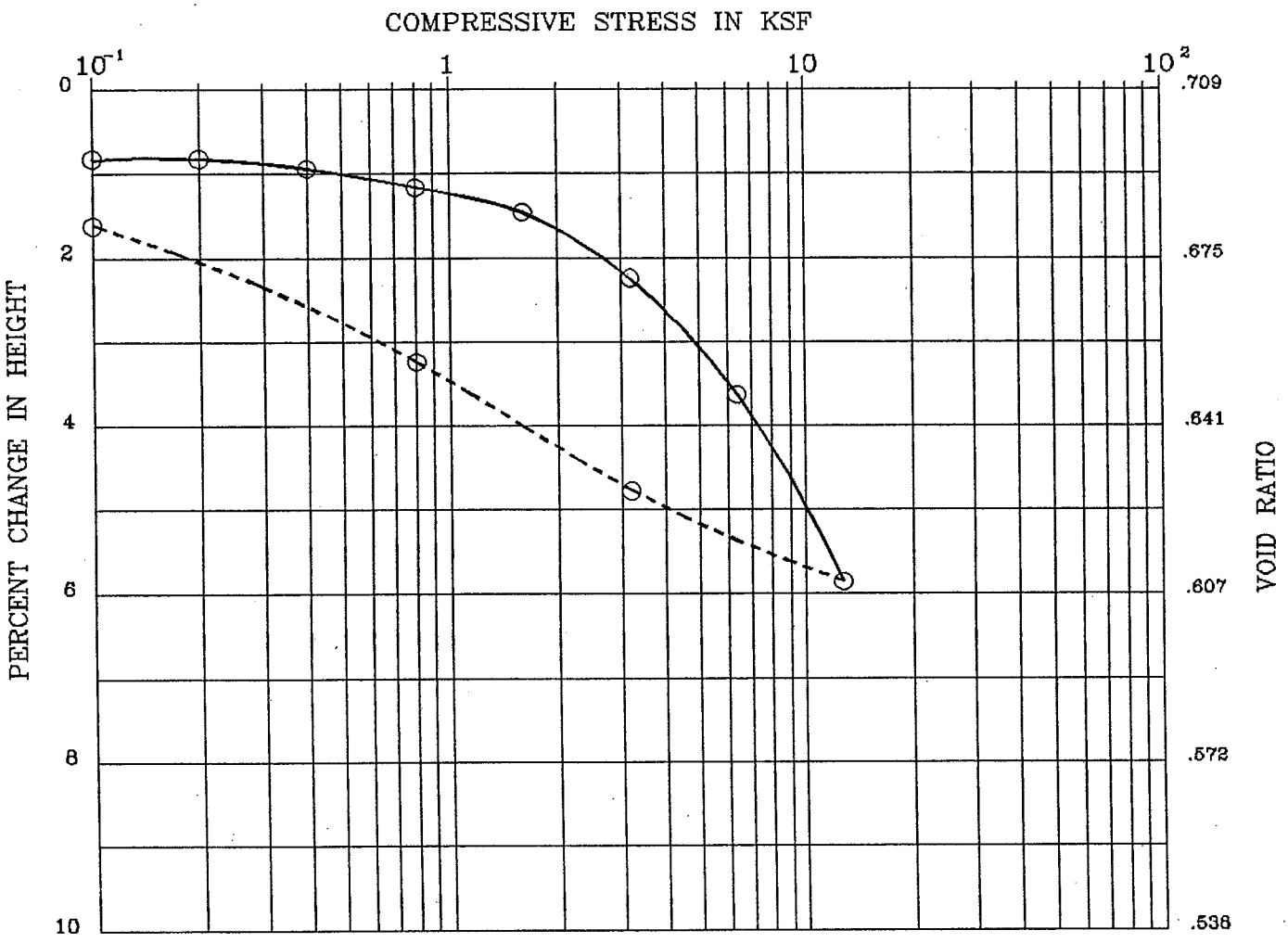


BORING	: SB11-35 /	DESCRIPTION	: BROWN CLAYEY SILT
DEPTH (ft)	: 35.0	LIQUID LIMIT	:
SPEC. GRAVITY	: 2.78	PLASTIC LIMIT	:

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	24.2	102.6	98	.690
FINAL	22.4	106.9	100	.623

Remark : INUNDATED AT 0.1 KSF

Project No.2058-2	S.WILLIAMS 13452-35952-TK16.DESN
SMITH EMERY	CONSOLIDATION TEST Plate No. 20



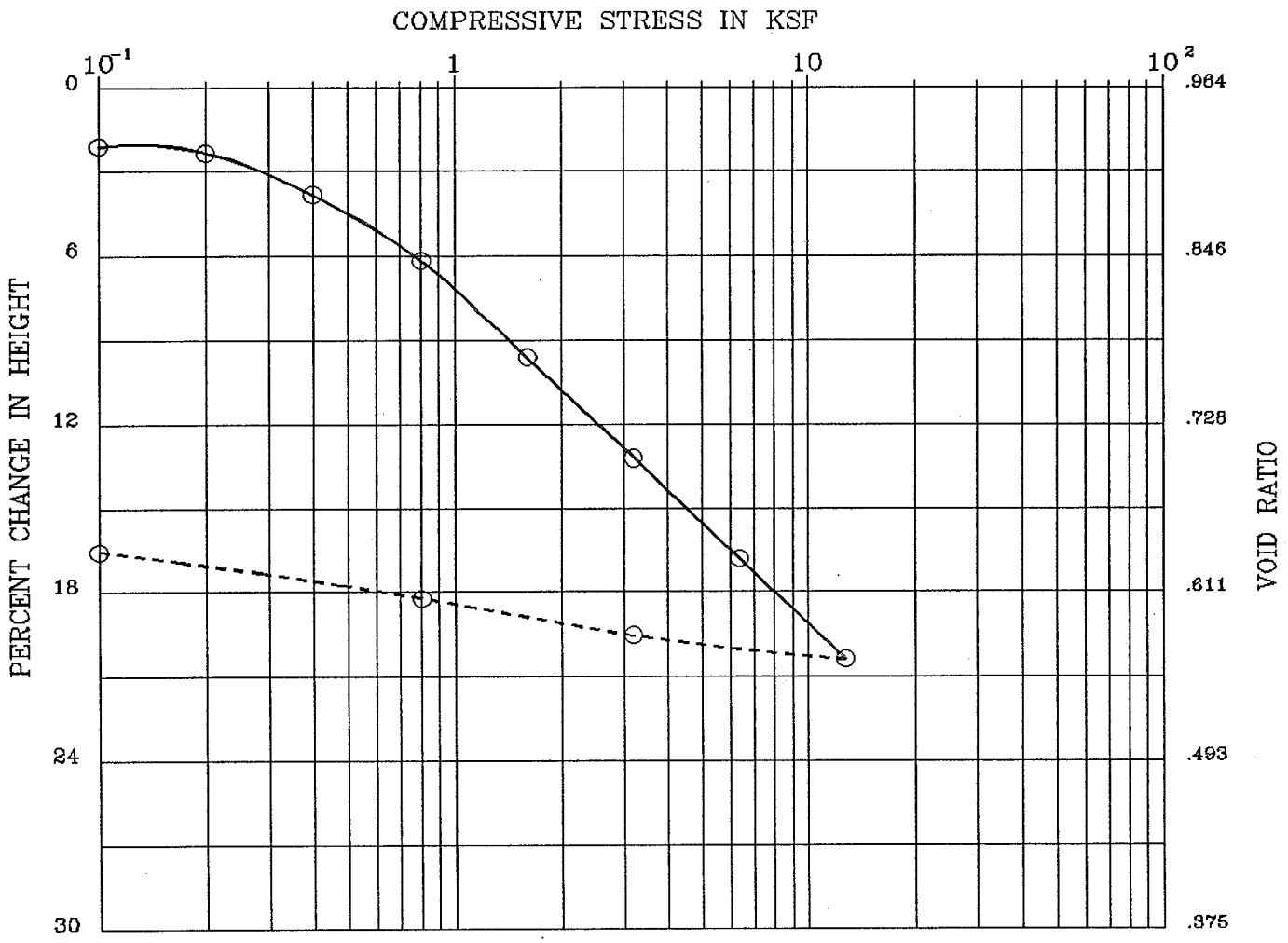
BORING : SB11-65 /
DEPTH (ft) : 65.0
SPEC. GRAVITY : 2.81

DESCRIPTION : BRN SILTY CLAY
LIQUID LIMIT :
PLASTIC LIMIT :

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	24.0	102.7	95	.709
FINAL	24.2	104.4	100	.682

Remark : INUNDATED AT 0.1 KSF

Project No.2058-2	S.WILLIAMS 13452-35952-TK16.DESN
SMITH EMERY	CONSOLIDATION TEST Plate No. 21



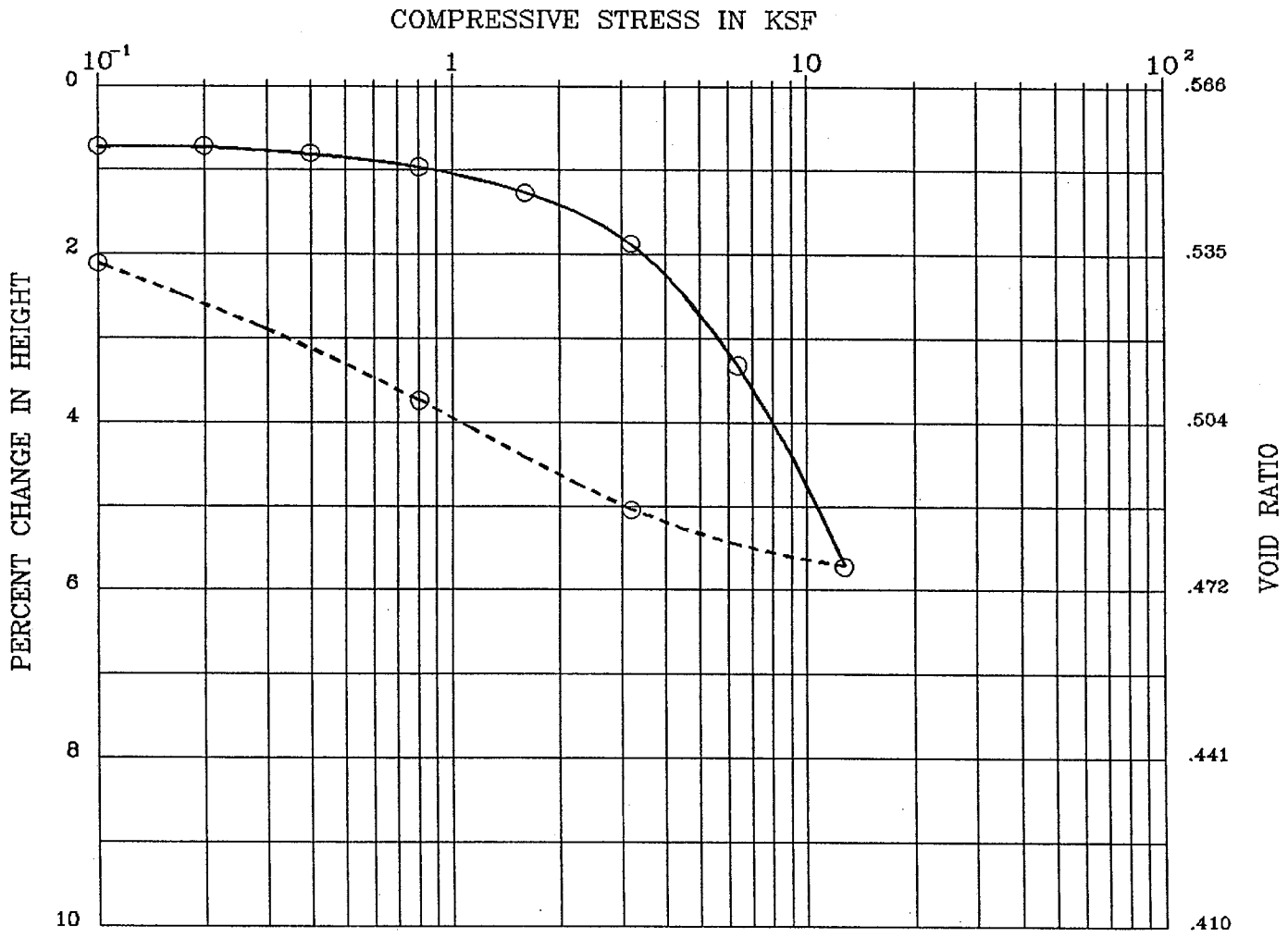
BORING : SB12-25 /
DEPTH (ft) : 25.0
SPEC. GRAVITY : 2.70

DESCRIPTION : BROWN SILTY CLAY
LIQUID LIMIT :
PLASTIC LIMIT :

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	34.3	85.9	96	.964
FINAL	23.1	102.9	98	.640

Remark : INUNDATED AT 0.8 KSF

Project No.2058-2	SHERWIN WILLIAMS .
SMITH EMERY	CONSOLIDATION TEST Plate No. 22



BORING : SB12-40 /
DEPTH (ft) : 40.0
SPEC. GRAVITY : 2.77

DESCRIPTION : BRN SILTY CLAY
LIQUID LIMIT :
PLASTIC LIMIT :

	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	PERCENT SATURATION	VOID RATIO
INITIAL	18.7	110.3	92	.566
FINAL	19.2	112.7	100	.533

Remark : INUNDATED AT 0.1 KSF

Project No.	S.WILLIAMS 13452-35952-TK16.DESN
SMITH EMERY	CONSOLIDATION TEST Plate No. 23

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* *
* E Q F A U L T *
* *
* Version 3.00 *
* *
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DETERMINISTIC ESTIMATION OF
PEAK ACCELERATION FROM DIGITIZED FAULTS

JOB NUMBER: 13452

DATE: 04-17-2003

JOB NAME: s-w

CALCULATION NAME: Preliminary Sample Run Analysis

FAULT-DATA-FILE NAME: CDMGFLTE.DAT

SITE COORDINATES:
SITE LATITUDE: 37.8343
SITE LONGITUDE: 122.2872

SEARCH RADIUS: 70 mi

ATTENUATION RELATION: 23) Abrahamson & Silva (1995b/1997) Horiz.- Soil
UNCERTAINTY (M=Median, S=Sigma): M Number of Sigmas: 0.0
DISTANCE MEASURE: clodis
SCOND: 0
Basement Depth: 5.00 km Campbell SSR: Campbell SHR:
COMPUTE PEAK HORIZONTAL ACCELERATION

FAULT-DATA FILE USED: CDMGFLTE.DAT

MINIMUM DEPTH VALUE (km): 0.0

EQFAULT SUMMARY

DETERMINISTIC SITE PARAMETERS

Page 1

	APPROXIMATE	ESTIMATED MAX. EARTHQUAKE EVENT		
ABBREVIATED FAULT NAME	DISTANCE mi (km)	MAXIMUM EARTHQUAKE MAG.(Mw)	PEAK SITE ACCEL. g	EST. SITE INTENSITY MOD.MERC.
HAYWARD (Total Length)	3.1(5.0)	7.1	0.434	X
HAYWARD (North)	3.1(5.0)	6.9	0.420	X
HAYWARD (South)	11.0(17.7)	6.9	0.197	VIII
CALAVERAS (No.of Calaveras Res)	14.0(22.5)	6.8	0.158	VIII
SAN ANDREAS (Peninsula)	15.4(24.8)	7.1	0.161	VIII
SAN ANDREAS (1906)	15.4(24.8)	7.9	0.209	VIII
CONCORD - GREEN VALLEY	16.8(27.0)	6.9	0.141	VIII
SAN ANDREAS (North Coast)	16.8(27.0)	7.6	0.178	VIII
RODGERS CREEK	17.8(28.6)	7.0	0.139	VIII
SAN GREGORIO	18.4(29.6)	7.3	0.150	VIII
GREENVILLE	21.2(34.1)	6.9	0.116	VII
WEST NAPA	22.9(36.9)	6.5	0.093	VII
GREAT VALLEY 6	25.7(41.3)	6.7	0.112	VII
MONTE VISTA - SHANNON	27.5(44.2)	6.8	0.110	VII
GREAT VALLEY 5	28.6(46.0)	6.5	0.094	VII
POINT REYES	30.8(49.5)	6.8	0.100	VII
HAYWARD (SE Extension)	33.2(53.4)	6.4	0.063	VI
GREAT VALLEY 4	34.4(55.3)	6.6	0.083	VII
CALAVERAS (So.of Calaveras Res)	38.6(62.2)	6.2	0.044	VI
GREAT VALLEY 7	39.5(63.6)	6.7	0.076	VII
HUNTING CREEK - BERRYESSA	43.1(69.3)	6.9	0.062	VI
SAN ANDREAS (Santa Cruz Mtn.)	48.0(77.2)	7.0	0.060	VI
SARGENT	51.6(83.1)	6.8	0.050	VI
ZAYANTE-VERGELES	54.3(87.4)	6.8	0.048	VI
MAACAMA (South)	55.8(89.8)	6.9	0.049	VI

GREAT VALLEY 3 | 56.5(91.0)| 6.8 | 0.058 | VI
MONTEREY BAY - TULARCITOS | 63.8(102.6)| 7.1 | 0.061 | VI
GREAT VALLEY 8 | 63.8(102.6)| 6.6 | 0.046 | VI
ORTIGALITA | 67.2(108.1)| 6.9 | 0.042 | VI
COLLAYOMI | 68.7(110.6)| 6.5 | 0.032 | V
SAN ANDREAS (Pajaro) | 68.8(110.8)| 6.8 | 0.038 | V
****

-END OF SEARCH- 31 FAULTS FOUND WITHIN THE SPECIFIED SEARCH RADIUS.

LARGEST MAXIMUM-EARTHQUAKE SITE ACCELERATION: 0.4335 g

CALIFORNIA INVENTORY OF HISTORIC RESOURCES



March 1976

State of California — The Resources Agency
DEPARTMENT OF PARKS & RECREATION

CALIFORNIA INVENTORY OF HISTORIC RESOURCES

March 1976

Edmund G. Brown Jr.
Governor
State of California

Claire T. Dedrick
Secretary for Resources

Herbert Rhodes
Director
Department of Parks and Recreation

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
P.O. Box 2390 Sacramento 95811

APPENDIX
ALPHABETICAL LISTING
OF
HISTORICAL SITES BY COUNTY

ALAMEDA COUNTY - 221 SITES (ALSO 344 ARCHAEOLOGICAL SITES)**

ALAMEDA COUNTY'S THIRD SEAT OF GOVERNMENT. 1925 E 14TH ST., ALAMEDA. *THEME: GOVERNMENT.*

ALAMEDA COUNTY COURTHOUSE. DAVIS STREET AT CLARKE STREET, SAN LEANDRO. *THEME: GOVERNMENT.*

ALAMEDA COUNTY GAZETTE NEWSPAPER. NORTHEAST CORNER OF DAVIS AND CLARKE STREETS, SAN LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

ALAMEDA COUNTY'S FIRST SCHOOL SITE. REDWOOD ROAD BETWEEN JAMES AND ALMA, CASTRO VALLEY. *THEME: SOCIAL/ EDUCATION.*

ALEMEDA COUNTY (FIRST) COURTHOUSE SITE. ALVARADO. *THEME: GOVERNMENT.*

ALEMEDA TERMINAL OF THE FIRST TRANSCONTINENTAL RAILROAD. FOOT OF PACIFIC AVENUE, ALEMEDA. *THEME: ECONOMIC/INDUSTRIAL.*

ALTAMONT LIBRARY. ALTAMONT PASS RD. 580, ALTAMONT. *THEME: RELIGION.*

ALVARADO BUSINESS BUILDINGS. UNION CITY. *THEME: EXPLORATION/SETTLEMENT.*

ALVARADO CITY/UNION CITY. ALVARADO/UNION CITY. *THEME: EXPLORATION/SETTLEMENT.*

ALVISO,(AUGUSTIN) ADOBE SITE. NEWARK BOULEVARD NEAR ARVIS AVENUE, UNION CITY. *THEME: EXPLORATION/SETTLEMENT.*

ALVISO,(FRANCISCO SOLANO) ADOBE. MEADOWLARK DAIRY FARM, PLEASANTON VALLEY, *THEME: EXPLORATION/SETTLEMENT.*

AMADOR,(JOSE MARIA) ADOBE SITE. SAN RAMON ROAD AND DUBLIN BOULEVARD, DUBLIN. *THEME: EXPLORATION/SETTLEMENT.*

ANNA HEAD SCHOOL. HASTE AND BOWDITCH STREETS, BERKELEY. *THEME: ARCHITECTURE.*

BACON HALL SITE. UNIVERSITY OF CALIFORNIA, BERKELEY. *THEME: SOCIAL/EDUCATION.*

BAY OR LAUREL TREE. 9 LEWELLING BLVD., SAN LORENZO. *THEME: EXPLORATION/SETTLEMENT.*

BELROSE AVENUE RESIDENCE. 2700 BELROSE AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

BENVENUE AVENUE RESIDENCE. 6487 BENVENUE AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

BERKELEY CITY HALL. 2134 GROVE ST., BERKELEY. *THEME: ARCHITECTURE.*

BERKELEY'S FIRST ADOBE SITE. 1304 ALBINA STREET, BERKELEY. *THEME: EXPLORATION/SETTLEMENT.*

BERNAL,(AGUSTIN) ADOBE. FOOTHILL ROAD, LIVERMORE. *THEME: EXPLORATION/SETTLEMENT.*

BERNAL,(PABLO) ADOBE SITE. ARROYO VALLE, PLEASANTON. *THEME: EXPLORATION/SETTLEMENT.*

BEST HOME. 1315 CLARKE STREET, SAN LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

BEST TRACTOR COMPANY. 800 DAVIS STREET, SAN LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

BLAISDELL,(FORMER GOV. OF NEVADA) HOME. 40572 MISSION BLVD., FREMONT. *THEME: ARCHITECTURE.*

BORAX WORKS. PACIFIC NEAR THIRD, ALAMEDA. *THEME: ECONOMIC/INDUSTRIAL.*

BROOKLYN (OLD COURTHOUSE). 1952 EAST FOURTEENTH STREET, OAKLAND. *THEME: GOVERNMENT.*

BROWN'S STAGE STATION. PATTERSON PASS ROAD EAST OF LIVERMORE, *THEME: GOVERNMENT.*

BUENA VISTA WAY RESIDENCE. 2701 BUENA VISTA WAY, BERKELEY. *THEME: ARCHITECTURE.*

BUENA VISTA WAY RESIDENCE. 2733 BUENA VISTA WAY, BERKELEY. *THEME: ARCHITECTURE.*

BUENA VISTA WAY RESIDENCE. 2704 BUENA VISTA WAY, BERKELEY. *THEME: ARCHITECTURE.*

BUENA VISTA WAY, RESIDENCE. 2753 BUENA VISTA WAY, BERKELEY. *THEME: ARCHITECTURE.*

BUENA VISTA WAY RESIDENCE. 2798 BUENA VISTA WAY, BERKELEY. *THEME: ARCHITECTURE.*

***CALIFORNIA NURSERY COMPANY GUEST HOUSE (VALLEJO ADOBE).** NILES BLVD. AT NURSERY AVE., FREMONT. *THEME: ARCHITECTURE.*

CALVARY CEMETERY. END OF VAN AVENUE, SAN LEANDRO. *THEME: EXPLORATION/SETTLEMENT.*

***CAMERON-STANFORD HOME.** 1426 LAKESIDE DR., OAKLAND. *THEME: ARCHITECTURE.*

CAMINO OF RANCHO SAN ANTONIO. SAN JOSE VICINITY. *THEME: EXPLORATION/SETTLEMENT.*

CAMPANILE. UNIVERSITY OF CALIF., BERKELEY. *THEME: SOCIAL/ EDUCATION.*

CASA PERALTA. 384 WEST ESTUDILLO, SAN LEANDRO. *THEME: EXPLORATION/SETTLEMENT.*

CASTRO PLAZA. MISSION BLVD. BETWEEN C AND D STS., HAYWARD. *THEME: ECONOMIC/INDUSTRIAL.*

CASTRO VALLEY EXCHANGE. GROVE WAY AND REDWOOD RD., CASTRO VALLEY. *THEME: ECONOMIC/INDUSTRIAL.*

CASTRO VALLEY'S FIRST PUBLIC SCHOOL SITE. REDWOOD ROAD, BETWEEN JAMES AND ALMA, CASTRO VALLEY. *THEME: SOCIAL/ EDUCATION.*

CASTRO,(GUILLERMO) RESIDENCE. 22738 MISSION BLVD., HAYWARD. *THEME: EXPLORATION/SETTLEMENT.*

NATIONAL REGISTER SITE

LOCATIONS AND MANY DESCRIPTIONS OF ARCHAEOLOGICAL SITES ARE NOT GIVEN TO ROTECT THESE RESOURCES. COUNTY ARCHAEOLOGICAL SITE COUNTS BASED ON THE CORDS ON FILE WITH CULTURAL RESOURCES SECTION OF THE CALIFORNIA EPARTMENT OF PARKS AND RECREATION.

CATHOLIC MASS SITE. LAKESHORE AVENUE, OAKLAND. *THEME: RELIGION.*

CENTERVILLE PRESBYTERIAN CHURCH. FREMONT BLVD. AND BONDI WAY, FREMONT. *THEME: RELIGION.*

CHABOT STREET RESIDENCE. 7133 CHABOT AT ROBLE ROAD, BERKELEY. *THEME: ARCHITECTURE.*

CHADBOURN CARRIAGE HOUSE. 39169 FREMONT BLVD., FREMONT. *THEME: ARCHITECTURE.*

CHASE,(MOSES) HOUSE SITE. 404 EAST EIGHT STREET, OAKLAND. *THEME: EXPLORATION/SETTLEMENT.*

CHURCH OF ST. JAMES THE APOSTLE. 1540 12TH AVE., OAKLAND. *THEME: RELIGION.*

CITY HALL. BERKELEY. *THEME: GOVERNMENT.*

CLAREMONT HOTEL. ASHBY AND CLAREMONT AVENUES, BERKELEY. *THEME: ARCHITECTURE.*

COHEN,(A.A.) HOTEL SITE. HIDDEN VALLEY RANCH END OF STANFORD AVENUE, FREMONT. *THEME: SOCIAL/EDUCATION.*

***COHEN,(ALFRED H.) RESIDENCE.** 1440 29TH AVE., FRUITVALE. *THEME: ARCHITECTURE.*

COLLEGE OF CALIFORNIA SITE. 14TH AND FRANKLIN STREETS, OAKLAND. *THEME: SOCIAL/EDUCATION.*

CONCANNON VINEYARD. 2 MILES S.E. OF LIVERMORE, *THEME: ECONOMIC/INDUSTRIAL.*

CRESTA BLANCA WINERY. LIVERMORE VALLEY, *THEME: ECONOMIC/INDUSTRIAL.*

DANIA HALL. FOOTHILL BLVD., HAYWARD. *THEME: SOCIAL/EDUCATION.*

DE FREMERY PARK. 18TH AND ADELINE ST., OAKLAND. *THEME: ARCHITECTURE.*

DERBY STREET RESIDENCE. 2924 DERBY STREET, BERKELEY. *THEME: ARCHITECTURE.*

DERBY STREET, RESIDENCES. 2814 AND 2816 DERBY STREET, BERKELEY. *THEME: ARCHITECTURE.*

DIBBLE AND SEMRAU STUDIO. 1772 LEROY AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

DRAWBRIDGE (GHOST TOWN). CUSHING RD., FREMONT. *THEME: ECONOMIC/INDUSTRIAL.*

***DUNSMUIR HOUSE.** PERALTA OAKS COURT, OAKLAND. *THEME: ARCHITECTURE.*

DUSTERBERRY,(H.) HOME. CENTRAL AND GLENMORE, FREMONT. *THEME: ARCHITECTURE.*

DWIGHT WAY RESIDENCE. 2727 DWIGHT WAY, BERKELEY. *THEME: ARCHITECTURE.*

DWIGHT WAY RESIDENCE,(KEELER RESIDENCE). 2733 DWIGHT WAY, BERKELEY. *THEME: ARCHITECTURE.*

EDEN APARTMENTS. 1410 B ST., HAYWARD. *THEME: ECONOMIC/INDUSTRIAL.*

ESSANY STUDIO COMPLEX. NILES DIST., FREMONT. *THEME: ARTS/LEISURE.*

ESTUDILLO HOME. 550 WEST ESTUDILLO AVENUE, SAN LEANDRO. *THEME: EXPLORATION/SETTLEMENT.*

ESTUDILLO HOUSE SITE. DAVIS STREET AND WASHINGTON AVENUE, PLEASANTON. *THEME: ARTS/LEISURE.*

ESTUDILLO,(JOAQUIN JOSE) FIRST HOME SITE. SOUTH BANK SAN LEANDRO CREEK, NEAR NIMITZ FREEWAY, SAN LEAND *THEME: EXPLORATION/SETTLEMENT.*

ETNA STREET RESIDENCE. 2515 ETNA STREET, BERKELEY. *THE ARCHITECTURE.*

EUCLID AVENUE RESIDENCES. EUCLID AVENUE AND BUENA VI WAY, BERKELEY. *THEME: ARCHITECTURE.*

FAGES/CRESPI TRAVEL ROUTE. FOOTHILL ROAD, PLEASANTO *THEME: EXPLORATION/SETTLEMENT.*

FALLON HOUSE. FOOTHILL ROAD, PLEASANTON. *THE EXPLORATION/SETTLEMENT.*

FIRST AND LAST CHANCE SALOON(HEINOLD'S). 50 WEBS STREET, OAKLAND. *THEME: SOCIAL/EDUCATION.*

FIRST CHURCH OF CHRIST SCIENCE. 2619 DWIGHT WAY, BERKE *THEME: ARCHITECTURE.*

FOUNDERS ROCK. LA LOMA ENTRANCE TO U.C. BERKE BERKELEY. *THEME: SOCIAL/EDUCATION.*

GALINDO HOTEL SITE. 8TH AND FRANKLIN STREET, OAKLA *THEME: ECONOMIC/INDUSTRIAL.*

GALINDO-HIGUERA ADOBE. CURTNER RD., FREMONT. *THE ARCHITECTURE.*

GALLEGOS ESTATE. 43182 MISSION BLVD., FREMONT. *THE ARCHITECTURE.*

GARCIA HOME. CHUMALIA AND HYDE STREETS, SAN LEAND *THEME: ECONOMIC/INDUSTRIAL.*

GLEN AVENUE RESIDENCE. 2204 GLEN AVENUE, BERKELEY. *THE ARCHITECTURE.*

GREEK THEATER. GALEY RD., BERKELEY. *THEME: ARTS/LEISURE.*

GREEN,(JOHN) HOME. SAN RAMON ROAD SOUTH OF DUI BOULEVARD, DUBLIN. *THEME: ECONOMIC/INDUSTRIAL.*

GREEN,(JOHN) STORE. SOUTHSIDE OF DUBLIN BOULEVARD W OF SAN RAMON ROAD, DUBLIN. *THEME: ECONOMIC/INDUSTI*

GREENVILLE. FOUR MILES EAST OF LIVERMORE, HWY. 50, *THE EXPLORATION/SETTLEMENT.*

GREENWOOD TERRACE, RESIDENCE. 1486 GREENWOOD TERR. BERKELEY. *THEME: ARCHITECTURE.*

GREENWOOD TERRACE RESIDENCE. 1459 GREENWOOD TERR. BERKELEY. *THEME: ARCHITECTURE.*

HACIENDA DEL POZO DE VERONA. CASTLEWOOD COUN CLUB, NEAR PLEASANTON. *THEME: SOCIAL/EDUCATION.*

HALL OF RECORDS, TEMPORARY. 1417 20TH AVENUE, OAKLA *THEME: GOVERNMENT.*

HARRISVILLE. NEAR LIVERMORE, *THEME: ECONOMIC/INDUSTI*

HARVEY-GRANGER GENERAL STORE. 3940 SMITH ST., UNION C ALVARADO. *THEME: ECONOMIC/INDUSTRIAL.*

HARVEY,(SYLVESTER P.) HOME. 32958 ALVARADO RD., FREMC *THEME: ECONOMIC/INDUSTRIAL.*

HAYWARD CARNEGIE LIBRARY SITE. FOOTHILL BLVD. AND E HAYWARD. *THEME: ARCHITECTURE.*

HAYWARD FIRE HOUSE. MISSION BLVD., HAYWARD. *TH SOCIAL/EDUCATION.*

HAYWARD GRAMMAR SCHOOL. 21651 THIRD ST., HAYW. *THEME: SOCIAL/EDUCATION.*

HAYWARD GRAMMER SCHOOL (EDEN TOWNSHIP) SITE. 1/4 BLOCK ON B ST., FOOTHILL BLVD AND C ST., HAYWARD. *THEME: SOCIAL/EDUCATION.*

HAYWARD HOTEL. A AND MAIN ST., HAYWARD. *THEME: ARTS/LEISURE.*

HAYWARD POST OFFICE. 22701 MAIN ST., HAYWARD. *THEME: GOVERNMENT.*

HAYWARD UNION HIGH SCHOOL. 22300 FOOTHILL BLVD., HAYWARD. *THEME: SOCIAL/EDUCATION.*

HAYWARD'S FIRST CITY HALL. 22938 MISSION BLVD., HAYWARD. *THEME: GOVERNMENT.*

HAYWARD'S FIRST HIGH SCHOOL. 685 A ST., HAYWARD. *THEME: SOCIAL/EDUCATION.*

HAYWARD,(WILLIAM) CAMPSITE. PALOMARES CANYON, HAYWARD. *THEME: EXPLORATION/SETTLEMENT.*

HIGUERA,(ABELARDO) ADOBE. WARM SPRINGS. *THEME: ARCHITECTURE.*

HIGUERA,(FULGENCIO) ADOBE SITE. WARM SPRINGS. *THEME: SOCIAL/EDUCATION.*

HONCHURENKO,(AGAPIUS) HOMESITE. CA. STATE UNIVERSITY, HAYWARD. *THEME: RELIGION.*

HOUSE OF BRONZE. 1076 59TH ST., OAKLAND. *THEME: ECONOMIC/INDUSTRIAL.*

HOWARD,(JOHN GALEN) RESIDENCE. 1401 LEROY AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

I.D.E.S. HALL. 1105 C ST.-FOOTHILL BLVD., HAYWARD. *THEME: SOCIAL/EDUCATION.*

I.O.O.F. BUILDING, LIVERMORE (CITY OF). 2160 FIRST ST., LIVERMORE. *THEME: SOCIAL/EDUCATION.*

I.O.O.F. HALL. 952 B ST., HAYWARD. *THEME: SOCIAL/EDUCATION.*

JENSEN HOME. 6650 JENSEN RD., HAYWARD. *THEME: ARCHITECTURE.*

JESSENS OR HAYWARDS LANDING. HAYWARD SHORELINE, HAYWARD. *THEME: ECONOMIC/INDUSTRIAL.*

JEWISH SYNAGOGUE. 59 CHUMALIA STREET, SAN LEANDRO. *THEME: RELIGION.*

KOTTINGER ADOBE BARN. 218 RAY ST., PLEASANTON. *THEME: GOVERNMENT.*

KROBER HOME. 1325 ARCH, BERKELEY. *THEME: ARCHITECTURE.*

LA LOMA AVENUE RESIDENCE. 1705 LA LOMA AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

LA LOMA AVENUE RESIDENCE. 1515 LA LOMA AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

LADDSVILLE SITE. NORTH OF THE S.P. TRACKS AND EAST OF JUNCTION AVENUE, LIVERMORE. *THEME: ECONOMIC/INDUSTRIAL.*

LAKE CHABOT. UPPER LAKE CHABOT ROAD, SAN LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

***LAKE MERRITT WILD DUCK REFUGE.** LAKESIDE PK., GRAND AVE., OAKLAND. *THEME: GOVERNMENT.*

LANDING PLACE OF OAKLAND'S FOUNDERS. FOOT OF BROADWAY, OAKLAND. *THEME: EXPLORATION/SETTLEMENT.*

LITTLE BROWN CHURCH. CLARKE STREET NEAR WEST JOAQUIN, SAN LEANDRO. *THEME: RELIGION.*

LIVERMORE MEMORIAL MONUMENT. LIVERMORE ROAD, LIVERMORE. *THEME: EXPLORATION/SETTLEMENT.*

MASONIC HOME AT DECOTO. MISSION BLVD., UNION CITY. *THEME: SOCIAL/EDUCATION.*

MASONIC TEMPLE. PARK ST. AND ALAMEDA AVE., ALAMEDA. *THEME: SOCIAL/EDUCATION.*

MAY SCHOOL. MAY SCHOOL RD., LIVERMORE. *THEME: SOCIAL/EDUCATION.*

MCCONAGHY HOUSE. 18701 HESPERIAN BOULEVARD, SAN LORENZO. *THEME: ARCHITECTURE.*

***MEEK MANSION AND CARRIAGE HOUSE.** 240 HAMPTON ROAD, HAYWARD. *THEME: ARCHITECTURE.*

MENDENHALL,(MARTIN) RANCH. 455 OLIVINA AVE., LIVERMORE. *THEME: ECONOMIC/INDUSTRIAL.*

METHODIST CHURCH. 1600 BANCROFT AVENUE, SAN LEANDRO. *THEME: RELIGION.*

MIDWAY. EAST OF LIVERMORE, *THEME: ECONOMIC/INDUSTRIAL.*

***MILLER,(JOAQUIN) HOUSE (THE ABBEY).** JOAQUIN MILLER RD. AND SANBORN DR., OAKLAND. *THEME: ARTS/LEISURE.*

***MILLER,(JOAQUIN) HOUSE - THE ABBEY.** JOAQUIN MILLER ROAD AND SANBORN DRIVE, OAKLAND. *THEME: ARTS/LEISURE.*

***MILLS HALL.** MILLS COLLEGE, OAKLAND. *THEME: ARCHITECTURE.*

MISSION PASS. HWY. 80 AT MISSION BLVD., FREMONT. *THEME: EXPLORATION/SETTLEMENT.*

MISSION PEAK. MILL CREEK RD., FREMONT. *THEME: EXPLORATION/SETTLEMENT.*

MISSION SAN JOSE OLD TOWN COMPLEX. MISSION AT WASHINGTON BLVDS., FREMONT. *THEME: EXPLORATION/SETTLEMENT.*

MOHR,(CORNELIUS) ESTATE. 24985 HESPERIAN BLVD., HAYWARD. *THEME: ARCHITECTURE.*

MOHR,(HERMAN) HOUSE. 2595 DEPOT RD., HAYWARD. *THEME: ARCHITECTURE.*

MORTAR ROCK PARK. INDIAN ROCK AVE. AND SAN DIEGO RD., BERKELEY. *THEME: ABORIGINAL.*

MOSS HOME. MACARTHUR AND BROADWAY, OAKLAND. *THEME: ARCHITECTURE.*

MOUNTAIN HOUSE. NEAR LIVERMORE, *THEME: EXPLORATION/SETTLEMENT.*

MULFORD CLUBHOUSE. 13075 AURORA DRIVE, SAN LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

MULFORD-VICKS LANDING. NEAR SAN LEANDRO MARINA ON MULFORD CANAL, *THEME: ECONOMIC/INDUSTRIAL.*

MURRARY,(MICHAEL) HOUSE. WESTSIDE OF SAN RAMON ROAD JUST SOUTH OF DUBLIN BOULEVARD, DUBLIN. *THEME: EXPLORATION/SETTLEMENT.*

NATION'S FIRST SUCCESSFUL BEET SUGAR FACTORY SITE. ALVARADO. *THEME: ECONOMIC/INDUSTRIAL.*

NEPTUNE BEACH. WEBSTER AT CENTRAL, ALAMEDA. *THEME: ARTS/LEISURE.*

NEWARK RAILROAD COMPLEX. RAILROAD JUNCTION/THORTON AND CENTRAL, NEWARK. *THEME: ECONOMIC/INDUSTRIAL.*

NILES OLD TOWN COMPLEX. NILES BLVD., FREMONT. *THEME: ECONOMIC/INDUSTRIAL.*

OHLONE INDIAN BURIAL GROUNDS. WASHINGTON BLVD., MISSION SAN JOSE. *THEME: ABORIGINAL.*

OLD HOTEL. HESPERIAN BOULEVARD AND SAN LORENZO CREEK BRIDGE, SAN LORENZO. *THEME: EXPLORATION/SETTLEMENT.*

PACHECO,(TOMAS) ADOBE SITE. SOUTH BANK OF ALAMEDA CREEK, WEST SIDE OF DECOTO ROAD, UNION CITY. *THEME: EXPLORATION/SETTLEMENT.*

***PACIFIC PRESS PUBLISHING COMPANY.** 1117 CASTRO ST., OAKLAND. *THEME: ECONOMIC/INDUSTRIAL.*

PALOMARES SCHOOL. PALOMARES RD., PALOMARES CANYON. *THEME: SOCIAL/EDUCATION.*

***PARAMOUNT THEATER.** 2025 BROADWAY, OAKLAND. *THEME: ARCHITECTURE.*

PATTERSON-ARDENWOOD ESTATE. JARVIS-NEWARK BLVDS., FREMONT. *THEME: ECONOMIC/INDUSTRIAL.*

PERALTA HOME. LAFETTE AND LEO AVENUE, SAN LEANDRO. *THEME: ARCHITECTURE.*

PERALTA,(ANTONIO) HOUSE. PAXTON AVENUE BETWEEN COOLIDGE AND 34TH AVENUES, OAKLAND. *THEME: EXPLORATION/SETTLEMENT.*

PERALTA,(HERMANIA) DARGIE HOME. 384 WEST ESTUDILLO AVENUE, SAN LEANDRO. *THEME: EXPLORATION/SETTLEMENT.*

PERALTA,(VICENTE) ADOBE SITE. REAR OF 5521 VICENTE STREET, OAKLAND. *THEME: ARCHITECTURE.*

POW-WOW TREE. 1399 A ST., HAYWARD. *THEME: ABORIGINAL.*

PROSPECT AVENUE RESIDENCE. 2301 PROSPECT AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

RAILROAD DEPOT. 464 7TH AVENUE, OAKLAND. *THEME: ECONOMIC/INDUSTRIAL.*

RANCHO SAN ANTONIO ADOBE. DIAMOND PARK, OAKLAND. *THEME: SOCIAL/EDUCATION.*

RANCHO SAN ANTONIO ADOBE SITE,(ORIGINAL). 2511 - 34TH AVENUE, OAKLAND. *THEME: EXPLORATION/SETTLEMENT.*

RAVENSWOOD SITE. 2647 ARROYO ROAD, LIVERMORE. *THEME: GOVERNMENT.*

RIDGE ROAD AND LEROY AVENUE RESIDENCE. RIDGE ROAD AND LEROY AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

RIDGE ROAD HOUSE. RIDGE ROAD, BERKELEY. *THEME: ARCHITECTURE.*

ROBERTS HOUSE. 524 EAST LEWELLING BOULEVARD, SAN LEANDRO. *THEME: ARCHITECTURE.*

ROBERTS LANDING. GRANT AVENUE, SAN LORENZO. *THEME: ECONOMIC/INDUSTRIAL.*

***ROOM 307, GILMAN HALL.** UNIVERSITY OF CALIFORNIA, BERKELEY CAMPUS, BERKELEY. *THEME: SOCIAL/EDUCATION.*

SAN ANTONIO RANCHO (PERALTA GRANT). SOUTHERN BOUNDARY OF RANCHO, SAN LEANDRO. *THEME: EXPLORATION/SETTLEMENT.*

SAN FRANCISCO WATER TEMPLE. EDGE OF SUNOL, *THEME: ECONOMIC/INDUSTRIAL.*

***SAN JOSE MISSION.** MISSION BLVD. AND WASHINGTON BLVD., FREMONT. *THEME: RELIGION.*

SAN LEANDRO BALL PARK. SAN LEANDRO BOULEVARD AND PARROTT STREET, SAN LEANDRO. *THEME: ARTS/LEISURE.*

SAN LEANDRO OYSTER BEDS. SAN LEANDRO MARINA, S LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

SAN LEANDRO PLAZA. JUNCTION OF EAST 14TH STREET A WASHINGTON AVENUE, SAN LEANDRO. *THEME: EXPLORATI(SETTLEMENT.*

SAN LEANDRO REPORTER. DAVIS STREET, SAN LEANDRO. *THE ECONOMIC/INDUSTRIAL.*

SAN LEANDRO'S TOWN HALL. 250 DAVIS STREET, SAN LEAND *THEME: GOVERNMENT.*

SAN LORENZO CEMETERY. HESPERIAN BOULEVARD NEAR NIMITZ FREEWAY, SAN LEANDRO. *THEME: EXPLORATI(SETTLEMENT.*

SANTA BARBARA ROAD RESIDENCE. 830 SANTA BARBARA RO BERKELEY. *THEME: ARCHITECTURE.*

SATHER GATE. UNIVERSITY OF CALIF., BERKELEY. *THEME: SOC EDUCATION.*

***SENIOR HALL (GOLDEN BEAR LODGE).** UNIVERSITY CALIFORNIA, BERKLEY CAMPUS, BERKELEY. *THEME: SOC EDUCATION.*

SHATTUCK AVENUE RESIDENCE. 1200 SHATTUCK AVEN BERKELEY. *THEME: ARCHITECTURE.*

SHELL MOUND SITE. SHELL MOUND STREET, EMERYVILLE. *THI ABORIGINAL.*

SHINN HISTORICAL PARK. 1269 PERALTA BLVD., FREMONT. *THI ARCHITECTURE.*

SIGMA PHI FRATERNITY HOUSE,(FORMER THORSEN RESIDEN(2307 PIEDMONT AVENUE, BERKELEY. *THEME: ARCHITECTURE.*

SMITH,(HENRY C.) HOUSE SITE. ALVARADO STREET, UNION C *THEME: ARCHITECTURE.*

SOUTH BAY SLOUGHS LANDING. EAST BAY AREA. *THI ECONOMIC/INDUSTRIAL.*

SOUTH HALL. UNIVERSITY OF CA., BERKELEY CAMPUS, BERKE *THEME: SOCIAL/EDUCATION.*

SOUTHERN PACIFIC FREIGHT STATION. 801 DAVIS STREET, LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

SPANISH CAMP SITE-SAN LORENZO CREEK. MATTOX ROAD CREEK, HAYWARD AREA. *THEME: EXPLORATION/SETTLEMENT.*

SPRUCE STREET RESIDENCE. 1104 SPRUCE STREET, BERKELEY. *THI ARCHITECTURE.*

ST. JAMES EPISCOPAL CHURCH. 37156 ST. JAMES WAY, FREMC *THEME: RELIGION.*

***ST. JOHN'S PRESBYTERIAN CHURCH.** 2640 COLLEGE A BERKELEY. *THEME: RELIGION.*

ST. JOSEPH CATHOLIC CHURCH. MISSION AND WASHING BLVDS., FREMONT. *THEME: RELIGION.*

ST. MARK'S EPISCOPAL CHURCH. 2314 BANCROFT, BERKE *THEME: ARCHITECTURE.*

ST. MARY'S CATHOLIC CHURCH. EIGHTH AND JEFFERSON STRE OAKLAND. *THEME: RELIGION.*

ST. MARY'S COLLEGE. BROADWAY AND HAWTHORNE, OAKLA *THEME: SOCIAL/EDUCATION.*

ST. RAYMOND'S CHURCH. DUBLIN. *THEME: RELIGION.*

STANDON HALL (CASTLE). 2ND ST. AND WALPERT A HAYWARD. *THEME: ARCHITECTURE.*

STANFORD,(LELAND) WINERY. HOLY NAME ROAD, MISSION SAN JOSE. *THEME: ECONOMIC/INDUSTRIAL.*

STANTON HOUSE. LAKE CHABOT ROAD, CASTRO VALLEY. *THEME: ARCHITECTURE.*

STRAUSS HOUSE. 8 STONEWALL ROAD, BERKELEY. *THEME: ARCHITECTURE.*

SUMMIT SCHOOL. ALTAMONT PASS RD., ALTAMONT. *THEME: SOCIAL/EDUCATION.*

SUNOL,(ANTONIO) ADOBE SITE. NEAR WATER TEMPLE, SUNOL. *THEME: EXPLORATION/SETTLEMENT.*

SURVEYORS TREE. MEMORIAL PARK, MISSION BLVD., HAYWARD. *THEME: EXPLORATION/SETTLEMENT.*

TEMPLE OF THE WINGS. 2800 BUENA VISTA, BERKELEY. *THEME: ARTS/LEISURE.*

TESLA SITE. SOUTHEAST OF LIVERMORE, *THEME: ECONOMIC/INDUSTRIAL.*

THRASHER PARK. DAVIS STREET NEAR ORCHARD, SAN LEANDRO. *THEME: ECONOMIC/INDUSTRIAL.*

THRASHER,(DR. WILLIAM) HOME. DAVIS STREET AND ORCHARD, SAN LEANDRO. *THEME: ARTS/LEISURE.*

TOWN AND GOWN CLUB. 2401 DWIGHT WAY, BERKELEY. *THEME: ARCHITECTURE.*

TREADWELL HALL. 5212 BROADWAY, OAKLAND. *THEME: SOCIAL/EDUCATION.*

UNITARIAN CHURCH. DANA STREET AND BANCROFT WAY, BERKELEY. *THEME: ARCHITECTURE.*

VALLEJO FLOUR MILL. NORTH OF NILES CANYON ROAD, NILES. *THEME: ECONOMIC/INDUSTRIAL.*

VALLEJO,(J.J.) HOME SITE. OLIVE HYDE CENTER, FREMONT. *THEME: MILITARY.*

VICTORIAN ROW. 9TH ST. BETWEEN BROADWAY AND WASHINGTON, OAKLAND. *THEME: ARCHITECTURE.*

WARREN,(EARL) HOME. 88 VERNON STREET, OAKLAND. *THEME: GOVERNMENT.*

WASHINGTON COLLEGE HOUSE. WASHINGTON BLVD. AND DRISCOLL RD., FREMONT. *THEME: SOCIAL/EDUCATION.*

WILLEY,(SAMUEL) HOUSE SITE. 2709 DWIGHT WAY, BERKELEY. *THEME: ARCHITECTURE.*

ALPINE COUNTY - 21 SITES (ALSO 105 ARCHAEOLOGICAL SITES)**

CARSON,(KIT) TRAIL. STATE HIGHWAY 88 THROUGH ALPINE COUNTY AND CARSONPASS, *THEME: EXPLORATION/SETTLEMENT.*

CENTERVILLE. *THEME: ECONOMIC/INDUSTRIAL.*

EBBETTS PASS ROUTE. EBBETTS PASS. *THEME: EXPLORATION/SETTLEMENT.*

FISK HOTEL (HOT SPRINGS HOTEL). MARKLEEVILLE. *THEME: ECONOMIC/INDUSTRIAL.*

GROVER HOT SPRINGS. MARKLEEVILLE. *THEME: ARTS/LEISURE.*

HARASZTHY,(COL. AGOSTON) CHAMPAGNE CELLARS. SILVER MOUNTAIN CITY. *THEME: ECONOMIC/INDUSTRIAL.*

KENNEDY WHEELS. JACKSON GATE ROAD, JACKSON. *THEME: ECONOMIC/INDUSTRIAL.*

KIT CARSON MARKER. 15.1 MILES WEST OF WOODFORDS, *THEME: EXPLORATION/SETTLEMENT.*

MARKLEE'S CABIN SITE. MARKLEEVILLE. *THEME: EXPLORATION/SETTLEMENT.*

MARKLEEVILLE JAIL. MARKLEEVILLE. *THEME: GOVERNMENT.*

MONITOR (OR LOOPE). 8 MILES NORTH OF SILVER MT., *THEME: ECONOMIC/INDUSTRIAL.*

MOUNT BULLION. JUNCTION OF SILVER MT. AND MONITOR ROADS, *THEME: ECONOMIC/INDUSTRIAL.*

ODD FELLOWS PIONEER MEMORIAL. 14.8 MILES WEST OF WOODFORDS, *THEME: SOCIAL/EDUCATION.*

OLD EMIGRANT ROAD. HWY. 88, NEAR TWIN LAKES, *THEME: EXPLORATION/SETTLEMENT.*

PONY EXPRESS REMOUNT STATION AT WOODFORDS. HIGHWAY 89, *THEME: GOVERNMENT.*

SILVER MOUNTAIN CITY. EBBETS PASS ROAD, S.W. OF MONITOR PASS ROAD JUNCTION, *THEME: ECONOMIC/INDUSTRIAL.*

SILVER MOUNTAIN CITY OLD JAIL. SILVER MOUNTAIN CITY. *THEME: GOVERNMENT.*

SMELTER. EBBETS PASS ROAD, SILVER MOUNTAIN CITY. *THEME: ECONOMIC/INDUSTRIAL.*

WADE HOUSE. WOODFORDS. *THEME: ARCHITECTURE.*

WEBSTER SCHOOL. MARKLEEVILLE. *THEME: SOCIAL/EDUCATION.*

WOODFORDS. *THEME: EXPLORATION/SETTLEMENT.*

AMADOR COUNTY - 43 SITES (ALSO 131 ARCHAEOLOGICAL SITES)**

AMADOR CITY DISTRICT. HWY. 49, 3 MILES NORTH OF SUTTER CREEK, AMADOR CITY. *THEME: EXPLORATION/SETTLEMENT.*

***AMADOR COUNTY HOSPITAL BUILDING.** 810 COURT STREET, JACKSON. *THEME: ARCHITECTURE.*

ARGONAUT AND KENNEDY MINES. JACKSON. *THEME: ECONOMIC/INDUSTRIAL.*

BIG BAR. HIGHWAY 49 AT AMADOR AND CALAVERAS COUNTY LINE, *THEME: ECONOMIC/INDUSTRIAL.*

BUENA VISTA STONE STORE. LANCHA PLANA-IONE AND JACKSON-STOCKTON ROADS, BUENA VISTA. *THEME: ECONOMIC/INDUSTRIAL.*

BUTTE STORE. 3 MILES SOUTH OF JACKSON, *THEME: ECONOMIC/INDUSTRIAL.*

CENTRAL EUREKA MINE. SUTTER CREEK. *THEME: ECONOMIC/INDUSTRIAL.*

CHICHIZOLA STORE. JACKSON GATE ROAD, JACKSON GATE. *THEME: ECONOMIC/INDUSTRIAL.*

CLINTON. 8.6 MILES EAST OF JACKSON, *THEME: EXPLORATION/SETTLEMENT.*

COMMUNITY METHODIST CHURCH OF IONE. IONE. *THEME: RELIGION.*

D'AGOSTINI WINERY. 8 MILES N.E. OF PLYMOUTH, *THEME: ECONOMIC/INDUSTRIAL.*

PROPERTY-NUMBER	PRIMARY-#	STREET.ADDRESS.....	NAMES.....	CITY NAME.....	OWN	YR-C	OHP-PROG	PRG-REFERENCE-NUMBER	STAT-LAT	NRS	CRIT
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138227			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F	1953	HIST.RES.	DOE-01-02-0130-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138237			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F	1952	HIST.RES.	DOE-01-02-0140-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138102			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F	1998	HIST.RES.	DOE-01-02-0077-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138233			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F		HIST.RES.	DOE-01-02-0136-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138232			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F	1970	HIST.RES.	DOE-01-02-0135-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138231			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F	1980	HIST.RES.	DOE-01-02-0134-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138101			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F	1953	HIST.RES.	DOE-01-02-0076-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138230			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F		HIST.RES.	DOE-01-02-0133-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
138229			PARKS RESERVE FORCES TRAINING AREA	DUBLIN	F	1944	HIST.RES.	DOE-01-02-0132-0000	05/29/02	6Y	
							PROJ.REVW.	USA020415A	05/29/02	6Y	
161780			PARKS RESERVE TRAINING AREA	DUBLIN	F		PROJ.REVW.	USA050323A	04/07/05	6Y	
161676			SHEEP PEN/CAMP PARKS RESERVE TRAIN	DUBLIN	F		PROJ.REVW.	USA040830A	11/08/04	6Y	
123702	01-010332	12TH ST	BLDGS 1108, 1109 - CAMP PARKS	DUBLIN	F		HIST.RES.	DOE-01-99-0073-0000	10/26/99	6Y	
							PROJ.REVW.	COE990927D	10/26/99	6Y	
123701	01-010331	12TH ST	BLDGS 1100, 1101, 1102, 1104 - CAM	DUBLIN	F	1944	HIST.RES.	DOE-01-99-0072-0000	10/26/99	6Y	
							PROJ.REVW.	COE990927D	10/26/99	6Y	
010610	01-003620	12TH ST	BLDG 1133 - CAMP PARKS, BUILDING 1	DUBLIN	F	1944	HIST.SURV.	4568-0002-0000		7R	
010612	01-003622	12TH ST	BLDG 1136 - CAMP PARKS, BUILDING 1	DUBLIN	F	1959	HIST.SURV.	4568-0004-0000		7R	
010611	01-003621	12TH ST	BLDG 1135 - CAMP PARKS, BUILDING 1	DUBLIN	F	1944	HIST.SURV.	4568-0003-0000		7R	
010613	01-003623	16TH ST	BLDG 1163 - CAMP PARKS, BUILDING 1	DUBLIN	F	1944	HIST.SURV.	4568-0005-0000		7R	
090529	01-008147	DONLON RD	ORIGINAL MURRAY SCHOOLHOUSE	DUBLIN	U	1856	PROJ.REVW.	HUD940818I	01/23/95	6Y	
							HIST.RES.	SPHI-ALA-029	12/22/75	7L	
090534	01-008150	DONLON WY	GREEN STORE	DUBLIN	P	1850	HIST.RES.	SPHI-ALA-032	12/07/79	7L	
090506	01-008127	6600 DONLON WY	ST RAYMOND'S CHURCH / DUBLIN HERIT	DUBLIN	M	1859	HIST.RES.	NPS-06000242-9999	04/12/06	1S	C
							NAT.REG.	01-0062	09/17/04	3S	C
							HIST.RES.	SPHI-ALA-001	07/18/67	7L	
161902		6600 DONLON WY	SAINT RAYMOND'S CHURCH CEMETERY AN	DUBLIN	M	1859	HIST.RES.	NPS-06000242-0001	04/12/06	1D	C
010615	01-003625	DOUGHERTY RD	BLDG 1180 - CAMP PARKS, BUILDING 1	DUBLIN	F	1944	HIST.SURV.	4568-0007-0000		7R	
010614	01-003624	DOUGHERTY RD	BLDG 1179 - CAMP PARKS, BUILDING 1	DUBLIN	F	1944	HIST.SURV.	4568-0006-0000		7R	
130771		11393 DUBLIN CANYON RD	KOLB RANCH	DUBLIN	P	1900	HIST.RES.	DOE-01-01-0021-0000	10/22/01	6Y	
							PROJ.REVW.	FHWA010912F	10/22/01	6Y	
181566		7743 HILLROSE DR		DUBLIN	P		PROJ.REVW.	HUD1101136	02/01/11	6Y	
010609	01-003619	7436 SAN RAMON RD	RASMUSSEN, PETER ANDERSEN, RESIDEN	DUBLIN	U	1915	HIST.SURV.	4568-0001-0000		7R	
183390		6407 TASSAJARA RD	BA52962-DUBLIN ROAD	DUBLIN	P		PROJ.REVW.	FCC100421A	05/30/10	6Y	
068797	01-005889		EMERYVILLE HISTORIC INDUSTRIAL DIS	EMERYVILLE	P	1907	HIST.RES.	DOE-01-90-0007-9999	10/05/90	2S2	AC
							HIST.SURV.	4608-0001-9999	10/05/90	3S	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2S2	AC
084097	01-007350	1122 36TH ST		EMERYVILLE	P	1900	HIST.SURV.	4608-0025-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084155	01-007356	1160 36TH ST		EMERYVILLE	P	1920	HIST.SURV.	4608-0026-0000	10/05/90	6Y	AC
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	AC
084156	01-007357	1168 36TH ST	ARROW TOWEL AND LAUNDRY/PACIFIC SP	EMERYVILLE	P	1920	HIST.SURV.	4608-0027-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900027X	10/05/90	6Y	
176640		1077 41ST ST		EMERYVILLE	P	1912	PROJ.REVW.	HUD090721S	08/17/09	6Y	
084032	01-007326	1290 45TH ST		EMERYVILLE	U	1922	HIST.SURV.	4608-0001-0025	10/05/90	3D	AC

PROPERTY-NUMBER	PRIMARY-#	STREET ADDRESS	NAMES	CITY NAME	OWN	YR-C	OHP-PROG	PRG-REFERENCE-NUMBER	STAT-DAT	NRS	CRIT
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084033	01-007327	1401 45TH ST	CALIFORNIA PLYWOOD COMPANY	EMERYVILLE	P	1913	HIST.SURV.	4608-0001-0026	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084034	01-007328	1420 45TH ST		EMERYVILLE	U	1927	HIST.SURV.	4608-0001-0027	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
106867	01-009879	1084 48TH ST		EMERYVILLE	P	1926	PROJ.REVW.	HUD970116E	02/21/97	6Y	
084035	01-007329	3601 ADELINE ST		EMERYVILLE	P	1920	HIST.SURV.	4608-0002-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
068798	01-005890	3604 ADELINE ST		EMERYVILLE	F	1895	HIST.RES.	DOE-01-90-0008-0000	10/05/90	2S2	C
							HIST.SURV.	4608-0003-0000	10/05/90	3S	
							PROJ.REVW.	FHWA900927X	10/05/90	2S2	C
084036	01-007330	3605 ADELINE ST		EMERYVILLE	P	1920	HIST.SURV.	4608-0004-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084037	01-007331	3608 ADELINE ST		EMERYVILLE	P	1925	HIST.SURV.	4608-0005-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084038	01-007332	3609 ADELINE ST		EMERYVILLE	P		HIST.SURV.	4608-0006-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084039	01-007333	3610 ADELINE ST		EMERYVILLE	P	1925	HIST.SURV.	4608-0007-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084040	01-007334	3612 ADELINE ST		EMERYVILLE	P	1925	HIST.SURV.	4608-0008-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084041	01-007335	3614 ADELINE ST		EMERYVILLE	P	1925	HIST.SURV.	4608-0009-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084042	01-007336	3622 ADELINE ST		EMERYVILLE	P	1900	HIST.SURV.	4608-0010-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084043	01-007337	3624 ADELINE ST		EMERYVILLE	P	1920	HIST.SURV.	4608-0011-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084044	01-007338	3625 ADELINE ST		EMERYVILLE	P	1915	HIST.SURV.	4608-0012-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084045	01-007339	3629 ADELINE ST		EMERYVILLE	P	1910	HIST.SURV.	4608-0013-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
114773	01-010095	4324 ESSEX ST		EMERYVILLE	P	1908	HIST.RES.	DOE-01-98-0014-0000	03/11/98	6Y	
							PROJ.REVW.	HUD980121D	03/11/98	6Y	
083968	01-007302	4070 HALLECK ST	WESTINGHOUSE PACIFIC COAST BRAKE C	EMERYVILLE	P	1930	HIST.SURV.	4608-0001-0001		3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
083969	01-007303	4224 HOLDEN ST		EMERYVILLE	P	1930	HIST.SURV.	4608-0001-0002	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084056	01-007340	4001 HOLLIS ST	BAY AREA WAREHOUSE COMPANY / WESTE	EMERYVILLE	P	1911	HIST.SURV.	4608-0014-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
083973	01-007304	4202 HOLLIS ST		EMERYVILLE	P	1925	HIST.SURV.	4608-0001-0003	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
083975	01-007305	4221 HOLLIS ST	MOREHOUSE MUSTARD	EMERYVILLE	P	1925	HIST.SURV.	4608-0001-0004	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
083977	01-007306	4224 HOLLIS ST		EMERYVILLE	U	1929	HIST.SURV.	4608-0001-0005	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
083979	01-007307	4227 HOLLIS ST		EMERYVILLE	U	1930	HIST.SURV.	4608-0001-0006	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
083989	01-007308	4245 HOLLIS ST		EMERYVILLE	U	1924	HIST.SURV.	4608-0001-0007	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
083994	01-007309	4512 HOLLIS ST		EMERYVILLE	U	1923	HIST.SURV.	4608-0001-0008	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
083996	01-007310	4525 HOLLIS ST		EMERYVILLE	U	1925	HIST.SURV.	4608-0001-0009	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084000	01-007311	4250 HORTON ST		EMERYVILLE	U	1925	HIST.SURV.	4608-0001-0010	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084001	01-007312	4525 HORTON ST		EMERYVILLE	U	1924	HIST.SURV.	4608-0001-0011	10/05/90	3D	AC

PROPERTY-NUMBER	PRIMARY-#	STREET ADDRESS	NAMES	CITY NAME	OWN	YR-C	OHP-PROG.	PRG-REFERENCE-NUMBER	STAT-DAT	NRS	CRIT
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
174018		5679 HORTON ST		EMERYVILLE	M	1963	PROJ.REVW.	FEMA080812A	09/18/08	6Y	
084059	01-007341	4055 HUBBARD ST		EMERYVILLE	P	1935	HIST.SURV.	4608-0015-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084060	01-007342	4056 HUBBARD ST		EMERYVILLE	P	1912	HIST.SURV.	4608-0016-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084002	01-007313	1175 PARK AVE		EMERYVILLE	U	1907	HIST.SURV.	4608-0001-0012	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084003	01-007314	1201 PARK AVE		EMERYVILLE	U	1913	HIST.SURV.	4608-0001-0013	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084004	01-007315	1219 PARK AVE		EMERYVILLE	U	1917	HIST.SURV.	4608-0001-0014	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084005	01-007316	1250 PARK AVE		EMERYVILLE	U	1919	HIST.SURV.	4608-0001-0015	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084006	01-007317	1255 PARK AVE		EMERYVILLE	U	1925	HIST.SURV.	4608-0001-0016	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
150930		1485 PARK AVE		EMERYVILLE	P	1940	HIST.SURV.	4608-0001-0028	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084007	01-007318	1500 PARK AVE	EMERYVILLE WAREHOUSE CO /PECK & HI	EMERYVILLE	P	1922	HIST.SURV.	4608-0001-0017	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084012	01-007319	1501 PARK AVE		EMERYVILLE	P	1935	HIST.SURV.	4608-0001-0018	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084018	01-007320	1510 PARK AVE		EMERYVILLE	P	1930	HIST.SURV.	4608-0001-0019	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084019	01-007321	1518 PARK AVE		EMERYVILLE	P	1935	HIST.SURV.	4608-0001-0020	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084028	01-007322	1526 PARK AVE		EMERYVILLE	P	1925	HIST.SURV.	4608-0001-0021	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084029	01-007323	1545 PARK AVE	TRADER VIC'S/WESTINGHOUSE PACIFIC	EMERYVILLE	P	1912	HIST.SURV.	4608-0001-0022	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084030	01-007324	1550 PARK AVE	PELCO DISTRIBUTORS/AIR REDUCTION S	EMERYVILLE	P	1917	HIST.SURV.	4608-0001-0023	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
084061	01-007343	3607 PERALTA ST	COMPLETE MOBILE REJUVENATING	EMERYVILLE	P	1940	HIST.SURV.	4608-0017-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084062	01-007344	3616 PERALTA ST		EMERYVILLE	P	1915	HIST.SURV.	4608-0018-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084063	01-007345	3618 PERALTA ST		EMERYVILLE	P	1920	HIST.SURV.	4608-0019-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
180153		1255 POWELL ST	SIERA DESIGN WATER TOWER	EMERYVILLE	P	1920	PROJ.REVW.	FCC100518A	09/23/10	2D2	AC
084064	01-007346	3601 SAN PABLO AVE	OLD DOMINION HALL	EMERYVILLE	P	1910	HIST.SURV.	4608-0020-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084065	01-007347	3617 SAN PABLO AVE	EMERY APARTMENTS/ROXY HOTEL	EMERYVILLE	P	1925	HIST.SURV.	4608-0021-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084066	01-007348	3631 SAN PABLO AVE		EMERYVILLE	P	1920	HIST.SURV.	4608-0022-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
066087	01-005790	4320 SAN PABLO AVE	SENIOR HOUSING REHABILITATION	EMERYVILLE	U		PROJ.REVW.	HUD890807B	09/06/89	6Y	
090212	01-008118	4600 SHELL MOUND ST	SHELL MOUND SITE	EMERYVILLE	P		HIST.RES.	SHL-0335-0000	08/08/39	7L	
084082	01-007349	4650 SHELLMOUND ST	PFIZER, MINERALS, PIGMENTS AND MET	EMERYVILLE	P	1935	HIST.SURV.	4608-0024-0000	10/05/90	6Y	
							PROJ.REVW.	FHWA900927X	10/05/90	6Y	
084031	01-007325	1450 SHERWIN ST	SHERWIN-WILLIAMS	EMERYVILLE	P	1924	HIST.SURV.	4608-0001-0024	10/05/90	3D	AC
							PROJ.REVW.	FHWA900927X	10/05/90	2D2	AC
118874	01-010205		COYOTE CREEK BRIDGE	FREMONT	P	1948	HIST.RES.	DOE-01-98-0055-0000	11/13/98	6Y	
							PROJ.REVW.	USCG980529A	11/13/98	6Y	
010127	01-003260	1ST ST	FREMONT ODDFELLOW HALL SITE / ODD FELLO	FREMONT	U	0	HIST.SURV.	4538-0014-0005		7R	
010126	01-003259	2ND ST	ESSANAY FILM STUDIO	FREMONT	U	0	HIST.SURV.	4538-0014-0004		7R	

4608-0001-0026
Prop 84031
NR·3D



Resource # B-50, Map C, Sheet 4 of 17
1450 Sherwin Street (Originally Shellmound Avenue)
Sherwin-Williams

"Fireproof" reinforced concrete with brick curtain wall. Built prior to 1924 when Sherwin-Williams did $7,000 worth of construction. Extensive additions were constructed in 1927, and in 1936, they added a three-story steel-frame and concrete factory and warehouse building. The original entry door, located on Shellmound, was a Classical portico, fully pedimented and supported on columns. The pediment was topped by a three-dimensional paint can and globe--the company's logo. The Plant expanded again in 1939.



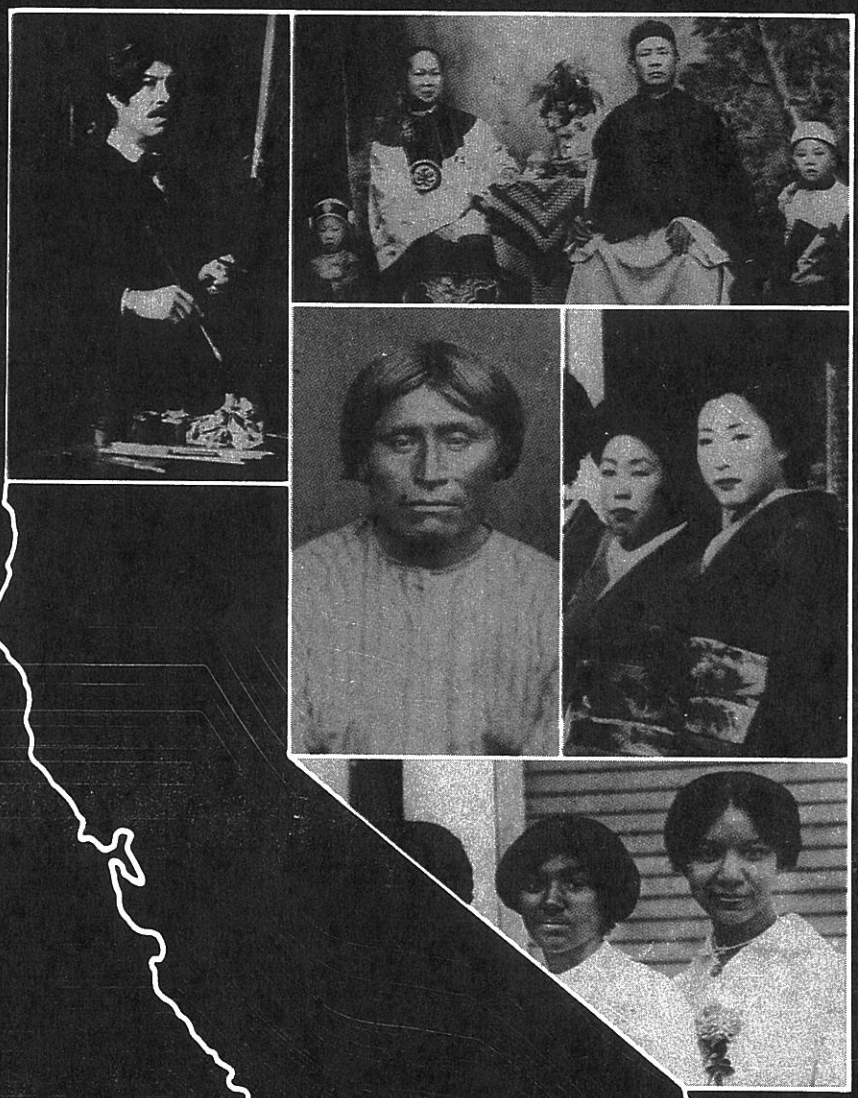
Historical View, c. 1940

Part of a district · See
4608-0001-9999

SITE-NUMBER	PRIMARY-NUM	NRS	EVL-DATE	PROGRAM REF.....	EVAL	OTHER NAMES AND NUMBERS.....
LA-000013	01-000034	2S2	09/01/83		KPNP	ALA-340 SFSC-ALA-1
LA-000015	01-000036	6Y	03/31/86	FHWA860214A		GREAT STONE FACE
LA-000060	01-000080	2S	03/04/81	FHWA820729R	KPNP	CASTRO VALLEY
LA-000307	01-000084	2S2	12/12/03	FHWA031101A	NTPR	NELSONS 307/WEST BERKELEY SHELLMOUND WEST BERKELEY BARKERS BERKELEY, 01-000084
LA-000416H	01-000142	6Y	09/15/92	COE920819A	NDPR	BLUEBIRD DUMP SITE
LA-000425H	01-000150	2S2	04/29/05	DOE050308A	WEPR	29.3
LA-000427H		6Y	04/29/05	DOE050308A	WEPR	
LA-000428/H	01-000152	6Y	04/29/05	DOE050308A	WEPR	GEARY RANCH 1865 BRINKER FAMILY 1939
LA-000442H	01-000164	6Y	08/10/87	WAPA870206A		OLD HOMESTEAD
LA-000455H	01-000177	6Y	08/28/92	PERC850526B	GRPR	SANTUCCI PROPERTY HOMESTEAD
LA-000456	01-000178	6Y	08/10/87	WAPA870206A		DEAD SKUNK CAVE
LA-000485	01-000201	6Y	07/18/02	COE010625A	MMPR	SL1, 01-000201
		6Y	10/19/01	ADOE-01-01-007-000	MMPR	
		6Y	10/19/01	COE010625A	MMPR	
LA-000486	01-000202	6Y	07/18/02	COE010625A	MMPR	SL2, 01-000202
		6Y	10/19/01	ADOE-01-01-008-000	MMPR	
		6Y	10/19/01	COE010625A	MMPR	
LA-000487H	01-000203	2S2	10/19/01	ADOE-01-01-001-000	MMPR	SL3
		2S2	10/19/01	COE010625A	MMPR	
LA-000488H	01-000204	6Y	10/19/01	ADOE-01-01-002-000	MMPR	SL4
		6Y	10/19/01	COE010625A	MMPR	
LA-000490H	01-000206	6Y	10/19/01	ADOE-01-01-003-000	MMPR	SL6
		6Y	10/19/01	COE010625A	MMPR	
LA-000491H	01-000207	6Y	07/18/02	COE010625A	MMPR	SL7
		6Y	10/19/01	ADOE-01-01-009-000	MMPR	
		6Y	10/19/01	COE010625A	MMPR	
LA-000492H	01-000208	6Y	10/19/01	ADOE-01-01-004-000	MMPR	SL8
		6Y	10/19/01	COE010625A	MMPR	
LA-000493H	01-000209	6Y	10/19/01	ADOE-01-01-005-000	MMPR	SL9
		6Y	10/19/01	COE010625A	MMPR	
LA-000494H	01-000210	2S2	07/18/02	COE010625A	MMPR	SL11
		2S2	10/19/01	ADOE-01-01-018-000	MMPR	
		2S2	10/19/01	COE010625A	MMPR	
LA-000495H	01-000211	6Y	07/18/02	COE010625A	MMPR	SL12
		6Y	10/19/01	ADOE-01-01-010-000	MMPR	
		6Y	10/19/01	COE010625A	MMPR	
LA-000496H	01-000212	2S2	07/18/02	ADOE-01-02-002-000	MMPR	SL13 UNION PACIFIC SALT WORKS
		2S2	07/18/02	COE010625A	MMPR	
LA-000498H	01-000214	6Y	07/18/02	COE010625A	MMPR	SL15
		6Y	10/19/01	ADOE-01-01-011-000	MMPR	
		6Y	10/19/01	COE010625A	MMPR	
LA-000499H	01-000215	6Y	07/18/02	COE010625A	MMPR	SL17
		6Y	10/19/01	ADOE-01-01-012-000	MMPR	
		6Y	10/19/01	COE010625A	MMPR	
LA-000500H	01-000216	6Y	07/18/02	COE010625A	MMPR	SL16
		6Y	10/19/01	ADOE-01-01-013-000	MMPR	
		6Y	10/19/01	COE010625A	MMPR	
LA-000501H	01-000217	2S2	07/18/02	COE010625A	MMPR	EDEN LANDING BARRON'S LANDING PETERMAN'S LANDING, 01-000217 ALA-489 ALA-497 2315
		2S2	10/19/01	ADOE-01-01-020-000	MMPR	
		2S2	10/19/01	COE010625A	MMPR	
LA-000536 H	01-000218	2D2	07/21/92	ADOE-07-92-001-025	GRPR	COUNTY LINE BARN
		2D2	07/21/92	BUR910227A	GRPR	
LA-000545H	01-000224	6Y	04/18/94	ADOE-01-94-001-000	NDPR	CIT 9101-02
		6Y	04/18/94	COE920819A	NDPR	
LA-000546 H	01-000225	6Y	04/18/94	ADOE-01-94-002-000	NDPR	CIT 9101-04
		6Y	04/18/94	COE920819A	NDPR	
LA-000547H	01-000226	6Y	04/18/94	ADOE-01-94-003-000	NDPR	CIT 9101-03
		6Y	04/18/94	COE920819A	NDPR	
LA-000549H	01-000228	6Y	04/18/94	ADOE-01-94-004-000	NDPR	543H
		6Y	04/18/94	COE920819A	NDPR	542H 416H 544H
LA-000586		2S2	07/01/02	ADOE-01-02-001-000	MMPR	
		2S2	07/01/02	FHWA020205A	MMPR	
LA-000605		6Y	06/03/03	ADOE-01-03-010-000	MMPR	
		6Y	06/03/03	FHWA030307A	MMPR	
LA-00425HH		2S2	04/29/05	DOE050308A	WEPR	
LA-00427HH		6Y	04/29/05	DOE050308A	WEPR	
LA-00428HH		6Y	04/29/05	DOE050308A	WEPR	
LA-00518HH		6Y	09/01/04	FTA040714A	CCPR	OAKS BUSINESS PARK AGRICULTURAL REMAINS, GD-4
LA-010526/H		6Y2	09/14/10	FAA100723A	TPPR	LIVERMORE AIRPORT PREHISTORIC/HISTORIC SITE, P-01-010526

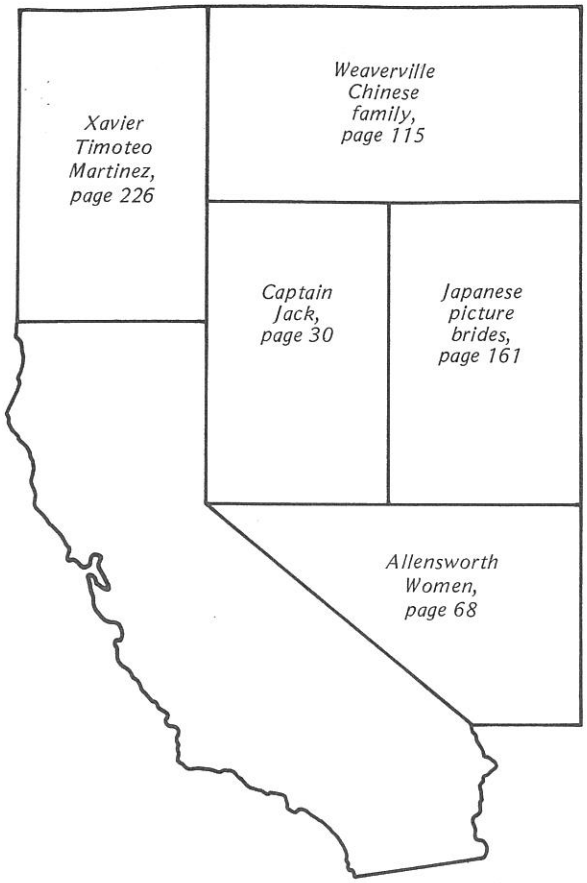
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ALA-Z00001		2S2	03/01/83	65000996	KPNP	SAN ANTONIO ADOBE HEADQUARTERS ARCHEOLOGICAL SITE
ALA-Z00004		6Y	06/29/00	ADOE-01-00-001-000	CCPR	DRILL TRACK, APN: 000-465-01
		6Y	06/29/00	FHWA000602A	CCPR	
ALA-Z00005		6Y	06/29/00	ADOE-01-00-002-000	CCPR	SOUTHERN PACIFIC RR YARD AND TRACKS, APN: 0-455-11
		6Y	06/29/00	FHWA000602A	CCPR	
ALA-Z00006		6Y	06/29/00	ADOE-01-00-003-000	CCPR	WESTERN PACIFIC RR YARD, APN: 0-435-05-2
		6Y	06/29/00	FHWA000602A	CCPR	
ALA-Z00007H		6Y	10/19/01	ADOE-01-01-006-000	MMPR	01-001791
		6Y	10/19/01	COE010625A	MMPR	
ALA-Z00008H		6Y	10/19/01	ADOE-01-01-014-000	MMPR	FW-1
		6Y	10/19/01	COE010625A	MMPR	
ALA-Z00009H		6Y	10/19/01	ADOE-01-01-015-000	MMPR	FW-2
		6Y	10/19/01	COE010625A	MMPR	
ALA-Z00010H		6Y	10/19/01	ADOE-01-01-016-000	MMPR	FW-11
		6Y	10/19/01	COE010625A	MMPR	
ALA-Z00011H		2S2	10/19/01	ADOE-01-01-019-000	MMPR	PF-1, PF-1
		2S2	10/19/01	COE010625A	MMPR	
ALA-Z00012		6Y	02/27/03	ADOE-01-03-001-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00013		6Y	02/27/03	ADOE-01-03-003-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00014		6Y	02/27/03	ADOE-01-03-003-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00015		6Y	02/27/03	ADOE-01-03-004-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00016		6Y	02/27/03	ADOE-01-03-005-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00017		6Y	02/27/03	ADOE-01-03-006-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00018		6Y	02/27/03	ADOE-01-03-007-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00019		6Y	02/27/03	ADOE-01-03-008-000	NTPR	
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00020		6Y	02/27/03	ADOE-01-03-009-000	NTPR	P-01-000257
		6Y	02/27/03	FHWA020823A	NTPR	
ALA-Z00021		6Y	11/15/01	ADOE-01-01-021-000	NTPR	TROUGH
		6Y	11/15/01	FHWA011017A	NTPR	
ALA-Z00022		6Y	11/15/01	ADOE-01-01-022-000	NTPR	JIM ANDERSON HOUSE SITE
		6Y	11/15/01	FHWA011017A	NTPR	
ALA-Z00023		6Y	11/04/03	ADOE-01-03-011-000	JDPR	HOMESTEAD AREA SITE
		6Y	11/04/03	FWS030721A	JDPR	
ALA-Z00024H		6Y	07/18/02	COE010625A	MMPR	FW-1
ALA-Z00025		6Y	07/18/02	COE010625A	MMPR	
ALA-Z00026H		6Y	07/18/02	COE010625A	MMPR	FW-11
ALA-Z00027H		6Y	07/18/02	COE010625A	MMPR	

F I V E



An Ethnic Sites Survey for California

V I E W S



FIVE VIEWS

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December 1988



The Journal of California Anthropology
UC Merced


Peer Reviewed

Title:
Cultural Diversity In Early Central California: A View from the North Coast Ranges

Journal Issue:
Journal of California Anthropology, The, 1(1)

Author:
Fredrickson, David A, California State College, Sonoma

Publication Date:
1974

Permalink:
http://escholarship.org/uc/item/8vg876v9

Keywords:
ethnology, archaeology, ethnohistory, native peoples

Abstract:
This paper focuses on the spatial and temporal relationships between the culture types which existed during the span encompassed by the Early and Middle Horizons in the Central California area within the regions of the lower Sacramento Valley, San Francisco Bay, and the North Coast Ranges. It seems clear that a simple unilineal sequence of culture types does not provide an adequate model for understanding the changes which appear to have taken place within this area during this time period and that the transition from one culture type to another did not take place uniformly throughout the area, but rather took place in different regions at different times. Thus, the absolute dating of transitions from one culture type to another must be determined independently for each region. It is recommended that an understanding of the changes which occurred in each region be sought through examination of both technoenvironmental and sociohistorical factors. The relationships proposed here are based upon published and unpublished data from the North Coast Ranges, as well as similar data from San Francisco Bay and the lower Sacramento Valley.

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Cultural Diversity in Early Central California: A View from the North Coast Ranges

DAVID A. FREDRICKSON

FOR more than 30 years the Central California chronological sequence proposed by Lillard, Heizer, and Fenenga (1939) with additions by Beardsley (1948, 1954) has formed the backdrop against which subsequent investigations have had to stand. Beardsley outlined several advances in method which allowed recognition of the temporal sequence of Early, Middle, and Late Horizons in Central California, an area which previously had been noted for absence of perceptible change (cf., Kroeber 1909, 1936). Briefly, the methods involved (1) deliberate investigation of small, single component sites as well as large stratified ones; (2) the treatment of each individual burial, including its associated artifacts and other attributes, as an analytic unit; and (3) the recognition of beads and ornaments, frequently found as grave furnishings, as sensitive indicators of temporal variation. Beardsley explicitly acknowledged that a sequence of burial complexes was obtained by these methods rather than a sequence of "prehistoric cultures in the full sense." The success of the third method sketched by Beardsley can be demonstrated by the fact that the established sequence of beads and ornaments, with refinements added primarily by Bennyhoff (cf., Bennyhoff and Heizer 1958), still offers a temporal framework for the cross-dating of archaeological sites throughout Central California and into the Great Basin.

When emphasis is shifted from beads and ornaments, however, to other elements of culture more intimately linked to basic subsistence patterns, the cultural picture which has developed in the past several years appears more complex than that suggested by the traditional Central California sequence. It is difficult to view the beads and ornaments as markers of cultural identity; rather they are more easily seen to represent trade or exchange horizons. While the examination of exchange networks would seem to have a great deal to offer with respect to the understanding of social relationships and political development (cf., Cohen n.d.; C. King 1973), this paper focuses on the spatial and temporal relationships between the culture types which existed during the span encompassed by the Early and Middle Horizons in the Central California area within the regions of the lower Sacramento Valley, San Francisco Bay, and the North Coast Ranges.[1] It seems clear that a simple unilineal sequence of culture types does not provide an adequate model for understanding the changes which appear to have taken place within this area during this time period and that the transition from one culture type to another did not take place uniformly throughout the area, but

rather took place in different regions at different times. Thus, the absolute dating of transitions from one culture type to another must be determined independently for each region. It is recommended that an understanding of the changes which occurred in each region be sought through examination of both technoenvironmental and sociohistorical factors.

The relationships proposed here are based upon published and unpublished data from the North Coast Ranges, as well as similar data from San Francisco Bay and the lower Sacramento Valley. Specifically, I refer to investigations, including radiocarbon dating, at Lak-261 near the town of Lower Lake (Fredrickson 1961, 1973), the analysis of Borax Lake obsidian carried out by Findlow, De Atley, and Ericson (1973), the obsidian hydration seriation and geological study of the Borax Lake site conducted by Meighan and Haynes (1968, 1970), the analysis and radiocarbon dating of Windmiller materials reported by Ragir (1972), the comparative analysis based upon the University Village materials from San Francisco Bay done by Gerow and Force (1968), and the investigations, including radiocarbon dating, at CCo-308 in interior Contra Costa County (Fredrickson 1966). A summary of these findings follows below while relevant radiocarbon dates appear as Table 1.

At the present time, the earliest cultural materials in the regions under discussion appear to derive from the Borax Lake site, about 90 miles north of San Francisco Bay. Although absolute dating is questionable, Meighan and Haynes (1970) found both obsidian hydration rim measurements and the geology compatible with an age of up to 10,000 B.C., but not necessarily of that age. This, of course, is a time depth considerably earlier than that proposed for the Early Horizon (cf., Heizer 1958a). The finding that the thickest hydration rims were obtained from Clovis-style fluted points and chipped crescentics gives credence to the view that the Borax Lake site was originally occupied at a very early time period (cf., Glennan 1971, Tadlock 1966). Provisionally, I refer to the culture represented by these earliest Borax Lake artifacts as the "Post Pattern" (named after Chester Post, the amateur who first called the site to the attention of professional archaeologists [Harrington 1948]). The suggestion of Meighan and Haynes that these materials may relate to localities such as Tulare Lake (cf., Riddell and Olsen 1969; Roehr and Wilwand 1968), where fluted points and crescents were found as part of a surface assemblage, appears reasonable, although fuller documentation and better dating are needed to determine relationships more precisely.

Meighan and Haynes also provide obsidian hydration measurements which indicate that the wide-stem Borax Lake projectile point may date back as far as 4000 to 6000 B.C. and further hypothesize its association with milling stones and hand stones. That this conjecture may be correct is suggested by the recent discovery of similar points in milling stone contexts in two Central California localities. In Little Indian Valley, about 9 miles northeast of the Borax Lake site, Orlins (1971, 1972) found such an association. Obsidian flakes from this context have yielded hydration rim measurements comparable to those from the wide-stem points from the Borax Lake site. In the Klamath Mountains, northeast of Redding, Clewett (1973) found an assemblage with a similar pairing. Clewett obtained a charcoal-based radiocarbon date of 4580 B.C., which provides considerable support to the Meighan and Haynes dating of the earliest milling stone occupation of the Borax Lake site. Provisionally, I consider this assemblage of wide-stem Borax Lake points and milling stones to be an early manifestation of the "Borax Lake Pattern," the milling stone

Table 1

SELECTED RADIOCARBON DATES FROM CENTRAL CALIFORNIA

Site	Lab No.	Pattern: Augustine	Berkeley	Windmiller	Borax Lake	San Dieguito	Remarks
Sac-21	M-885	1700 ± 150					Middle Phase 1
CCo-309	I-1193	1665 ± 95					Phase 2
Sac-60	M-749	1638 ± 200					Phase 2a
CCo-138	M-884	1450 ± 150					Late Phase 1
Sac-21	M866	1440 ± 150					Middle Phase 1
Sac-6	M-648	1330 ± 200					Late Phase 1 or Phase 2
Mrn-115	C-186	1230 ± 130					Phase 1 or Middle Horizon
CCo-138	M-865	1025 ± 150					Middle Phase 1
Sol-236	M-886	870 ± 200					Middle Phase 1
CCo-138	C-689	721 ± 200					Middle Phase 1
Sac-29	M-752		200 ± 500		A.D.		End Middle Horizon
Mrn-27	I-3148		30 ± 95		B.C.		Middle Horizon
Lak-261	I-2791		150 ± 150				Houx Aspect
CCo-259	UCLA-297		230 ± 250				Ellis Landing Facies
Ala-309	LJ-199		360 ± 220				Ellis Landing Facies
Mrn-27	I-3149		370 ± 190				Middle Horizon
Ala-328	C-690		389 ± 150				Ellis Landing Facies
Sac-6	C-691	460 ± 200					Late Phase 1 or Phase 2
Ala-307	M-121		500 ± 250				
SJo-142	I-2750a			545 ± 120			Phase 5?
SJo-142	I-2750b			635 ± 100			Phase 5?
Sac-197C	GX-0659			725 ± 135			
SMa-77	L-187A		750 ± 350				Early SF Bay
SJo-56	I-2751			905 ± 115			Phase 3
Ala-307	M-123		930 ± 300				
SJo-68	I-3038			1030 ± 110			Phase 4
Sac-168	I-3037			1120 ± 170			Phase 3?
Sac-107C	I-2748			1125 ± 105			
SJo-68	M-646			1130 ± 300			
Ala-307	M-126		1190 ± 300				
SMa-77	L-197B		1200 ± 300				Early SF Bay
Ala-307	M-127		1250 ± 250				
Ala-307	M-122		1260 ± 300				
SJo-142	GX-0660			1495 ± 110			Phase 5?
SJo-68	L-2749a			1635 ± 110			Phase 1
Ala-307	M-124		1650 ± 250				
Lak-261	I-2754				1740 ± 130		
SJo-68	I-2749			1825 ± 160			Phase 1
Ala-307	M-125		1910 ± 450				
SJo-68	C-440, 552			2102 ± 160			
SJo-68	M-645			2150 ± 250			
SJo-68	M-647			2400 ± 250			
CCo-308	UCLA-259		2500 ± 400				Early Middle Horizon
Men-581	GX-0229				3370 ± 145		
Sha-S258	GAK-4219				4580 ± 300		
Ker-116	I-1928					5650 ± 200	
Ker-116	LJ-1356					6250 ± 400	
Ker-116	LJ-1357					6250 ± 400	

complex described by Meighan as early as 1955, which is widespread throughout the North Coast Ranges and the adjoining region to the northeast (Fredrickson 1973). It is also important to note that Dotta (personal communication) obtained a charcoal-based radiocarbon date of 3370 B.C. for a milling stone assemblage in Mendocino County, while at Lak-261, about 9 miles south of the Borax Lake site, charcoal from another milling stone assemblage was dated at 1740 B.C. The Lak-261 assemblage is artifactually similar to the later manifestation of the Borax Lake Pattern distinguished by Meighan and Haynes at the Borax Lake site, and placed by them within the time range of 1000 to 3000 B.C. At Lak-261, stemless points, including nonfluted concave base ones, predominated, while milling stones and hand stones, occasional mortars, and a burin industry were other characteristics of the assemblage.

Thus, it appears that the adaptation of the Borax Lake Pattern existed in the North Coast Ranges at a time depth comparable to that of the Early Horizon, that is, the "Windmiller Pattern," in the lower Sacramento Valley. While the earliest radiocarbon date for Windmiller is about 2400 B.C., Ragir (1972) gave it a maximum age of about 3000 B.C., stating that she found little evidence to substantiate Lillard, Heizer, and Fenenga's (1939) prior estimate of 5000 B.C. Ragir placed the terminal date for Windmiller at about 1000 B.C., although radiocarbon dating of bone collagen suggested that it may have been as late as 500 B.C.

The terminal dating for Windmiller, which is considerably later than the date of 2000 B.C. cited by earlier workers (cf., Heizer 1958a) gives support to Gerow's contention, first made as early as 1954, that materials from the University Village site on San Francisco Bay were stylistically similar and of an age comparable to Windmiller, while the burial mode and general technology indicated that the site was more closely related to Middle Horizon than to Windmiller. Provisionally, I have grouped Gerow's Early San Francisco Bay materials, dated by radiocarbon as early as 1200 B.C., with later Middle Horizon materials under the rubric of "Berkeley Pattern." Additional support for occupation of the Bay by Berkeley Pattern peoples comes from the suite of C-14 dates from the West Berkeley mound (Heizer 1958a), the bottom portion of which Wallace (Gerow and Force 1968:10) had identified on stylistic grounds as contemporaneous with Windmiller. Finally, the Berkeley Pattern assemblage and charcoal-based radiocarbon date of 2500 B.C., obtained from CCo-308 at the western foot of Mount Diablo (Fredrickson 1966), offers more weight to the proposal that Berkeley Pattern on the Bay was contemporaneous with Windmiller Pattern in the Valley, as well as with the later portion of the Borax Lake Pattern in the North Coast Ranges.

Sometime between 500 and 1000 B.C., the Berkeley Pattern replaced Windmiller in the Valley, while in the North Coast Ranges, at least in the localities south of Clear Lake, what I refer to as the "Houx Aspect" of the Berkeley Pattern replaced the Borax Lake Pattern. A charcoal-based radiocarbon date of 150 B.C. was obtained from the Houx Aspect component which was situated stratigraphically above the Borax Lake Pattern component at Lak-261. The Houx assemblage included mortars and pestles, but lacked milling stones and hand stones. There was a large number of projectile points, presumably dart points, suggesting that hunting was considerably more important in the Houx Aspect than in the earlier milling stone period. There was also continuation of the earlier burin industry. In short, the assemblage appeared to contain elements of both the Borax Lake and Berkeley Patterns and is tentatively considered to be a coalescent pattern. Fig. 1 is a

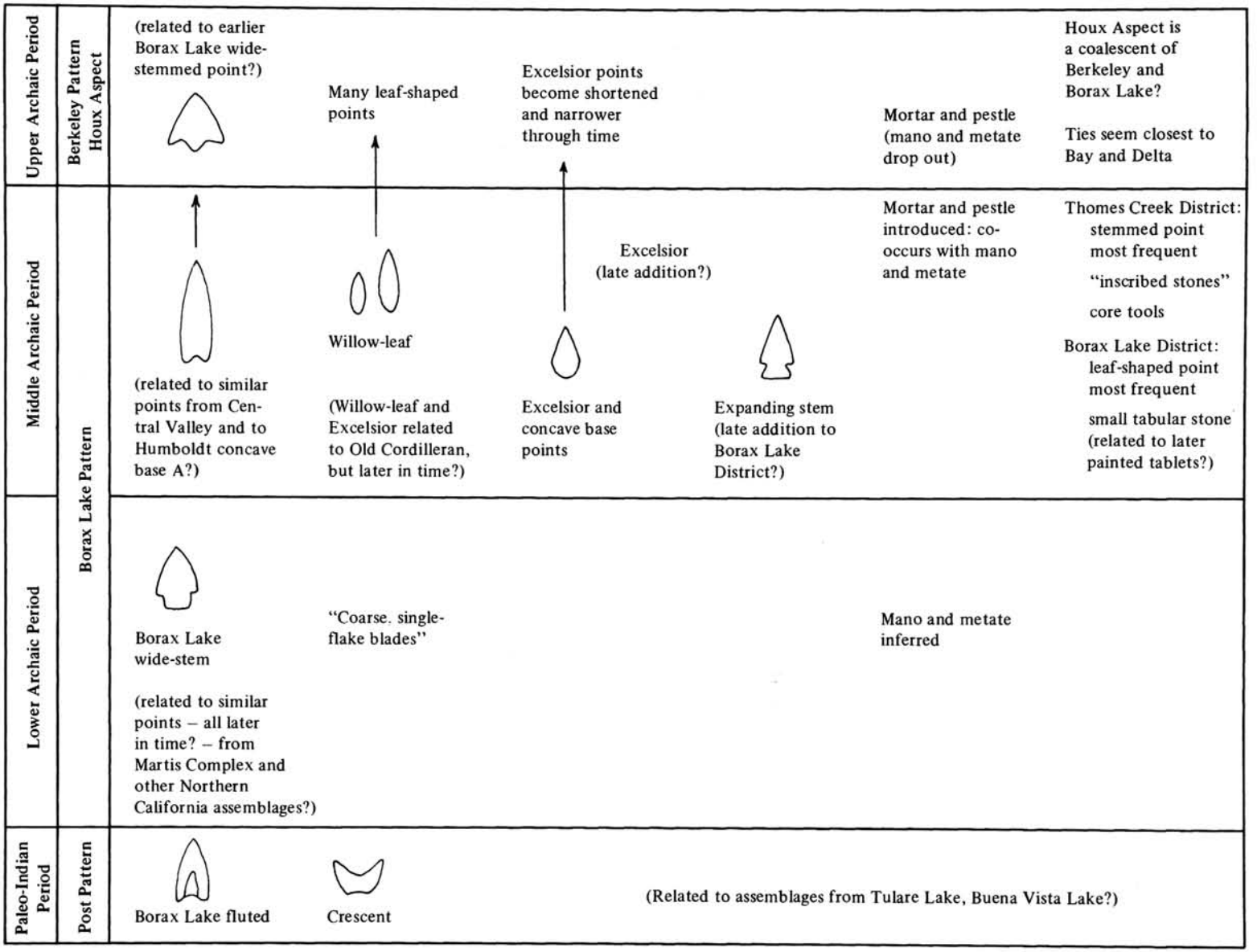


Fig. 1. Cultural Sequence Within the North Coast Ranges (Paleo-Indian and Archaic Periods).

schematic representation of the early cultural sequence described above for the North Coast Ranges.

By 500 B.C., then, the Berkeley Pattern appears to have been firmly established in the San Francisco Bay region, to have replaced the Windmiller Pattern in the lower Sacramento Valley, and in the North Coast Ranges to have merged with the Borax Lake Pattern to form the Houx Aspect. I suggest that the archaeological record would produce even greater diversity with respect to basic adaptive and economic modes in Central California at this time level–approximately 2500 B.C. to the early portion of the Christian era–if greater geographic scope were included in this discussion. For example, Bennyhoff's (1968) "Meganos Aspect" of the Berkeley Pattern, centered in the northern San Joaquin Valley, which follows Windmiller in time, appears to be a merging of Windmiller and Berkeley elements. The relationships between these patterns in the North Coast Ranges, San Francisco Bay and lower Sacramento Valley are diagrammed in Fig. 2.

Some kind of integrative framework to encompass this diversity would be useful. I propose that the dating and identification of temporal periods in California prehistory be kept separate from the dating and definition of particular patterns and suggest the following framework (cf., Bennyhoff and Fredrickson n.d.). The time span under consideration here is generally accepted to be characterized by the adaptive pattern of the Archaic (cf., Meighan 1959). In California, the beginning of the Archaic is marked by the introduction or development of milling stones and an accompanying emphasis upon the collection of plant foods (cf., C. King 1967; Kowta 1969). An interval from 6000 B.C. to 3000 B.C. is acceptable for the predominance of the milling stone adaptation and the span of what I refer to as the "Lower Archaic Period." The cultural developments at this time depth may possibly be linked to the Altithermal, a climatic regime believed by some to have been characterized by relatively high temperatures and low precipitation (cf., Antevs 1952, 1953; Bryan and Gruhn 1964; Kowta 1969). In general, the cultures of the Lower Archaic Period appear to have emphasized the collecting and processing of seeds, with hunting of more significance in northern California than in the south. As yet, no direct evidence of acorn utilization has been found for this period and tools characteristic of ethnographic practices involving the acorn, namely, the pestle and deep mortar, are absent from the Lower Archaic Period inventory. Nowhere during the initial portion of the period did fishing or sea mammal hunting seem important, although by the final part of the period in southern California both of these resources were gaining in significance.

Sometime between 3000 and 2500 B.C., the mortar and pestle, and presumably the acorn processing technology, were introduced or developed in California, marking the beginning of the "Middle Archaic Period." The cultural transition from Lower to Middle Archaic may have been associated with the end of the Altithermal and the beginning of the Medithermal, the climatic regime which persists through the present day. The Middle Archaic Period is dated here from 3000 B.C. to about 1000 B.C. and was marked by the geographic spread of the mortar and pestle. Hunting appears to have become significantly more important as compared with the Lower Archaic Period, and, in general, the economic base became more diversified. Shellfish collecting spread as a local specialization while sea mammal hunting and fishing became particularly significant on the south coast.

The new technologies of the Middle Archaic Period may have been the result of the intrusion of a new population or populations which coexisted with the earlier population, ultimately merging with or replacing it cul-

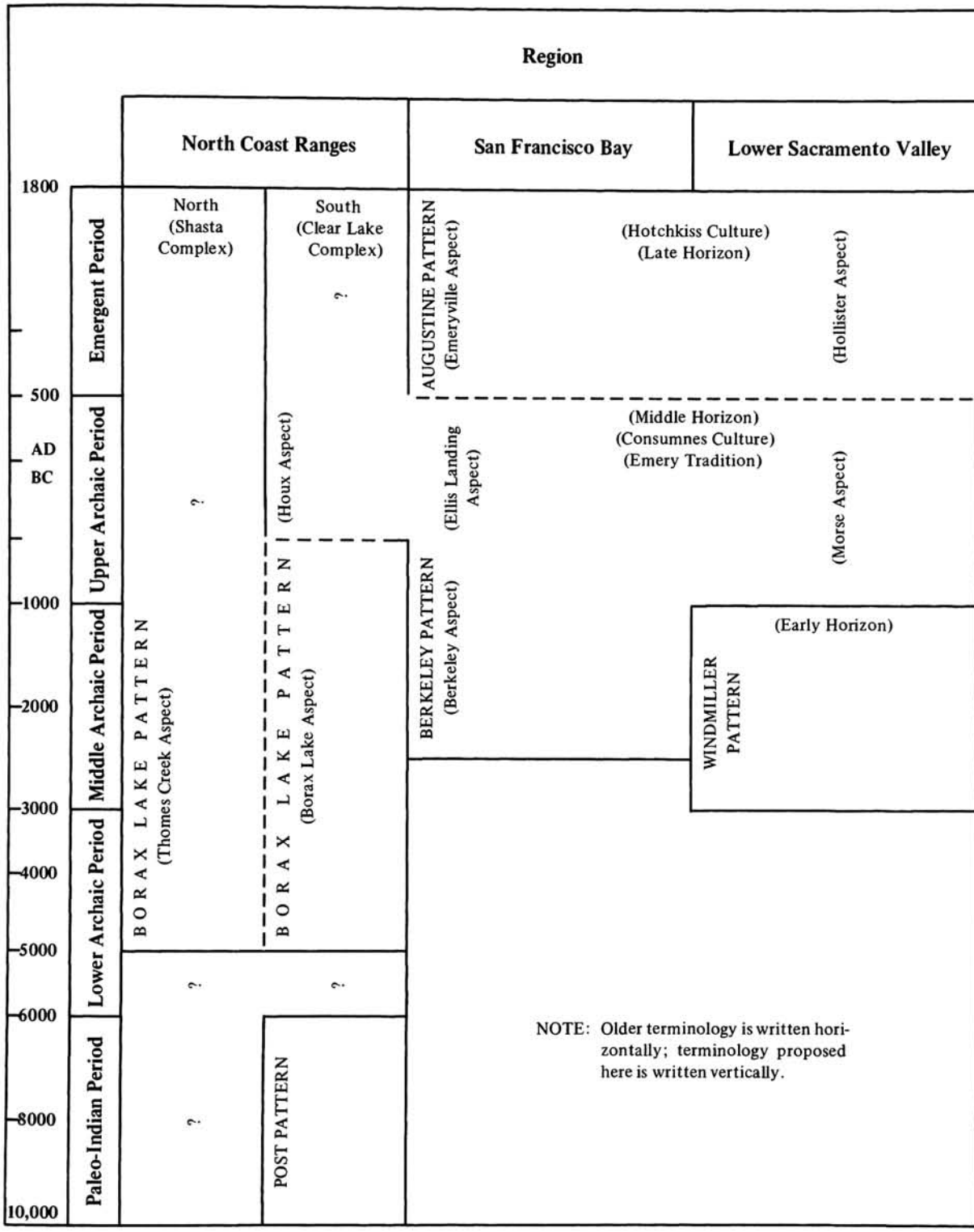


Fig. 2. Periods and Patterns in the North Coast Ranges, San Francisco Bay, and the Lower Sacramento Valley.

turally. The new food grinding technology spread rapidly though not uniformly, and, through processes perhaps associated with technological advantage, eventually either replaced the earlier milling method, was adopted as a complementary method, or was not adopted at all. In some regions, such as those in southern California, the mortar and pestle were not accepted and the milling stone remained the primary food-grinding tool. Environmental influences were probably crucial here as they may have been in other regions, such as the Sierran portions of Central California, where the milling stone and mortar technologies coexisted within the same cultures. Overall, the transition from milling stone to mortar, when it did occur, did not necessarily take place in all localities at the same time. Social influences also can be postulated to have been operative in all regions where the adaptive competition between the acorn technology and previously developed strategies occurred. For example, we can speculate that the social cohesion of the Windmiller Pattern, a characteristic inferable from the pattern's tightly organized burial practices, may have been a factor perpetuating its coexistence vis-à-vis the competing Berkeley Pattern. The overall data available as of now suggest that by 1000 to 500 B.C. the resolution of most of the cultural conflicts had taken place, although some readjustments were still to come, such as the expansion and later contraction of the Meganos Aspect of the Berkeley Pattern from the Stockton District to the Diablo and Alameda District reported by Bennyhoff (1968).

For the purposes of this discussion, the "Upper Archaic Period" is placed within the interval between about 1000 B.C. and A.D. 500. While technological and environmental changes appear to have provided the dominant themes for developments during the Middle Archaic, the Upper Archaic seems to have been marked by ever-increasing sociopolitical complexity, a growth of status distinctions based upon or marked by relative wealth, the emergence of group-oriented religious activities, and greater complexity of the exchange systems (see T. King 1972).

Sedentary life appears to have become fully established in many regions, and the developing economic efficiency may have contributed to population growth. Although similar developments appear to have been taking place in several different regions of the state, the developments in any one region may have occurred more or less independently of events in other regions. Over time, however, possibly facilitated through religious and economic exchanges, groups in different regions tended to become interdependent, but with the northern and southern portions of the state remaining relatively independent of one another.

As an aside, I refer to the Late Period in California prehistory, the beginning of which is placed at A.D. 500, as the "Emergent Period." Without summarizing arguments as to whether certain Californian cultures of the ethnographic period should be classified as Archaic or Formative (cf., Baumhoff 1963; Heizer 1958b; Meighan 1959; Willey and Phillips 1958), I propose the concept of the Emergent as a nonagricultural equivalent to the Formative. Evidence continues to accumulate that Californians modified the environment to increase its natural productivity (Lewis 1973; Steward 1930, 1941:232; Voegelin 1942:176), that food storage and exchange relations served to equalize the distribution of resources unequally distributed in time and space (cf., Bean 1971; Chagnon 1970; Davis 1961), that complex forms of social, religious, and occupational organization were emerging (Bennyhoff 1961; Goldschmidt 1948; Loeb 1926; McKern 1922), and that ranking societies and possibly chiefdoms were developing in several regions of the

		Period Characteristics
1800	Emergent Period Upper	Clam disk bead money economy appears. Increasing quantites of goods moving farther and farther. Growth of local specializations re: production and exchange. Interpenetration of south and central exchange systems.
1500	Emergent Period Lower	Bow and arrow introduced, replace dart and atlatl; south coast maritime adaptation flowers. Territorial boundaries fairly well established. Evidence of distinctions in social status linked to wealth increasingly common. Regularized exchanges between groups continue with more material entering into the network of exchanges.
500 AD / BC	Upper Archaic Period	Growth of sociopolitical complexity; development of status distinctions based upon wealth. Emergence of group-oriented religions. Greater complexity of exchange systems; evidence of regular, sustained exchanges between groups. Shell beads gain in significance, possibly indicators of both exchange and status. Possible origins of Kuksu religious system at the end of period.
1000	Middle Archaic Period	Altithermal may have ended by ca. 3000 B.C.; climate becomes more similar to present-day. Mortars and pestles and inferred acorn technology introduced. Hunting important. Possibility of entry of new population. Diversification of economy; sedentism more fully developed, population growth and expansion. Technological and environmental factors provide dominant themes. Little evidence for significant changes in exchange relations.
3000	Lower Archaic Period	Altithermal may have begun about 6000 B.C.; ancient lakes drying up. Milling stones develop or are introduced; plant food emphasis, little hunting. Although semi-sedentary life style, exchange seems similar to previous period. Most artifacts manufactured of local materials. Little emphasis upon wealth.
6000	Paleo-Indian Period	First demonstrated entry and spread of humans into California. Lakeside sites with a probable but not clearly demonstrated hunting emphasis. No evidence for a developed milling technology although cultures with such technology may exist in state at this time depth. Exchange probably ad hoc, individual, one-to-one. Social unit not heavily dependent upon exchanges; resources acquired by changing habitat.
10,000		(No satisfactory information from the preceding Early Lithic Period.)

Fig. 3. Hypothesized Characteristics of California's Prehistoric Periods.

state (cf., Fredrickson 1971; C. King 1971, 1973; T. King 1970, 1972). This is not, however, the context to examine this body of evidence.

On the basis of the above model, I hypothesize that during much of the Middle Archaic Period throughout California, which dates from about 3000 B.C. to about 1000 B.C., considerable pattern diversity and cultural variation will be found. Considerable population movement should be evidenced and the early milling stone pattern should be altered both by significant internal development and by the introduction of new industries. In some regions complete replacement of the earlier pattern should be observed relatively early, in other regions relatively late. In some regions evidence of assimilation and coalescence should be forthcoming, again with probable temporal differences. Following historical reconstructions based upon ethnographic and linguistic evidence (cf., Klimek 1935; Kroeber 1923), Penutian entry into California may have been linked to the appearance of the new technologies, complicating the interrelationships between both people and technologies. Due to the nature of the hypothesized population and culture contacts, it would seem unlikely that complex, long-standing, or extensive trade networks would develop during the earlier portion of this period of change. In other words, there is

little reason to expect uniformity of culture pattern, stability of population, or regularization of cultural influences during the period from about 3000 B.C. to about 1000 B.C., that is, during the Middle Archaic Period, and possibly, in some regions, into the Upper Archaic. Fig. 3 outlines the hypothesized characteristics of California's prehistoric periods.

In conclusion, it can be pointed out that the environmental, cultural, and linguistic diversity within ethnographic California has frequently been remarked upon. It is only reasonable to expect a prehistoric period with comparable diversity. As has been noted by other researchers, California offers an excellent research area for the study of the adaptations and development of hunters and gatherers.

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NOTES

1. This paper is a revised version of a presentation given at the Thirty-Eighth Annual Meeting of the Society for American Archaeology, San Francisco, California, May 3-5, 1973.

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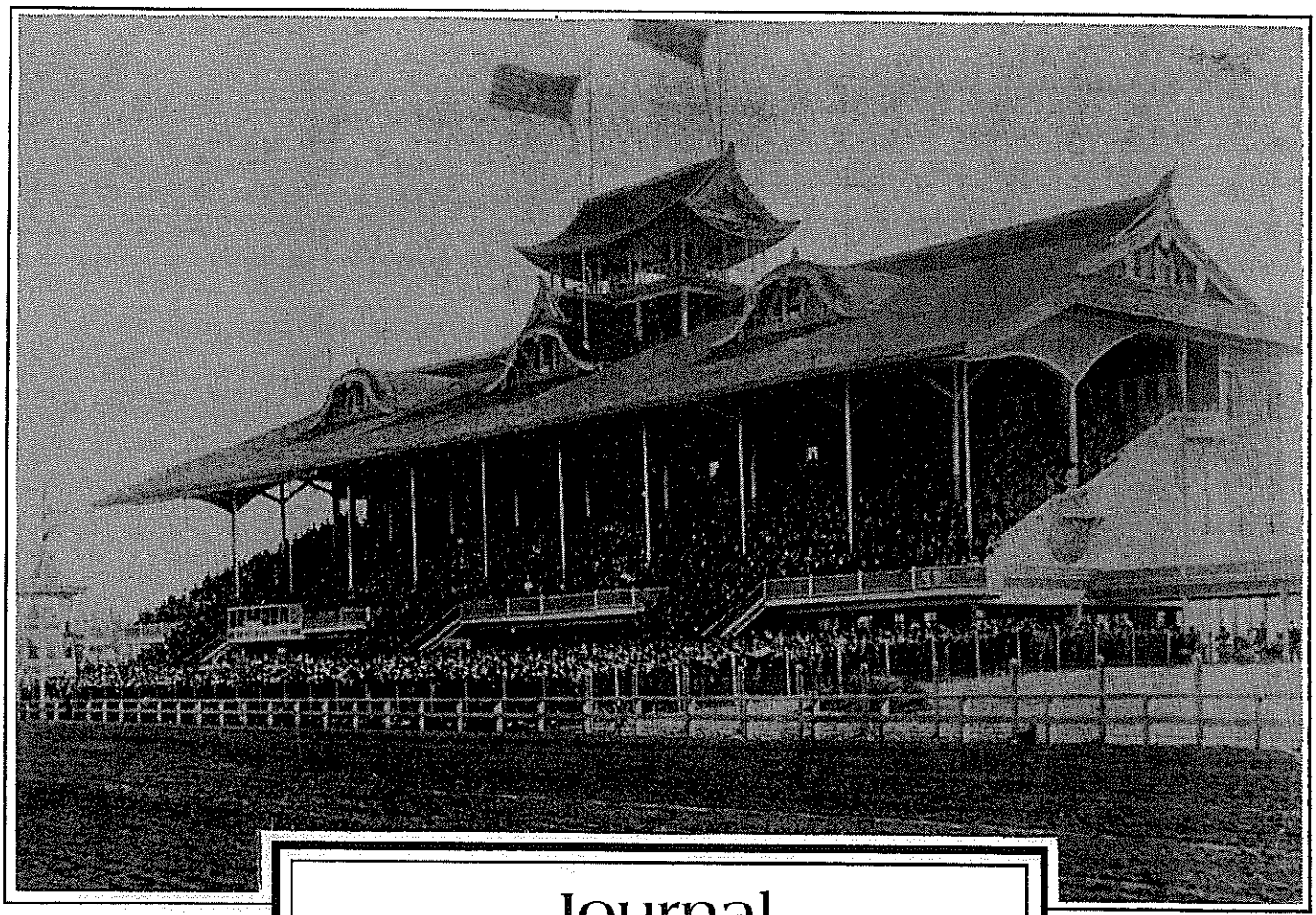
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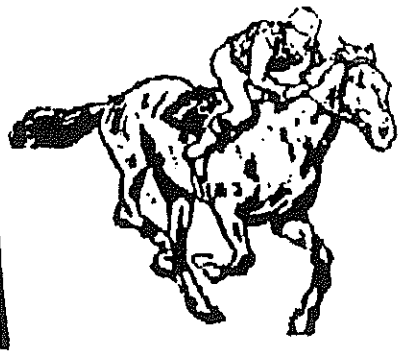
Special Issue:

The Emeryville Horse Race Track: 1871-1915

by Donald Hausler



Journal
of the
Emeryville
Historical Society
Volume V, Number 1 — Spring, 1994



RACING

New California Jockey Club

OAKLAND RACE TRACK—Racing Every Week Day—Rain or Shine. Six Races Every Day. FIRST RACE AT 1:40 p. m.
Admission: Men, $2.00; Ladies, $1.00. Take street cars from any part of city, transfer to San Pablo avenue.
PERCY W. TREAT, Secretary. THOS. H. WILLIAMS, President.

Racetrack advertisements: *Oakland tribune of February 11, 1911. Below, July 2, 1887*

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April 1 to May 30

Race Track Exhibit

Celebrating the Horse and Dog Tracks of Alameda County.

An exhibit of historical photographs and facts compiled by the Emeryville Historical Society.

Three major horse race tracks have operated in the east bay since California became a state in 1850. Alameda County's first official race track opened in 1858 and was located in Pleasanton. Still operating, the Pleasanton horse track has been the major attraction of the Alameda County Fair since 1912. The second major track was built in Emeryville in the early 1870s. The Emeryville track, originally known as the Oakland Trotting Park and after 1896 as the California Jockey Club, closed in 1911. The third major track, Golden Gate Fields, opened in Albany in 1941 and is still in business. In addition to the horse tracks, several dog race tracks have operated in the east bay cities of Emeryville, San Pablo, El Cerrito, and Alvarado.

Presented in the Oakland History Room of the Oakland Public Library
125 - 14th Street

This newlsetter is a companion piece to the exchibitt. Presented on the occassion at the public reception opening the exhibit on Saturday, April 2, 1994.

OAKLAND TROTTING PARK.

GREAT ROMAN CHARIOT RACES!

SUNDAY, JULY 3, 1887,

RACES!  RACES!

☞ GREAT RUNNING RACE. ☜
Purse $300. ½ Mile and Repeat.

E. DONNER names.....Lize Clark, 105 lbs.
Lee Shaner names.....Belshaw, 105 lbs.
R. Fallon names.....Harriet, 115 lbs.
J. H. Muse names.....Black Pilot, 105 lbs.

SAME DAY,

☞ GREAT ROMAN CHARIOT RACE ☜
For a purse of $200 betwben
MADAME LE MER and MARIETTA STARR;
Best 2 in 3, Mile Heats.
Madame Le Mer's team will not be attached to the chariot until the day of the race.
Admission, 50 cents, Children Half Price.
Grand Stand Free. j30-3t

The Quarterly Newsletter of the Emeryville Historical Society
Vol V, No. 1 — Spring 1994
800 copies printed

Editor & Production: Paul Herzoff
Halftones: Jewels Graphics
Printing: Copymat

EHS core group members:
Don Hausler, Vernon Sappers, Arrol Gellner, Nancy Smith, Paul Herzoff, Phil Stahlman, Tony Molatore, Ray Raineri, Richard Ambro

Editor's Introduction: Emeryville, an East Bay Coney Island

Twenty-five years before there was Emeryville there was only a simple horse race track at Emery's station and a rustic amusement park at the old Indian shell mound to draw visitors out to the western marshes of the East Bay.

An engraved illustration of the Emery mansion in around 1876 shows those two monuments to leisure time looming in the empty landscape behind the founder's ornate homestead.

Between them in the picture runs a steam train of the Northern Railway, which in 1874 linked the San Francisco ferryboats to Martinez, and in 1876 to Berkeley. This new line, developed by Central Pacific (under a different corporate name and under pressure from interests in Berkeley), incidentally stopped in Emeryville to deliver horserace fans to the track and picnickers to Shellmound Park.

Unlike in some areas of the East Bay, where symbiotic partnerships of transportation and real estate promoters built attractions to lure prospective residents out to distant suburbs, the Northern line didn't contribute much to the residential development of Emeryville. Presumably the types of people who came here for recreation weren't looking for a place to settle down, and anyway the area lacked the natural charm that drew people to relocate in "the country."

Evidently though, it was a great place for stockyards and steel mills, because the bigger impact of rail transportation on Emeryville's development was made by the expansion of industry served by the Southern Pacific — but that's material for another newsletter.

The Northern, while shortening the route to Berkeley, brought increasing numbers of people-with-cash-to-spend over from the San Francisco ferry and thus contributed to the commercial development of the districts adjoining the racetrack.

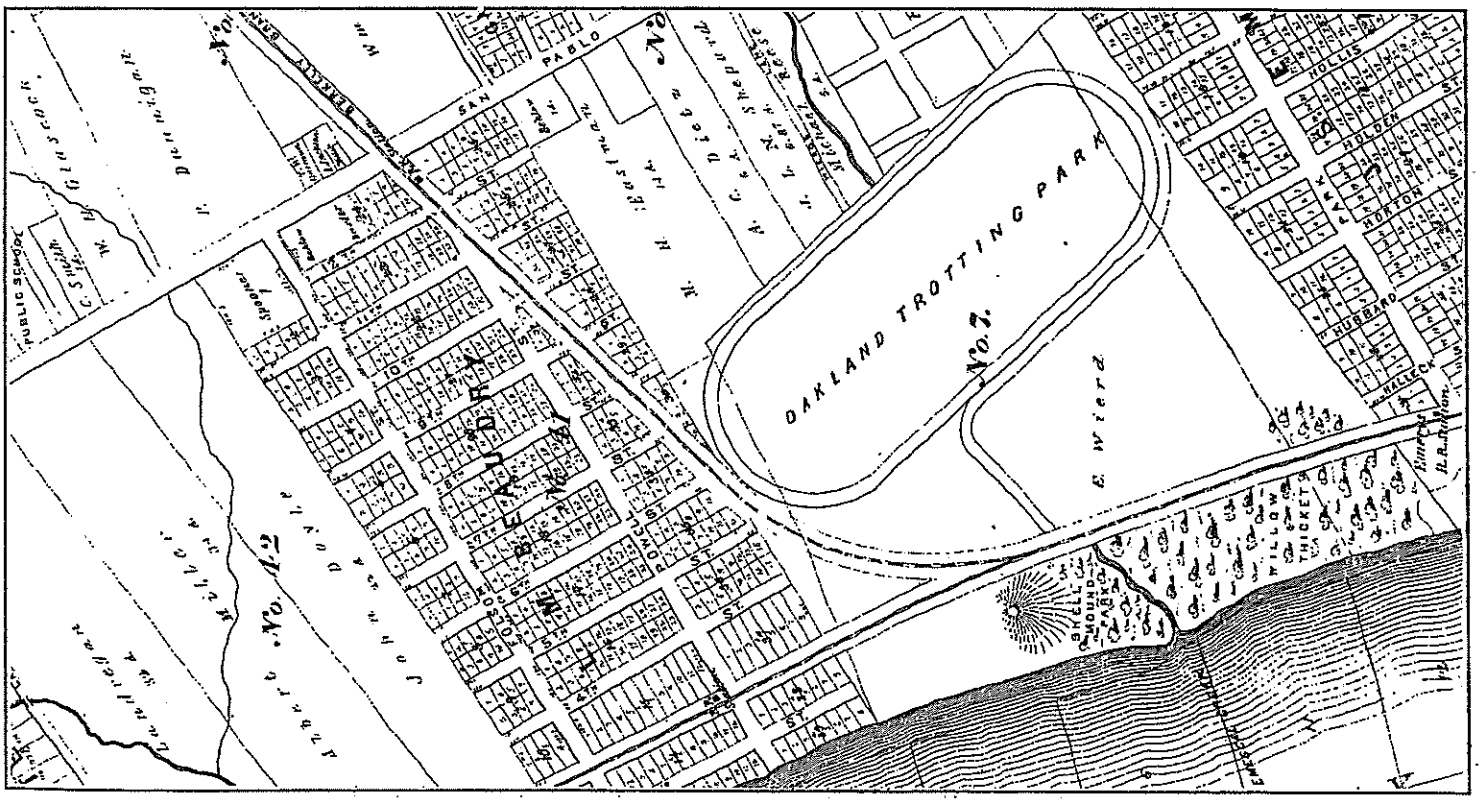
The area boomed towards the turn of the century and this prosperity contributed to the need (and the means) for the town's incorporation in 1896, albeit without the participation of many nearby residents, who were morally offended that the local economy leaned so on tourism and gambling,

The Trotting Park had been built a few years before the trains came — a relatively small operation served by local horsecar lines and the Oakland/S.F. ferry. At the start, the track was a rural attraction in a semi-rural area that was rebuilt and expanded to serve the crowds brought in by the swift new trains.

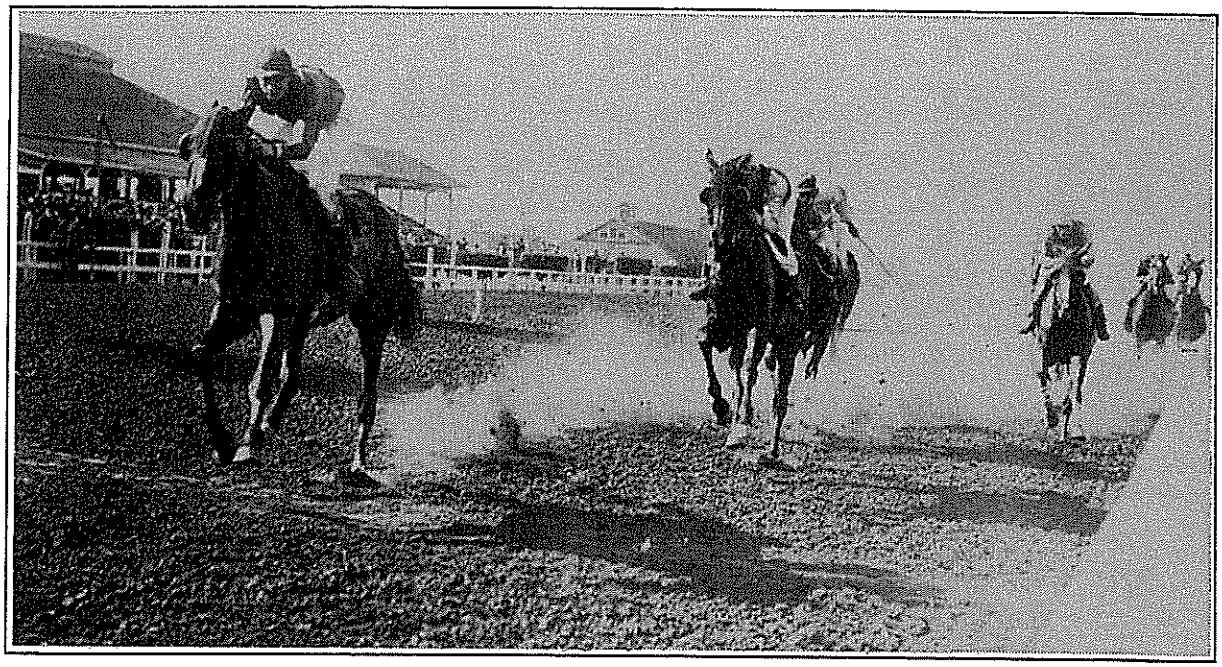
Shellmound Park was developed some years later, the railroad having secured the park's easy access by regional crowds of up to 20,000. Most importantly for our account, Capt. Siebe's playland by the bay served local needs for recreation and a provided a place for organized gatherings.

Shellmound Park could only exist in a place and time when family recreation was more formal and slower paced than today's. Emeryville's pioneering entertainment complex grew out of a San Francisco tradition of East Bay summer homes and local needs for social centers. While it was important to locals, for whom hitching up a wagon and riding for an hour or so was accepted as reasonable effort for a day's entertainment, it was intended to draw customers from San Francisco. For these pleasure seekers, the traveling, including a ferry ride, was part of the party.

While the trains didn't create these attractions, it helped them and, in turn, the surrounding area to grow. We might surmise that the parks' developer had some prior knowledge of the railroad's future path, but whether it was inside or public knowledge remains unresearched. In any event, J.S. Emery was a railroad man, and the historical record suggests that he and the local entrepreneurs associated with him were sharp players who forsaw major opportunities to improve their holdings and acted upon them. cont.



Emeryville in 1878: *Historical Atlas of Alameda County, by Thompson & West. Note mispelling of Wiard's name.*



Thoroughbreds racing at Emeryville: *View of finish line shows stables and grandstand in background*
(Photo Courtesy of The Bancroft Library)

In regard to E. Wiard, it didn't take a steam engineer (which he was) to think of buying land in the future path of a railroad; but it probably took some inside business connections to unite with the group of sporting gents who had joined J.S. Emery in snapping up bayfront chunks of the newly available Peralta Rancho.

The titles to Spanish land-grant properties had been challenged after the gold rush, and the Ranchos were being broken up under the pressure of squatters and commercial interests. Don Vicente Peralta's heirs were selling their little corner of the giant Rancho San Antonio while they still had something to sell, and waves of land speculators were churning the deeds until they were acquired by high-rolling gold rush capitalists like Joe Emery — men of vision who were ready to settle and develop the desolate outlands — men who, having settled and developed, were ready to bet on a card game or a horse race.

Emery himself seems to have had a prescient understanding of how cities grow. He had the foresight to establish the California-Nevada Railroad; he founded Mountain View Cemetery and the Emery grammar school; and he was to dredge the entrance to Oakland's harbor — which brought rail service to the city and set the East Bay on the road to world trade. His horsecar line was the first public transportation to bring people from downtown Oakland to the Trotting Park that used its name. That the town surrounding the track ended up using his name is a fitting tribute to Joseph Stickney Emery's vision and energy.

The Oakland Trotting Park would probably have been built regardless of the prospect of the railroad. The racetrack was a more important place than modern sensibilities can appreciate, since it was founded in a time when American society ran on horse-power and people had daily, familiar contact with horses.

It was a culture where everyday people worked and played with horses; and the wealthy studied, collected, and bred them. Racetracks were the ultimate proving ground for breeding and training and the grand meeting places for experts in the era's main mode of transportation.

In the late 19th century, people related to horses and took pride in their horse-knowledge the way many modern Americans do with their cars. Trotting races involved horses pulling vehicles not too different from the ones that brought the spectators, and their appeal was similar to that generated by stock car races in the early days of auto transport. In Victorian times, the Sport of Kings wasn't just an exotic excuse for gambling, but a spectacle closely related to real life issues. Enthusiasts of the sport knew the horses personally and admired them as athletes. Jockeys were superstars. The drama of their competition fired up discussion and opinion among the fans, who were willing to back their opinions with wagers — which set up a convenient way to finance the whole enterprise. But that's yet another newsletter.

In this one, we are pleased to publish a major article by Don Hausler, whose command of local historical resources makes him a resource in himself. His tireless research is steadily pushing back local tendrils of the historical fog that seems to gather around the affairs of earlier generations.

Thanks to Sandy Sher, whose deep research into primary sources provides valuable corroboration and correction of our media-derived facts.

Thanks also to Arrol Gellner — whose ability to analyze architecture extends backwards in time to long forgotten buildings — for sharing his knowledge regularly and generously.

Acknowledgments are due to Charles Wollenberg, whose Vista College series on Berkeley history is an enjoyable introduction to the area's foundations.

Our gratitude is extended once again to Vernon Sappers, whose fluency in local history is sharp enough to deflate the most reasonable sounding of erroneous theories — before they are committed to print as "historical" fact and allowed to replace forgotten truths.

The limits of human memory are a sad fact of life, but a fine justification for the existence of historical societies. In accord with our corporate purpose ("To research, publicize and promote information about the history and traditions of the town..."), we of the Emeryville Historical Society are pleased to uncover these forgotten facts and relationships for the entertainment and education of our neighbors. We write in hope that the understanding of our roots will promote the appreciation of our surroundings and inform our plans for the future.

Respectfully Submitted,

Paul Herzoff
March 23, 1994

History of The Emeryville Horse Race Track

by Donald Hausler

Few people are alive today who remember the old Emeryville racetrack that stood by the bay for almost 45 years. Since it burned down in 1915, its connection with the founding of Emeryville has largely been forgotten.

It has been 125 years since construction commenced on the track, and this anniversary is an appropriate time to acknowledge the significance of the horse racing industry in the early development of Emeryville and the importance of one of the town's earliest and most enduring attractions.

The Emeryville horse race track, originally known as the Oakland Trotting Park and later as the California Jockey Club, was built next to the marshes of the East Bay by Edward Wiard, a native of New Haven, Connecticut, born in 1815.

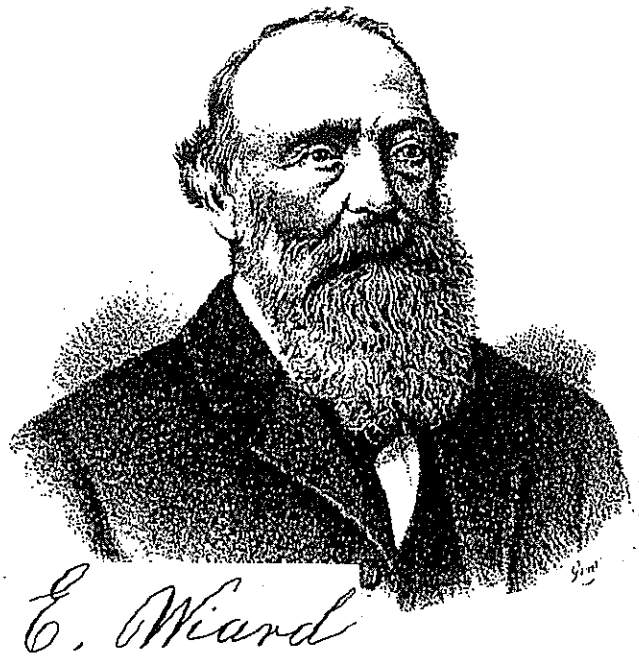
As a young man Wiard worked as a steam engineer in Georgia, then joined the gold rush to California, arriving in San Francisco in 1850. After working for several years in the gold mines of the mother lode, Wiard settled in the East Bay and in 1859 purchased a 115-acre tract of land for $7000 in what was to become the town of Emeryville.

Located north of Oakland next to San Francisco Bay, the Wiard tract lay across the obvious path of the East Bay's first railroad tracks, and in 1874 the property was bisected by the Northern Railway tracks connecting Oakland with Martinez.

Wiard's property was located west of San Pablo Avenue, north of Park Avenue, and south of Stanford Avenue, and became the magnet that drew visitors, residents, development and industry to this remote and undeveloped corner of the East Bay.

Wiard's land west of the tracks was to become Shell Mound Park, a famous resort and picnic area that featured a shooting gallery, beer garden, merry-go-round, foot race track, and dance pavilion.

Shell Mound Park was leased to its developer, Captain L. Siebe, and it remained a popular attraction from 1876 to 1924, when prohibition shut its beer taps.



Builder of the Oakland Trotting Park: *Portrait of Edward Wiard from Wood's History of Alameda County, 1883.*

Edward Wiard built his Oakland Trotting Park on the portion of the property to the east of the eventual path of the Northern Railway.

Wiard began construction in the late 1860s, and the one-mile race track (2,000 feet long and 900 feet wide) was completed in 1871.

Temescal Creek flowed west through the center of the track, and bridges had to be built where the race track crossed the creek.

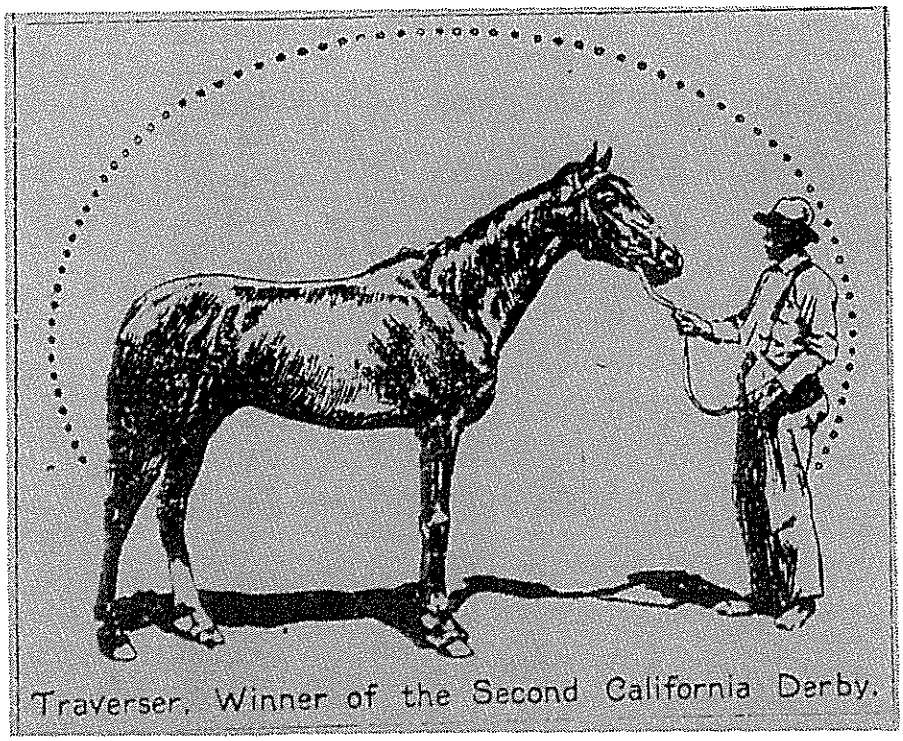
A seven-foot high fence surrounded the grounds, and the entrance was on Hollis Street, one block north of Park Avenue.

Edward Wiard was owner-in-residence at the track, acting as manager of the hotel he built there to accommodate the race track fans. The two story hotel, which had a veranda on each floor, was later moved to the foot of Park Avenue near the railroad tracks.

The race track complex also included stables and a grandstand, with the racing infrastructure located on the north and west sides of the track. The tack rooms and jockey club were located between what are now 45th and 53rd Streets, and the stables on the Shellmound side of the track, directly over the creek, which presumably brought drinking water at the top, and possibly was used as a sewer at the bottom. The surrounding commercial area catered to the track and its denizens,and eventually included various saloons, hotels, restaurants and bordellos.

Wiard hired H. A. Randlett to manage the Oakland Trotting Park, and Randlett worked in this capacity for only a year, leaving to build his own hotel, known as the Randlett House, on the southwest corner of Park Avenue and Hollis Street. After Randlett's departure, Wiard appointed his son-in-law, George M. Palmer, as track manager.

When the track opened in July,



Traverser, Winner of the Second California Derby.

1871 the following article appeared in the Oakland News.

> This new race course was regularly opened for a short trotting season on the Fourth (July). Some five or six hundred people were in attendance, a large number of whom were ladies.
>
> The three year old colt trotting race between the "Casserly" colts "Honest John" and "Grey Eddy" for $4,500, for which the match was made at the time of their foaling, had been looked forward to with some eagerness. It proved a great disappointment, however, to the expectants, the former balking terribly at the start in each heat. The race was won by "Grey Eddy" in two heats.

For the first 25 years of its existence the Oakland Trotting Park featured harness racing, in which horses pull two-wheeled sulkies with seated drivers at a trotting gait. Harness racing comprises three one-mile heats between two horses, and the best two out of three races wins. In those days the sulky was made of wood and had spoked wheels of large-diameter.

The First California Derby was held at the Oakland Trotting Park in May, 1873. This was thoroughbred racing between running horses with jockeys riding in the saddle. Inclement weather and poor attendance detracted from the event, according to an Oakland Transcript article.

> A dreary day was that for the inauguration of the Derby races yesterday over the Oakland Trotting Park. The weather was wintry, a piercing gale blowing up the Golden Gate, and a drizzling rain falling at intervals though the afternoon.
>
> The attendance at the hour appointed for the races to begin, was scarcely greater than on the preceding day. Everybody felt cross, chilly and generally disgusted. A dozen or more ladies, wrapped in furs and shawls, shivered on the balcony. The race was a sweepstakes for colts and fillies three years old...

The mile and a half race was won by Camilla Urso, and despite the bad weather, the First California Derby is a significant date in California race track history. It marks the beginning of a 20-year shift in popular taste from trotting to thoroughbred racing, two forms of the same art whose shifts in popularity reflect broader changes that were affecting American society.

While historians might profess that the change in racing style paralleled the country's shift from an agrarian to an industrial tradition (in which human transportation shifted to the horseless carriage and horseracing shifted to the carriageless horse), race fans may hail the fact that Emeryville was the site of the first of many California Derbies, and a place where trotting and thoroughbred racing coexisted for many years.

Local interest in the trotting races always intensified when horses from out of state challenged California thoroughbreds. In 1873 a trotting race between Elmo, an East coast horse, and Jerome, a California horse from Siskiyou County, was the talk of the race track fraternity. The Oakland Transcript covered the event in the following article:

> California racing stock suffered another humiliating defeat at the Oakland Trotting Course yesterday. The whole "horse community" was in attendance to witness the match between Elmo and Jerome. The day was one of the most delightful of the season. Pool selling (betting) had been lively all over San Francisco on the previous evening, although very greatly in favor of the Atlantic stallion. Excitement, therefore, ran high, particularly among the sporting fraternity who confidently anticipated fast time and a well-contested race. The noon and next trains were densely crowded with passengers.
>
> No wind, two stands filled, balconies crowded, and track all around as level as a sheet of note paper. In the second heat the Eastern stallion led from the first quarter, but allowed the California horse to look at him from the hind wheel. They came down the home stretch at a fair pace, Elmo trotting easily under the string in 3:32 1/2.

On October 25, 1879 the legendary horse St. Julien broke the one mile trotting record at the Oakland Trotting Park. General Ulysses S. Grant, having served two terms as President, happened

to be visiting the Bay Area at the time, and after dining at Wiard's hotel, was actually present at Oakland Trotting Park when St. Julien set the world record. He was in the timer's stand to witness St. Julien crossing the finish line in 2:12 3/4, breaking the previous record by one second. The Oakland Tribune reported the event enthusiastically:

> ...the 3,000 people assembled at the Oakland Trotting Park were wild with excitement over the performance of St. Julian, who had just trotted a mile in the hitherto unsurpassed time of 2:12 3/4. There the time hung out in plain sight could not but be convincing. No carping could change it. The track is known to be three feet over a mile. A hundred watches timed the heat, none of which marked over 2:13, and from that to 2:12 1/2. A feeling of wonder was observed to mingle with the enthusiasm that shone on everyone's face.

In order to preserve the memory of this famous record, an inscription was placed in the judge's stand which read: "St. Julien, 2:12 3/4, October 25, 1879." This inscription remained in the judge's stand until the day the race track burned down in 1915. A Currier and Ives lithograph (submitted as evidence of mass media attention as well as for its stylized elegance) of "St. Julien breaking the record at Oakland Trotting Park" is reproduced here, as an indicator of the national significance of the event.

The "feeling of wonder" experienced by the audience is impressive when we consider that before televised sports, the only people to witness an important event were the ones who were actually there. To stand in the presence of a world-record performance must have been exhilarating for the local aficionados.

In its earliest years, the racetrack grounds were used for purposes other than horse racing. The Alameda County Fair was held there periodically before it settled in Pleasanton in 1912. To accommodate the fair, Wiard constructed sheds and buildings at the track for the proper display of prized livestock, including cattle, sheep, and hogs.

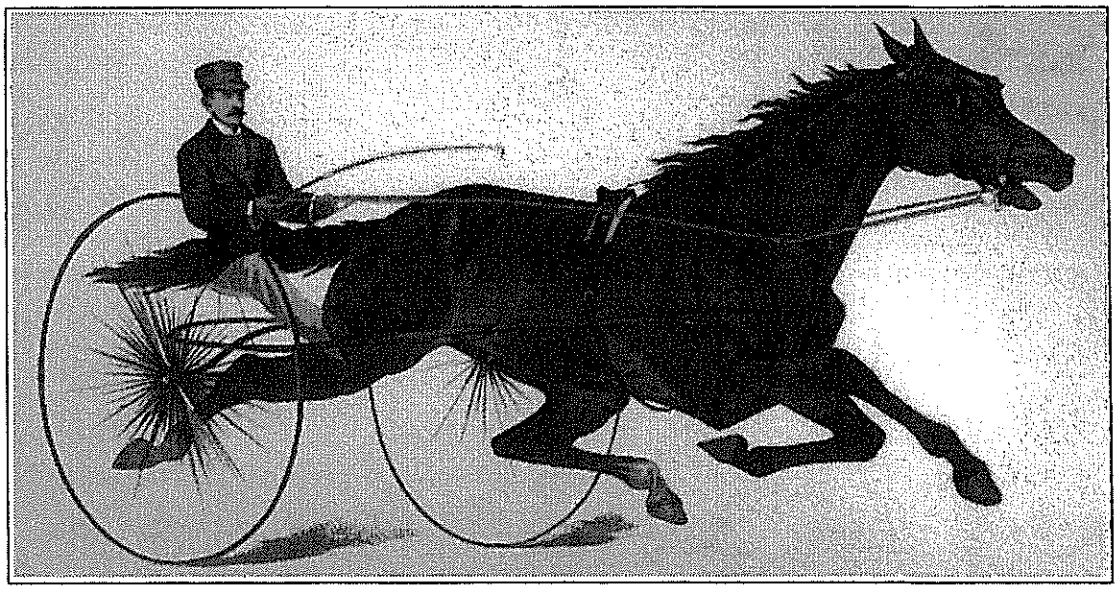
The 1880s proved to be disastrous for Edward Wiard. Early in the decade Wiard lost the race track because of financial difficulties, and his wife, Mary Jane, died in 1884. Distraught over the loss of his wife and property, Wiard died a broken man in 1885.

Judge James Mee of San Francisco bought the property and assumed the $81,000 mortgage in July, 1886. The Oakland Trotting Park remained in business after the change of owners, and George M. Palmer continued as track manager.

Edward Wiard left one son, George Edward Wiard. George, who was born in 1871, moved from Emeryville after his father's death, but years later he still remembered the early days of the Oakland Trotting Park and Shell Mound Park. He lived to be an old man, and in 1960, almost 90 years old, George was interviewed by an Oakland Tribune reporter. He related the fascinating story of the old race track, and the interview appeared in the Knave section of the Oakland Tribune on November 27, 1960.

In this interview, Wiard reminisced about the seven-foot fence that completely surrounded the Oakland Trotting Park, and the barges unloading manure from San Francisco on the beach, so it could be hauled up and mixed with the turf to make the track soft and spongy.

James Mee, the new owner, loved horses and was determined to keep the race track in operation. An Irishman born in 1828, Mee arrived in San Francisco in 1850. He made a fortune in the mining industry and moved to San Mateo County in 1857, where he raised cattle and held the position of Justice of the Peace. He later moved to San Francisco where he practiced law. According to a biographical account, Mee became interested in raising horses and improving the breed before he purchased the Oakland Trotting Park. According to The Bay of San Francisco: a History, an 1892 account,



St. Julien: *Currier & Ives illustration of the great horse smashing the mile record on October 25, 1879, driven by Orrin Hickok.*



O. A. HICKOK, THE FAMOUS VETERAN TRAINER AND DRIVER.

O.A. Hickok, the famous veteran trainer and driver, 1895. (S.F. Chronicle)

Mr. Mee is a great lover of horses, and is largely interested in the development and improvement of the breeds. For twenty years he owned an extensive stable, and spent much time on the turf. He is acknowledged one of the best horsemen on the Pacific coast, and one of the largest collection of books relating to the horse that can be found in the State of California.

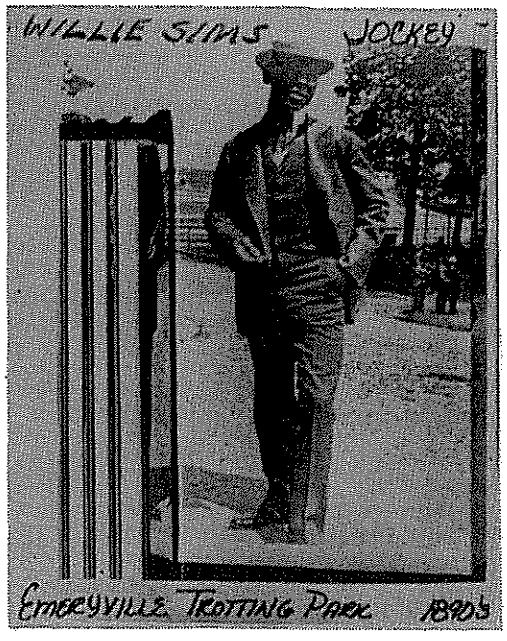
Mee operated Oakland Trotting Park until his death in 1894, after which the the Emeryville track had a renaissance. In May, 1894 Thomas H. Williams, President of the California Jockey Club, leased the Oakland Trotting Park from the Mee Estate and within a year turned it into a modern showplace of a racetrack.

Thomas H. Williams Jr. came from a prominent Bay Area family. He was son of Thomas Hansford Williams, a lawyer and major landholder who was elected attorney-general of the state in 1859 and served one term before returning to private practice and his duties as a principal in the Comstock Mine.

Born on December 9, 1859, young Thomas attended Oakland High School and public schools in San Jose. He went to U.C. Berkeley and Santa Clara College, and graduated in 1880 with a B.A. and B.S. degree. After graduation he went to work managing his father's extensive holdings in Northern California and raising thoroughbred horses. In 1890 Williams gained control of the California Jockey Club as a principal stock holder and held the position of President for 20 years.

Harness racing was still popular in those days, and in 1895 The San Francisco Chronicle published an article which provides us information about the training and exercise of trotting horses at the Emeryville track and an inside view of racetrack culture.

> Over at the pretty Oakland (Emeryville) track the scene is different. Every morning you will find these same quiet, well-dressed men hard at work with their charges. There is no time here for gossip, for the trotting horse trainer has a different lot from his brother trainer in the running game.
>
> The runner is brought out on the track and slowly galloped over the course a few miles and then breezed through the stretch a fast quarter as a warmer-up. Then he is sent a fast mile more or less, as the trainer may elect, and in fifteen minutes he has cooled out.
>
> The trotting horse is taken up differently. He is handled with great care. His first fast work will probably be one heat. Then a day or two later he may be given two heats. At last comes the time for final preparation, and then he gets five or six heats, the same as if he was in an actual race. After this it takes from two to three hours to cool him out.
>
> This is the season of the year when the trotting men begin to ask their charges for the final question. There are many of the long tails about the city who will soon board the cars bound for the Eastern circuit, and the entire trotting horse world is anxious to know how its favorite pets have weathered the winter...
>
> Most of the other cracks (horses) are quartered at Oakland where fast work can be seen every morning. The track is as fast as a bullet just now, and some rattling time has been made. A well-known trainer timed a heat so fast one day this week that he though something must be the matter with his watch or his eyesight. He waited until the work was over and then called all the boys to the bar and after treating, showed his watch, and whispered the name Fitzsimmons.
>
> The watch showed 2:05. The timer had split all right, but unfortunately for the trainer it had run down for the want of winding just before the mile was completed.
>
> O. A. Hickok has the prettiest mare that ever stepped down a stretch. Hulda, by Guy Wilkes? out of Jenny, with a record of 2:08 1/2, cannot be beaten for good looks
>
> William Johnson, known on every race track in the country as "Nigger" Johnson, has the largest string at the track. He has twenty-three crabs (horses) in his lot, and it is a funny sight to see the old colored driver sending one down the stretch. He drives an old-fashioned sulky with wheels reaching as high as his head. His whip is an old affair with the end turned up the reverse way. On his horse are boots and trotting trappings from the ears down. With a cigar in his mouth, the peak of his cap blown up until it stands perpendicular and his coat tails flying out behind the sulky, this fellow, who is as black as ink, comes tearing down the stretch, with every wag at the track jeering. He takes the "joshing" good-naturedly; in fact, he loves it...



William Johnson was not the only black man to race horses at the Emeryville track. Several black jockeys rode there in the 1890s, and were very competitive until they were forced out of the sport by a hostile association of white jockeys. Well known local riders of color included Jess "Long Shot" Conley, Felix Carr, Alonzo (Lonnie) Clayton, Andrew Thomas, and Willie Simms.

The newspaper's inclination to denigrate black participants is one that is, thankfully, history. It is reproduced here as a reminder of where we have come from and a marker of our real, if limited progress in the struggle with racism. (The story of racial politics in horseracing is a remarkable sidetrack to our story, and the subject of the side article excerpted from the Winter 1991 newsletter of the Northern California Center for Afro-American History and Life.)



Jockey Felix Carr: A newspaper sketch (from a photograph by Bushnell) of a black jockey who was popular in the 1890s.

EMERYVILLE'S BLACK TURFMEN

by Donald Hausler

Built in 1871 by E. Wiard, the Oakland Trotting park featured a one-mile race track and stalls for 300 horses. The track stretched from one block north of Park Avenue to Stanford Avenue, with its northern end located just three blocks west of the Golden Gate Branch Library in Oakland.

During the racing season, turfmen from all over the Bay Area concentrated there, and the trotting park became the largest employer of African-Americans in early Emeryville.

After it was rebuilt and reopened as the California Jockey Club in 1896, the track hired many Black workers to train and care for the horses. The 1910 census identifies 38 African-Americans who worked at the race track as stablemen (6), grooms (20), horse trainers (3), cooks (5), and jockeys (4).

Many of these employees were from Kentucky, a state with a long tradition of horse racing, and the census reports that they lived in dormitories on the grounds.

From 1890 until 1911, a number of Black jockeys raced at Emeryville on a regular basis, including Jess "Longshot" Conley, Alonzo "Lonnie" Clayton, and Felix Carr. These men had outstanding careers while they were permitted to race, and their names remain prominent in the annals of horse racing.

The record indicates that 1898 was "Longshot" Conley's best year, although he won many races here during the 1890s. Described by one newspaper as the "ebony hued demon," Conley defeated Ted Sloan, a famous white jockey who had conquered the race tracks of England and America, in two races.

In the first, Sloan rode the favorite Wawona while Conley, living up to his nickname, rode a 30-to-1 longshot Our Climate to victory. In the second race, Conley rode Libertine to first place. Conley also won the Latonia Derby in Kentucky that year. In 1911 he took third place in the Kentucky Derby. Conley was the last Black jockey to ride in that classic race.

Alonzo Clayton won the Kentucky Derby in 1892 when he was only 15 years old. The the next six years he won races all over the United States, including the Alabama Stakes (1892), the Kentucky Oaks (1894), the Great Western Handicap (1897), and the Clark Handicap (1897). Clayton's greatest California race was on April 2, 1889, when he rode Traverser to victory at the Second California Derby at Ingleside Race Track before a crowd of 8,000. Traverser led the race from start to finish, and, according to a contemporary account, Clayton rode "with rare judgement, and [got] every ounce out of his mount."

Felix Carr, another Emeryville star, had acquired a reputation as a winner by the early 1890s. In 1895 he won the Burns Handicap, an important California race, and he soon became "the idol of the California turf." By 1896, Carr had "grown too heavy to ride in ordinary events, and devoted his time to learning the art of training."

Willie Simms was probably the greatest Black jockey to race at Emeryville. Born in 1870, Simms won a succession of important races all over the United States and England, including the Kentucky Derby twice (1896 and 1898) and the English Sweepstakes. Simms became a popular jockey at Emeryville in the 1890s, where according to one account "he was premier in the saddle, honest and fearless..."

Among other African-American jockeys during Emeryville's racing years were Andrew Thomas, Monroe Johnson, James Coles, Frank Bowers, and John H. Smith.

William Johnson, referred to in the local press as "Nigger" Johnson, had a career as a driver and trainer that spanned several decades.

The abrupt closure of the the Emeryville track in 1911 was a devastating blow to the employment opportunities of Blacks in Emeryville. For the jockeys the end of racing in California coincided with a decline in opportunity all over the United States.

The Jockey Club had been formed as in 1894 as an association to license riders, and by the second decade of this century the white interests who dominated it had eliminated African-American jockeys from horse racing.

An account of this injustice is found in Arthur Ashe's three volume work, A Hard Road to Glory: A History of the African-American Athlete 1619-1918.

Apparently the members of the Jockey Club were uncomfortable with the fact that between 1880 and 1905, African-American jockeys won thirteen Kentucky Derbies. §§§

The young, rich, and ambitious Tom Williams was dissatisfied with the dilapidated state of his 25–year old plant, and wanted to transform the old race track into a modern facility. Williams planned to build a fast track with splendid new facilities for the horses and their fans.

For openers, all of the buildings connected with the race track, including the original grandstand and stables, were torn down, with the exception of the judge's stand with the inscription honoring St. Julien's record.

A magnificent grandstand, resembling a Japanese pagoda, replaced the original one, and a covered walkway was built from the train depot to the grandstand so that fans arriving by train would be protected from the rain. Renamed the New California Jockey Club, the renovated race track flourished into the twentieth century, always under the direction of Thomas Williams.

The day before the grand opening of the New California Jockey Club race track, October 23, 1896, the Oakland Enquirer shared the low-down on the new facility:

> The first racing season at the Oakland track of the California Jockey Club will begin to-morrow. This will be the formal opening of the new racing park, which has been erected on the site of the old Oakland race course. The work which has been going on there for some six months past has been mentioned from time to time in these columns...
>
> For two months more one thousand men, including carpenters, masons, grocers, teamsters, painters, engineers and landscape gardeners have been at work, under the supervision of A. M Allen, who has had charge of the construction of the buildings and the laying out of the course.
>
> During this space of time a magical transformation has been accomplished. Nearly every vestige of the old buildings has disappeared, the course has been resurveyed and remade. The grade of the entire track has been changed. New ground elevated for the site of the buildings; the stables reconstructed; paddocks and section barns built. The chiefest of the new structures is the magnificent pagoda pavilion or grand stand, which will comfortable seat about 3,000 spectators, and surpasses in its arrangement and appointments any similar structure in the United States. It is the boast of the California Jockey Club and will be to the credit and fame of Oakland, that the speed park at Emery's will be the most modern and complete in the world. Racing men who are familiar with Eastern and European tracks say that this is not an extravagant statement.
>
> The new main entrance from Oakland, with carriage way, is from Park avenue by an extension of Holden or Louise street. A handsome ornamental gate way of oriental design, in harmony with the pavilion, will span the entrance. The roadway is being macadamized and plank sidewalks laid from Park avenue to the grand stand. There will be ticket offices at either side of the entrance and turnstile registers on the footways. For the convenience of those who come by train from San Francisco and elsewhere a new station has been established between Emery's and Shellmound, from which a covered way 600 feet in length, rising by steps to the grand stand, with two landings under a roofed pavilion, with a magnificent outlook upon the bay of San Francisco. The new waiting space or shelter along the Berkeley local track is roofed and tracked for a distance of some 500 feet, and converges to the entrance through self-registering turnstiles, flanked by ticket offices on both sides.
>
> Spur tracks have been laid from the railroad to the reservation for section barns to facilitate the handling of horses, that come in by rail, and also for convenience in bringing in hay and feed.
>
> The most conspicuous structure is, of course, the grand stand, which is placed upon a rise of ground some six feet above the level of the track, which was made by the displacement and heaping up of some 335,000 cubic yards of earth. In the accomplishment of this an army of graders were employed day and night for weeks and a special track laid on which dump cars were run. The foundations had to be securely laid in concrete and upon this the pavilion, which is in a modernized Japanese pagoda style of architecture, was raised to a height of 100 feet from foundation to top of the central cupola.
>
> The ground dimensions are 110 by 280 feet. The first floor on the ground grade is paved with bitumen and contains the betting ring, with bar, lavatory and pool selling paraphernalia. It is estimated that 4000 persons can conveniently stand within the floor space of this portion of the pavilion. Here are the twenty book makers' stands with the desks for clerks, black boards for combinations and other arrangements with an out-look upon the entire course. At one side of the betting ring is a bar fifty feet in length....
>
> To the north of the main pavilion is a saddling paddock with colonial portico 70x180 feet. Besides the twenty paddocks for racers and space for weights, the officers of the course have their headquarters in this building.
>
> To the east, north and south of the track on the opposite side from the pavilion and paddock are 344 single stalls, with a frontage of more than three-fifths of a mile. These are substantially built, completely drained and ventilated.



Thomas H. Williams, Jr.: Emeryville's racing czar was a youthful looking 39 in this 1898 photo from an Oakland Tribune yearbook on this "The Eden of the Pacific."



California Jockey Club Stables: A view from the Clubhouse to the northwest. Shell Mound Park's dance pavilion is seen in the background on the right. (Photo courtesy of The Oakland Museum)

Toward the railroad track and back of the pavilion are twelve detached section barns, for the accommodation of private strings of horses. These contain from twenty-two to sixty stalls with space for grain and hay, and accommodations for jockeys or grooms...

The only vestige of the old buildings is the old pagoda of the judge's stand, which bears the inscription, "St. Julien, 2:12 3/4, October 25, 1879." This time, made when General Grant visited this city, lowered the trotting record.

The track, which is the regulation mile course, is as near perfect as engineering skill can make it. The old course was changed somewhat resurveyed and the grades readjusted. The roadbed is sixty-five feet wide in the main, with a width of eighty feet on the stretch. At the quarter turns the raise is one inch to the foot toward the outer line. Underlying the track is nine inches of rock, which acts as a sub-drain. Above this is a dressing of twelve inches of soil. In making the base of the course some twenty thousand yards of broken rock were required...

Openiung day, October 24, 1896, was a memorable day at the races. The crowd exploded with excitement when jockey Eddie Jones achieved the impossible by winning four races. But this was a dangerous sport, and in a later race, Jockey Jones fell from a racing steed and received injuries which permanently crippled his body.

The New California Jockey Club proved to be a success, and in this form the track continued to operate for another 15 years.

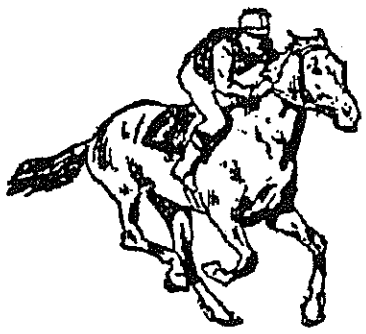
Thomas Williams and his business partners had invested heavily in the New California Jockey Club, and they wanted to protect their investment. The race track officers were afraid that the track, situated on unincorporated land, would be annexed by a municipality that did not share their enthusiasm for race track gambling — or shared it enough to want a share of the proceeds. In order to forestall this possibility, Williams and his associates, along with capitalists from nearby Butchertown, promoted the incorporation of Emeryville into a town.

Their proposal was approved by the Alameda County Board of Supervisors, and an election was held in December, 1896. Incorporation carried by a landslide, thanks in part to the voting of race track employees, and Emeryville became a town.

On the map, Emeryville presented an irregular shape, like a piece of a political puzzle, rather than a domain marked by geographical boundaries. The new municipality's odd shape was partly a result of the unwillingness of the conservative residents of Golden Gate to be a part of the sleazy, sinful Gomorrah that Emeryville was sure to become.

RACING

New California Jockey Club



OAKLAND RACE TRACK

Racing every week day, rain or shine.

SIX RACES EACH DAY.

First race at 1:40 p. m.

ADMISSION—Men $2.00, ladies $1.00

Take street cars from any part of city, transfer to San Pablo avenue.

THOMAS H. WILLIAMS. President.

PERCY W. TREAT. Secretary.

Golden Gate had sufficient churches to counter Emeryville's many saloons, and the general feeling up there was that the race track was "a crime factory" and they'd just as soon live in Oakland, thank you.

These sentiments are associated with the start of a Progressive Era that would bring social reforms like the closing of racetracks and the prohibition of alcoholic beverages. These reforms had limited success in Emeryville, where reaction and resistance to them turned this entertainment center into the East Bay's headquarters for vice and corruption.

In 1903 the city built its town hall on Park Avenue, only one block from the race track entrance. City officials needed only to look out the window to see the source of their jobs (or their family fortunes), and needed only to cross the street to drink to their employer's health.

The old Oakland Trotting Park and the New California Jockey Club had a tremendous impact on the early development of Emeryville, rather like Disneyland's effect on Anaheim. Park Avenue, because of its proximity to the track, became the commercial strip and center of population. Several hotels, restaurants, and bars were built there to accommodate race track fans who arrived from all over the Bay Area by carriage, train, and streetcar. Emeryville became by reputation the entertainment center of the East Bay.

The Commercial Union Hotel, the Randlett House, the Park Hotel, and Dugan's Hotel and Cafe on Park Avenue, and the Race Track Hotel on Stanford Avenue were prominent among the hotels catering to race track fans.

Thomas Williams continued to operate the California Jockey Club into the twentieth century. Over the years Williams had developed a humanitarian and charitable side to his character, which he kept "hidden under the cloak of modesty and aversion to publicity."

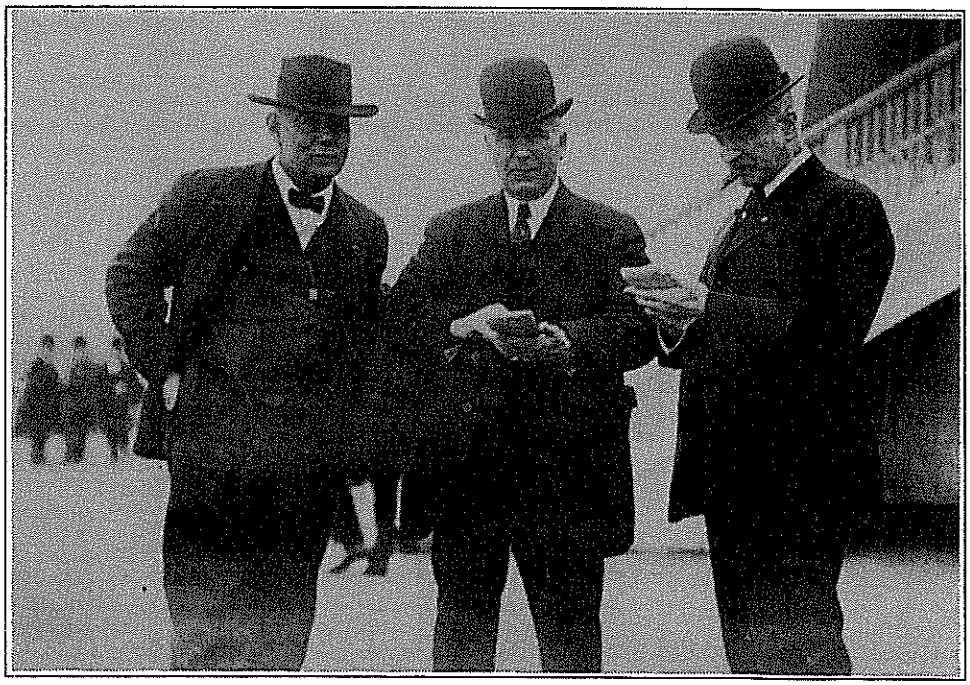
Following the 1906 San Francisco earthquake, he opened the track to thousands of refugees. According to one source, "He threw open the Jockey Club grounds at Emeryville to over 4,000 homeless suffering people, who stood in the famous 'bread lines' to save themselves from starvation."

The military authorities who supervised this huge camp were less bighearted, managing the homeless civilians like unruly recruits. The daily drill was strict and military style, with dawn reveille, physical exercises, group bathing in the bay, and work details. Reportedly, reluctance to participate was grounds for being shot. The food, provided by local restaurants was said to be plentiful and excellent, and morale was good.

Bill Siebe, the son of Captain William Siebe, who operated Shell Mound Park, in an interview remembered Thomas Williams as a "good-hearted man." According to Siebe, "In those days when we had roads and very few sidewalks, it was Tom Williams who kept the street watered and the dust down. He also kept the same streets in repair, and helped our scattered but scanty population build sidewalks. He was a good hearted man."

Despite the generosity of Thomas Williams, the Progressive Era reform movement opposed race track gambling in California. The anti-race track faction gained support because of the perception that the California Jockey Club, which also owned the Ingleside and Tanforan tracks, had a monopoly on horse racing in the state. The proliferation of race tracks and a proposed extension of the race season from 90-day meetings to year round operation also provoked the opposition.

The state legislature, responding to the anti-betting forces, passed the Walker-Young anti–gambling law in 1910, which made race track betting illegal and curtailed the greed of the racing interests.



Prominent Turf Men: Three leading Emeryville citizens compare race cards at the California Jockey Club. (L. to r.), Councilman John T. Doyle, track superintendent James Grant, and Mayor William H. Chrisitie.

The anti-gambling bill took effect in February, 1911, and the New California Jockey Club race track was forced to close, since there was little enthusiasm for horse racing without the opportunity to bet on a winner. As a result of this law all of the horse race tracks in California which permitted betting went out of business.

The last race at the Emeryville track was held on February 15, 1911. There was a record crowd on the final day. Fans came from all over the state to say goodbye to the sport of kings. Over 200 of the fans present had witnessed the opening of the California Jockey Club in 1896, 15 years before. Thomas Williams, still President and principal stock holder of the California Jockey Club, was "conspicuous by his absence."

The horse Massa, with jockey Roy Selden up, won the final race. On this final day, the crippled jockey Eddie Jones, his body broken by the sport he loved, leaned against the rail and wept.

When the Emeryville track closed, the following article appeared in the San Francisco Chronicle of February 16, 1911:

> The cosmopolitan and picturesque crowd which has followed the fortunes and vicissitudes of the turf bowed to the force of the law yesterday and the Emeryville race meeting came to a close. As the band struck up the strains of "Auld Lang Syne" after the seventh and last race had been run, the crowded grand stand of racegoers took up the tune and joined in with the band, but beneath it all there were many heavy hearts. Other seasons have come to a close at bay track and the followers of the thoroughbred have parted before with a good word and here and there, but yesterday was different.
>
> The seventh race, in which old Massa carried off the honors, may be the last one California will ever see, and old-timers of the sport could not but feel the effect. The Walker-Young anti-gambling law sounded the death knell of a sport that has flourished in California for years.
>
> Men who have grown gray in the interest of the sport were at the track yesterday by the scores, and it must have been an ordeal for them to watch the game pass away. These men gathered in groups, and through the noise and excitement of the close there was a husky voice and dim eye here and there that spoke volumes for their feelings.
>
> Eddie Jones, the once great little jockey, presented a pitiable scene as he stood supporting himself against the grand stand stairs just after the seventh race. The crippled little fellow was wiping a tear from his eye. Here was a man paralyzed from receiving a fall in a race, and his entire life has been given to the game which yesterday came to an end in California. Jones was the jockey who rode four winners the day the Emeryville track opened, and it is little wonder that he grieved to see the familiar course closed.
>
> W. P. Maxwell, one of the oldest turfmen in America, was another who was deeply affected. "Well, I guess I will go to the mountains for three or four months," spoke the veteran, and he explained that he wanted to try and forget that the sport which he had followed for half a century had passed out of existence in California.

The race track facility did not sit idle for long. Barnstorming aviators found it a worthy landing spot, and for some years local residents could come by on an afternoon and hire a ride in a biplane. Lincoln Beachey, the most famous of the aviators, hangered his plane at the track and flew tours out of there, according to Marjorie Doyle Vinther, who was a little girl then.

It was also used by a Chinese pilot named Tom Gunn, who was the star of local air shows due to his enthusiastic following among the Chinese community. The dashing young aviator had the charisma of a movie star and was surrounded by (mostly female) fans whenever he climbed out of his airplane.

As a flyer, Gunn was a relative novice, mostly remembered for crashing into an outbuilding of the Paraffine factory after his motor failed on takeoff and a gust of wind disrupted his attempt to land on Powell Street. Gunn survived the wreck and eventually returned to China to be a flight instructor.

In February, 1912, the Third International Aviation Meet was held at the California Jockey Club. Famous aviators from all over the United States, including Lincoln Beachey, Phil O. Parmalee, Miss Blanche Scott, Weldon Cooke, Farnum Fish, Tom Gunn, Glenn Martin, and William H. Hoff participated at the meet. The aviation meet lasted for a week and involved lots of entertaining stunt flying. On the educational side, demonstrations in air mail delivery and the transmission of wireless messages showed the spectators that aviation also had practical applications. Although several airplanes crashed, no one was killed, and the meet was considered a success.

In 1914 a unique race was held at the Emeryville track, in which Lincoln Beachey, the daredevil aviator, flew a Curtiss Biplane in contention with Barney Oldfield, the famous race car driver in a Simplex racer.

This race occurred at a time when the top speed of a race car and an airplane were about the same and intense public interest

promoted the comparison of these new transportation technologies.

The airplane, flying low to the ground, raced the automobile around the track for the speed championship of the world. Oldfield won the race in his Simplex by only 20 feet. In another event Beachey attempted to fly upside down while Oldfield, with a photographer as a passenger, tried to keep up with him. Beachey lost control of his biplane and heroically crashed it into the ground to avoid hitting the car speeding beneath him. Beachey survived that wreck, but he died in 1915 when an experimental stunt plane he was testing plunged into the bay.

In 1915, four years after the closing of the track, the Mee estate announced that the race track property would be subdivided into factory sites. In the fall of 1915 a wrecking crew began to dismantle the grandstand and other buildings that comprised the track complex. On the night of December 15, 1915, before this demolition project could be completed, the remaining buildings caught fire and burned to the ground. The Emeryville fire department had difficulty containing the blaze, and at one time the flames threatened to burn the adjacent residential neighborhood. By morning only charred ruins remained of the famous grandstand. The race track had been in existence for 44 years when it burned.

A dramatic account of the fire appeared in the next day's San Francisco Chronicle:

> The old Emeryville race track, where fortunes were won and lost and gay throngs thrilled with the sport of kings, went up in smoke at 8 o'clock tonight...For miles around a great pillar of fire was visible, awakening memories of the days of many a sensational equine contest.
>
> With the old stables, once filled with some of the world's finest horseflesh, and the dilapidated outbuildings doomed, the fire departments of Emeryville and Oakland devoted their efforts to save surrounding homes, which were threatened with destruction when the flames, fanned by a lively breeze, leaped across the open spaces from the southwest corner of the course...
>
> Lack of water gave the blaze, which originated from an unknown cause in the southwest corner of the rambling stables, a good start and by the time apparatus arrived on the scene and a stream was brought from San Pablo avenue two blocks away it was apparent the place was doomed.
>
> The time-worn frame work of the tottering buildings, which formed the last vestige of the once proud course, burned like tinder. The fire, working in a circle etched its way around the track, enveloping the various buildings and the long trail of fence.
>
> In the clear, crisp night the conflagration flared skyward and was visible from all the bay shores. Thousands were drawn to the scene by the spectacular play of the flames and the sentimental knowledge that the final vestige of the place which was the center of thoroughbred activities in the old days were passing to return no more.

Thomas H. Williams did not live to see the destruction of his race track, dying in November of 1915, one month before the fire. An Oakland Enquirer obituary suggests that Williams had a negative influence on the sport of horse racing and that he was responsible for its downfall.

> For years he was known as the "czar of the turf," and he was one of the most forceful characters the game has every known. By many it was felt that the influence of Mr. Williams on turfdom was a very direful one, and it was said by many that it was the Williams' management that closed the racing game in the state of California. When racing was the leading sport in the state. Williams was a complete czar. He ruled the sport with an iron fist.

The race track property was developed and subdivided as planned and the land became an industrial park. Water mains had to be installed, streets extended, and spur tracks built before the land could be sold. The property's commercial value was enhanced by its proximity to the railroad tracks and its central location in this crossroads of the East Bay.

Several industries were built in the 1920s on the site of the old race track. P.G.&E. constructed two large plants of concrete on the west side of Hollis Street that are still standing. The Watkins company erected a brick factory at the south end of the track on Hollis Street and Western Electric built a large factory at the north end of the track which is now part of the Chiron campus. Nothing remains of the original race track but a ghost of its shape in the train tracks that curve around the north end of the site, and there is yet no plaque to mark its location.

While living memory has lost sight of the old racetrack and its role as the grain of sand around which the pearl of Emeryville once formed, we hope that this account provides residents with a sense of the track's important position in the area's colorful history, and a better appreciation of how Emeryville has come to be.

§§§

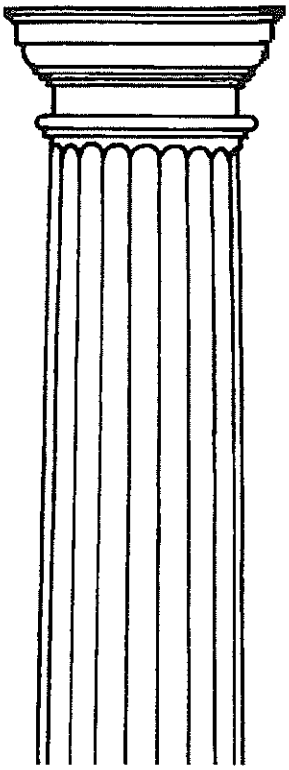


The EHS seeks information and materials relating to the town's history and traditions. Residents (past and present) with pictures, stories, and artifacts from Emeryville's past are encouraged to contact the EHS. Items of personal and sentimental value can be copied or photographed and returned. Materials that need a home will find a happy one in the collection of the EHS.

Phone messages may be left at (510) 655-9320 and (510) 658-5038.

THE ARCHITECTURE COLUMN

by Arrol Gellner, Architect



The New California Jockey Club

The huge grandstand of the New California Jockey Club exemplifies an unusual orientalizing style which appeared intermittently during the Victorian era. It ranks among a relative handful of such structures in the Bay Area, ranging from Oakland's Pagoda Hill — the outlandishly exotic residence of author and world traveler J. Ross Brown (circa 1875) — to San Francisco's bizarre Vedanta temple (1905).

The Victorian period began with fairly sedate revival styles such as Gothic, Italianate, and Mansard. As the nineteenth century drew to a close, however, the sources of architectural inspiration became increasingly exotic, culminating in the borrowing (and occasional intermixing) of details as diverse as Chinese pagoda roofs and Russian Orthodox onion domes. That such buildings were built at all attests to the prodigious skill of Victorian era carpenters, who were able to duplicate all manner of complicated details in wood.

Despite their staid reputation, the Victorians were fascinated by the exotic, which they found in the culture and decorations of the orient. They eagerly read books on the Near East such as Bayard Taylor's *The Land of Saracen* and Dr. Richard Burton's racy translation of *The Arabian Nights*, which helped popularize orientalizing styles in the same way *Wuthering Heights* had boosted the Gothic Revival.

Hence, in Emeryville, we find a racetrack grandstand in the incongruous form of a Chinese temple. Beneath that enormous pagoda roof, which stood a hundred feet tall at the cupola, the 110-by-280-foot structure seated 3000 spectators in relative shelter from the elements. Tucked under the sloping tiers of seats were a betting ring accommodating 4000 patrons, a 50-foot-long bar, lavatories, and 20 bookmakers' stands.

With characteristic Victorian hubris, the structure was proclaimed by the Oakland Enquirer as "a magnificent pagoda (which) surpasses in its arrangement any similar structure in the United States... the speed park at Emery's will be the most modern and complete in the world." Constructed in eight months and opened on October 24, 1896, the grandstand was one of the most unusual building types to be built in this exotic style, as well as one of the largest.

At the turn of the century it was common practice to construct buildings as many as five or six stories high entirely out of wood — a practice no longer allowed by modern building codes. When fire broke out in these structures there was little that any fire department could do but try to prevent it from spreading to adjoining properties.

Such a fire began in an outbuilding at the California Jockey Club during the course of its demolition in 1915, and it rapidly involved not only the grandstand but all the other wooden buildings of the complex. Like so many others before it, this curious and short-lived Victorian monument was quickly reduced to a tottering ruin. §§§

Emeryville Historical Society

Membership Form

Name _____

Address _____

Phone(s) _____

Period of residence or work in Emeryville _____

☐ Active / Volunteer Member ☐ Subscriber (Newsletter and Notices)

Interests:

☐ Historical Research ☐ Oral History Project ☐ Interviewing/Transcribing

☐ Publications ☐ Organization/Administration ☐ Photography/Video ☐ Education

☐ Exhibits ☐ Meetings/Refreshments ☐ Recruiting Speakers ☐ Other

Individual Membership costs $10.00 per year. Mail check & completed form to: Emeryville Historical Society, 1420-45th St. #37, Emeryville, CA 94608



Lincoln Beachey: A 1914 photo of the famed aviator soaring over the packed grandstand of the Emeryville horse race track.
(Photo from the collection of Louis Stein)

The Emeryville Historical Society is a non-profit volunteer organization dedicated to the study and communication of local history. It is supported by subscriber memberships, donations (including exchanges of money for publications, services, and promotional merchandise) and a Community Promotion Grant from the City of Emeryville.

Future funding will require a vigorous membership drive, including the creation of supporting and patron memberships. Subscribing memberships will continue to cost $10 per year. Current members would earn undying gratitude by renewing subscriptions without further solicitation. Thank you for your support!

Membership in the EHS costs $10.00 per year and entitles members to the delivery of four newsletters per year, admission to public events, and good deals on promotional tchotchkes. So join, already!

The Emeryville Historical Society
1420 - 45th St., #37, Emeryville, CA 94608
510 • 658-5038
510 • 655-9320

Address Correction Requested

LSA's record of S-W

State of California — The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
PRIMARY RECORD

Primary #
HRI #
Trinomial
NRHP Status Code
Other Listings
Review Code _____ Reviewer _____ Date

 Resource Name: The Sherwin Williams Company Paint Company

P1. Other Identifier: Sherwin-Williams
P2. Location Unrestricted
a. County: Alameda
b. USGS 7.5' Quad: Oakland West **Date:** 1993 Unsectioned lands of Rancho San Antonio Land Grant; Mount Diablo Base Line and Meridian
c. Address: 1450 Sherwin Avenue **City** Emeryville **Zip** 94608
d. UTM: Zone 10; 562567 **mE** /4187447 **mN**
e. Other Locational Data:

P3a. Description: The Sherwin-Williams Company Paint Factory consists of a complex of three reinforced concrete and brick buildings, a brick building, a frame building clad in corrugated metal, and several associated buildings, tanks, and storage facilities, as well as a modern (1964) reinforced concrete building used for raw materials storage, shipping and receiving. A Union Pacific railway spur, constructed in 1964, provides access to the north side of the complex. There are large asphalt areas for parking, storage, and equipment.

The primary structure (**Building 1**) is a three-story reinforced concrete building with a brick curtain wall. It was built in 1920 as a general office and warehouse, with an addition to the north elevation constructed in 1938 (**Building 31**). Continued on Page 2.

P3b. Resource Attributes: HP8 Industrial Buildings; HP11 Engineering Structures
P4. Resources Present: ☒ **Building** ☒ **Structure** ☒ **Object** ☒ **Element of District**

P5a.



P5b. Description of Photo: Building 1, 1450 Sherwin Avenue. View to northwest
P6. Date Constructed/Age and Source: Historic; 1920-1965 Entrix, Inc., 2002, *Remedial Investigation, Sherwin-Williams Site, Emeryville, California*, Entrix, Inc., Walnut Creek, California.

P7. Owner and Address:
Sherwin-Williams Company
101 Prospect Avenue
Cleveland, Ohio 44115

P8. Recorded by:
Judith Marvin, RPH #525 and
Randy Groza, RPA #12670
LSA Associates, Inc.
157 Park Place
Point Richmond, CA 94801

P9. Date recorded:
February 15, 2005

P10. Survey Type:
Intensive

P11. Report citation: Groza, Randy, Judith Marvin, and Ben Matzen
2005 *A Cultural and Paleontological Resources Study for the Sherwin-Williams Development Plan Project, Emeryville, Alameda County, California*. LSA Associates, Inc., Point Richmond, California.

Attachments: ☒**Location Map** ☐ **Sketch Map** ☒ **Continuation Sheet** ☒ **Building, Structure, and Object Record**

DPR 523A (1/95)

Both buildings, which are connected, have flat roofs with simple raised pediments, reinforced concrete posts and beams, and brick curtain walls.

The primary façade, on Sherwin Avenue, has three bays, the top two stories each have a central bay with two windows flanked by paired windows, and the outer bays each have two windows. The main entrance is located on the first story, with a double set of concrete steps providing access to the modern (1965) glass and aluminum doors, which are flanked by aluminum frame windows, beneath a rectangular canopy. The original entry door was a Classical portico, fully pedimented and supported on columns. The pediment was topped by a three dimensional paint can and globe—the company's logo. Side elevations on each building feature nine bays. Each first story originally had double wood doors, now all but one have been replaced with modern roll-up garage type doors. Original fenestration on the building consists of multi-light industrial metal sash, with vented windows in the center. All windows on the primary façade have been replaced with aluminum frame windows, as have some of the others on the side elevations. Floors on the interior of the building are reinforced concrete, supported by reinforced concrete pillars. The buildings have had various uses over the years, including administration, hectograph and stock departments, advertising, and now administration and warehousing.

Building 2, facing Sherwin Street and west of Building 1, was built in 1920 and used for paint manufacturing. It is three-stories high, has seven bays on the east and west elevations, and a flat roof with raised square pediments on the north and south elevations. Fenestration consists of industrial multi-light metal sash. When first constructed, the building faced west, towards the Southern Pacific Railroad tracks, with a water tank on its north elevation. Today, however, the main entrance is at the south. In 1929, Building 21, the foreman's office, was built adjacent to and south of Building 2. However, when Building 28 was built in 1936, Building 21 was removed, leaving a small gap between buildings 2 and 28. Since its original construction, Building 2 has been almost subsumed by buildings 28, 4, 30, 35, and 36 (Buildings 35 and 36 were built in 1964; Building 36 was expanded in 1994 to connect Building 28 with Building 2).

Building 4 is immediately north of Building 2, and was also built in 1920. It is a two-story frame building clad in corrugated metal. It has a front-gable wood truss roof, concrete floor and foundation, and is attached to other structures in the complex. It was originally used for can storage, and has become part of buildings 28, 2, and 30. Currently Building 4 contains a laboratory, and is also used for paint filling and packaging.

Building 12, a boiler house, was constructed in 1924 along with buildings 11 through 25. Only Building 12 remains of these support buildings which were associated with pump housing and lead arsenate production. Various buildings have been attached to Building 12 and later demolished. Building 38, constructed in 1965, is north of and adjacent to Building 12.

Building 28 was constructed in 1936, south of Building 2, in what was at that time the southwest corner of the facility, prior to the acquisition of the Union Pacific property in 1964. It is a three-story reinforced concrete building with brick curtain walls. It has a flat roof, four bays, and tripartite multi-light industrial metal sash windows. A covered metal catwalk connects Building 28 to Building 1. Building 28 was used for, and continues to be used for, paint production purposes such as grinding, filling, and dry storage.

Building 29 was built in 1936 to cook varnish. It is a free-standing building north of Building 30. Building 29 currently contains a glycol tank. **Building 30** was also built in 1936 and was used for filling. It is adjacent to and north of Building 4, and is currently a laboratory, and also used for paint filling and packaging.

Buildings 28, 2, 4, 30, 35, and 36 appear to be one building from the exterior. Inside, contiguous walls lead to formerly individual buildings that are marked with original building numbers.

Other structures on the site include modern reinforced concrete buildings, tanks, reclamation plants, pipes, tubes, and steel frameworks.

The Sherwin-Williams Complex is situated on a level lot, fronting on Sherwin Avenue to the south, between Horton Street on the east and the trackage of the former Southern Pacific Railroad on the west.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
LOCATION MAP

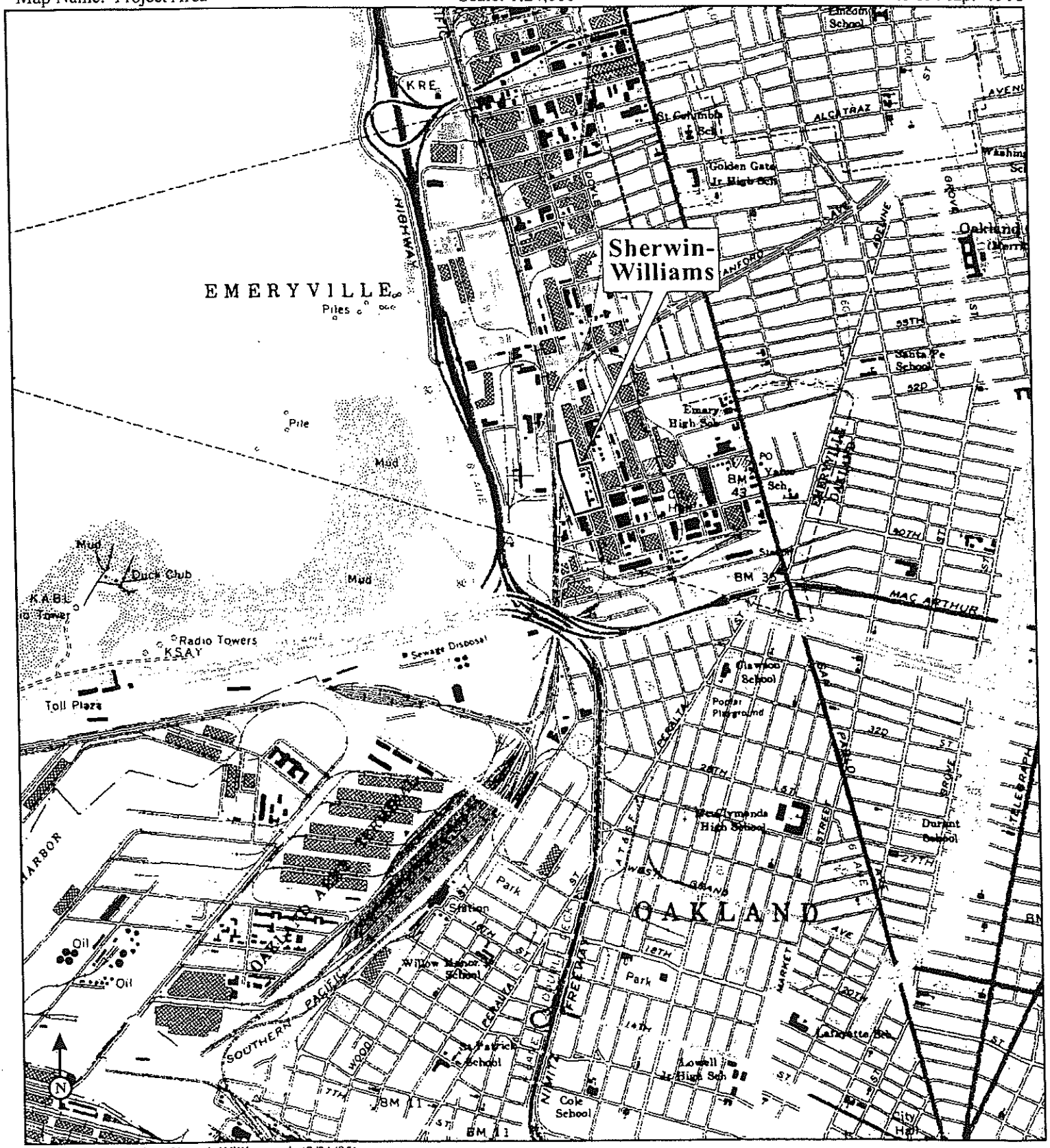
Primary #
HRI #
Trinomial

*Resource Name: The Sherwin-Williams Paint Company

*Map Name: Project Area

*Scale: 1:24,000

*Date of Map: 1993



P:\CEM430\g\DPRformSherwinWilliams.cdr (3/31/05)

B1. Historic Name: The Sherwin Williams Paint Manufacturing Company
B2. Common Name: None
B3. Original Use: Paint Factory
B4. Present Use: Paint Warehouse, Manufacture, Storage, Shipping and Receiving
B5. Architectural Style: Brick Commercial Classical Revival
B6. Construction History: The extant buildings in the complex were built at various times from 1920 through the 1960s. The circa 1920 to 1930s brick buildings were modified over the ensuing years to accommodate different uses and technologies. Alterations to the two primary buildings (Building 1 and Building 31), include the installation of modern aluminum frame windows and doors and roll-up doors in 1965. In 1936, Building 2 was subsumed by Building 28, a rear frame can-storage building. Buildings 2, 4, 28, 30, 35, and 36 appear to be one building from the exterior, though inside, they are individual buildings that retain their original building numbers. Numerous interior alterations have also occurred, but have not been documented. The most recent Sherwin-Williams buildings are Buildings 35 and 36, constructed in 1964, and Building 38, constructed in 1965.
See Continuation Sheet.
B7. Moved? ☒ **No**
B8. Related Features: Union Pacific Railroad Trackage (formerly Southern Pacific)
B9. a. Architect: Unknown
b. Builder: Unknown
B10. Significance: Theme: Industrial Development **Area:** Emeryville
Period of Significance: 1919-1955 **Property Type:** Paint Factory **Applicable Criteria:** A and C

B11. Additional Resource Attributes: HP8 Industrial Buildings; HP11 Engineering Structures
B12. References:
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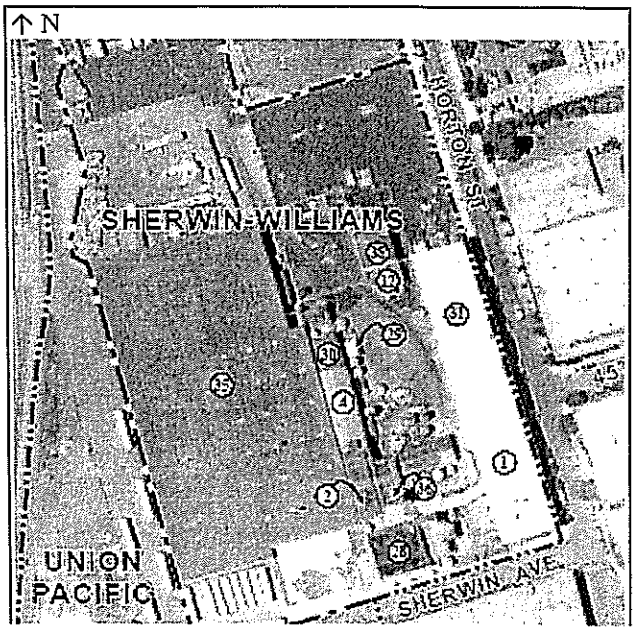
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B13. Remarks: None

B14. Evaluator: Judith Marvin, RPH #525
Date of Evaluation: February 15, 2005

(This space reserved for official comments.)



*Recorded by: Judith Marvin and Randy Groza *Date: February 15, 2005 ☒ Continuation

The Sherwin-Williams Company was founded in 1866 in Cleveland, Ohio, by Henry A. Sherwin and Edward T. Williams, and in 1873, began the manufacture of ready-made paints in an old cooperage shop beside the Cuyahoga River, Cleveland, Ohio. From this inauspicious beginning, the company grew to become the world's largest producer of paints, varnishes, lacquers, and other protective coatings. By the 1960s the Sherwin-Williams Company had manufacturing operations in 23 cities and eight countries (Sherwin-Williams Company n.d.).

In 1919, Sherwin-Williams established a simple pigment plant in Emeryville, but soon found that there was a large market for paints on the west coast. By the mid-1920s, the Emeryville administration building (Building 1) controlled the business of the Sherwin-Williams Company in all the states west of the Rocky Mountains. As the main factory production plant, it supplied the plants in Los Angeles, Pasadena, Portland, Seattle, Spokane, Salt Lake City, and El Paso. The company produced paints, colors, varnishes, sprays, and insecticides (*Oakland Tribune* n.d.).

The Emeryville Sherwin-Williams complex developed on the corner of Sherwin (then Shellmound) Avenue and Horton Street A Southern Pacific Railroad spur provided access to Building 1, and Building 2 was next to the Southern Pacific Railroad tracks on the then west boundary of the property (Hausler and Hersoff 1997:162). By 1924, the company had completed 25 buildings, most of which were support buildings associated with pump housing and lead arsenate production. Other buildings followed, and were altered or demolished as times and technologies dictated. In 1939, the year the fair opened on Treasure Island, the company constructed a huge electric sign on the roofs of its administration buildings. The 320-foot long sign included the Sherwin-Williams trademark, the company name and a tipping paint can pouring neon paint over the world globe, with the words "Cover the Earth" flashing on and off. The company changed its trademark in 1974 and Emeryville's most famous landmark was dismantled in July 1977.

Major changes occurred in 1964, when Building 35, the modern warehouse, shipping, and receiving facility, was constructed on property purchased from the Southern Pacific Railroad to the west of the original complex. At this time, the railroad tracks were realigned to the west, and a spur line constructed into the modernized complex. Various alterations were also made to all the existing structures at this time.

The Sherwin-Williams Company complex was evaluated as eligible for listing on the National Register as a contributor to the proposed Emeryville Historic Industrial District by the California Department of Transportation in 1990. The buildings that comprise the district were built primarily between 1907 and 1930 for manufacturing and warehousing activities. The predominant architectural style is Classical, and the predominant exterior material is brick. The District was considered eligible for the National Register under Criteria A and C (Parks et al. 1990). The Federal Highway Administration (FHWA) concurred with the determination of eligibility, and forwarded the determination to the State Historic Preservation Office (SHPO). The SHPO also concurred, and the historic district was considered eligible by consensus determination (Snyder 1993 and Lortie 1994, in South Bayfront Project 1998).

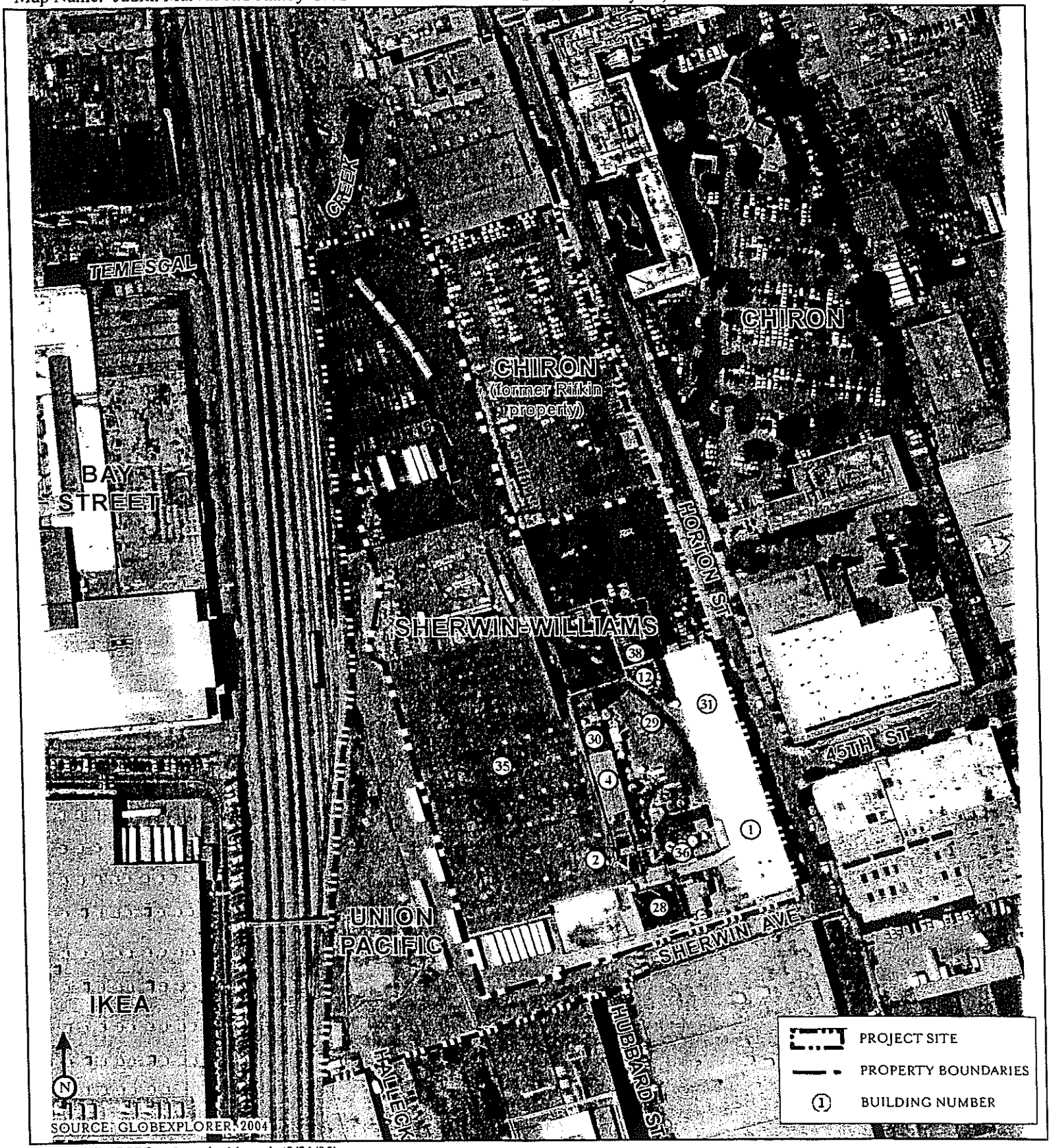
Four of the buildings within the Sherwin-Williams complex appear to be contributors to the National Register District: Building 1, the original administration building; Building 31, the northern addition to the administration building; Building 28, the paint factory constructed in 1936, and Building 2, the early brick paint factory originally. The remaining buildings and structures are either modern, lacking in integrity, or typical examples of common resource types.

State of California – The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
CONTINUATION SHEET

Primary #
HRI #
Trinomial

Page: 6 of 6 *Resource Name: The Sherwin-Williams Paint Company

*Map Name: Judith Marvin and Randy Groza *Date: February 15, 2005 ☒ Continuation



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EXCAVATION OF THE EMERYVILLE SHELLMOUND, 1906

NELS C. NELSON'S FINAL REPORT



TRANSCRIBED AND PREFACED BY
JACK M. BROUGHTON

Number 54 ■ Contributions of the University of California ■ Archaeological Research Facility ■ Berkeley



Emeryville Shellmound (ALA-309): Southerly wall of east part of Area 7, Area 8, west part of Area 9. Levelling of the mound in 1924. Compliments of the Phoebe A. Hearst Museum of Anthropology.

Cover Photo: Site of excavation, showing the grade of the mound, the railroad which cuts it at the extreme lower right hand corner and which runs on a level some eleven feet above its actual base. Compliments of the Phoebe A. Hearst Museum of Anthropology.

ISBN No. 1-882744-05-5

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Library of Congress Catalog Card Number 96-84122
ISBN 1-882744-05-5
© 1996 by the Regents of the University of California
Archaeological Research Facility
University of California at Berkeley

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Preface

Jack M. Broughton

Introduction

In 1902, Max Uhle pioneered stratigraphic excavations in American archaeology at the deepest site in the greater San Francisco Bay: the Emeryville Shellmound (CA-ALA-309). Since these landmark, turn-of-the-century investigations, Emeryville has become one of the most well-known archaeological sites in North America and has attracted relentless interest by archaeologists.

In 1913, E. W. Gifford (1916) used materials from Emeryville in his seminal analysis of midden constituents, launching an approach that would later become known as the California School of midden analysis (Ambrose 1967). In her 1929 study of the Emeryville avifauna, Hildegarde Howard published what remains one of the premier analyses of bird remains from a North American archaeological site (Howard 1929). Artifacts from Emeryville have, of course, played a pivotal role in the development of central California culture history (Beardsley 1948; Bennyhoff 1986). Indeed, materials from Emeryville provided the linchpin for J. A. Bennyhoff's influential shell bead typology, which would ultimately find application throughout California and the Great Basin (Bennyhoff 1986; Bennyhoff and Hughes 1987).

Even though the present location of the long-since leveled mound now sadly serves, in part, as a toxic waste dump for a Sherwin-Williams paint factory, research on the Emeryville collections continues unabated. In ongoing analyses of the human remains from Emeryville, G. Richards (in press) has revealed an unprecedented case of prehistoric cranial surgery in North America. L. Ingram and B. Berry are currently investigating late Holocene climatic fluctuations from strontium isotope ratios obtained from Emeryville shell samples as well as radiocarbon reservoir effects from charcoal and shell samples. I recently conducted a stratigraphic analysis of the vertebrate materials collected from the site. That analysis documented that the inhabitants of Emeryville had substantial impacts on local vertebrate populations (Broughton 1995).

Given the unparalleled historic and scientific value of the Emeryville Shellmound,

the following heretofore unpublished manuscript of Nels C. Nelson's 1906 excavation at Emeryville will be of great interest to scholars of both shell middens and the history of American archaeology in general, and to California archaeologists in particular. This report, manuscript number 348 of the Archaeological Research Facility, University of California, Berkeley, describes in great detail the excavation of, and the materials obtained from, a six-foot square unit sunk to the base of the east side of the mound. Complete with original plates and a large series of detailed maps and figures, the manuscript represents an account of one of only three major excavations at Emeryville.

In 1906, the year of the excavation, Nels C. Nelson was a graduate student of the fledgling Anthropology program at U.C. Berkeley, a program that was led by Frederic Ward Putnam and funded by Phoebe Apperson Hearst. The actual excavation was conducted by Nelson, A. V. Wepfer, and Pliny E. Goddard from May 28 to June 20, under the supervision of Samuel A. Barrett and John C. Merriam (see pages 34-36 of this volume for correspondence concerning the excavation). At the time, Wepfer, Goddard, and Barrett were also graduate students at Berkeley, while Merriam served as an Assistant Professor of Palaeontology as well as a member of the Advisory Committee which guided the young Department of Anthropology (see Thoresen 1975).

As a descriptive report, Nelson's 1906 manuscript provides far more detail on the character and composition of the internal structure of the Emeryville Shellmound than either Uhle (1909), whose earlier work was quite thorough, or Schenck (1926), whose efforts were certainly compromised by the salvage setting into which he was thrust. In fact, Nelson's highly detailed descriptions of the various natural strata and his meticulous excavation methods rival the standards of many current projects.

In the tabulation of artifact frequencies stratum by stratum, this report compares with the careful work of Uhle and hints of Nelson's later investigations in the Galisteo Basin (Nelson 1914) and the Tano Ruins (Nelson 1916). However, by presenting frequency data for major vertebrate classes stratigraphically, Nelson's report goes beyond what Uhle, Howard, or Schenck managed to provide. Moreover, because Nelson carefully recorded provenience information for the specimens he collected, including vertebrate remains and bulk sediment samples, and most of these materials remain at the Phoebe A. Hearst Museum, stratigraphic analyses can still be conducted with these data.

While Nelson's published interpretations of the San Francisco Bay shellmounds (Nelson 1909, 1910) have been regarded as cautious, in contrast to the later well-reknowned insights that emerged from his work in the Southwest (Willey and Sabloff 1974:63), the present report exhibits a concern for many issues that most would associate not with the turn-of-the-century, but with an American archaeology of only the last few decades.

In many respects, Nelson was an archaeologist in advance of his time. This is nowhere more evident than in his analysis of the structure and composition of the Emeryville Shellmound. Based on characteristics of the sediments, such as particle shape and size, orientation, degree of weathering, and the frequency distribution of these variables within and between strata, Nelson attempts to decipher the complex processes that formed the mound. In so doing, Nelson's insights of 1906 foreshadow the current emphasis in archaeology on formation processes and taphonomy. The manuscript contains many such precocious archaeological insights.

A Note on Editorial Policy

The method of transcription I have employed follows accepted principles and conventions for the textual editing of histori-

cal documents (see Tanselle 1978; Burkhardt and Smith 1985:xxvi-xxvix). I strictly follow Tanselle (1978:48) in his recommendation that transcribed historical documents "should not contain a text which has editorially been corrected, made consistent, or otherwise smoothed out." I have preserved intact the spelling, capitalization, punctuation, footnote style (but numbers have been added), and grammar of Nelson's original manuscript. I also note that the original manuscript contains marginal comments and editorial suggestions made by J. C. Merriam, for whom the manuscript was originally prepared. Since these comments or corrections were mostly illegible and/or stylistic in nature, I have not incorporated them here. In some instances I could not clearly decipher Nelson's writing. In such instances I have employed the following standard conventions:

[some text] 'some text' is the probable reading of a word that was difficult to read;

[some text] 'some text' is a description of a word or passage that could not be transcribed, e.g., *one word illeg.*

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Excavation of The Emeryville Shellmound,

being a partial

Report of Exploration for the Dep't. of Anthrop.

During the year

1906.

N. C. Nelson

Outline

I. Dr. Uhle's Work

1. Nature of excavation

2. Results

3. Conclusions

II. Supplementary Excavation

1. Location + Construction

2. Method of Work

3. Nature, Extent and General Results (Statistics)

4. Structure and Composition of Mound

5. Collection:

a. Rocks

b. Animal Bones

c. Artifacts

1.) Stone

2.) Bone etc

d. Human Remains

Report

Nels C. Nelson

DURING THE SUMMER of 1906 the Department of Anthropology of the University of California resumed systematic investigation of the shellmounds in the San Francisco Bay region. The work was carried on by A. V. Wepfer, a graduate student, in conjunction with the writer, under the immediate supervision of Professor J. C. Merriam. Two large mounds, one on the east, and the other on the north shore of the Bay, were chosen for operations, the work being completed only on the first named site, of which alone the following furnishes a partial report.

This east shore mound, forming at present a conspicuous feature of the recreation grounds called Shellmound Park, is the largest of what was originally a cluster of a half dozen or more, located on the alluvial flat at Emeryville, a suburb of the city of Oakland. The immediate attraction of this spot as a dwelling site was probably the small Temescal creek which, in its course from the foothills east of Berkeley to the Bay, passes the mound on its south side at a distance of 200 feet. This mound, it should be explained was the object of extended exploration by Dr. Max Uhle and Professor J. C. Merriam of the Department five years ago, the report of the work having been published by the University only recently;[1] and the present investigation was undertaken mainly to corroborate or modify certain exceptionally striking results then obtained. In order, therefore, to make clear the actual relation of these two interdependent investigations, it seems necessary here to restate briefly the nature and result of the former undertaking.

Quoting measurements from Dr. Uhle's report (p 3), the Emeryville mound has the form of a truncated cone, with and east-and-

1 Max Uhle—Emeryville Shellmound. Univ. of Cal. Publications Am. Arch. and Ethnol; Vol VII, No 1.

west basal diameter of 270 feet, and a diameter of 145 at its top, which is 27 feet above the level of the immediately surrounding plain. This plain in turn has an elevation of from three to four feet above high tide level, the approaching waters of which are at present less than 130 feet from the superficial western base of the mound. On the north side the cone slopes gradually, and, according to Dr. Uhle's findings extends a hundred feet farther out over the plain; to which may now be added the later ascertainment that disintegrated shell and refuse, several feet deep, extends actually 150 feet beyond the 100 foot mark, or in all 385 feet from the center of the mound.

Dr. Uhle chose the west side of the mound as the one best suited to his purpose, and began a radial cut, from five to ten feet wide, running it towards the beach as far as necessary to ascertain the real peripheral limits, and towards the center just as far as time and conditions permitted (pp 7, 8 + 9). The truncated top being encircled by a cypress hedge, and also crowned by a large pavilion, it was impossible to carry an open trench across the mound; but it was run within twelve feet of the hedge, and from that point a tunnel was driven twenty-three feet farther, i.e., eleven feet inside the upper perimeter and to within sixty-one feet of the cones actual center. The total length of this excavation was something over 125 feet. At both its extremities, and also at intervening intervals the trench was sunk to a sharply defined yellowish alluvial clay, at the original surface upon which the mound rests (pp 9 +10). This bottom surface at the inner end of the cut, or at about 70 feet from the mound's center, gave indications of a slight rise eastward, while westward, along the trench for a distance of 55 feet, it continued perfectly level, but was [—and this is the remarkable fact—] two feet below the level of high tide. In the next 35 feet the bottom fell one foot and seven inches and in the last 17 feet it rose again one foot and three inches (1 ft. 3 in), to where the basal periphery of the mound terminated between layers of clay, at a point 177 feet from the mound's center.

The trench and tunnel together furnished only a partially complete radial section of the mound; but, nevertheless, enough to reveal its interesting structure. Dr. Uhle observed ten fairly distinct layers with conforming planes of deposition. The upper six of these layers dipped, more or less uniformly at the same angle as the surface of the mound while the remaining four layers followed practically horizontal planes. From this fact Dr. Uhle infers that two different principles governed the growth of the mound and suggests that it probably signifies a change in the character or culture of its inhabitants (pp 15 +16). In addition to these layers there were noticed also many small but independent beds of ashes, mixed with charcoal and large blackened pebbles, as evidence that fire was continually used in the preparation of food (p 19).

In working out this excavation, some 200 cu. m. of characteristic mound material, composed mainly of mussel, clam and oyster shells, was carefully sifted over and made to yield in all 570 artifacts, besides a large quantity of whole and broken rocks, together also with fragments of osseous remains of many different species of mammals, birds, and fishes. Of the 570 artifacts, however, 88, largely decorative objects, were found with five out of ten different burials occurring in the sixth, seventh and eighth layers, of which, they cannot properly be counted as representatives. From the fact that no interments were found in the upper layers, coupled with the signs of charred remains in the same, Dr. Uhle conjectures that the last mound dwellers probably practiced cremation, and would in so far seem to be a new, and a third type of inhabitants (p. 37).

The uncovered artifacts are mostly imple-

ments of bone and stone, finished to differing degrees of perfection and for more or less evident purposes. Speaking of the artifacts as a whole, it must suffice to say that they comprise a variety of shell and bone beads, pendants of stone, shell and mica; several forms of awl and blunt-pointed implements made of bone, and in two cases of stone; straight and curved bone needles with and without perforations (eyes); chisel-like implements made of antler; about a dozen notched bones; quite a number of ground mortars and pestles, mostly in a fragmentary condition; some grooved stone sinkers; some hammer like stones; "charmstones" of several different forms; a few soft stone pipe-bowls and cylindrically worked stones with longitudinal perforations; some fragments of obsidian spear and arrow points, together with a few unshaped pieces of the same material; and finally, a large number of mostly reject chert flakes. These are, besides, a number of complete and fragmentary pieces of a (more) doubtfull nature. The objects of the collection, if laid out according to their relative vertical positions in the mound, exhibit as viewed from the bottom up, a gradual but decided perfection of workmanship, and also an increasing differentiation and fixity of types. Excluding mortars and pestles, ground stone implements, with one single and peculiar exception in layer eight, all occur near the surface. The same is the case with obsidian, while the roughly flaked chert fragments increase rapidly towards the bottom. The awl type of implement, of which more than one hundred specimens were found, occur in all the layers; but it must be distinctly emphasized that those from the lower layers are all merely rough bone splinters one end of which was pointed enough to be of use.

From the foregoing facts, Dr. Uhle concludes (1) that the mound represents culturally two, and probably three, quite distinct peoples or stages of development (pp 15 + 40) and (2) that since the deposition of refuse began, the solid surface upon which it rests has sunk at least three (3) feet, which suggests aside from the great volume of the mound itself, the probable remote date at which man inhabited the Pacific Coast.

Supplementary Excavation

The object now of further investigation being chiefly to supplement and verify Dr. Uhle's findings, a spot was selected on the land side of the mound as nearly opposite the former site of excavation as convenient for work.[2] From the assumed center of the mound a northeasterly meridian was determined, and on the north side of this line was laid off area for a vertical six foot square shaft, the center of which was about twelve (12) feet horizontally outside the upper perimeter of the truncated top, and eleven feet and eight inches (11 ft. 8 in.) below its level.[3]

The mound having at this point a nearly fifty percent grade, it was necessary to erect a bulkhead on the side hill to retain all the material for refilling the shaft, so as to cause no inconvenience to the owner, Captain Seeby, who throughout the month while we were at work extended us every courtesy. In order also to facilitate and fix all measurements, a horizontal curbing was built at a convenient level above the surface its inner vertical planes being flush with the perpendicular walls of the shaft. Along the edges of the up-and-downhill faces of this curbing yardsticks were nailed on which to read horizontal distances from the meridian wall. For the other other horizontal measurement a sliding "straight-edge", likewise provided

2 The two excavations lacked nearly 50º of being exactly opposite.

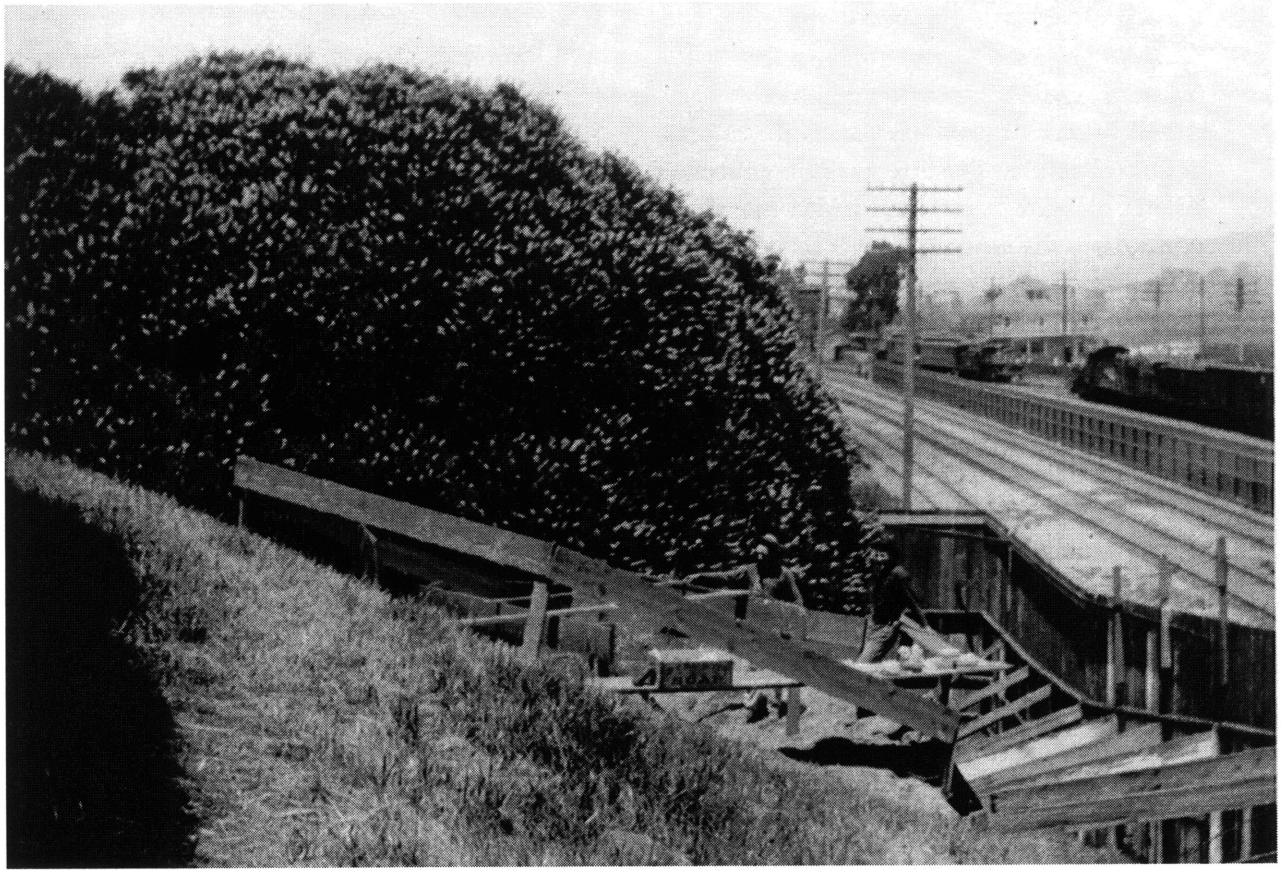
3 For relocation of shaft site, levels etc., consult diagrams in accession envelope No. 206.

with yardsticks, was used: and from this also the weighted tape was dropped to any desired point in the shaft for vertical distances. In this simple manner the objects were fixed by three measurements, taken almost at a glance, and with but one or two movements.[4] It is possible, of course, that horizontal measurements for so small an area may never be of any scientific value, and in cases of ordinary rocks or very common and insignificant fragments of animal bones, groups were made, and only the average location taken. Beyond these constructions no timbering was found necessary, the mound material being compact enough to justify sinking the shaft without casing.

When actual excavation began a division of responsibilities was made, one attending to the shaft, the uncovering and location of objects; while the other, who remained at the surface, read the measurements and also numbered and packed the specimens. Each worker took notes on his own particular [phases] of the work, but on many points of special or peculiar interest these overlapped not a little.

The material of the shaft, while varying

4 It should be explained that measurements given in the catalogue are those taken from the above mentioned horizontal curbing; and, furthermore, that as the tape used has since been found one inch short in every six feet, a double correction has to be made for any absolute depths desired.



Site of excavation, showing the grade of the mound, the railroad which cuts it at the extreme lower right hand corner and which runs on a level some eleven feet above its actual base.

considerably in fineness and compactness, was easily workable; and was all carefully "turned over" with a small trowel before being hoisted to the surface. When objects were to be uncovered a whisk-broom was found usefull; but, on the whole, nothing proved quite equal to the bare finger nails. Particular pains were taken to guard against objects of any kind falling accidentally to the working level from the walls of the shaft and the possibility of such objects being located at a lower level than that at which they actually occurred.

After four weeks of such slow and careful procedure the bottom of the mound material was reached at an average depth of thirty-three (33) feet, measured from the mound's leveled top. The sharply defined transition from shell into clay, shown in cat. No. 9894, occurred between four and five inches below the practically constant water level—except in the inner corner (next the meridian wall) where the yellow clay was more than a foot lower. The material here intervening between shell and clay was as a grayish-black sticky mud, which probably conducted a water vein; for the water bubbled up here almost as fast as it could be bailed out. Pits were sunk another two feet into the solid clay (see # 9895), making the total depth reached thirty-five (35) feet.

The volume of material thus turned over amounted to 774 cubic feet. And, scattered somewhat unevenly through this mass, comprising eleven distinct layers, were found about 1100 rocks and larger pebbles; something over 2000 animal bones, mostly in fragmentary state; and 70 artifacts with an additional 5 collected from a burial, and still another 20 of a more doubtful nature, 15 of which were also obtained from a grave. Presented statistically the results are as follows:

TABLE 1

Strata	Shell			Artifacts						Animal Bones								Whole + Broken Rock		
	Matrix		Bone		Stone															
	cu. ft	Strict	Pr Cu ft	doubt	Strict	p c	doubt	total	p c	Fish		Bird		Mammal		total	pr cu		pr cu	
I	38													8	4.7	8	4.70			
II	40	4	10					4	10			25	1.6	40	1	65	.62	10	4.	
III	40			.(1)	3	13.3		3	13.3	5	8	74	.54	161	.24	240	.16	45[3]	.9	
IV	120	5	24	[15]	1[4]	120	1	6[5]	20	30	4	266	.53	203	59	499	.24	141[2]	.84	
V	38	1	38		2	19		3	12.7			15	2.5	22	1.7	37	1	68	.56	
VI	48	1	48					1	48	8	6	18	2.75	22	2.2	48	1	15	3.2	
VII	25				1		1	1	25	1	25	6	4	39	.64	46	.54	50	.5	
VIII	25				2	12.5		2	12.5					21	1.2	21	1.2	70	.35	
IX	20	1	20					1	20			20	1	66	.3	86	.23	35	.57	
X	44	3	14.7	.(1)	4	11		7	6.3	22	2	12	3.7	142	.31	176	.25	145+(5)	.3	
XI	336	17	19.8	.(3)	23	14.6		40	8.4	1[1]	336	40	8.4	761	.44	802	.42	515+ (5)	.6	
Totals	774	32	24.2	5[15]	36	21.5	2	68[5]	11.4	67[1]	11.5	476	1.6	1477	0.5	2028	.4	1100	.7	
		Brackets [ ] indicate burial finds																		
		Parentheses ( ) " doubtful																		
// Simplification, additions + other changes proposed.//																				

There is evident danger, however, in attaching too rigid significance to these figures; but in a general way they may have something to tell. For instance, it seems a little startling, indeed, a priori improbable, that in the eleventh layer, amounting in volume to nearly half the contents of the entire shaft, there should have been found only *one* fish bone, when that one might easily, in spite of all possible care, have fallen from somewhere in the walls above. On the other hand, if this bottom layer is taken as lacking all fish remnants, and the remainder of the column is literally accepted, it tells, in the light of the other figures, a rather doubtful story. Nevertheless, Dr. Uhle records only two finds of fish bones (Nos. 672 and 901) in the tunnel or lower layer excavated by him; which lends some support to the possible view that these peoples had not yet accomplished the art of fishing.[5] The fact that sting-ray spines occur in the lower layers on both sides of the mound is not conclusive, as at the spring season scores of these monsters are often observed dead or dying on the beach where the receding tide waters have left them.

Structure of The Mound

The internal structure of the mound, as exhibited by the perpendicular walls of the shafts, was of such order as to require detailed consideration. In all, eleven distinct layers of alternating light and dark-colored material were recognized. The varying thickness of these layers, their slope and general contour, were carefully recorded, and samples of each were preserved, together with samples also of every special occurrence such as pockets of clear ash, streaks of unmixed and unbroken shells, and other unusual formations. The variation in color of these layers, it should be made clear, was not owing to any sudden changes in the shell species represented, but due entirely to the nature of the material in which the shells were imbedded. In the light colored layers the matrix was ashes; in the dark-colored layers, a black earthy substance; all shells in the former being charred, while in the latter they showed no evidence of having been subjected to heat. At the same time bits of charcoal were very common throughout all the black layers, and No. 9888 is a sample of a clod of ashes found in the bottom layer which otherwise contained no signs of burnt shell.

As may be observed on the accompanying diagram of the meridian wall, the upper five layers slope almost uniformly with the surface of the mound; while the next five, besides being thinner and more irregular, tend towards a more horizontal grade. Especially is this true of the surface of layer VIII, and to a less degree of layer VI. Finally, the surface of the eleventh, or bottom layer has a rise of only eight inches in six feet. Following is a detailed description of the individual layers.

The top layer, designated I, (sample 9869) was simply surface soil, long subject to vegetative processes; and hence, when fresh, a fine-grained black substance, which however on closer examination, reveals its shell composition. This layer, partly sod, was about one foot deep, and shaded very gradually into a coarser material of a lighter color. It contained no artifacts and but few animal bones were found.

The main part of layer II (Sample 9870) was of a uniformly porous texture, the composition being made up of mediumly broken mussel shells with a small amount of considerably larger clam shell fragments—the whole imbedded in a fine grained material much like that of the layer above. A few small pebbles were noted in it. Some exceptions to the general uniformity occurred here and there in

5 Dahl, W. J.—Contrib. to N. A. Ethnol. Vol. I. p 77— thinks that the shell heaps of the Aleutian Islands are *devoid* of fish bones in lowest layer.

the form of small clods or pockets made up of more finely broken burnt shell and yellowish ashes (see sample 9871). In fact the uphill wall showed an irregular streak of this composition running almost the whole six feet, separating layers I and II. The occurrence may be observed in upper central part of plate , which in fact gives a fair idea of the first four layers as they occurred in the uphill wall.[6] Another peculiarity was an abrupt "sink" of the material of the second layer perpendicularly into and practically clear through the next underlying layer.[7] But for this fact layer II was little more than a foot in thickness. It yielded as shown in the preceeding table, the first artifacts; and on filling the shaft a complete adult skeleton, Pl ? , was also found in this layer just outside the uphill wall limit.

Layer III, sample 9872, also about a foot thick, was much like the special occurrences just mentioned, the only difference being that here, in the third layer, the shell fragments were larger and the ashes several shades more yellow.[8] Oyster shells were also more noticeable. Pebbles were not uncommon; and quite a few bits of burnt clay, having more or less of form and marks to indicate that they had been brought to their state of hardness while incased in a bivalve of some kind. Number 9609 e.g. was evidently the contents of a mussel shell. Apparently, the mollusc gatherers used little discrimination. Calcined bones, some of them burned to a chalk color, with now and then a bluish tinge,[9] were fairly abundant, and rocks of fist size showing the effects of heat were frequently met with. Animal bones were more numerous here than in any other layer, but only three artifacts occurred. A separate human skull was also accidentally discovered at this level but outside the shaft limits. The special variations of this layer consisted of several rather large white masses of what appears to be completely calcined bone and shell (see 9873). These accumulations may mark fire places; although general appearances hardly favor such a view. Note for instance the angle of the mass shown the diagram. Aside from these peculiarities, this layer corresponds closely to the second, third and fourth layers by Dr. Uhle from the west side of the mound.[10]

The thickness of layer IV almost equaled that of the sum of those already described, its volume being in fact greater, owing to a steeper grade. This layer, very sharply defined from those above and below, was of uniformly fine and consequently compact structure—except for an occasional thin streak of unbroken shells lacking matrix; and presented a homogeneous grayish-black appearance. It composition was mainly mussel shell, with an occasional fragment or even a complete valve, of clam and oyster. Small pebbles and bits of charcoal were noticeable; but, as the table indicates, artifacts and animal bones were comparatively scarce, rocks being however, slightly in excess of previous occurrences. A burial lying partly outside the shaft was discovered in this layer, and with this occurred the only samples of obsidian found in the excavation. A small mass of unusually fine black material (no 9875) was found in the uphill wall: at the time of collection scarcely a sign shell could be detected in it, but on shaking the powder in its dry state shell is quite apparent.

Layer V (no 9896) was again light colored, much like the third layer and the special occurrence in the second. In fact the light

6 See also field sketch II.

7 See also field sketch II.

8 That is, in the fresh and moist state.

9 The blue looks as if due to presence of copper.

10 See pp. 22 +23. [Max Uhle—Emeryville Shellmound. Univ. of Cal. Publications Am. Arch. and Ethnol; Vol VII, No 1. (title added by editor)]

colored layers did not (really) vary enough in color and composition for me to state the difference in words. The ash layers were all yellow, with occasional specks of rusty red brick dust due to disintegrating fragments of red sandstone. If anything, the ashes here were of a slightly duller, i.e., grayish color. The same kinds of shell; all of them charred, continued; and in addition, a fragment of cardium shell was noticed. Rocks increased in frequency, otherwise there was a noteably dearth of material for collection. The layer averaged fully a foot in depth, but practically "pinched out" in the down-hill wall. The only thing unusual in the structure of the layer was a streak of clean, unbroken shells (no 9877) occurring in the uphill wall.

The matrix of layer VI was nearly black in color; but the composition as a whole was coarser and less compact than the fourth layer. This coarseness was apparently due to a lesser abundance of fragile mussel shells. However, the more resilient oyster shells were here also almost a negligible quantity. The forty-eight cubic feet yielded only one artifact: rocks also were unusually scarce; while animal bones occurred with the same frequency as in the layer above. The depth of the material was something over one foot; and its composition was uniform throughout with the exception of a thin streak of exceedingly fine-grained substance, (no 9879), practically devoid of shell, which occurred in the uphill wall.

In layer VII there were two distinguishable kinds of ashes, the main part of the usually light yellow mass (no 9881) being overlaid and underlaid by thin wedges of much darker, i.e. grayish hue (no 9880). The burnt shell were perhaps a little more finely broken than customarily in the light-colored layers—especially was this true of the darker parts of the layer. Small and tiny pebbles were noted. There was a prevailing dearth of artifacts, but animal bones and rocks showed a decided increase. This was the thinnest layer thus far worked: starting from the uphill wall over a foot deep, it suddenly dropped to a thickness of six inches, and tapered out to even less as it approached the opposite wall.

Layer VIII reversed the wedge and tapered from barely one foot to less than four inches in depth as it entered the uphill wall. This layer was made up of whole and coarsely broken shells imbedded in a rather scarce grayish-black matrix (no 9883). Pebbles were less, and charcoal more noticable than usual: rocks were more plentiful than hitherto but artifacts, and particularly animal bones, were scarce.

Layer IX, the thinnest in the shaft, was made up of quite finely broken burnt shell, imbedded in a grayish ash (no 9883), just a shade darker than 9880. Pebbles were noticeable as were also occasional bits of oyster shell. Bone artifacts, entirely absent from the two preceeding layers, reappeared; but the single find, in the shape of a broken awl, is a little doubtful owing to circumstances connected with its uncovering. Animal bones showed an enormous increase numerically, whole rock continued almost the same as above. The layer averaged scarcely six inches in thickness, and might, so far as its composition was concerned have been related to the layer below, just as in the seventh layer two distinctly light-colored compositions were considered as belonging together, the darker colors in both cases being the result of contact with black layers.

The lowest of the light colored mixtures, designated layer X, tapered from a thickness of almost three feet in the uphill wall to a mere thin streak on the opposite side. (As a matter of fact, it ended about one and one-half feet beyond the downhill wall, as was found later by letting the wall cave in.) The layer

11 The dry samples as now preserved give no correct idea of now the freshly cut walls appeared.

was composed of mediumly broken burnt shell, bits of burnt clay and pebbles, imbedded in a light yellowish ash,[11] (no 9884). No. 9885 shows an odd occurrence of pure clean whitish ash found midway in the layer. Artifacts occurred in greater abundance than in any other layer, while rocks and animal bones little more than held their own. Completely calcined bones with the aforementioned bluish tinge were also quite common.

We have at last the bottom layer. For a distance nearly nine (9) feet this division maintained an almost uniform blackish color, and apparently a homogeneous composition. The samples, Nos. 9890 to 9894, taken at the surface of the layer and at every two feet thereafter down to the last, which gives the clay bottom, indicates only a slight increase in the size of the shell fragments, beginning about two feet below the surface and lasting to the bottom. There was also in the last two or three feet, which was decidly moist and sticky, a noticable white tinge imparted to the matrix, due probably to a solution rather than mechanical breaking up of the shells. At the surface of the layer e.g., to show contrast, the shells were finely broken and the whole mixture had the appearance, when fresh, of a fine black mould, exactly like the top sod; and inasmuch as the surface of layer XI was about on a level with the gently rising plain east of the mound, it seems not impossible that this fine grained material may at one time have been subjected for quite a long period to vegetative actions. There were, however, no further visible signs to substantiate such a view.

Considering this layer as a whole, it may be said not to agree entirely with Dr. Uhle's findings on the opposite side of the mound as regards stratification. Dr. Uhle found the "planes of deposition" to be practically horizontal, and has indicated them on his sketch Pl IV, fig 2; but, strictly speaking, here, in the walls of the shaft, there were no planes of deposition observable. The whole layer seemed one homogeneous mass devoid of structure so easily noticed in the layers above; so that while there was little to dispute the natural supposition that the strata were horizontal, there was nothing to prove that such was actually the case. Depositions of comparatively long animal bones e.g., seemed to occur at any angle.

Pebbles of all sizes were noticable throughout, and charred bones (no 9658) and charcoal continued in abundance right to the surface of the clay bottom. This last statement may be verified by a close examination of number 9894, a sample showing the transition from black mound material to pure yellow clay to take place in less than a two inch space. Of special occurrence there were a couple of cubic feet of unusually coarse material (no 9886) located at the surface of the layer in the uphill corner next the meridian wall; a thin streak[12] 2 1/2 ft below the surface of extra finely broken shells, oysters among them, no 9887; small clod of ashes mixed with a few burnt shells, 9888, found four feet down in the mass; and also a small piece of red ochre-like material obtained below the water level.

In regard to finds this heavy layer presented some striking peculiarities, the tabulated statement being here quite misleading. The first foot of this material yielded fourteen (14) artifacts, about two-hundred (200) rocks, and something over three-hundred-twenty (320) animal bones; and the greater portion of this collection was found *in* or very close the surface. The rocks and bones were generally larger and less broken up than hitherto; but the size and number of the finds excepting rocks decreased considerably below this level; became in fact at times even scarce, until near

12 This streak was nearly horizontal, and about the only sign suggestive of the horizontal stratification of layer XI.

the bottom, where they again occurred, if not in large numbers, at least in unusual sizes representing large animals. The rocks decreased only gradually both in number and size towards the bottom.

The incomplete remains of an adult were also found in this layer about three feet below its upper limit, and sixteen feet below the side-hill surface of the mound.

In view now, of all the foregoing details, the internal structure of the mound, taken as a whole, presents some curious problems. The apparent double principle of construction suggested by Dr. Uhle is strongly confirmed. That is to say, judged from this last excavation, when the so called tenth layer began to deposit, the mound was a broad nearly flat topped pile, which had for some lengthy period supported vegetation. It is however likely that deposition began near the center of this old substructure, and that further excavation of the upper part of the mound in the direction of the center would reveal layers in addition to the ten now obtained near the periphery. It seems also most plausible, in the light of many little and, taken separately, insignificant facts, to suppose that the material comprising these alternating light and dark colored layers is not in its original place of deposition; but was, after undue accumulation on top of the central superstructure, scooped out over its edge and down a gradually steepening incline, to stoop only at the surface of the older mound. On this hypothesis too may probably be explained the remarkable accumulation of rocks, animal bones etc. on and near the surface of layer XI as already mentioned. In scooping refuse over the edge of the superficial mound, however, large bones and all heavier objects would roll in most instances to the bottom of the incline and would be covered up gradually as the lower periphery of the superstructure expanded. Here e.g. were found the largest and best preserved bones, among them a complete carnivor skull and part of a deer skull with both antlers, in perfect condition, still attached; together also with several other finds of complete but separate antlers. Furthermore, on the basis of what is now known, if the whole top of the cone should be lowered by, say ten feet, there would probably be revealed an array of concentric circles of alternating light and dark colored material. Some of these circles would be very thin and others comparatively thick; and one need hardly suggest that the material was not originally laid down in this fashion. The oft referred to clods of cemented ashes and the slanting position of the larger masses of such material would alone negative such a supposition.

But precisely how did these alternating layers originate? Do the light and dark colored variants represent different cultures, each remaining for some considerable period of time, or do these layers simply represent seasonal variations in the mode of life of an identical people? If the latter, then the upper part of the mound at least need not be considered very old; although it almost certainly anti-dates the advent of Europeans. But that the variations are merely seasonal is hardly, in view of the volumes represented, an entertainable hypothesis.

Turning to the substructure, there is ground here also for believing that the material composing it is not in the place of its original deposition. The lack of stratification or structure to this mass has already been referred to. In addition there is the occurrence of a single small clod of ashes, no 9888, four feet below the surface of the layer. Its presence is strange and unaccountable. It might have been intruded from the surface, as was probably the case with burial no 4, only five feet away and one foot nearer the upper limits of the layer; but there was no sign of disturbance. The homogeneous nature of the layer, however, coupled with the fact of a consider-

bance. The homogeneous nature of the layer, however, coupled with the fact of a considerable increase in the size of the shell fragments, and the increased number and size of animal bones found near the bottom, leads one to the strong notion that it was formed after the same manner as the superstructure. Furthermore, on what other reasonable supposition can be explained the fact that fragments of mortars and pestles, implements of bone and antler etc. were found in close proximity to the clay bottom, their workmanship being equal to that of artifacts found much nearer the surface. In fact, though the types of artifacts extracted from the shaft differ in some respects, the difference is not absolute; and the quality of the workmanship is not so widely different as might reasonably be expected, considering the great period of time involved. Charcoal and other signs of the use of fire also continued with undiminished frequency to the bottom as another indication of the similarity of culture represented. Dr. Uhle clearly found conditions quite different on the west side of the mound there being a striking gradation in the kind and quality of implements used. But it seems clear that investigation of the Emeryville Shellmound cannot be considered satisfactorily complete until something like and open trench has been carried clear across the mound laying bare its core.

In regard to the various species of shells represented in the mound material, little need (perhaps) be said here as no identifications have been made. Unscientifically speaking the body of the shell refuse was made up of clam and mussel shells, with a few oyster shells irregularly interspersed, and in addition a few samples of cardium shells. Only two univalves were found, and these of different species. Dr. Uhle identifies (p 16) no less than nine dif species and two subspecies.

THE COLLECTION

Rocks—The occurrence of rocks throughout the shell refuse may perhaps necessitate little further comment. The specimens, mostly sandstones, with a few samples of a tufa-like material, are in the form of whole and broken boulder varying in size from large pebbles up to two and three pound weights. Those from the ash layers show marked effects of heat. Some of them e.g., are cracked and brittle (and many, when dry, emit on being stroked with the hand, the sound peculiar to burnt brick.) Others are blackened, not only on the surface, but partway through. Stone obtained from the black layers show much less, and sometimes no, signs of heat; though possibly expert knowledge may reach a different conclusion. Several specimens, particularly from the black layers, still have remains of barnacle scales on them, showing that they were picked up on a stony beach— such as is not now found for miles either north or south.

Of flint or chert there was obtained only ten pieces. One of these, however, no 9602, a piece of rather striking color, was found with a burial in the fourth layer; with which occurred also no. 9601, a small agate-like pebble, evidently also valued merely for its beauty. In this grave, moreover, was obtained eight pieces of obsidian, the only samples found in the excavation. But of chert strictly belonging in the fourth layer, there were only two pieces. One of them, no 9618, was classed among the artifacts (but probably wrongly so) owing to its axe-like shape, due most certainly, however, to natural cleavage. In the remaining seven pieces, there were found in the tenth, and four in the eleventh layers. This slight increase of chert towards the bottom agrees with Dr. Uhle's findings; about 100 specimens having been obtained by him in the lower layers on the opposite side of the mound, the apparently great discrepancy in numbers being nearly proportionate to the amounts of material removed.[13]

13 In the bottom layer occurred also some fragments of quartz-like material.

roughly classified the osseous remains of the animals consumed by the mound builders, very little more can be said at present, inasmuch as the species represented have not yet been carefully identified. Taking the most general view of the collection and its occurrence it may be affirmed that bird and fish bones showed a decided decrease towards the bottom; whereas mammalian bones increased in the same direction both in number and size, if not in actual variety of species. Especially was this true near the top and bottom of the lowest layer, due probably, as has been suggested, to artificial manipulation of the mound material, which if a correct view, invalidates in a measure the general statements about occurrences in the bottom layer. However, these general facts are in agreement with Dr. Uhle's observations.

More specifically, *carnivors*, of which there were a few small representatives, seemed to be confined largely to the burnt layer, while ungulates prevailed throughout, one species of deer being however apparently limited to the upper ten layers. In the lowest layer occurred large fragments of spongy bone, and also numerous vertabrae of the cetacean order. In one case only, near the top of the layer, was found parts of the bones of some cetacean lying apparently in their natural order.[14] (This it will be seen is evidence against the idea of artificial manipulation of the layer). Parts of the scapula of one of the largest ungulates represented was found on the bottom, below the water level; and three vertebrae with the limb bone of such others were met with only two or three feet above. At the bottom occurred also fragments of the roots and tips of antlers, besides two heavy wedge-like implements of the same material.

14 Found on the same level and very close to human remains no 4.

Artifacts—Considering an artifact to be any object "worked" for a more or less evident purpose, there were found in this excavation, as already stated, 70 pieces about which this can be no doubt. Objects of stone slightly outnumber those of bone; but, to counterbalance, all the former with the exception of two charmstones, are mere fragments while of the latter there are several complete and comparatively fine specimens. If the so called charmstones, about the use of which there is so little certainty, be eliminated, the objects fall into the following classes:

Utensils—mortars and pestles——27.
Implements—awls, wedges, bone blades——21.
Weapons—spear and arrow points of bone and obsidian——6.
Ornaments—Tubular bones, bird + human(?)——7.
Miscellaneous worked stone———3.

There may, however, be some risk in attempting to classify objects according to their uses when these are not, as is often the case, altogether apparent. It seems, therefore, well in this case to adhere to Dr. Uhle's scheme, based on the materials of which the objects are made.

A. Objects of Stone

The objects made of stone comprise chiefly fragments of mortars and pestles; in addition four incomplete "charmstones" and also a few miscellaneous worked pieces. The materials represented by these objects include several grades of sandstone and quartzite.

1) The mortar fragments represent vessels of varying sizes and shapes. Nos. 9612a and 9643 e.g., are neatly rounded borders of what were probably concavo-convex mortars; while nos. 9612b and 9640 appear to be the broad flat rims of flat bottomed forms with straight but oblique exteri-

ors. Number 9520 is a comparatively large fragment of a shallow mortar of less than six inches in diameter and with only a slightly worked exterior. A better example of a good sized mortar hollowed out of a rough boulder is no. 9649, found about two feet down in the eleventh layer. It is the largest piece occurring in the excavation.[15]

2) Pestle fragments are comparatively scarce, one only being found in the third, and another in the fourth layers, with the remaining five occurring at different levels in the substructure, the last of them, no 9672, exactly in the water line. The fragments are rather small and consist of one complete and two partial cross sections; the rest being longitudinal sections, in all cases but one, from the heavy end of the pestle.

Roughly considered, these objects increased in frequency down to and including the top of the bottom layer: below that level there were only nine small and one large fragments, rather evenly scattered. The workmanship of these ten is noticeably inferior to that of the samples from the superstructure although there are samples of ground stone even in the lowest layer e.g., no. 9656. The rather curious fact about these fragments is their diminutive size. One is not a little inclined to accept the explanation suggested by Rust that these household utensils were often purposely shattered by attacking enemies.[16]

3) Of the charmstone type there are only three forms represented, viz., the oblong, the pear-shaped and the *[globase]*. The last named is a new form, Dr. Uhle having none like it in his collection. This specimen, no 9621, is almost complete, lacking only one of its two projecting points or axis. It shows distinctly the pecking traces by which it was brought into shape, the same being *[marred]* only by two opposing sides being ground and polished down into gradually approaching planes. The pearshaped stone, no 9619, has also one end of its axis broken off. It was made from a stone too small to allow a symmetrical specimen; but in so far as finished it has been brought down to a semi-polished state. The remaining two specimens are represented only by fragments. No 9589 is an end section, 2 inches long, apparently of the common symmetrically oblong form; and no 9630 is a four inch section or a little more than half the entire lenght of a similar form. Both the last named are pecked but unpolished. All four pieces are found in the superstructure, no 9589 in layer III and the other three close the surface of layer XI.

4) Of miscellaneous pieces of worked stone there is no 9591, a sample of yellow ochre-like material with noticable scratches, occurring in the third layer; no 9607a, a fragment of quartzite with opposing, but approaching, *[ground planes]*, taken from the fourth layer; from which was also obtained no 9607b a thin blackish piece of shale or schist with sharp edges such as might well have been used for scraping surfaces. There are, lastly, three pieces of worked sandstone from layer XI.

5) The five obsidian pieces, nos. 9596-9600, obtained with burial no 3, are very poor specimens of workmanship compared with some of those found by Dr. Uhle.

B. Objects Made of Bone and Antler

The objects made of bone and antler occurred irregularly throughout all levels of the shaft. Strangely enough, the type of objects and qualities of workmanship do not vary quite as might have been expected. There are (really) more types in the bottom

15 Dr. Uhle has some smaller forms of mortars, but hardly so many fragments. The fragmentary condition of the mortars is itself an interesting question.

16 Horatio N. Rust—A Cache of Stone Bowls in Cal., Am. Anthrop. Vol VVVI; No. 4., p 686.

layer than in all the other layers combined; while the workmanship, so far as types can be compared, is, in some instances, little inferior in the lowest layer. But on the whole there is, as in the case of stone artifacts an advance towards the top. The bone artifacts fall into six general types:

1 THE AWL-TYPE OF IMPLEMENT

a) In the upper four layers occurred a form of awl of which no 9610 is the finest of four complete specimens found. It is a dagger shaped tool of about five inches lenght, curving gracefully to a fine point and maintaining in some instances, a very high polish. The tool is split from the of deer with its portion of the condyle left to afford an easy and secure handhold; and in most cases the cross section is concavo-convex, giving more strenght the implement than if the inner channel was obliterated. It is termed by Dr. Uhle the *common awl* and is illustrated on plate IX, figs. 1, 2 and 3; none of which, however, are equal to the specimens found in the shaft.

b) Another form of awl occurring in layers VIII, IX and X is represented by no 9625. It is likewise split from the shank bone, but is more slender, triangular in connection, and nearly two inches longer.

c) A third form of awl, no 9635, was found in the eleventh layer. It resembles somewhat the first form described, but is broader and hence more deeply channeled, being made from a different and longer shank bone. The form is figured by Dr. Uhle as no 28 and mentioned as having a "peculiar shape".[17]

d) The fourth well recognized form of awl represented by only a fragment, no 9893, is made from the ulna of the deer, the olecranon being used as handhold.[18] Dr. Uhle found complete specimens of this form and figures are on page 69.

e) The last recognizable awl form, no 9636, is made from the distal end of the large of a deer. The specimen, if complete would measure about eight inches in lenght; but the head of the tool (formed by the condyle) and also a section near the point was crushed and lost in excavating. It is a unique piece because it is still largely in the rough, just as left after the dorsal side of the bone was split off, only the point being smoothed down.

A still more interesting specimen is no 9626. It is made from the bone also; but the fracturing process was evidently not successful, the side wanted breaking off too short, leaving however an assymmetrical blunt point which shows evidence of considerable use. If this bone was fractured simply for the marrow, as is apparently sometimes the case, then it is a fine example of the accidental tool, serving as a transition between natural implement which met the first needs of primitive man and which probably suggested the artificially improved types.

f) Beside these well defined forms a miscellany of pointed bones occurred. Some of them are apparently mere accidental splinters; others show marks of use, although, aside from their pointedness, they are not naturally adapted for tools. No 9593 already referred to under the fourth form seems to have been used in its fragmentary condition. Nos 9633 and 9659, very sharp pointed splinters from rather heavy limb bones, are two and one-half and three (2 1/2 + 3) inches long respectively, and the former has been worked down somewhat in the form of a three-[cornered] drill point. It might well have been used to point a weapon, but it shows no evidence of having been attached to anything.

17 Compare also figures by Smith from the Lower Frazer River in British Columbia. Mem, of Am. Mus. Nat. Hist. Vol IV, p. 174).

18 See Moorehead—Prehist. Implements, p 142. (from [Tennessee])

Finally, no 9660, an unrecognizable fragment of bone shows longitudinal scratches and other indications of having been used as a pointed instrument although the point is now missing. The two last mentioned objects occurred in the bottom layer.

2 THE "PAPER CUTTER" TYPE

Near the bottom of the last layer was found, side by side, two peculiar long thin curved blades, nos. 9666 and 9667. They were found unexpectedly and as a result came out in a fragmentary state. On cementing the pieces, however, the result is two nearly complete implements. One is plainly made from from a large rib, shaved down on the inside and brought to a dull point by the irregular cutting or wearing away of the margins. With the head end missing, and discounting its curve, the tool measures eight inches in lenght. The other specimen is a very neatly made object. It is a thin, smoothly worked blade, expanding in its seven inch lenght, by straight margins, from what was probably a blunt rounded point to one and three eights (1 3/8) inches in width. The implement has a slight transverse as well as a longitudinal curve, and thickens a little towards the point. The most remarkable feature about the specimen, however, is the appearance of ornamentation on the convex side, consisting of two rows of dots impressed in wavy lines along the margins. It is the only sign of ornamentation of its kind found in the mound, and being an example of art purely for its own sake, coming from within three feet of the bottom, it seems worthy of special attention.

In addition to these two is no 9648, a 3 1/2 in. section of a 1/2 inch wide rib shaved quite thin and somewhat polished on the natural side.[19]

3 THE ARROW POINT TYPE

A third type of artifact of which one good example, no 9663, occurred three feet from the bottom, is a small lanceolate blade termed "arrowpoint" by Dr. Uhle, who found several similar forms in what he called the eight layer.[20] This particular specimen is about half an inch wide at the collar and tapers to a point, the whole blade from collar to point being little more than an inch long. The constricted stem is incomplete but it is interesting in that it shows plainly the whitling process by which it was brought into shape. Some slight traces of asphalt still remains on this part. No 8870 (fig. 15, Pl. IX) of Dr. Uhle's collection is almost an exact counterpart of *this* specimen.

4 THE WEDGE-LIKE TYPE

Implements of the heavy wedge-like type occurred only near the bottom. No 9674 is wedge made from a split elk horn. It is 5 1/2 inches long, 2 inches broad, and nearly 1 in thick. A fragment is knocked from one corner of the butt end and the softer inside structure is partly dissolved, but the natural exterior with the somewhat dull cutting edge is all intact.[21] Almost alongside this was number 9673, a slightly curving pointless antler, oval in cross section, with the flat sides smoothed by use. The missing point was apparently destroyed by fire, leaving a section 3 1/2 inches long. The but end has the appearance of hard usage, several chips of the surface layer having been split off. No 9665 is the gathered fragments of the point end of a similar implement about, 1 inch wide, found three feet from the bottom. It presents a fine

19 Dr. Uhle on pp 73 and 74 describes fragments of several such implements, one of them, ornamental with geometric figures, and all occurring in the lower layers.

20 See pp 41 and 76; and figs 11-16 Pl. IX.

21 In Dr. Uhle's collection there were no forms like the 1st, and none exactly like the 3d; but quite a number of the 2d form occurred in layer 7, 8 + 9 (see Pl VIII figs 1, 2, 3 and 7).

gathered fragments of the point end of a similar implement about, 1 inch wide, found three feet from the bottom. It presents a fine semicircular cutting edge slightly polished and also blackened as if by fire.[22]

5 THE SAW-LIKE TYPE

Anther type of implement is the so called saw, or, as termed by Dr. Uhle, saw-like notched bones. Of these peculiar objects six fragmentary specimens occurred, no. 9584 in the second layer, no 9613 in the fifth layer; nos. 9652, 9661 and 9662 in about the middle of the eleventh layer, and no 9671 at the bottom of the mound, i.e., from below the water level, but under circumstances that warrants the genuiness of the find. The first, second and last of these pieces are alike made from the scapula of
some not very large ungulate; and the notches in each case on the posterior border.[23] The notches are irregular both as to depht and interval, those in no 9584 being cut rather deep, apparently with a thin sharp tool; but the others, likewise probably started with a cutting tool are shallow and rounded at the bottom as if worn by a string.

Nos. 9652 and 9661 are fragments of what may well be taken for fish bones, with quite irregular shallow notches. The teeth on each piece tend to point in one direction. No. 9662 is the most interesting and suggestive specimen. It is a small fragment of channeled bone, one irregular and thick margin of which has nine smooth and shallow notches running across it. On the opposite margin, but nearer one end of the bone, is a large smooth groove slanting across the face of the bone towards the small notches. There can be little doubt that the small notches were worn by strings running separately across one edge, and that these same strings gathered into a bundle produced the large groove on the opposite edge. This implement, as no other of its type found in this region, tends to confirm Dr. Uhle and Prof. Ranke's suggestion that they were used for some kind of weaving.

6 THE TUBULAR BONE TYPE

The last type of objects to be described from the excavation is the tubular bone. These pieces are mostly hollow bird bones from one to three inches long, with square cut ends and varying degrees of polish. They occurred in the second, fourth and eleventh layers; and of the five specimens found only the one from the second layer, no 9588, is complete. This piece shows some transverse lines produced by a fine edged cutting tool, and also some indentations made by teeth; but its polish is not so marked as in the case of fragments no 9634, found on the surface of layer XI. The remaining pieces from the fourth and the middle of the eleventh layers are less characteristic; being in a partly dissolved state. One other specimen of tubular bone, of a different character, occurred in the tenth layer. It is a piece, 3 1/2 inches long and 7/8 inches in diameter, made almost certainly from the distal end of a human upper arm bone. One end is cut off and smoothed, the other was fractured in unearthing.

In addition to these artifacts above described there are about fifteen stingray spines, found in a bundle on the chest of human remains No 3, in the fourth layer. They show no particular preparation for attachment, or any signs of use; and yet, the fact that they were found with weapons of obsidian and other things useful and ornamental makes it seem likely that they also served some useful purpose.

Comparing the results of the two excavations in reference to artifacts, it is to be observed that Dr. Uhle's collection furnishes

22 Dr. Kroeber says that similar implements are still in common use by modern Indians of the Coast.

23 Illustrated by Moorehead—Prehist. Impl. p 236.

several more types, among them: sinkers, such as no's. 8669 and 8534 (figs 20 and 21), found near the surface; straight and curved bone needles, and also a variety of types of ornaments found in the graves. The present collection does however, as pointed out, furnish some additional forms of the old types. As a curious coincidence may also be mentioned the fact that the number of objects in the two collections are almost in exact proportion to the amounts of material removed.

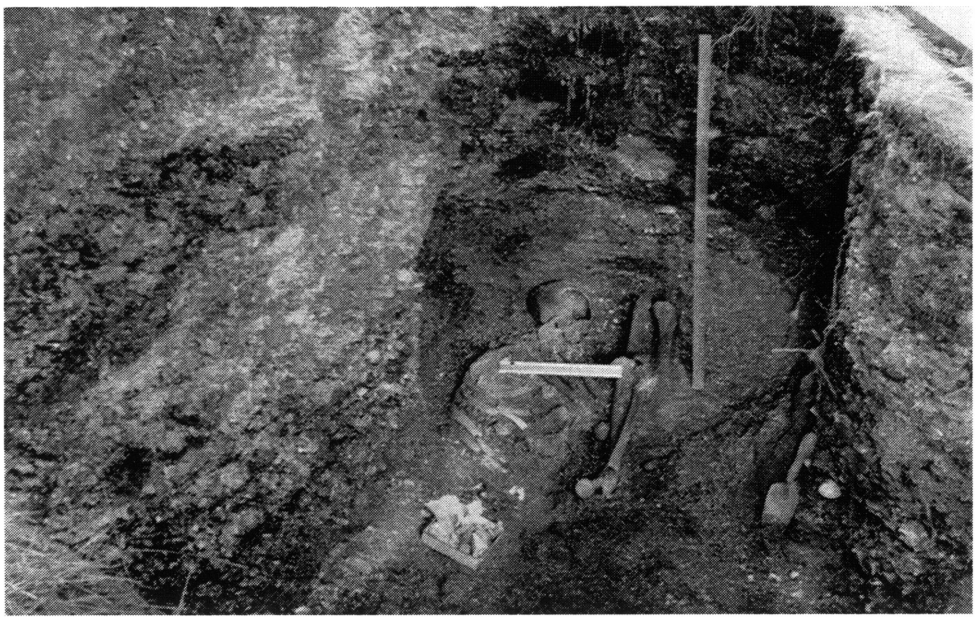
The Burials

Four graves were discovered in this excavation, all of them as it happened, along the same corner of the shaft, but partly outside it, and at widely different levels. Three of them occurred near the surface of the mound and the fourth at a depth of sixteen feet. Only two of the remains were complete, and but one those furnishing any artifacts. Separately considered the four finds were as follows:

No , a complete adult skeleton in comparatively good condition, found in the second layer, about a foot and a half below the surface and just outside the uphill wall of the shaft. The position was level supine, head south, face west; left upper arm extended at an angle to body axis and forearm parallel to same; right upper arm parallel to body axis, forearm crossing body leaving hands in close proximity; legs drawn up loosely at right-angle to body axis with knees to the left. The skull was crushed.

No a separate skull found in an upright position outside the shaft in the third layer. It fell to pieces on exposure, but a low brow and strong supercilliary ridges were noticed.

No , a complete adult skeleton, found near the bottom of the fourth layer or about 5 1/2 feet below the surface, with only the proximal end of one femur extending into the shaft. The remains lay on the left side in a doubled up position and on a slant, the pelvis being lower than the head, which was north-west. Spine was curved and the legs were flexed with the knees (pointing north-west and one of them) brought up on line with



[no 3]

The left half shows also the first four layers as they appeared in the uphill wall.

top of head, but nearly a foot away from the face. The arms were flexed with hands laid together under the cheek. On the neck and chest of this individual was found the obsidian blades and stingray spines already mentioned, and between the face and knees occurred a fragment of an awl of the first form, no 9603; the small agate-like pebble, no 9601; and also no 9602, a rather pretty piece of coffee brown chert with some discoidal fractures.

No , the partial remains of an adult occurring three feet below the surface of the eleventh layer. The position was level, supine, head south-west; lower girdle with lumbar vertebrae in natural order; left leg and arm flexed and laid alongside trunk. The skull was entirely missing, and the right appendicular parts were represented only by the proximal end of the femur and a short section of the tibia, both showing old fractures. The burial was evidently secondary.

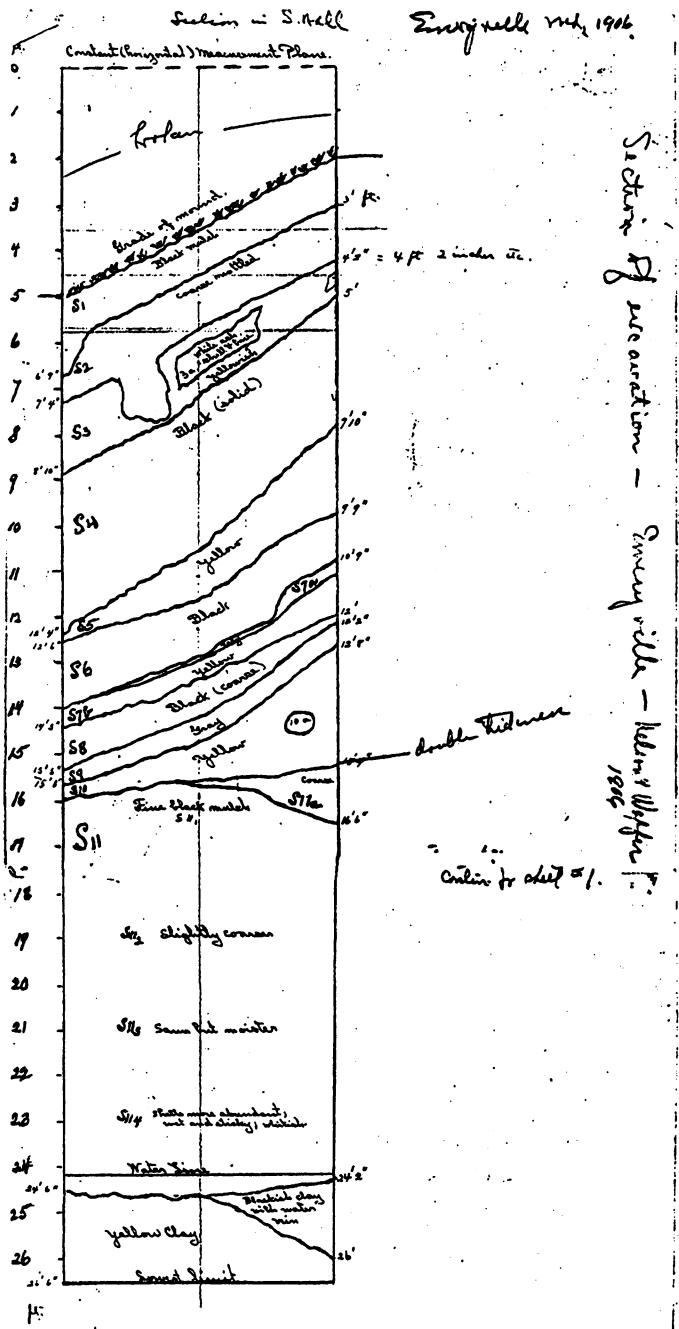
Of cremation there was no sign near the surface, as was the case on the sea side of the mound. But the small area excavated hardly allows the assertion that cremation might not have taken place. Dr. Uhle, on the other hand, found no burials near the surface, which fact likewise must for the present remain inconclusive.

The facts stated, there remains but to briefly compare conclusions. On some specific minor points there has been shown to be discrepancies, but in reference to all the broader and really significant facts there is all the agreement that might reasonably be expected (in so unscientific a structure as a shellmound.) (Not one absolute contradiction is apparent.) There is agreement in regard to the bottom of the mound as below sea level; the internal structure is quite similar on both sides, the only exception being the fact that layers are more readily distinguishable near the bottom on the sea side; and the nature, frequency and relative order of occurrence of artifacts tallies to a a surprising degree. The only contradictory facts is the apparent substitution of cremation for burial in the upper layers on the sea side, and the lack of signs of cremation near the surface on the land side, where burials are frequent. However, without further superficial excavation on both sides of the mound, it is hardly safe to accept either fact as conclusive, unless as seems probable, the mound in the course of its growth was building towards the east, or land side. In that case Dr. Uhle may be assumed to have worked the older part of the deposit; and the burials near the surface on the east-side may be indications of a fourth and later people who contributed the last additions to the mound.

N.C.N.

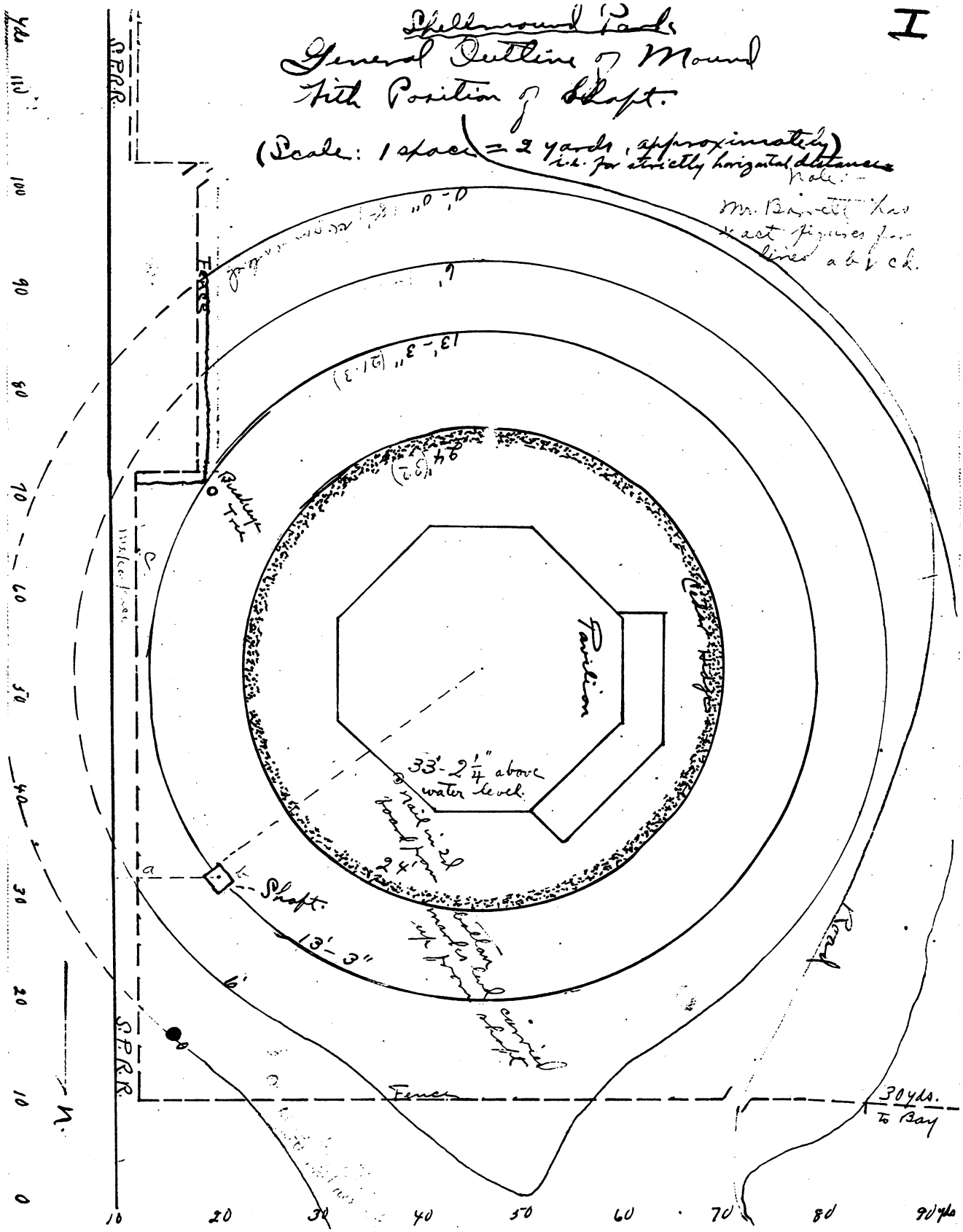
Reproductions of

Maps, Diagrams, and Letters

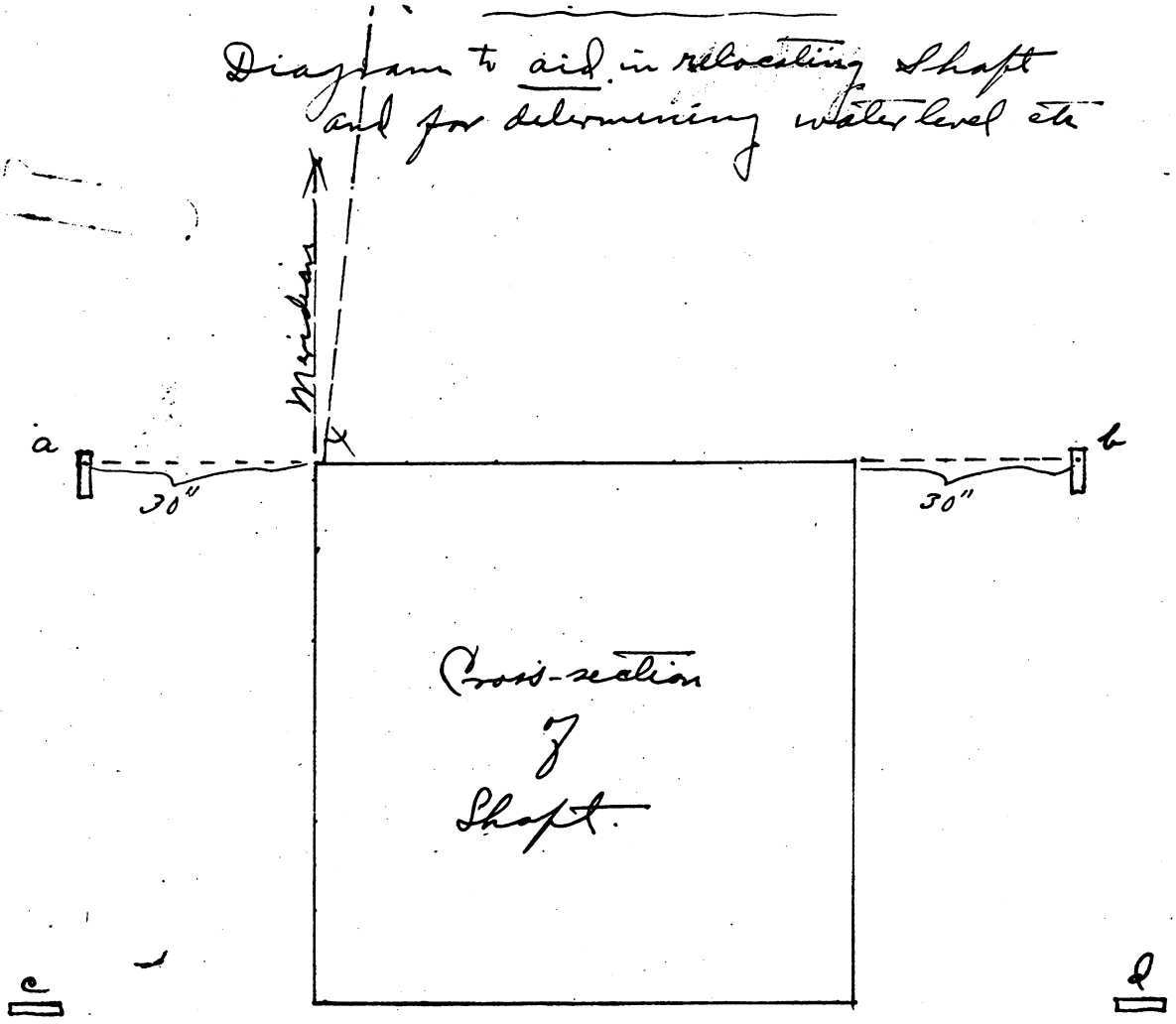


The above is a copy of the original section. You will see that the measurements were all made from an arbitrary horizontal plane from 2–5 ft. above the sloping side of the mound, hence to get actual depths of any specific sample, you'll have to deduct according to your own judgment. The elaborate scheme was initiated by Dr. P. A. Bennett and not by myself.

M. E. N.


Shellmound Park
General Outline of Mound
with Position of Shaft.
(Scale: 1 space = 2 yards, approximately)
i.e. for strictly horizontal distances
I
Mr. Barrett has
exact figures for
lines a b & c d.
S.P.R.R.
Fence
Bulkhead Line
Pavilion
33'-2 1/4" above
water level.
9 nail in 2 sl
board from
2 4"
Shaft.
13'-3"
Fence
30 yds.
to Bay
N.
10
20
30
40
50
60
70
80
90 yds

Ia



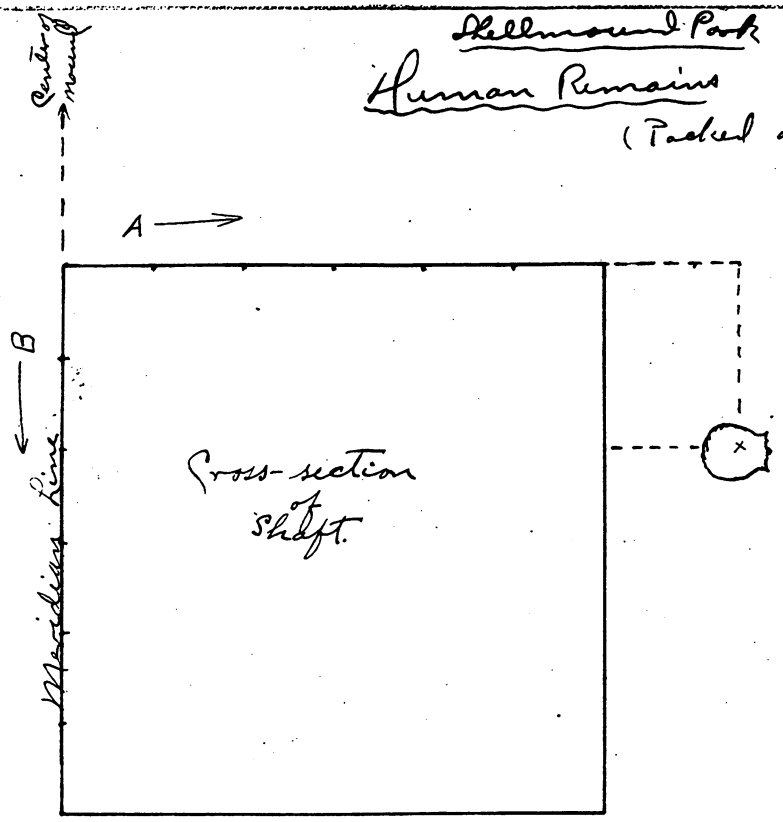
Explanatory: a b and c d are stakes (made of 6" board and put down solidly) marking the position of shaft and also baselines for all measurements. a and b are on a level (the chosen surface level), and the line from nail to nail determines one face of shaft. c & d are on a level (the chosen surface level) and exactly three feet (3') below level of a b. But c d are not put down (like a & b) at any fixed distance from shaft — owing to a "cave in". x-y approx. direction for water level mark on Pavilion.

Shellmound Park

Human Remains

III

(Packed as number 25)



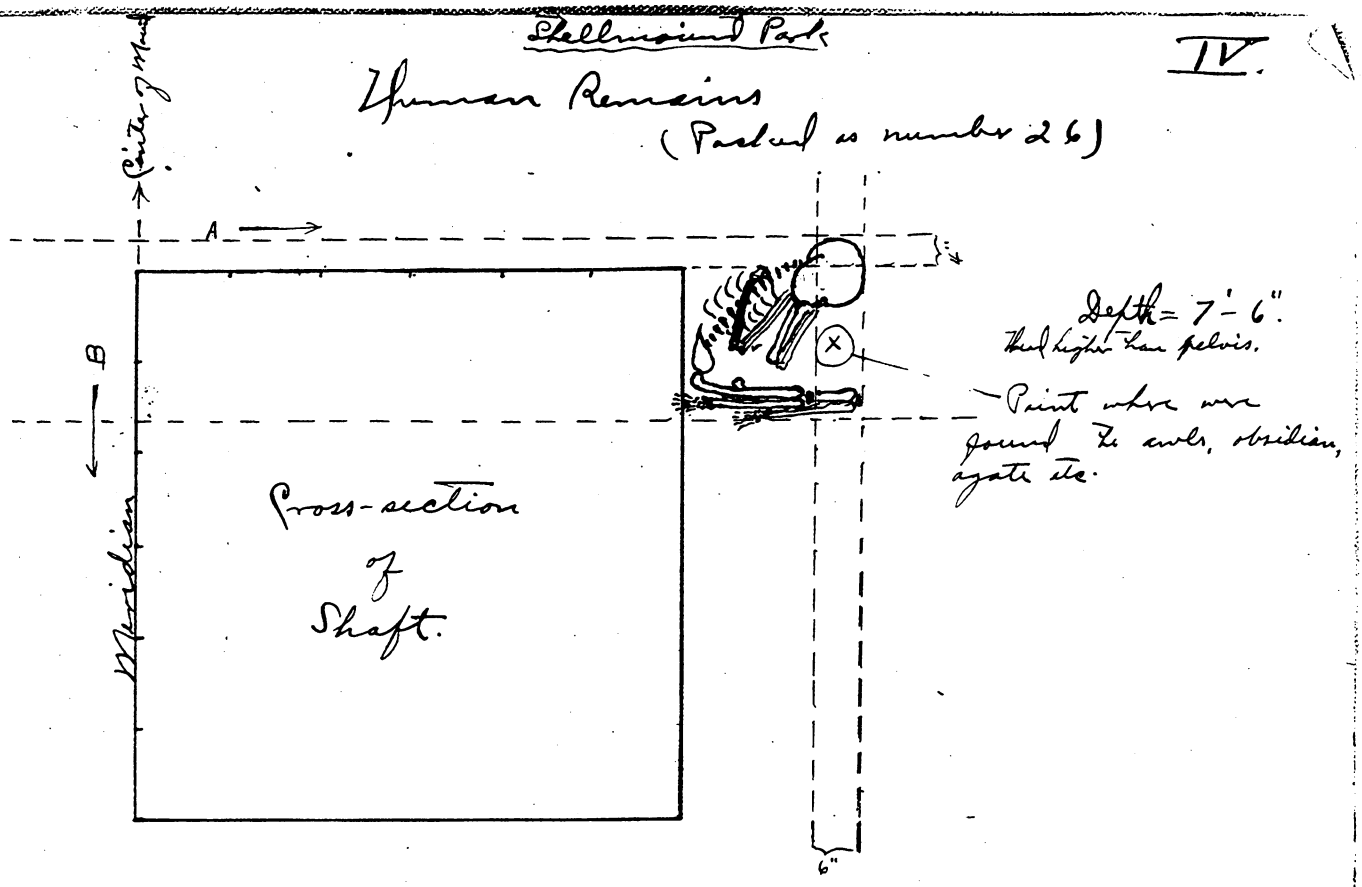
Actual Position

a = 7'-6"
b = 2'-
c = 5'-

Skull placed in almost erect posture.

Scale: one space (1 1) = 4 inches.

N.C.N. 6-5-'06.


Shellmound Park
IV.
Human Remains
(Packed as number 26)
Point 7 mts.
A
B
Meridian
Cross-section
of
Shaft.
Depth = 7' - 6".
Head lighter than pelvis.
Point where were
found 2 awls, obsidian,
agate etc.
6"

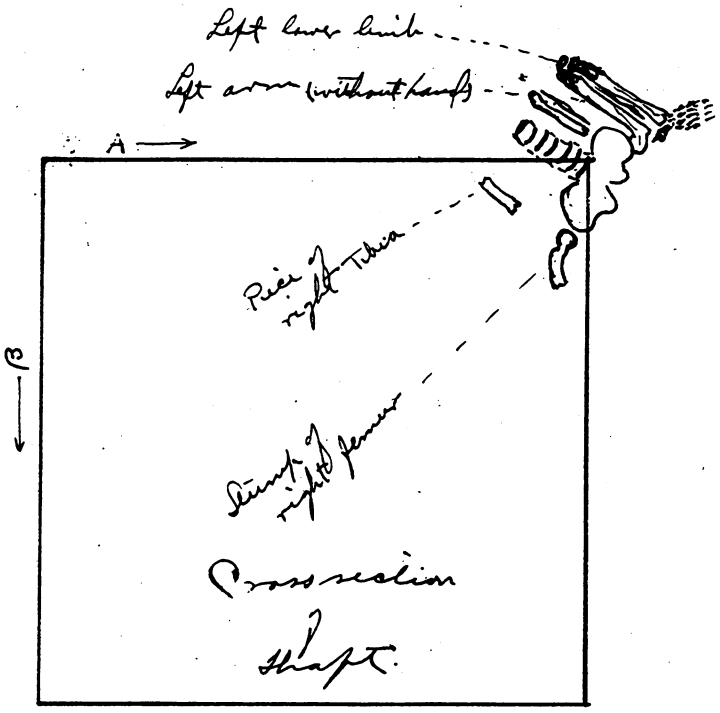
M.S.M. 6-5-06.

Shellmound Park

V.

Human Remains

(Packed as no. 82)



a = 4'-9" to 6'-9"

b = 1'-4" to -9"

c = 18' i.e. about

five (3) feet below

mound bottom proper or

3 ft below level of railroad

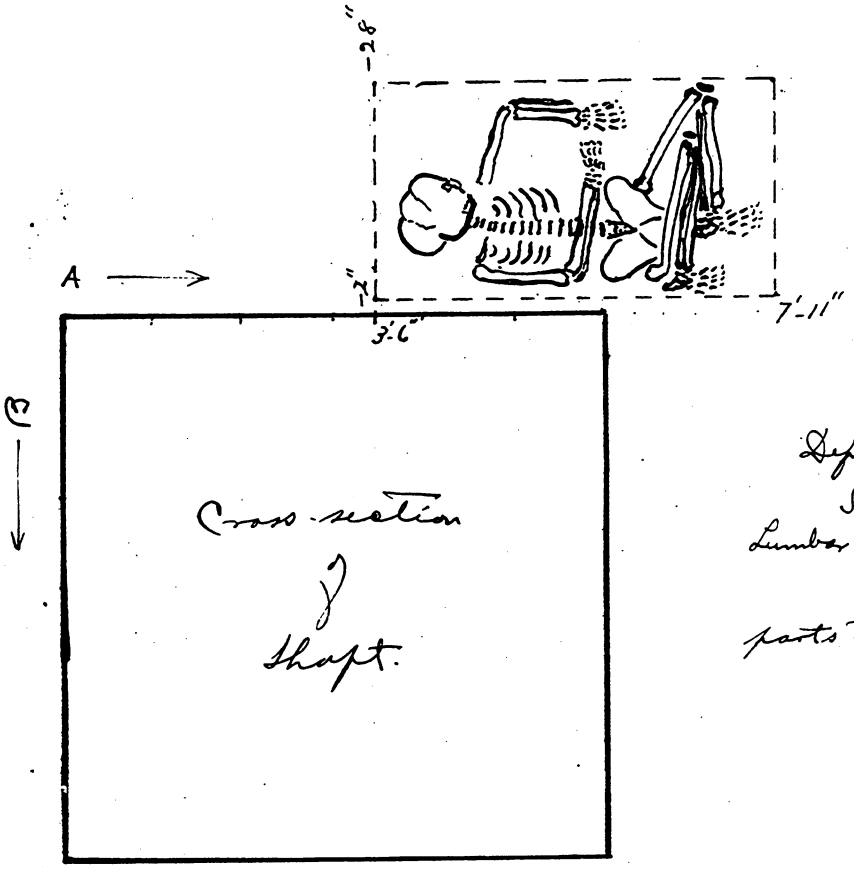
n.c.n. 6-25-'06

Shellmound Park

Human Remains

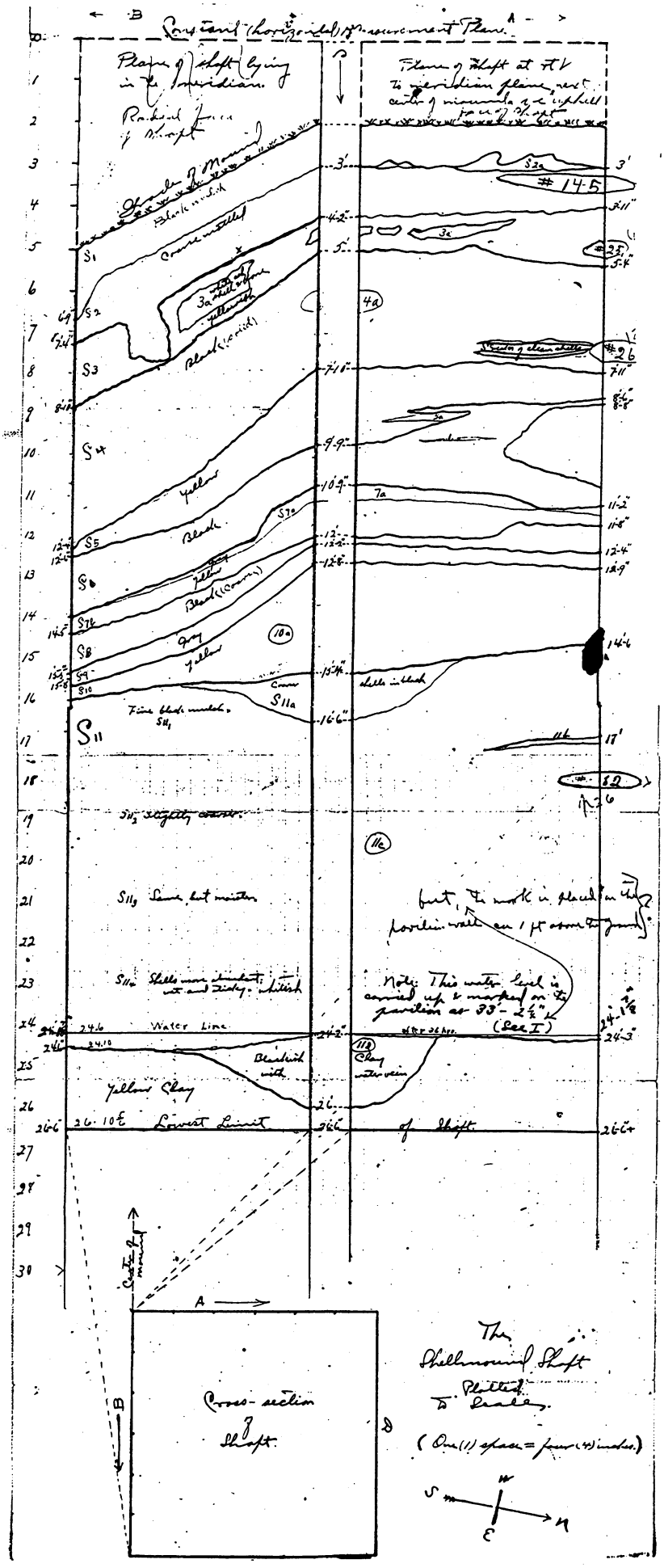
VI.

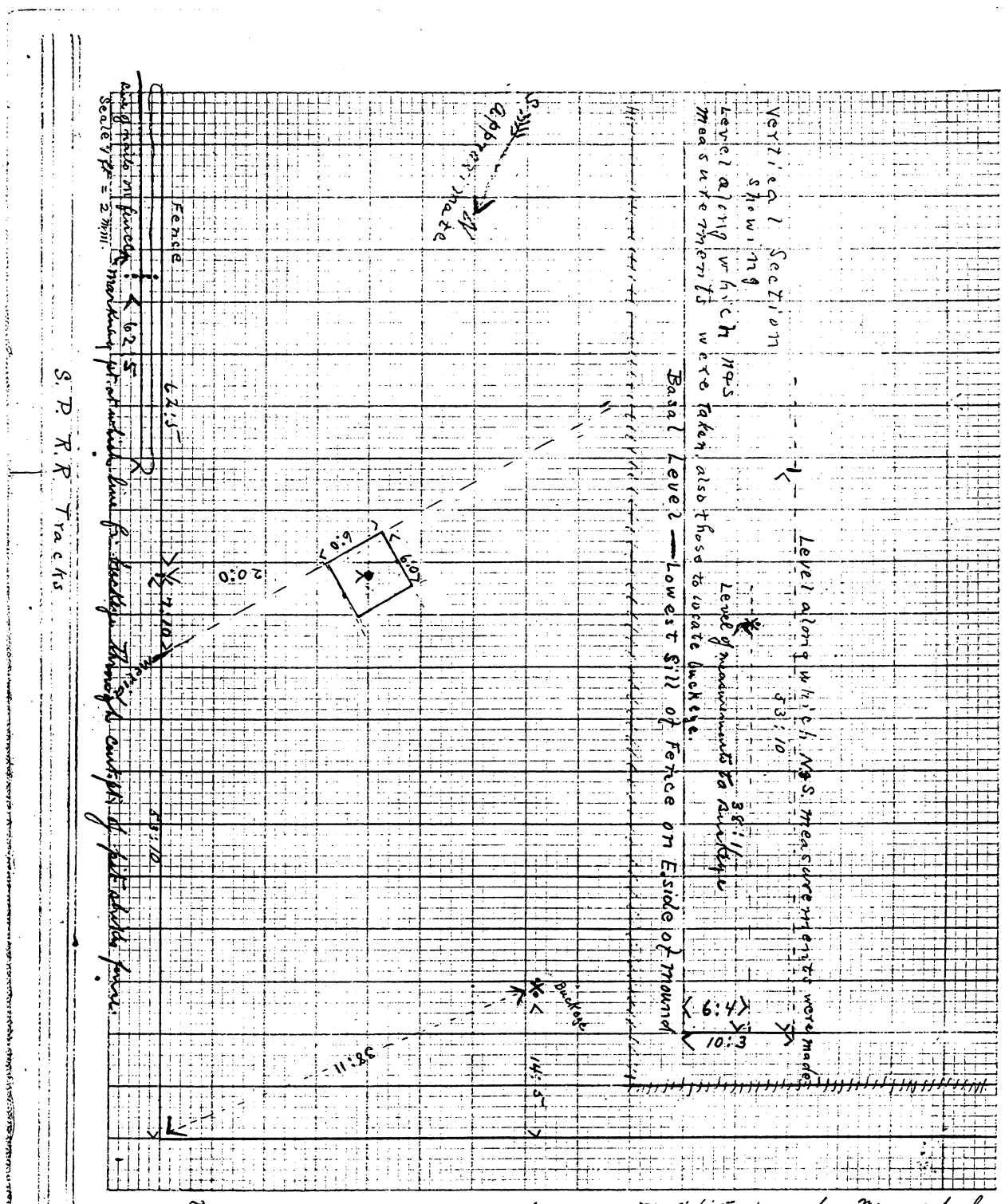
(Pasted as no. 145)



Depth:
Skull 3'-3"
Lumbar Vert. 3'-9" i.e. in the second stratum, parts touching the top of S3.

N.S.N. 6-27-06.


Plane of shaft lying in the meridian.
Plane of shaft at right angles to meridian plane, next outer of mounds on shell heap.
Shell mound
Black mould
Coarse shell
Yellow
Blue
Gray
Water Line
Yellow Clay
Lowest Limit of Shaft
Note: This water level is carried up & marked on the pavilion as 23' - 2½" (See I)
Cross-section of shaft
The Shellmound Shaft
Plotted to Scale
(One (1) of these = four (4) inches)

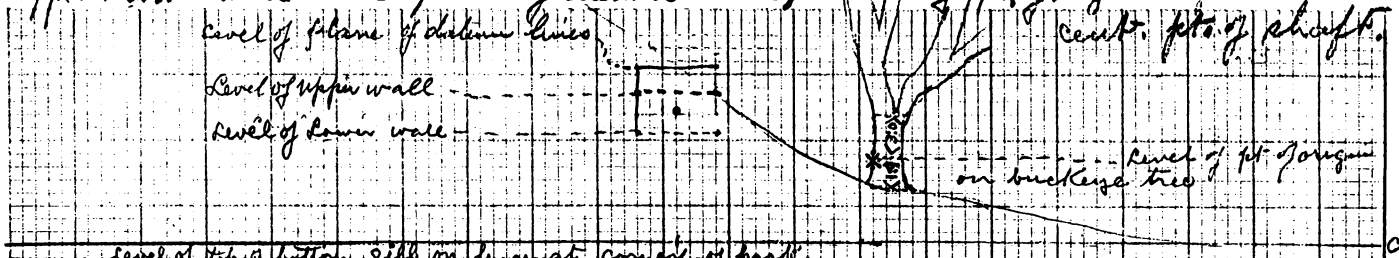


Note:- The long dist. (by plat) fr buckeye to center of pit is 42:6. Measured along the incline of side of mound it is 50:10

S. P. R. R. Tracks

Contour of Mound — not drawn to scale

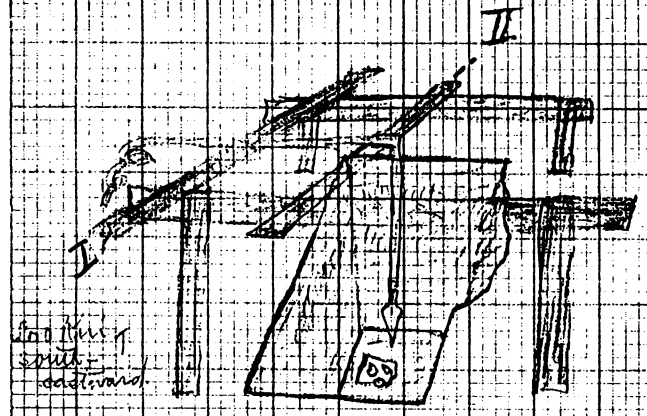
Showing Relative Levels of pts. of origin — corner of fence and Buckeye tree — and shaft & centre lines upper & lower wall and plane of datum lines). Level of pt. of origin on fence is same as level of



corner of fence on E side of shaft.

Centre pt. of shaft — 10.3 above level of lowest sill of fence at N.E. corner of park.
Upper edge of upper wall of shaft 1.6 above level of centre pt of shaft.
" " lower " " " 1.7 below " " " "
Elevation of plane of datum lines above the SW corner of shaft 1.9
" " " " " " Centr. pt. " " 3.8

All measured on the meridian of the mound. The remainder of the opening of the shaft is practically at the same level as the meridian. The N. wall is about 2 in. lower than the meridian



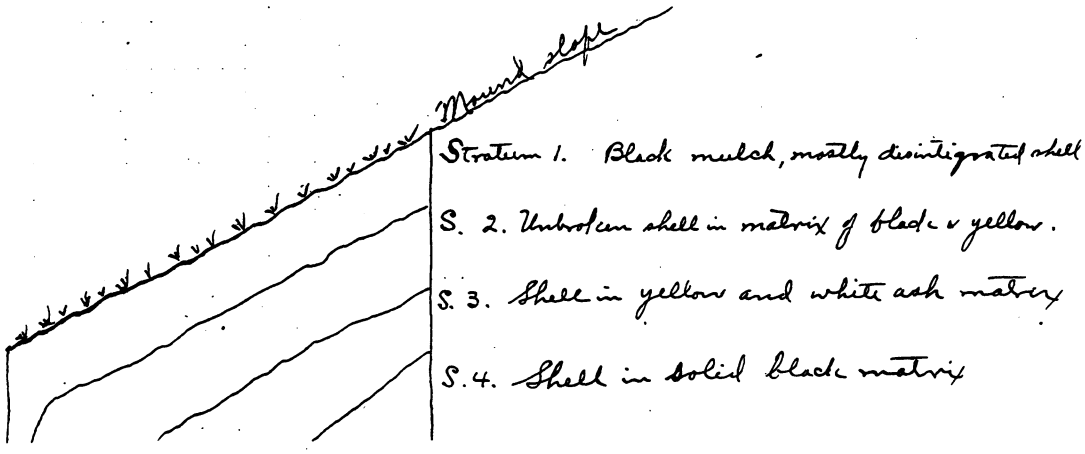
Sketch
Showing Superstructure used to establish the plane of the datum lines.
I = Fixed datum line along meridian of mound.
II Movable str. edge, to be moved parallel to I. A pt. Rectangularly measured by the distance A as noted in preceding note. By directing the plane line over II, the measurement B is obtained & by measuring the length of the line the measurement C is obtained.

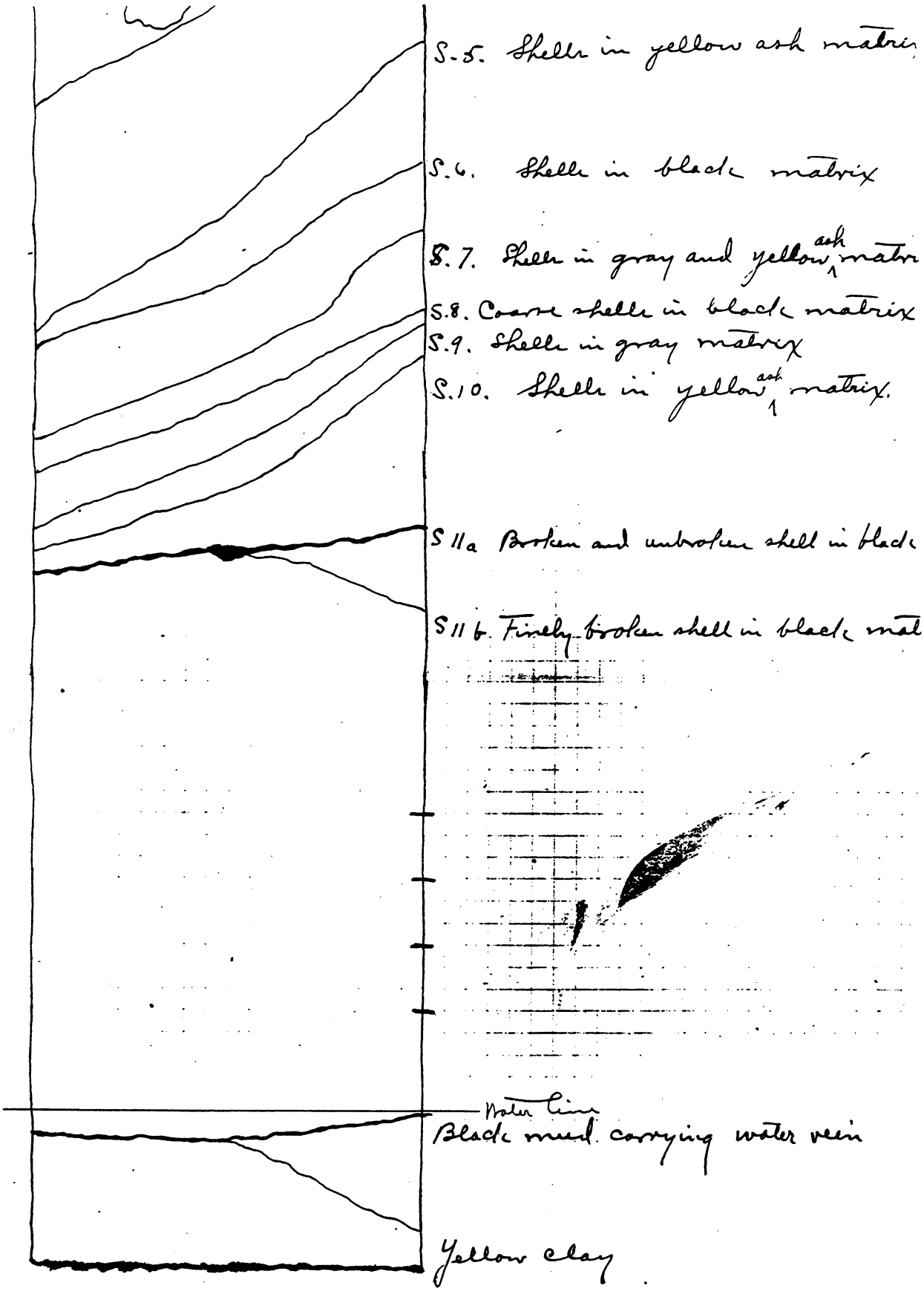
not drawn to scale.

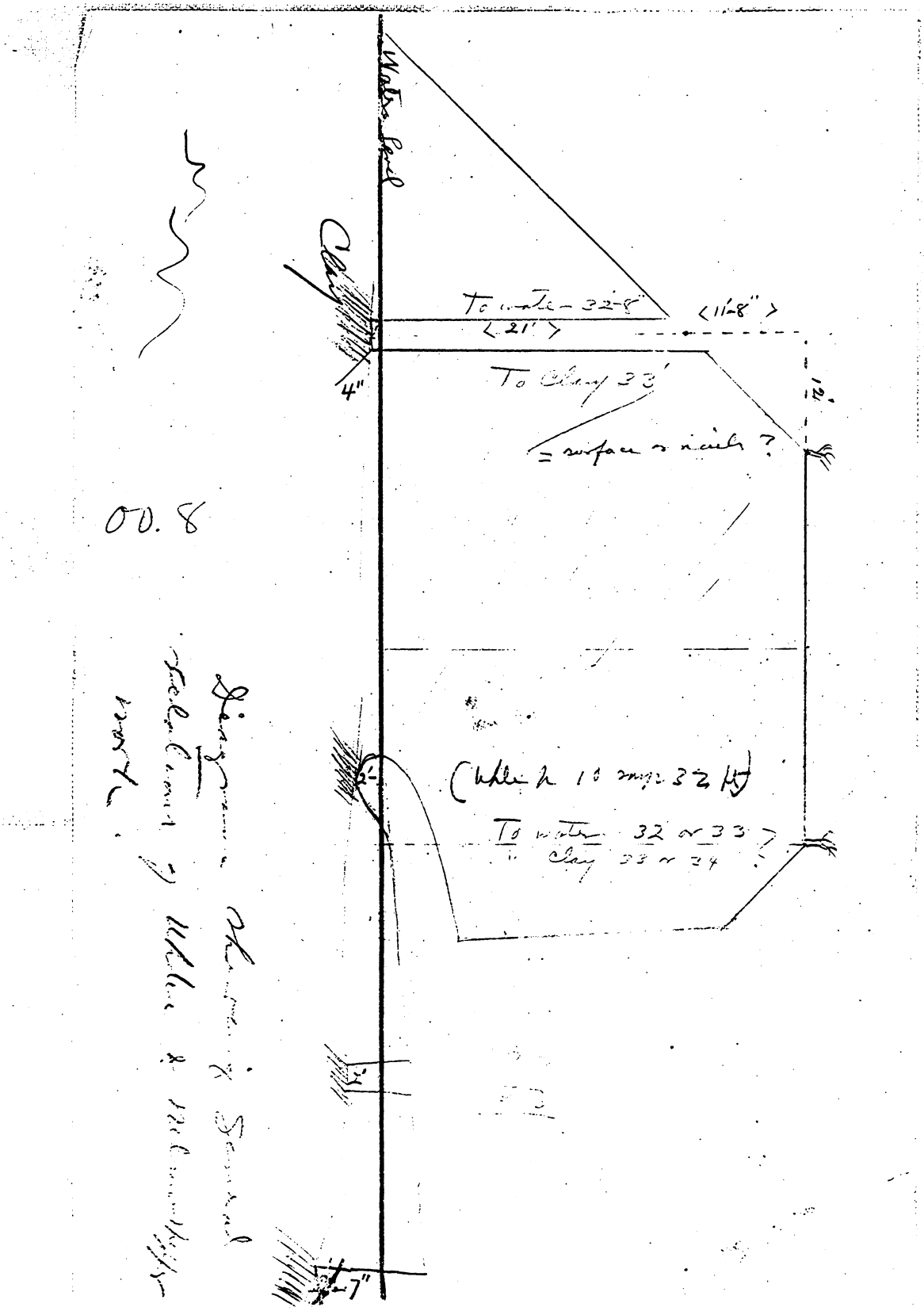
June 7 '06

Emeryville
Radial Section
(2 sheets)

June
1915




S-5. Shells in yellow ash matrix
S.6. Shells in black matrix
S.7. Shells in gray and yellow ash matrix
S.8. Coarse shells in black matrix
S.9. Shells in gray matrix
S.10. Shells in yellow ash matrix.
S 11a Broken and unbroken shell in black
S 11 b. Finely broken shell in black mat
Water line
Black mud carrying water vein
Yellow clay


Water level
Clay
To water - 32-8"
<21'>
<11-8">
4"
To Clay 33'
= surface ninth ?
00.8
(Water at 10 min. 32 ft)
To water 32 or 33 ?
Clay 33 or 34 ?
7"

Excavations on the
Northeastern slope of
the Mound at
Shell Mound
Park
, Emeryville,
June 1 to

S.A. Barrett.

UNIVERSITY OF CALIFORNIA
DEPARTMENT OF ANTHROPOLOGY
BERKELEY, CALIFORNIA

19
June ~~20~~, 1906.

Prof. J.C.Merriam,
University of California,
Berkeley, California.

My dear Dr. Merriam:-

According to plan I am leaving for the north day after tomorrow. The excavations at Shell Mound seem to be progressing very nicely. I visited the mound about noon today and at time the depth was about 20 feet. The character of the bone objects found in the last four feet or thereabouts is very different from the character of the bone found in the higher strata. At the present time they are working in an almost level stratum of heavy black fairly compact earth containing much broken shell, many bones and many stones. Nelson tells me that near evening today he sunk a small pit in one corner of the shaft to a depth of about three feet beyond the floor of the present level and found that at two feet or so the evidence is quite strong that the bone, stone and other signs of human agency are about at an end; but the black earth still continues. In all probability the bottom of the mound will be reached within a short time, but there is a sufficient amount of the appropriation left to carry the two men about ten days, which will, I think, easily insure their reaching the bottom of the mound.

I have left the management of affairs until your return in the hands of the two, Nelson being responsible as before for the shaft and Goddard for the labeling, note

keeping, packing and shipping. I have asked them, when they have reached the bottom of the mound so that they have a complete radial section, to plot to scale in detail the radial wall and the uphill wall, which is at right angles to the radial. Having done this I have asked them to write up in full the notes upon their particular parts of the work, each one referring as needed to the work and notes of the other, that is to say, Nelson's report will be a complete and detailed report of the shaft with special reference to the stratification, pockets of peculiar earth and ash, and the general character of the remains found in each layer. Wepfer's report will deal particularly with the specimens themselves, noting all striking points about each, as also the general character of the strata in which they were found and the general surrounding conditions. These reports I have asked them to leave with Miss Jones for you in case you have not returned when they are finished.

I saw the younger Mr. Siebe today concerning our leaving the shaft open until your return and he assured me that it would be entirely agreeable to them to have it left open provided, of course, the time was not too long. Mr. Nelson will attend to the covering of the mouth of the shaft when it is ready to be closed and will nail the cover very securely upon the standards in such a manner that there is very little doubt that any one will disturb it. I told Mr. Siebe that you had written that you expected to return to Berkeley at the end of the month, but that it might be possible that you would be detained and would not arrive until the first week of July, thus making provision for an emergency. Of course Mr. Siebe would like to have the shaft closed up as soon as possible after

you have finished with your inspection. Mr. Siebe thinks it advisable that a watchman be left with the shaft on the few picnic days which may occur between the time of the final closing of the shaft and the time of your arrival, and I have asked Mr. Nelson and Mr. Wempfer to arrange the matter of watching between themselves, and they say they will be entirely responsible for the shaft until after your arrival and will arrange it so that either one or the other will be there on picnic days, or in case they are unable to come themselves will see that some one is on hand.

Mr. Siebe also gives us permission to do some drifting, if desired. This privilege I asked of him some days ago as I thought that if I heard nothing from you and there was a sufficient amount of appropriation left at the end of the work to warrant such excavating, it might be advisable to do a little lateral work along on the level in which the complete skeleton was found. From the circumstances surrounding this burial it seems possible that there may be others along this same level and that a little lateral work, to prospect for them, might be profitable if the money was available for it.

It is probable that both Mr. Nelson and Mr. Wepfer will be in town when you return, and certainly one of them will be so that you will be able to connect with one or the other or both, and have them to explain to you the condition of the various strata, if you so desire. Mr. Nelson would be especially qualified to do this as he has done almost all of the work of the shaft itself and practically all of the uncovering of specimens has been done by him, so that he knows the general character

of the specimens found in each layer. However, in case you are unable to find either one of the men, their reports will probably be available by the time you return and will, I think, be such that you will be able to determine pretty clearly the details of the conditions in the various strata.

Upon my visit to the mound today I settled in full with Mr. Nelson and Mr. Wepfer for their work up to and including tomorrow, the 20th, as also for all incidental expenses which they had incurred and I am enclosing herewith a full expense account with vouchers for the period from May 28th to June 20th, inclusive. As you will see, this account is somewhat in excess of the check which you gave me before leaving, but this we can settle at your convenience. I told Mr. Wepfer and Mr. Nelson that after the present time I should not be where they could communicate with me and that everything concerning the mound and their wages for work from the 21st on would be left with you.

In buying lumber at the outset of the work we made provision for lumber for casing, 15 feet, as also for lumber for the bulkhead, and so on. The excavations have gone to a greater depth than we have anticipated and some of the lumber has been needed for bulkhead and fencing, but so far no casing has been needed, thus there is left some lumber which has not been used at all, in addition to that which has been used about the bulkhead, and so on. Of the former there is probably not enough to make it worth while to return it to the yard and pay the hauling charges, etc. and I had thought to suggest that if Capt. Siebe is to receive no compensation for the privileges which we have enjoyed, it might be advisable to

leave this lumber for him. I have, of course, said nothing to him or to any one else about the matter and what I have said here is merely a suggestion, and I hope you will consider it only as such.

You will notice that one of the items on the accompanying expense bill ~~has~~ is a bill running to myself for time put in on the work at the mound. Since you left Berkeley my position has been somewhat altered by my resignation of the Le Conte fellowship and the acceptance of an assistantship in the department, thus removing the objection which I made at the time you mentioned it of taking anything in the way of remuneration for the time which I was to spend on the work of the mound, and I have therefore included in the accompanying statement a bill for the actual time which it took, figured at the rate which you mentioned to me. Had I remained Le Conte fellow I should not have considered it proper to put in such a bill or accept any remuneration for the time spent, or, on the other hand, if my position of Museum Assistant had yet begun I should not consider it proper. However, inasmuch as I at present hold neither of these positions, having resigned the fellowship and the assistantship not beginning until July 1st, and inasmuch as I have spent a considerable of the time which I should otherwise have put in at my own research work I do not see that there can be any technical objection to my accepting the remuneration of which you spoke.

I am also enclosing herewith my report upon the location of the mound. I think that the report with the accompanying rough diagrams will, in all probability, be sufficient to

establish the point at which the shaft was sunk, but if upon your arrival you find that there is anything lacking, as for instance, a measurement to some point toward the center of the mound as well as toward the perimeter, you can have such measurements made without a great deal of trouble, for both Wepfer and Nelson were with me at the time these measurements were taken and they know the points of origin and the lines along which measurements were taken.

Hoping that you will be able to obtain the desired information concerning the level of the floor of the mound from the notes and the inspection of the radial section, I remain

Very sincerely yours

S. A. Barrett

EXPENSE ACCOUNT
of
S.A.BARRETT.

FOR ARCHAEOLOGICAL EXCAVATIONS AT SHELL MOUND, EMERYVILLE, Cal.
FROM MAY 28, to JUNE 20,1906.

Item.	Quantity	Voucher	Amount.
Lumber		1	14.80
Tape line			.25
Stamps			.10
Coordinate paper			.15
Twine			.10
Note book			.10
Whisk broom			.15
Films		2	.70
Padlock		2	.90
Screw eyes		2	.05
Plumb bob		2	.20
Line		2	.05
Memo books			.25
Nail bags		3	.65
Nail bags		4	.35
Tacks		4	.05
Tags		4	.05
Trowel		4	.05
Film pack adapter		5	1.50
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Nelson's Expense bill for incidentals		11	5.15
Typewriting		12	2.50
S.A.Barrett, supervision of excavations, May 28 to June 20			26.25
			142.75

Deduct, 1 R. film (returned) .35

142.40

Received from Dr. J.C. Merriam June 26"06 100.00

Balance 42.40

Whites bills for developing and printing are yet to be added, when he sends them in.

E. A. Barrett N.C.N.

1

Excavations on the Northeast Slope of the Mound at

Shell Mound Park, Emeryville

June 1, to 1906.

In locating the point at which to sink a shaft on the northeastern slope of this mound an offset of 20 feet was taken from the fence which runs along the eastern side of Shell Mound park. The point from which this offset was taken is ~~xxxxxx~~ 53:10 feet in a horizontal line from the northeast corner of this fence. At a distance of 14:5 feet from the fence which runs along the north side of Shell Mound park there is a very large Buckeye tree on the southern side of which there is a small approximately circular scar about the size of a half dollar, which will, in the course of two or three years, be over grown by the bark. A cross was cut into the wood in this scar and two large nails driven in the upper and lower angles of this cross. This arbitrary point of origin is 1:9 feet from the base of the tree and 3 feet from the first crotch where the trunk branches.

With this as a point of origin a second measurement was made along the slope of the mound to the point above mentioned as being 20 feet from the eastern fence. This distance according the measurement up the slope is 55:10 feet, which does not exactly agree with the plot as here given owing to the fact that the plot is, of course, on a horizontal plane and also to the fact that the fence xxxx makes an angle slightly greater than a right angle at its northeastern corner. Measuring on from the point taken as the center of the shaft in a direct line from the Buckeye tree to the eastern fence the distance is 64:5 feet. At this point a line of nails was driven into the top stringer of the fence in order to give a permanent mark as a third point of origin. The distance from this point to the point from which the 20 foot offset above mentioned was taken is 62:5 feet. In measuring this 20 foot offset a horizontal line as nearly as possible was maintained from the mound to the point of origin on the eastern fence,

also in measuring the distance from this point of origin to the northeastern corner of the fence a horizontal line was maintained and the point on the northeastern corner of the fence which is on a level with this point of origin is 10:3 feet ~~from~~ above the top of the bottom stringer of the fence. The point of origin ~~xxxxxxxxxxxx~~ on the Buckeye tree is 6:4 feet above the top of the bottom stringer of the fence at this same corner.

In order to have a true section through the mound a radius was, as nearly as possible, determined. This was done by assuming the flagpole which is on top of the pavilion at the top of the mound to be approximately over the center of the mound. With this as a center ~~xx~~ an allignment was made so that the radius should pass at a distance of 3 feet from the center of the proposed shaft, this distance, of course, being measured at right angles to the radius. This radius or meridian was found to cross the fence on the east side of the park at a point 7:10 feet toward the corner of the fence from the point from which the 20 foot

offset was measured.

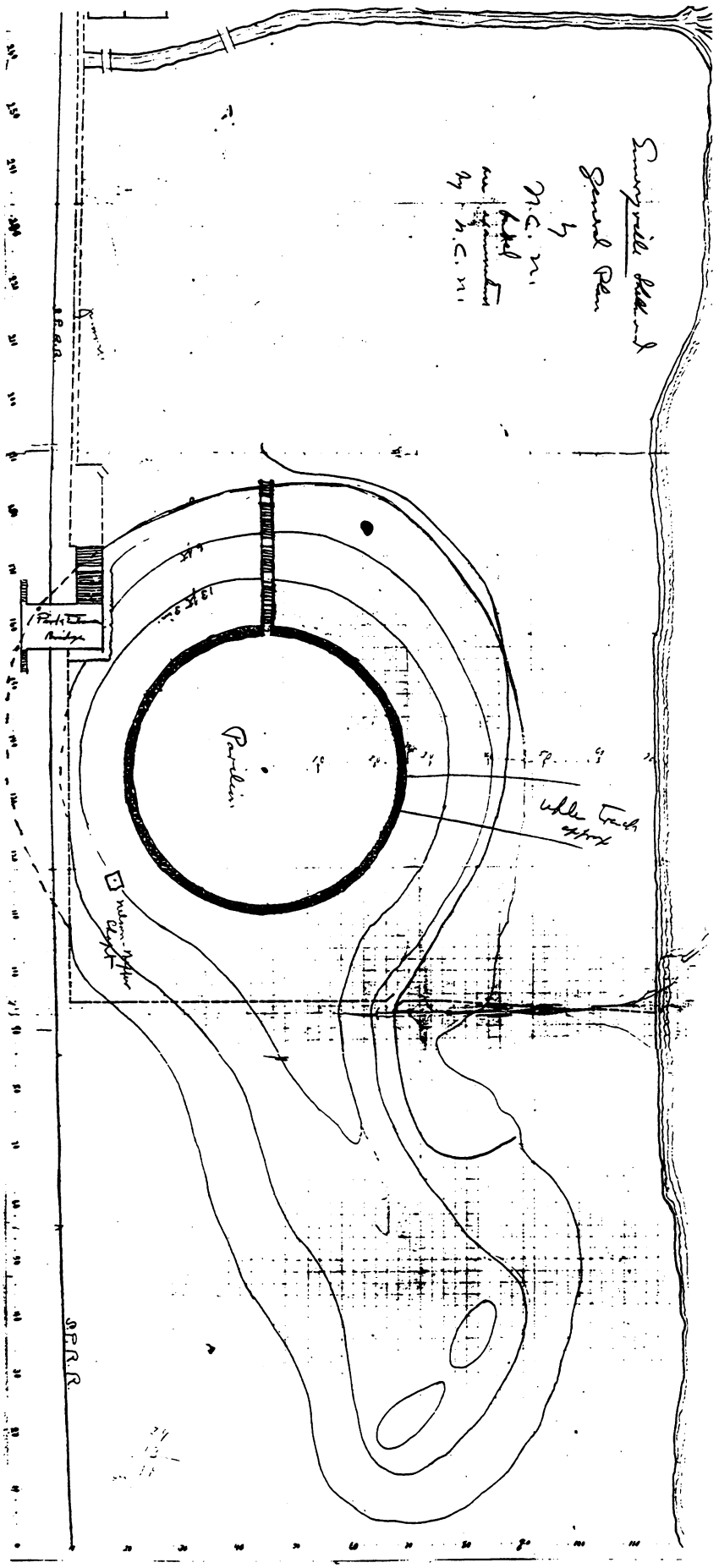
With this radius as one side of a square a 6 by 6 foot shaft was sunk.

Datum Lines.

For the purpose of accurately measuring the depth to which the shaft was sunk and the depths at which the various objects are found posts were set and a superstructure constructed above the shaft such that one side of the superstructure lay directly along the meridian, an other side being directly above the up hill wall of the shaft, and the whole superstructure being constructed so as to cut a horizontal plane over the mouth of the shaft. On the first side mentioned yard sticks were nailed in such a manner as to automatically give the horizontal distances of any point in the floor of the shaft from the meridian. As is shown in the rough drawing there was a third side to this superstructure, placed directly above the down hill wall of the shaft and of course on the same horizontal plane with the other

two sides mentioned. Thus by running a straight edge, ~~from~~ which were nailed ~~xxxxxxxxxx~~ parallel to the board which marked the meridian, and from one to the other of the two lines which were directly over the up hill and down hill walls of the shaft and dropping a plumb bob attached to a tape line to the point ~~xxxxxxxxxxxxx~~ on the floor of the shaft where any object was found, an automatic and accurate measurement in three dimensions ~~would be~~ was obtained: A, the distance from the meridian northward along the line directly over the up hill wall of the shaft, B, the ~~xxxx~~ distance along the straight edge which is parallel to the meridian, and C, the vertical distance from the straight edge to the position of the object. This superstructure rested upon four posts, the upper pair of which differed from each other in length about an inch and a half, the northern post being the longer, ~~and~~ the lower pair ~~xxxxxxxxx~~ standing in about the same relation to each other. The post ~~xxxx~~ at the up hill ~~side~~ wall and on the line of the meridian of the mound was /!// feet above the

mound, while the post at the down hill side and on a line with the meridian of the mound was 4 ; 5½ feet above the level of the mound at this point. The difference in level between the up hill wall and the down hill wall of the mound was 3 feet and 1 inch.


Sunnyside Mound
General Plan
by
N.C. Nelson
Pavilion
S.P.R.R.

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UNIVERSITY OF CALIFORNIA PUBLICATIONS
IN
AMERICAN ARCHAEOLOGY AND ETHNOLOGY
Vol. 7 No. 4

SHELLMOUNDS OF THE SAN FRANCISCO BAY REGION.

BY
N. C. NELSON

BERKELEY
THE UNIVERSITY PRESS
DECEMBER, 1909

UNIVERSITY OF CALIFORNIA PUBLICATIONS

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AMERICAN ARCHAEOLOGY AND ETHNOLOGY
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SHELLMOUNDS OF THE SAN FRANCISCO BAY REGION.

BY
N. C. NELSON.

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INTRODUCTION.

During the season of 1908 the writer completed a somewhat detailed survey of the evidences of prehistoric man in the San Francisco Bay region. The work, which had been under way for some time, was finished probably none too soon, because the obliterating agencies of nature have been strongly reinforced in the last four or five decades by the hands of modern man, and the ultimate destruction of every suggestion of former savage life seems not far off. Professor John C. Merriam, who directed the investigation, had himself for some years been collecting data on the subject, and a comparison of his results with our present knowledge shows only too plainly how rapidly the monuments and relics of primitive times are disappearing from the bay shores.

The field work connected with the present study represents a review of Professor Merriam's data, with the addition of much information that is new. In the course of three months, the writer traversed the entire country bordering San Francisco, San Pablo, and Suisun bays; including the tide-water districts of the entering streams and also a short strip of the Pacific Coast adjacent to the Golden Gate. The ancient remains discovered or re-examined include shell heaps, earth mounds, and a few minor localities that cannot perhaps be termed anything but temporary camp sites. Of the two most numerous forms, the earth mounds are nearly all located by the entering streams, close to the upper reaches of the tide-waters; and their number could be increased indefinitely by searching these stream valleys toward their sources. But as those rather common and widely spread accumulations appear, in many cases, to be of relatively recent origin and possibly representative of distinct cultures, the present paper is restricted to a consideration of the shell heaps.[1] These fairly numerous deposits, with a few exceptions, are situated close to the open bay and may, geographically at least, be regarded as a distinct group.

[1] The earth mounds of Central California have been considered briefly by W. K. Moorehead in his Primitive Implements, p. 258; and by W. H. Holmes, *Smithsonian Report*, 1900, p. 176.

Thus far only three of the four hundred and twenty-five shell heaps composing the group have been carefully excavated, and those three were unfortunately on the same side of the bay and not very far apart.[2] Nevertheless, guided by this limited amount of intensive work, the rather more than superficial examination of all the remaining mounds, supplemented by such sifted information as could be obtained from owners and local residents, may allow some safe generalizations for the group. The purpose of this paper is, therefore, to show by a map the actual location of all the ancient middens known, to consider the broader facts apparent in the relation of the mound distribution to the local topography, and, finally, so far as is warranted by available knowledge, to make some comparisons of the mound group and its culture with that of similar occurrences in other parts of the world. The paper should be considered only a general or preliminary report which it is hoped may be expanded from time to time as further systematic investigation shall be made possible.

The support of the field work has been generously furnished by Mrs. Phoebe A. Hearst, through the Department of Anthropology. The study as a whole has been pursued as graduate work at the University of California, under the immediate direction of Professor Merriam, who has also kindly revised the manuscript and read the proofs.

THE SAN FRANCISCO BAY REGION, AS ADAPTED FOR PRIMITIVE HABITATION.

With the present tendency of historical research apology is scarcely required for devoting some attention to geography as in part the underlying basis of ethnic conditions. At the same time, science may doubtless easily overreach itself in the attempt to account all phases of human culture the product merely of external conditions, and the consideration of environment is not taken up here solely in order to explain archaeological facts, but is made necessary by the established relation between some of the shell heaps and certain events in the history of the local topography. That material conditions do play a fundamental

[2] See report on the Emeryville Shellmound by Dr. Max Uhle in Vol. 7 of the present series. Reports on the other mounds are awaiting publication.

part in human development is not to be questioned. Indeed it would seem as if environment had so particularly favored primitive human life in California that it must in the end be accepted as one of the chief factors in explaining the presence of the unusually numerous linguistic stocks, and the fact that they managed to exist within these narrow territorial limits without losing their identity.

GEOGRAPHICAL POSITION.

The relation of the region to be considered to the city of San Francisco makes its geographical situation a matter of common knowledge. Definitely fixed, the particular area concerning us is included between 121° 56′ and 122° 42′ west longitude and between 37° 23′ and 38° 18′ north latitude. In more general terms, the territory extends from the cities of Napa and Petaluma on the north to San Jose on the south and from the Pacific Coast eastward to the Great Valley, the respective distances being about sixty-five and forty-five miles. The bay itself, with its flood lands, covers approximately 120 square miles and is bounded by more than 300 miles of shore line.

PHYSIOGRAPHICAL AND GEOLOGICAL CONDITIONS.

The waters broadly designated by the term San Francisco Bay are confined to a series of connected depressions in the heart of the Coast Range. The mountain system referred to reaches its narrowest limits in this latitude, where its two or three main ranges have probably always been characterized by a general transverse sag, through which the interior basin of the state connected with the ocean. Since middle Tertiary times, the oscillating movements of the coast, amounting it seems to over 2,000 feet, have concentrated tidal and drainage currents on this pass until at the present time, when the land is relatively high, the enormous drainage of the interior basin reaches the ocean by way of an irregular line of deep gorges, cut through the three or four low barriers that still remain. Descending upon this transverse channel are some six or seven partly united and more or less directly opposable valleys, two from the south and the others

from the north; and it is these valleys which, after a partial re-submergence, have given rise to the present three divisions of San Francisco Bay.

The outermost and the largest of these divisions, that is San Francisco Bay proper, is an elliptical body of water about forty-five miles long and as much as twelve miles in width. It lies mostly south of the transverse channel and is flanked on the east by the Mt. Hamilton Range and on the west jointly by the Santa Cruz Range and the mountain block north of the inlet, of which Tamalpais is the culminating peak. At the present time its shores are generally low, marshy and unapproachable, except in certain places about the northern end. Here, especially on the west side, from San Bruno Point north, several secondary mountain features run out at an angle to the general trend of the shore line, producing an alternating series of inlets and headlands, the latter of which furnish easy approaches to the open bay. The resisting extremities of some of the most prominent of these headlands or peninsulas appear as islands in the bay; and one of these islands, the Potrero Hills, which was once a part of the western shore, has recently, by sedimentation, been linked to the opposite shore, while the originally insulating channel furnishes the only entrance to the second or central compartment of the estuary, namely San Pablo Bay.

San Pablo Bay is a roughly circular twelve-mile expanse, actually called Round Bay by the early Spanish explorers. It is walled in on the west by the same mountain block that separates the lower bay from the ocean but on the east by only a low and narrow strip of the Mt. Hamilton Range. On the north it sends three long tidal arms up the Napa, the Sonoma and the Petaluma valleys—now all choked with silt; while on the south it meets, somewhat abruptly, a broad section of the Mt. Hamilton Range. In other words, the basins of the two lower divisions of the estuary do not meet end to end but are roughly parallel and connect at present by a diagonal channel, the San Pablo Strait.

San Pablo Strait, like the Golden Gate below and Carquinez Strait above, appears to be the joint result of subsidence and wave erosion, completed perhaps within recent geological time, but still prior to the oldest records of the shellmound people in

the region. Probably the older channel, or at any rate the truly structural connection of the two basins, ran between the Potrero Hills and the Mt. Hamilton Range. This passage is now practically obstructed by the joint deltas of the San Pablo and Wildcat creeks, forming the plain on which the city of Richmond is building. The delta material, containing shell strata in places, is over 500 feet deep; and upon its surface are situated some of the largest and oldest of the shell heaps.

To the east of the remaining narrow portion of the Mt. Hamilton Range is the third and smallest of the estuary divisions, usually distinguished as Suisun Bay. The basin containing this body of water is now largely open to the Great Valley, subsidence and erosion having removed or obscured the dividing ridge. The result is that Suisun Bay, almost entirely silted up and reduced to tule marsh, appears to be topographically one with the adjacent floodlands of the Sacramento and San Joaquin rivers. These stretches of level floodlands, extending over a large area of the lower portion of the Great Valley, are marked by certain noteworthy features in the form of isolated sand dunes, rising like islands through the surrounding peat which often attains a depth of forty or fifty feet. We may leave the origin of these eminences for others to explain, but they are particularly interesting to the archaeologist by reason of the fact that they furnish evidence of having been more or less permanently occupied by the aborigines. (See pl. 35, fig. 2.)

Whether Suisun Bay has been large enough or deep enough to admit the sea since prehistoric times seems doubtful. There are, on the one hand, several old beach marks along its shores, and the lowest of these is not many feet above the present water level; but, on the other hand, the very largest and perhaps the oldest of the shell heaps in the Suisun Bay basin, no. 250, near Concord, lies approximately at sea level and may therefore have been begun at a time when the bay was even smaller than to-day. To be sure, there are other shell heaps in the vicinity of Martinez and above Cordelia that lie on higher ground, but these are insignificant, in fact almost obliterated, and do not furnish any reliable tests. In view of these facts it will seem natural enough, therefore, that the remainder of this study should be restricted

almost entirely to conditions as they exist on the two lower divisions of the estuary.

The basins of San Pablo and San Francisco bays may, for our purposes, be considered as a unit and as physiographically distinct from the Great Valley, although receiving and transmitting the immense drainage of the latter. Being quite limited in extent, the watershed belonging to the basin is unable to develop any large streams. There are some sixty named and recognized water-courses, besides many more wet-weather gullies that descend from the surrounding hills; but of those named only the Guadalupe and the Coyote at the southern extremity and the Napa at the northern, are dignified by the doubtful term "river." Those three, together with the Sonoma and the Petaluma creeks, also on the north, are the only permanently flowing streams native to the basin. Of the remaining creeks, however, many, such as the Rodeo, the San Pablo, the San Leandro, the San Lorenzo, and the Alameda on the east side, and at least the San Francisquito and the San Mateo on the west, would under normal conditions, flow at all seasons of the year; and would, consequently, be lines of attraction for primitive populations. As it is, the water of nearly all the streams has been diverted in the foothills to satisfy the requirements of modern civilized life.

In connection with this preliminary statement of the physical features of the bay region it seems desirable also to call attention to the influence of the drainage entering or passing through the bay. The processes of erosion and of deposition are both in action at the same time and often in close proximity; but the wearing-down work is generally confined to the central section of the bay and the building-up process to the extremities. It is along the line of the great current from Carquinez Strait to the Golden Gate, and at a few other points on the lower bay, as far south as the latitude of San Mateo, that wave erosion is apparent. Wherever the projecting headlands reach the open waters high and steep cliffs are usually present. These cliffs have either been worked out since the last subsidence or are holding their own concomitantly with a slow sinking movement, of which it appears that at least the last eighteen or twenty feet have taken place since man's

occupation of the region. Either supposition indicates a considerable age for some of the shellmounds.

The most readily observable progress of erosion is of course confined to the recent formations, such as the soft conglomerates about Point Pinole and the gravels and clays of the alluvial slope bordering most of the lower bay. Perhaps the most notable wave work within historic times is that on the east shore, between Oakland and Richmond, where the marsh belt and the detrital slope have been eaten back for a considerable distance. The waves have here in all probability also cut away a number of the ancient shell heaps.

But the tearing down processes about the bay are more than counterbalanced by those that build up. In the first place, subaerial erosion in the flanking mountains has produced an alluvial slope extending from San Bruno Point around the south end of the bay and along the east side almost to Point Pinole. This slope, upon which are built some of the principal bay cities, varies from one-half mile to five or six miles in width, being most prominent off the points where the larger streams issue from the foothills. The deltas of the San Pablo, the San Francisquito and the Alameda creeks show even a fan-like contour; and the last named fan has thrown a dam across the mouth of a small lateral valley giving rise to several minor lagoons near the foothills, between the towns of Irvington and Niles. The shores of these fresh-water lagoons furnish distinct evidence of permanent settlements in former times, and the fact that the old San Jose Mission is located very near seems in a measure to warrant the opinion that the Spaniards found Indians living in that locality.

In the second place, there are the notable results of the deposition of the suspensible matter brought into the quiet waters of the bay by the streams. Almost the entire bay is fringed with a belt of tide-land, salicornia marsh, which attains a width of from three to five miles at the extremities and is absent only in the constricted central portion, chiefly about the heads of the more prominent peninsulas. Some vegetable matter enters into this marsh composition but it is made up chiefly of a very fine bluish silt. The sources of this silt and the rate of its deposition have probably been much altered in the last fifty years. There

can be no doubt, for example, that the supply has been at once appreciably reduced for the smaller streams and increased for the Sacramento and San Joaquin rivers, whose carrying powers have been much increased by the confinement of their channels. Whether or not this change has worked any rapid transformation in the upper bay is not known; but it is a fact that at the present time the open waters of the entire San Pablo Bay, excepting a broad channel across the southeastern half, average less than ten feet in depth at mean low tide.[3] A similar condition is true also for San Francisco Bay below the latitude of San Bruno Point, save for a narrow, central channel which still maintains a depth of about forty feet. These facts regarding the deposition of silt are more or less relevant to the archaeological problem, because the continually widening marsh belt has left many of the shell heaps quite far from the open waters, suggesting that a large part of the depositional work was done since the middens were abandoned. Furthermore, several of the shell heaps situated on the tide lands are deeply imbedded in the silt itself.

This partial submergence of mounds in the tide-lands furnishes occasion for a final word with reference to the recent subsidence of the bay region. There is of course no question about the origin of San Francisco Bay. Its very setting is suggestive, and examination of the details of the shore line could not leave even the untrained observer in doubt. Nor should it have been necessary to investigate the shell heaps for evidence of recent subsidence. The manner in which the foothills descend directly to the marsh level, without any intervening alluvial slope, would seem sufficient proof. Similar suggestions are also furnished by the small islands scattered in the marsh along the western shore from Petaluma to San Mateo. And on the east side, well towards the southern extremity of the bay, the Coyote Hills, a narrow range several miles long, rise about three hundred feet out of the

[3] In 1775, when José de Cañizares, pilot to Commander Ayala of the San Carlos, made the first reconnaissance of the bay region with copious soundings of the estuary, he found, at low tide, about five feet of water in San Pablo Bay outside the main channels. He also mentions two large harbors (now silted up) on the west shore and a large body of open water in what is now Petaluma Slough. See translation of Ayala's report by E. J. Molera, with photographic reproduction of the original map of San Francisco Bay, in *The March of Portolá,* published by the California Promotion Committee, San Francisco, 1909.

marsh,—a particularly striking example of the many outcropping remnants of the older drowned topography.

CLIMATE.

California is distinguished as perhaps the most unique of the world's thirty-four climatic provinces. No other territory covering an equal extent of latitude shows the same uniformly mild temperature. Certain sections of the west coasts of South America and of British India offer the nearest approach to California conditions, but in those places the mean annual temperature is 10° Fahr. higher than in California. This does not mean that extremes are wanting in specific localities in California. Far from it: the state not only reaches over a great extent of latitude but its altitude ranges from 400 to 500 feet below sea level, in Death Valley, to the horizons of continual snow in the mountain ranges. It is owing chiefly to the fortuitous combination of the warm ocean currents and the general arrangement of the broad features of relief that the really habitable portion of the state possesses an equable temperature which is highly favorable to vegetable and animal life. Broadly speaking, the climate is sub-tropical; and that of the San Francisco Bay region, tempered as it is by the prevailing ocean winds, may be characterized as insular.

Two seasons, a wet and a dry, are to be sharply distinguished. The rainy period may be said to last from October to April and is on the whole the pleasantest part of the year. The precipitation, which increases rapidly with the latitude, for San Francisco ranges from 23 to 28 inches. Snow is a rare sight and frost seldom touches the low country about the bay. The prevailing winds are from the southwest during the dry season and it is these that bring the fogs. Winds blowing from the opposite direction sometimes bring the heated air from the interior valleys and produce the only hot spells that may be experienced in the bay region. The mean summer temperature for San Francisco is about 60° and the mean winter temperature about 51° Fahr. The mean annual average for thirty-one years is 56° Fahr., while the extreme annual range is only about 60° Fahr.

FLORA AND FAUNA.

The particular configuration of the state, which in a large measure causes the remarkable uniformity of temperature in certain regions, introduces also the important element of variety. This whole phenomenon is perhaps best expressed in terms of the flora and fauna. The life zones range from arctic down to subtropical; and this fact, combined with the general geographic position of the region, has resulted in a remarkable diversification of the plant and animal life.

The San Francisco Bay region itself, while appearing to contain all of the more valuable economic plants of the state, could probably never have furnished the variety found in some other parts of this large political division. This specific section of the Coast Range is quite limited in extent as well as relatively low, and the general northwest-southeasterly trend of the relief gives only a small amount of favorable exposure. The hills on the east and north sides of the bay are therefore almost barren, except in the minor side canyons; but on the west, where the ranges are more thoroughly broken up, the vegetation is fairly luxuriant.

In the valleys, and on the lower foothills bordering the bay, grow several species of oak, especially the Valley Oak, *Quercus lobata,* and two Live Oaks, *Quercus agrifolia* and *Quercus Wislizenii.* The willow, *Salix,* is also common along some of the streams crossing the border plain. Farther back, in the canyons and on the hillsides, flourish the Mountain Laurel or Bay tree, *Umbellularia californica,* and the Buckeye or Horse Chestnut, *Aesculus californica;* and close to these may be found two or three species of the manzanita, *Arctostaphylos,* and the hazel, *Corylus californica.* Finally, in the higher hills appear several conifers among which are the Douglas Spruce, *Pseudotsuga taxifolia;* the Hemlock, *Tsuga heterophylla;* the Yellow Pine, *Pinus ponderosa;* and the Digger Pine, *Pinus Sabiniana.* The Redwood, *Sequoia sempervirens,* is also quite abundant, especially on the sea side of the western range. Besides these larger trees, the products of most of which have been used in some way by the Indians of late times, there are two or three species of the wild cherry, *Cerasus;* a plum, *Prunus subcordata;* and a huckleberry,

Vaccinium ovatum. The Elderberry, *Sambuscus racemosa,* and Wild Grape, *Vitis californica,* are also common. Finally, there are several of the common berries such as the Thimbleberry, *Rubus parviflorus;* the Blackberry, *Rubus vitifolius;* and several species of gooseberry and currant, *Ribes;* in fact the saxifrage family is well represented, though it is perhaps not as valuable here as elsewhere.

Of the smaller flora in the region many families are unusually well represented. Among the most common of these are the sunflower family, *Compositae;* the mustard family, *Cruciferae;* the crowfoot family, *Rununculaceae;* the poppy family, *Papavraceae;* the pea family, *Leguminosae;* and the lily family, *Liliaceae.* There are about thirty different species of lily bulbs and of these the famous Indian soaproot, *Chlorogalum pomeridianum,* is very abundant. Many other useful plants such as the Milkweed, *Asclepias mexicana,* and various grasses and sedges are also found.

No detailed study of the local flora has been attempted or deemed necessary in connection with this shellmound investigation inasmuch as it is not possible to determine to what extent the prehistoric inhabitants utilized vegetable products.[4] It may be worth while, however, to cite the results of Mr. Chesnut's recent studies among the Indians of Mendocino County, which adjoins the bay country on the northwest.[5] Mr. Chesnut lists and describes the various uses of no less than 212 plants in that region and shows how thoroughly versed primitive peoples may be in the botany of their respective habitats. It is not known just what the difference in geographical distribution may be, but certainly the majority of the economic plants of Mendocino County are to be found also in the vicinity of San Francisco Bay.

The indigenous fauna of California is now much depleted, but there can be no doubt that it once corresponded to the flora in richness. There are some three hundred and fifty species of birds in the state; and of these many of the game birds were until late years very plentiful in the bay region. Of the mammals the state contains fifty-three out of the sixty-six genera in North America,

[4]For a full account of the flora of the region consult Jepson, W. L., Flora of Middle Western California, 1901.

[5] Chesnut, V. K., Plants used by the Indians of Mendocino County, California. *The U. S. National Herbarium,* Vol. III, No. 3.

and the species number about two hundred and seventy-five.[6] But several of these have been much thinned out, and some, like the antelope, *Antilocapra americana,* have disappeared entirely. All the more useful mammalian orders such as the cetaceans, the ungulates, and the rodents were once well represented in the bay region. The particular species hunted in prehistoric times will be enumerated later in the paper and need not be given here.

Fishes also, especially the salmon, were supposedly always plentiful; but it is difficult to determine whether or not the primitive inhabitants were able to fish successfully in so large a body of open water.[7] The minor streams entering the bay afforded far more favorable opportunities; but these water-courses probably never contained more than a limited number of small species. It appears, however, that at the present time these streams are continually being restocked from the Sacramento and San Joaquin rivers, probably during the excessive spring floods.[8] Finally, the shoaling bay was well stocked with molluscs, particularly the mussel, *Mytilus edulis,* and the clam, *Macoma nasuta,*—a fact which may have drawn the first settlement to its shores.

We have then, to sum up the environmental conditions, a large body of water, favorably isolated and sheltered by encompassing mountains. The bay itself is extensive and broad enough to constitute a natural barrier for people without well developed means of navigation; and the border country, which is either partitioned by low mountain ranges or is suitable for habitation only along the widely separated streams, also tends to develop a certain degree of isolation and thus favors segregated community life. Under former normal conditions the hill slopes and the valleys of the region were tolerably well supplied with fresh water; while food products of all kinds were plentiful and near at hand. When we add to these characteristics a climate as

[6] Stephens, F., The Mammals of California, 1906.

[7] The pilot Cañizares, already referred to, found in 1775 an Indian rancheria near the west end of Carquinez Strait, where various kinds of fishes (among them salmon) were offered the explorers as presents. See *The March of Portolá,* p. 66.

[8] J. O. Snyder, Notes on the Fishes of the Streams Flowing into San Francisco Bay. *Report of Bureau of Fisheries,* 1905; p. 329.

favorable as is known, it should be no cause for wonder if the human species early seized upon the region for permanent habitation.

DISTRIBUTION OF THE SHELLMOUNDS.

PRESENT NUMBER.

The group of shellmounds examined in the San Francisco Bay region and located on the accompanying map numbers 425 separate accumulations. It is not to be supposed, however, that this figure exhausts the evidences of aboriginal occupation to be found within the given territorial limits, because the shellmounds are confined to a narrow belt around the open waters of the bay and grade off landwards into earth mounds of a more or less artificial character. In fact, some of the deposits shown at the northern and southern extremities of the map, specifically those on Sonoma Creek and on the Napa and Guadalupe rivers, contain a larger percentage of earth and ashes than of shell. According to reports, moreover, earth mounds and "old Indian rancherias" are situated on the banks of the Alameda and San Francisquito creeks, above the alluvial plain in the foothills; and it is hardly to be doubted that sites of this character could be found in great numbers by following up any other of the minor streams. As it is, several more or less obliterated camp and village sites of late and ancient date are definitely known in the region, some of them even on the University Campus in Berkeley; and the publication of news items relating to discoveries here and there of relics and skeletal material is no uncommon occurrence.

The now known list of genuine refuse heaps certainly falls short also of the number that originally existed in the region. Many of the deposits appear to have been either obliterated or destroyed by natural causes. Thus there were discovered, quite by accident, four shell heaps of unknown lateral extent, but from one to three feet deep, that were completely covered by natural deposits, ranging in thickness from one to two and a half feet. Of these four, no. 6 lies at the bottom of Elk Canyon, northwest of Sausalito, and its covering is simply a light sandy alluvium; but nos. 4 and 15, below Mill Valley, lie on hillsides and the covering here is a hard clay or adobe that could have washed

from the slope above only very slowly. The last, no. 96, situated west of Point San Pedro, lies in the edge of a reclaimed salt marsh, and was discovered only through the presence of a ditch lately dug across the area containing the buried deposit.

Another point worthy of note is the fact that there are at the present time no less than thirty relatively large mounds so situated by the shores, central on the bay, that they are subject to wave action (pl. 34). Some of these mounds have their foundation below sea level while others are raised on high bluffs and cliffs; but they are all alike disappearing, though necessarily at very different rates. One such mound, no. 266, situated on the bay shore north of San Pablo Creek, has been washed away within the last three or four years, the only signs of its former presence being certain fragments of worked stone and a few human bones that lie scattered over the muddy beach.

The suggestion that some of the deposits examined have their bases below sea level is of special significance and will be considered in detail later; it will be enough to state here that the subsidence appears to have affected the entire San Francisco Bay region, and that it is of such magnitude as to make it seem probable that a large number of mounds may have sunk entirely out of sight.

In addition to these natural forces, acting in the capacity of destroyers, there are to be taken into account several artificial agencies. Thus agriculture has been practiced more or less intensively in the region for over one hundred and twenty-five years; and, judging from reports as well as from conditions at the present time, it is not improbable that many of the mounds have been either plowed down or literally removed. In a number of cases where mounds have evidently disappeared in recent years, reliable information was not to be obtained. The majority of the country population, especially around the northern end of the bay, are Portuguese ranchers, mostly of the first generation, who know little or nothing about the recent history of the region. A little experience made it evident that negative information was not to be implicitly relied upon. All the more suitable places, such as springs and streams and canyons, were visited; but very often mounds of comparatively large size were found by chance in what appeared to be most unnatural situations.

All the foregoing circumstances clearly confirm the opinion that the original number of shell heaps on the San Francisco Bay shores may have been much larger than the figure now given, and that indeed this figure may not even include all the deposits existing at the present time. As to the latter point, however, it is fairly certain that no mounds of any considerable size or special importance are left unnumbered.

APPEARANCE, SIZE AND STATE OF PRESERVATION.

To detect the presence of a shell heap, even if inconsiderable in size, is not as a rule a very difficult task. During the dry season, and especially after the crops have been removed or the natural vegetation has died down, a slightly bluish tinge, imparted by the mussel shells, distinguishes these places often at a considerable distance. So also, immediately after the first heavy rains, the mound material being unusually rich and vegetation quick to respond, the sites lie revealed here and there before the observer as richly green spots in the generally barren, dull-colored landscape. Another fact which drew attention to the deposits was a frequently accompanying growth of buckeyes (*Aesculus californica*). Indeed, after the relation once became apparent, the discovery of a group of these trees often became an irresistible argument for making long detours into parts otherwise judged unsuitable for mound sites. As a rule trees do not grow directly on the mounds, unless there happens to be a good deal of earth mixed up with the shell and ashes; and the presence of the buckeyes immediately about the deposits is somewhat of a puzzle. It is well known that the Indians of recent times prepared the large, bitter nuts of this tree for food. They are said, moreover, to have used its soft wood for making fire and to have believed in the medicinal virtues of its bark. There can be no doubt, therefore, that at least the latest of the shellmound people also used some of the products of this tree; but it is impossible to say whether they planted the trees about their camps or whether the sites were originally chosen because of the presence of the trees. The latter alternative seems hardly tenable however; and neither may be correct, as the trees in many instances (*i.e.*, where they grow on top of the mounds), must have developed from seeds scattered perhaps accidentally at the time of the departure of the inhabitants.

Certain definite physical conditions, such as the presence of fresh water, timber, shelter from the wind, and easy access to the sea shore, appear to have controlled the location of most of the camps; and the presence of these elements, singly or in combination, in turn yields valuable guidance. Fresh water was probably one of the first essentials, and it is often to-day a matter of superstitious conviction with the old settlers that "wherever you find an Indian mound, there you'll find water—if you look long enough." Generally the connection holds, but not invariably, and this partly by reason of the geological changes which have taken place in the region since the shellmounds were begun.

The size and form of the shell heaps, while often much altered by one cause or another, are still in most cases approximately determinable. For instance, if a mound has been partly hauled away, abundance of material made economy unnecessary, and the thinner peripheral portion is usually left undisturbed. Actual dimensions vary greatly. Thus the basal diameters range from thirty to six hundred feet, and the height runs from a few inches up to nearly thirty feet. Curiously enough, the famous mound referred to the San Francisco Bay region by Southall and De Roo,[9] and probably the same that Marquis Nadaillac[10] locates at San Pablo, was not found; and in spite of the fact that it is definitely described as measuring one mile by a half-mile across and as having a height of over twenty feet, it appears never to have existed. There are, however, three mounds of more than average size in the vicinity of the old Spanish town, and the circumstance that these lie within the area of half a square mile may possibly have given rise to the error.

The typical shell heap of the San Francisco Bay region is oval or oblong in outline, with smooth slopes, steepest of course on the short transverse diameter; and the longer axis is generally parallel to the shore-line or stream to which the pile may be contiguous.

A remarkable fact about the accumulations is that while they are made up of comparatively loose material they do not appear to weather appreciably. This may be due partly to the resisting

[9] P. de Roo, Hist. of Am. before Columbus, p. 54.

[10] Marquis de Nadaillac, Prehist. Am., p. 50.

quality of the shells and partly also to the binding power of the broken fragments which, when laid down horizontally, may in some degree resemble loess in structure, and, like loess, cave less readily than ordinary soil. To illustrate this binding power may be cited the fact that it has been found safe and practicable to sink a vertical shaft, six feet square, through twenty-five feet of the material without the provision of a curbing. In one instance such a shaft was carried about twelve feet below sea level, but even the strong head of water failed to break down the walls. At the surface, the shell disintegrates somewhat, but probably more in consequence of vegetal processes than those of weathering. It would appear therefore that under perfectly natural conditions the configuration of the mounds would have remained perhaps almost unchanged for many decades, if not for centuries; and they might in that condition have told a valuable story. As it is, on account of recent artificial disturbances, it is generally uncertain precisely in what state the mounds were left. Nevertheless, a few of the larger and better preserved examples present roughly flattened tops and in two instances these surfaces are dotted with distinct saucer-like depressions, as of house pits.

The state of preservation of the mounds, just touched upon, is a matter of some consequence. It so happens that the majority of the larger accumulations lie precisely in the places since found suitable for habitation by the modern invaders, and therefore have to give way to the requirements of civilization. Towns are growing up in the principal valleys favored by the shellmound peoples; and in the canyons, as well as on the plains, ranch houses often cluster about, and not infrequently occupy the summits of these ancient dwelling sites. The accumulated refuse has also been found useful in many ways. For example, the composition will sometimes yield splendid crops of potatoes and other vegetables; and this fact, as it has become known, has generally led to reduction and cultivation of the mounds. In addition to this source of destruction, the material is removed to serve a variety of purposes, such as ballast for roads and sidewalks, as garden fertilizer, and even as chicken feed. It is said that the mound material, mixed with rock salt, produces tennis courts that for combined firmness and elasticity are unexcelled. The result is

that while there is still ample opportunity for the investigator, not a single mound of any size is left in its absolutely pristine condition.

Many of the accumulations, as indicated on the map, have disappeared in recent years, leaving only the faint traces that lead to inquiries, and usually to only very general results. The artifacts from these obliterated deposits have as a rule been scattered broadcast among individual curio seekers; and even when found in more or less representative groups, there are no accompanying data. It is said that a good share of the archaeological material from the two large mounds formerly located in the town of San Rafael found its way to the British Museum in London; but, according to the informant who claims to have culled the deposits for the one-time English consul at San Francisco, no detailed records went with it. From only two more of the destroyed sites is any collection known to be extant. The Golden Gate Park Museum of San Francisco obtained some years ago a small but quite complete culture exhibit from mound no. 276, at one time located in the yards of the Standard Oil Company at Richmond; and only recently the city of Alameda collected a small group of implements from no. 316, a large shell heap formerly located near the intersection of High Street and Santa Clara Avenue.

Exclusive of the results obtained in the systematic work carried on during the last six years by the University of California, there are only a few minor collections from mounds still partially intact. The Stanford University Museum is in possession of several pieces from no. 356, near Mayfield; the owner of no. 3, at Sausalito, shares with the public school of that place a collection of skulls and stone implements; and from no. 199, at Lakeville, a small exhibit has found its way to the Dime Museum in Petaluma. All of these collections, while taken from scattered sites, are numerically small and probably in no case fully representative of the given culture, and cannot therefore furnish an entirely safe basis for comparison and generalization. Enough is known to warrant the statement that a general similarity in culture obtains for the entire region; but the differences, if any, remain to be brought out clearly.

SITUATION WITH RESPECT TO SHORE-LINE AND SEA-LEVEL.

The shell heaps under consideration are situated in a great variety of places; but, on the whole, the positions may be characterized as *convenient* rather than in any sense *strategic*. Many of the largest mounds are located at the head of the sheltered coves, yet not a few deposits lie in thoroughly exposed places, out on the bluffs and higher headlands. Occasionally a hillside, with or without any accommodating shelf or hollow, has been chosen, doubtless on account of some small spring issuing in the vicinity. Good illustrations are furnished by no. 65, at Corte Madera, and no. 379, near South San Francisco. From San Rafael northward nearly every ravine and every gully appears to have offered attractions. But the great majority of the mounds are situated on or near the small streams, though with considerable indifference, it seems, as to whether the surrounding country is barren plain or timbered hills. Wherever a group of separate deposits line a stream it is usual to find the largest accumulations at the lower end of the series. Lastly, some mounds are found in apparently unnatural situations, such as on the plain where no streams pass, or out in the salt-marsh where fresh water could not be had; and a few deposits are to be seen also on the small islands, both those immediately surrounded by marsh and those which are completely insulated by deep and swift currents.

Normally the shell heaps lie quite close to the open waters. The only general variation from this rule occurs on the north and northwest, where some of the deposits are situated four or five miles back from the present shore. But it seems legitimate to assume in explanation of this fact that at least the larger and older of the accumulations in this locality were begun, if not actually abandoned, prior to the building up of the now broad belt of reclaimable marsh, away from which they do not in any case extend very far. A more singular and striking exception occurs on the east, between Rodeo Creek and Carquinez Strait, where two neighboring mounds are situated comparatively far inland and at unusual elevations. Thus no. 254, directly east of the town of Rodeo, is located nearly one and one-fourth miles back from the shore, at an approximate elevation of two hundred

and twenty-five feet; and south of this mound, on Rodeo Creek, lies no. 259, which is over two miles inland and about one hundred and twenty-five feet above sea level. Both were extra large mounds and probably of relatively great age.

The unusual situation of the two deposits mentioned above, while suggestive perhaps of a local rise, may after all be perfectly normal. The barren hills close to the shore offer little attraction, while back in the canyons, where the mounds lie, the laurel and the oak find existence possible on the shaded slopes, about the springs and along the wet-weather gullies. There is also the further argument against a recent upward movement, namely, that within two or three miles on either side of the elevated deposits several shell heaps of more than average dimensions are situated at sea level, with indications of having been lowered into their present position. Among these apparently lowered deposits may be specified no. 236, at the head of Glen Cove on Carquinez Strait, and no. 262, on the San Pablo Bay shores, southwest of Pinole. But, whatever may have taken place in this particular locality, there can be no doubt about the subsidence of the bay region as a whole or concerning the fact that however ancient or slow this movement, the latter portion of it was witnessed by man.

As a natural consequence of favoring proximity to the open shore, the shell heaps tend to keep close to sea level. The fact is that nearly all the mounds lie within fifty feet of the surface of the bay waters, and this may be termed the normal zone. But exceptions occur on either side of this zone; and these, because of their numerical scarcity, are perhaps all the more significant. We have already seen that two mounds lie very far above the normal zone, and there remains only to state that at least ten of the known deposits extend below sea level. Most of these sunken accumulations, it is true, occur in the central part of the region, about Berkeley and Richmond, and also on the opposite shore, near Tiburon; but good examples are not entirely wanting at either extremity. Thus to the north one large mound lies well out in the Petaluma Creek marsh, off Lakeville; while to the south there remains at least one small shell heap, scarcely noticeable any longer, out on the reclaimed flood lands on the north bank of the

Coyote River; and there is evidence that two additional deposits once lay on the marshy shore near the south end of the Coyote Hills.[11] Besides these ten or twelve partially submerged accumulations, there are also the scattered deposits previously mentioned as giving indication of having been lowered to their present position, within reach of the waves.

The foundations upon which the submerged refuse heaps rest are generally of firm material, excluding the possibility of the accumulated weight of the mound having forced the mass below sea level. Several of these unique deposits lie on the alluvial slopes; but others, such as those on Brooks Island (pl. 34, fig. 2) and at Tiburon, rest on older formations, even upon solid rock. Up to the present time only three of the ten submerged deposits have been carefully tested for depth, and these show a subsidence ranging from three to eighteen feet.

GEOGRAPHICAL DISTRIBUTION AND ITS CONTROL.

A glance at the map will show the relative frequency of the shell heaps along the bay shore to vary somewhat locally. It is uncertain, of course, what the original geographical distribution may have been, on account of the disturbing factors, more or less active, all around the bay. At the same time, it is hardly to be doubted that economy was in some sense a primitive trait, or that these rude savages had intelligence enough to take advantage of a combination of favorable circumstances. At any rate, judging from present conditions, the general scarcity of mounds at the extremities of the region under consideration does not seem inexplicable. The southern arm of San Francisco Bay can not now be regarded as entirely suitable, even if molluscs were abundant; and there is no indication of any very recent change from a better to a worse condition. To be near the main source of animal food would often mean to be several miles distant from the foothills which yielded wood, acorns, berries, etc. And granted even that the alluvial slope was covered with live-oak, which is not at all probable, the water supply close to the shore-line, would still be

[11] Since formulating the above statement the writer visited Halfmoon Bay to locate the mounds thought to exist in that region and thus to complete the survey of the coast line included in the accompanying map. Several mounds were found here and the largest of these, situated just inside Pillar Point, lies well out in the marsh and certainly goes below sea level.

a very uncertain quantity during the dry season. Finally, to judge from the nature of the shell heaps now remaining about the southern end of the bay, molluscs then as now, were not plentiful or were not easily obtained. Central on the bay, however, and especially on the west side from San Mateo to Petaluma, the more or less wooded hills, charged with springs and streams, come in many places directly to the open water and here, consequently, as might be expected, the mounds are relatively numerous. On the east side, from Alameda to Carquinez Strait, the deposits are also at intervals quite well represented both as to number and size; and this fact can hardly escape relation to another fact, namely, the comparative narrowness or entire absence of the alluvial plain, which brings the small wooded canyons within easy reach of the shore. There is one exception to this generalization in the case of the mounds located on or near the Potrero Hills in the vicinity of Richmond; for here, at the present time at least, both water and wood are practically absent. It may be assumed, however, that recent changes have removed these necessities or else that an extraordinary abundance of shell fish was the compensating element.

Reasonable proof of the suggestion that the presence of shell fish was the first essential to a camp is furnished by the ocean shore. Conditions have been closely studied here for about two hundred miles adjacent to San Francisco Bay, *i.e.*, from Halfmoon Bay to the mouth of the Russian River; and the results are not without interest. Water and shelter are easily obtained and timber also is fairly abundant north of the Golden Gate; but the nature of the beach is either unfavorable for a molluscan fauna or is too steep and difficult of approach. Consequently, within the mapped limits, mounds are scarce except at the head of Halfmoon Bay, where shelter is good though timber is lacking. The few deposits indicated along the coast northward are often not even near any of the predisposing elements, but lie exposed on high barren rocks and sand dunes. But along the coast immediately to the north of the map, shell heaps, though usually small, are very numerous, particularly on Tomales and Bodega bays where all the favorable conditions obtain.

NATURE OF THE SHELLMOUNDS.

GENERAL STATUS OF SHELLMOUND INVESTIGATION.

Since the first recognition of their place in culture history, artificial heaps of shell have been observed in many parts of the accessible world. They occur not only on various of the islands and along the continental shores, but have been traced inland along the rivers and their lacustrine ramifications, being here often partially or wholly replaced by accumulations of earth. Even the more isolated lakes of the far interior, whenever capable of supporting molluscan forms of life, appear to have attracted more or less permanent settlement of primitive peoples. In brief, it seems to be true that, given the proper environment, these accumulations have been found wherever due search has been made.

Actual study of the contents of these shell heaps has not yet proceeded very far on a world scale. Aside from the initial work in Denmark,[12] begun in 1851, systematic investigation seems to have been carried on most extensively in the United States, specifically in Florida[13] and the adjacent Atlantic and Gulf states, on the Aleutian Islands,[14] and in the Puget Sound country.[15] Some minor studies have also been made in scattered places on the Pacific Coast from the Columbia River to Southern California, as well as on the Atlantic shores from Virginia to Labrador. There are besides, for the world at large, some more or less complete records of investigations in such widely separated localities as the West Indies,[16] Brazil,[17] Chili,[18] Peru,[19] Japan,[20] Australia,[21] Italy,

12 Smith. Rep., 1860; also Affaldsdynger fra Steenalderen in Danmark by Sophus Muller, K. J. V. Steenstrup and others, Kjöbenhavn, 1900.

13 Moore, Clarence B., Certain Shellheaps on the St. John's River, *Amer. Naturalist*, 1904. Also this author's publications by the Academy of Natural Science of Philadelphia.

14 Dall, W. H., Tribes of Extreme Northwest, *Contrib. N. Amer. Ethnol.*, Vol. I.

15 Smith, H. I., *Mem. Am. Mus. Nat. Hist.*, Vol. I, part 6; Vol. II, parts 4 and 6, of the publications of the Jesup Expedition.

16 Fewkes, J. W., The Aborigines of Puerto Rico, *Ann. Rep. Bur. Amer. Ethn.*, 25, p. 275.

17 Reclus, J. J. E., The Earth and Its Inhabitants, Vol. II, p. 88.

18 Evans, O. H., Notes on Stone Age in Chili; *Man*, London, 1906.

19 Uhle, Max., Los Kjoekkenmoddings del Peru; *Rev. Hist.*, Lima, 1906.

20 Morse, E. S., Shellmounds of Omori, *Univ. of Tokio Pub.*, 1879.

21 Roth, W. E., *North Queensland Ethnog. Bull.*, No. 3, 1901, p. 7.

Spain,[22] France, and the British Isles. In many cases, however, the work seems to have been inadequate for rigid analysis; and the present study, which is scarcely more than superficial, must therefore be limited to comparisons along only the broadest lines.

RELATION OF SHELLMOUNDS TO OTHER PRIMITIVE STRUCTURES.

The abundance and world-wide distribution of shellmounds may, it seems, be considered as tending to indicate the wide distribution of the human race by the time it had begun effectively and consistently to devise improvements on nature. The shell heaps are themselves a species of invention; and as such they are particularly interesting from a psycho-historical point of view, in that it appears as if they might have resulted from an accident by which, possibly, they became the models for the earthworks so exceedingly numerous in the interiors of Europe and North America. It would be going too far perhaps to assert, without qualification, that all the shell heaps antedate all the earth mounds, either temporally or culturally. At the same time, it would seem in accord with reason, and certainly not contrary to the accounts of early explorers, that, exclusive of limited groupings in the caves and natural recesses of the interior, the most primitive form of voluntary community life began, and was for a long time confined, largely to the shore margins of the continents. Here only could animal food be obtained in any quantity and literally bare-handed. The enforced community life may also be supposed to have furthered the division of labor necessary to the perfection of implements and weapons with which to conquer the interior. At any rate, permanent settlement or continued maintenance of life in the interior required, besides considerable knowledge respecting the utilization of vegetable products, a certain skill in the production and use of weapons such as only a long period of time and experience could supply.

It is possible that what the observed geographical distribution suggests may be disproved by a thorough examination of cultural

[22] Ranke, J., Der Mensch II, p. 553.
For a fuller bibliography of the Pacific Coast shellmounds see Vol. 7, No. 1, p. 6, of the present series.

and palaeontological remains. It is probable, moreover, that the designer of modern palaces may disdain tracing the origin of his art to any thing so lowly as even the most elaborate executions done in earth; although, for our purposes, it is essential to acknowledge every perceptible or possible step in both art and science. And, if in looking for the beginnings of architecture, we are permitted to pass beyond the rough masonry of the cliff-dwellers and the rude, often earth-covered, burial chambers of Megalithic times, to the earth mounds themselves, then perhaps we may proceed even so far as the shell heaps; for these accumulations appear in reality to represent the transition from what began as a mere accident and often ended in a structure with more or less definitely recognized purposes.

Turning to the shell heaps in the San Francisco Bay region, it is only by a wide stretch of the imagination that they can be considered "structures" in an architectural sense. They are thus at once to be distinguished from the pretentious earthworks of the Ohio Valley. Beyond the fact that the shell heaps under consideration were used for burial and domiciliary purposes, and were sometimes raised into more or less conical mounds, they show no evidence of consciously constructive design. There are no effigy mounds among them, as in Brazil;[23] nor are there any strong suggestions of defensive or ceremonial purposes about them, as in Australia.[24] At the same time these accumulations are not quite in the same class with the enormous shell heaps which, whether entirely artificial or not, are found in several places on the Atlantic shores of both North[25] and South America. where they often cover many acres to a depth of as much as twenty feet. From previous description it will be recognized that the San Francisco Bay shell heaps are comparatively small

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[23] See Reclus, The Earth and the Inhabitants, p. 108.

[24] Roth points out that the large and remarkably steep-sided shell heaps at the junction of the Hey and Embley rivers in Australia could readily be defended against attacking enemies and suggests further that the shell-and-ash composition probably afforded protection against fleas and other insects. *North Queensland Ethnography Bull.*, 3, p. 7.

Mound no. 256, east of Rodeo, is situated on a hillside directly above the entrance to a cave. This cavern, said to be forty feet long and of more than man's height, may well have served for protection against enemies but its chief importance was probably as a source of water supply.

[25] *e.g.*, Holmes, W. H., *Am. Anthropologist*, n. s., Vol. IX, p. 113.

in volume; but, judging from the nature of their composition and the probable slow rate of their accumulation, they may reasonably be considered fully as ancient as any known deposits elsewhere in America. They are kitchen middens, of the type found in Denmark, and have their counterpart in certain shell heaps in the Gulf and Atlantic Coast states, and in their general nature quite agree with the refuse heaps in the vicinity of Puget Sound on the northwest coast. From a strictly cultural standpoint the group may in a way be said to show wide affiliations along certain broad lines, but to be otherwise quite isolated.

COMPOSITION AND INTERNAL STRUCTURE.

The San Francisco Bay shell heaps contain, besides molluscan remains, a large percentage of ashes and charcoal, together with varying quantities of broken rock and waterworn pebbles. Occasionally there seems also to have been added more or less of ordinary earth or dirt, until in some of the mounds—and usually those farthest from the shore—the shells become an almost negligible element. The presence of the pebbles in some of the deposits is difficult to explain, unless they were brought with the earth; and this seems not always to have been the case because the pebbles are often most abundant in the accumulations containing little but shell and ashes. Furthermore, it is to be observed that some of the mounds containing the pebbles are situated on the marsh and in other places near which pebbles are not now to be obtained.

The cracked and broken rocks, which were supposedly brought together chiefly for hearth and cooking stones, vary in kind locally, but foreign specimens are everywhere present and some of these must have been brought long distances.

The internal structure of the mounds has been studied with some minuteness in three places, and has besides been observed in several other widely separated localities where either natural or artificial agencies have exposed the interior to view. To speak of definite structure in a promiscuous mixture of more or less broken shell and other matter may be unwarrantable; nevertheless, bedding planes or lines of deposition are often made visible by sudden changes in the shell species or may be inferred

from streaks of ashes running through the mass. In the Emeryville mound distinct strata are in fact produced by alternating depositions of raw and calcined shells. But this is an exceptional occurrence. The burnt shells and ashes, always most apparent in the upper levels of the deposits, occur usually in streaks and sometimes in large pockets, mixed with rock, as if marking individual fireplaces. It is a noteworthy fact, however, that, unlike the shell heaps in the Aleutian Islands, these show unmistakable evidences of the use of fire from the very beginning Thus, while actual fireplaces are not readily detectable in the lower levels, charcoal is abundant at the bottoms of two thirty-foot mounds and has been brought up repeatedly from points twelve to eighteen feet below high tide level. In one of the mounds, however, a shade of doubt is cast on this point owing to the fact that the material at the bottom seems to have been disturbed or at any rate does not truly represent the center, *i.e.*, the oldest part of the accumulation.

In general, the vertical section of a mound begins at the top with a foot or two of somewhat finely disintegrated material; grows loose, coarse and distinct in structure for some distance; and, finally, the lower end of the column becomes a compact and practically homogeneous mass in which nearly all the shells are crushed. At first, such a condition seems perfectly natural. But the rule does not hold in all cases. That the disintegration at the surface is the normal result of weathering and vegetal processes need not be doubted; but the finely broken shells of the lower half or two-thirds of the pile do not represent a clear case of disintegration. It is true that the lower levels of the mounds in question are made up largely of mussel shells, the bits of which are somewhat softened and fragile, though they still retain their lustre; and it might be argued that the mere weight had crushed the mass and reduced it to its present consistency. However, there is a small admixture of clam and oyster shells, nearly always crushed to the same fineness as the mussels, but sometimes scattered about entirely unbroken. The clam and oyster fragments are still quite as firm as the shells of the present day; and if weight or disintegrating processes reduced some, why not all? Again, if the weight could crush the mussel shells in some of the

mounds, why not in the rest? It would seem that the lower, compact portions of some of the mounds were laid down under different conditions from those on the top. In two mounds the line dividing the finer and the coarser depositions is very sharp and distinct, but whether it represents a long interval of time or corresponds to a change of inhabitants is made clear neither by the remains of the higher animals nor by the cultural evidences.

MOLLUSCAN REMAINS.

Of the molluscan remains the "soft-shelled" clam, *Macoma nasuta,* and the "soft-shelled" mussel, *Mytilus edulis,* are common to all the mounds, and usually make up the bulk of the material. The only marked exception to this rule occurs in the mounds at Point Isabel, West Berkeley, Alameda, and San Mateo, where the oyster, *Ostrea lurida,*—practically absent in the sites bordering the extremities of the bay—is found in great quantities. Other species such as the large "hard-shelled" clam, *Tapes staminea;* the long "hard-shelled" mussel, *Mytilus californianus;* the cockle, *Cardium corbis;* the abalone, *Haliotis rufescens,* and three small univalves, *Purpura crispata, Cerithidea californica,* and *Acmaea patina* are only sparsely represented. Of these, the two first named univalves and the mussel may have had restricted habitats in the bay; while the clam, the cockle and the abalone were probably brought from the ocean shore.

Some changes appear to have affected the species and their habitats in the bay since the shellmound people arrived. The native oyster, for example, no longer breeds in the bay, except possibly off San Mateo; the "hard-shelled" mussel has been observed only on the ocean shore where the rough surf plays; and none of the univalves mentioned above have been noticed anywhere about the bay. A particular species of clam, *Mya arenaria* Linn., observed only in one mound, central in the region, seems now to thrive wonderfully in most parts of the bay. A new mussel, *Modiola* sp., is said to have been imported from the Atlantic Coast within historic times and samples of its shell have been found on the surface of one or two of the mounds. Oysters from the Atlantic Coast have been planted in the bay in recent times and these appear to thrive fully as well as any of the native

molluscs, though at the present time all of them are threatened by crude petroleum which escapes in the form of waste from the various oil-works located on the bay shore.

Of all the molluscs represented in the shellmounds only the common clam and mussel seem to have persisted since the middens began to accumulate; and these are still found in sufficient quantities in the bay to supply the markets of all the bordering cities. Certain mounds do nevertheless furnish indication of probable local changes in the preponderating species; and wherever these changes are marked, it is the mussel which is most abundant in the lower strata while the clam becomes suddenly quite excessive in the upper horizons. It is impossible to say whether these changes are due to biological or geological causes. Probably the rate of sedimentation has been a vital factor; in any case, the sinking of the region and the disappearance of rock-bound shores would have seriously affected the life of the mussel. It is interesting also in this connection to learn from the fishermen that the last twenty years have witnessed some very marked fluctuations both in the quantity and the habitat of the shellfish.

Following is a list of molluscs known to occur in the shellmounds:

Oyster, *Ostrea lurida.*
Mussels, *Mytilus edulis* and *M. californianus.*
Modiola, sp.
Soft-shelled clams, *Macoma nasuta* (and *M. edulis?*).
Myra arenaria.
Hard-shelled clams, *Tapes staminea* and *T. tenerrima.*
Cockle, *Cardium corbis.*
Abalone, *Haliotis rufescens.*
Purpura crispata and *P. caniculata.*
Cerithidea californica.
Olivella biplicata.
Acmea patina.
Standella, sp.
Land snails, *Helix,* two species.

VERTEBRATE FAUNA.

While the indicated change in the preponderating shell species is of no particular cultural significance, it is otherwise with the remains of the vertebrates represented. There are no sharp changes from invertebrates to vertebrates and from fishes to

mammals, such as Dall appeared to find in the Aleutian Island shell heaps. But progress is here. Mammalian bones seem to occur at all levels in some of the largest mounds; yet it is safe to say that more than ninety-five per cent., quantitatively measured, are confined to the upper six or eight feet. The doubt implied is again due to the uncertainty as to whether or not the excavations reached the oldest part of the mounds. But in any case, the occasional surprise or accidental capture in earliest times of big game, marine or terrestrial, counts little against the successful slaughter of a great variety of animals in later days.

Fishing may or may not have been an important industry. There happen to be very few fish bones in the mound material, although the grooved stones, usually held to have been net-sinkers, occur at all levels in some of the deposits. It is of course possible that fish may have been cured for consumption elsewhere.

Bird bones, apparently of ducks and waders, are rather numerous, especially in the upper strata. Their presence suggests two things: first, that at least the latest mound people lived on the bay shore during the winter time, when ducks were present; and, second, that these peoples possessed no domestic dog. The latter inference is based simply on the fact that no half savage, hungry dog would have left the bird bones in the condition in which they are often found.

The identified animal bones include the following species:

Deer, *Cervus*, sp.
Elk, *Cervus canadensis*.
Sea-otter, *Enhydra lutris*.[26]
Beaver, *Castor canadensis*.
Squirrel, *Spermophilus*, sp.
Rabbit, *Lepus*, sp.
Gopher, *Thomomys talpoides*.
Racoon, *Procyon lotor*.
Badger, *Taxidea*, sp.
Skunk, *Memphitis occidentalis*.
Wild cat, *Lynx*, sp.
Bear, *Ursus*, sp.
Dog, *Canis familiaris*.[27] (?)
Seal, *Phoca*, sp.
Sea-lion, *Zalophus californianus*. (?)
Porpoise, *Phocaena communis*.
Whale.
Canvasback Duck, *Aythya vallisneria*.
Goose. (?)
Cormorant, *Phlaeocorax*, sp.
Waders, or some large birds.
Turtle.
Skates, Thornbacks, and other fish.
Wolf, *Canis*, sp.

[26] Otter must once have been plentiful in the region because, according to Spanish history, the skin was an object of trade for an indefinite period from the time of occupancy in 1769.

[27] The remains found, in one case at least, were doubtless those of a recent animal accidentally left on the mound.

CULTURE AND HISTORY OF THE SHELLMOUND PEOPLE.

MATERIAL CULTURE.

The augmenting capacity of the shellmound people, implied in a measure by their more and more successful hunting, is made sufficiently evident by a study of the artifacts. As with the animal bones, while some of the preserved suggestions of industrial life occur from the bottom of the accumulations to the top, they are after all relatively abundant only in the upper levels. But this fact would of itself prove little did not the implements of later times also show much greater variety and specialization as well as perfected workmanship. Viewing the culture as presented in its entirety however, the change or progress is not perhaps so clear and marked as might have been expected. These people, rude as they may have been, from the start employed fire; used prepared vegetable foods; satisfied their hunting instinct; and fished, supposedly with seine—if they ever fished at all. They also used body-paint and they buried their dead. In other words, they were from the beginning quite above the stage in which savage man may be supposed to have struggled for his mere existence alone. The later mound occupants may have brought, or, if they were direct descendants of the first inhabitants, may have originated activities along other fundamental lines; though the clear proof of such seems wanting. For instance, it is tolerably certain that skin-dressing and basketry were practiced in late times, but with our present knowledge it would be unsafe to say when these arts began or even that they did not arrive with the first appearance of the mound people. More evident seems the relatively recent development of certain luxurious habits and tastes such as are implied by the presence of pipes, musical devices and decorative objects. Finally, it may be well to add that there appears to be no form of artifact found at the bottom of the accumulations that does not also occur near the top.

The culture as observed, were one to describe it in terms of the present system of archaeological classification, is neolithic. Some roughly chipped flint and chert flakes were indeed found in the lower horizons of one of the shell heaps, but these pieces may

hardly be considered palaeolithic in the true sense. As would be expected, only such effects as are made of bone and stone and shell have resisted disintegration, and these remnants include weapons, household utensils, working tools, ornaments and possibly ceremonial objects. Such fundamental things as spear and arrow points, mortars and pestles, hammer stones and roughly grooved sinkers occur at all levels in many of the deposits; but the shapely and sometimes highly polished bone awls, the graceful "charm stones," the delicately worked stone pipes, the bone whistles, the stone labrets and certain shell beads and pendants, all appear to be confined to the upper horizons in at least some of the very largest mounds. The record, apparently so clear and simple, is nevertheless difficult to interpret with certainty, and even if it be accepted at face value, there still remains a legitimate doubt as to whether the cumulative nature of the culture is due to the natural development of a fixed population or is the result of substitution by conquest or migration.

Mention may be made of certain minor local variations in the culture of the mound group. Some of these changes may possibly correspond to the recently determined geographical limits of native linguistic stocks, but there are others of which this cannot be true. For example, the grooved sinker occurs in great abundance in some deposits; while in others, closely adjacent, it appears to be entirely absent. There has been found also in the northeastern part of the region a particular form of mortar—a large, roughly rectangular slab with a small bowl on the smoothed side—which has not been observed anywhere else, the usual mortar being either globose or bucket-shaped. Other differences are apparent, but they must await further investigation.

While, as previously observed, the study of shell heaps here and elsewhere does not yet warrant detailed culture comparisons on a world scale, some features at least seem to stand out pretty clearly. In the first place, this type of culture represents almost everywhere a relatively low stage and for that reason—the primitive needs being identical—shows several broad similarities, particularly in the nature of the pointed and sharp-edged types of implements. Thus the bone awl, the wedge, the flint flake, and even spear and arrow points differ comparatively little for the

entire world. All this seems natural enough because the piercing point and the cutting edge really embody fundamental requisites, such as are furnished by nature to many of man's competitors in the animal world.

Specialization is probably a question both of time and of ingenuity. For a long period it was doubtless held in check partly by the manner of occupation a given environment compelled and partly also by the nature of the raw material furnished by any particular geographical area. Consequently it may be assumed that real differentiation did not appear, on many lines, until individual imagination and taste were ripe enough for expression. But even the artistic instinct has asserted itself similarly over vast geographical areas, though doubtless many products apparently under this category may be the result either of trade or migration. As examples may be mentioned the "charm stones" and certain shell ornaments that are found on the Atlantic as well as on the Pacific shores of North America. In the second place, if we except Europe or those parts of the world thoroughly changed by Aryan or other acculturation, it may be stated with some degree of confidence that cultures of the various shellmound groups, in so far as they differ among themselves, usually agree with or shade into the civilization attained by the natives perhaps still occupying the respective regions.

Referring to the positive side, the culture of the San Francisco Bay shell heaps conforms, at least in its broader features, to that of the late Indians of the surrounding territory roughly designated as Middle California, somewhat as the attainments of the shellmound peoples on the Atlantic shores appear to have shaded into the civilization of the there native Red Man of historic times. Again, negatively considered, while pottery or evidence of work in clay is common to every one of the known shellmound groups in all the rest of the world, it is absent from the San Francisco Bay deposits precisely as it is in Central California ethnology. In conformity also to the same rule, no native-worked metals have been found here although such occur in many shell heaps, even in those so near as Puget Sound, where are also found certain entirely unique rock sculptures. It would appear, therefore, that so far as may be judged from the cultural evi-

dences above, no very definite conclusions can ever be reached regarding the origin of the shellmound peoples and their possible migrations. There remains, however, another means of determination, which may prove more fruitful, namely an examination of the skeletal material.

HUMAN REMAINS.

Fortunately the shellmound peoples everywhere it seems, except in Denmark, have interred their dead in the accumulated refuse on which they lived. It is certain at least that all the mounds of any size in the San Francisco Bay region contain numerous burials and the remains, even those beneath the sea-level, are often remarkably well preserved.

At the outset one is disposed to wonder at such a world-wide practice that really appears to have no precise explanation. The religious motive is sometimes assigned, and while there is no good ground for disputing such a view, especially as nearly all human actions appear to have had some religious significance at one time or another; still a thoroughly practical reason may not be entirely wanting. The shell deposits, it will be recognized, are made up usually of loose, porous material very easily dug into with a stick or a shell or even with the bare fingers; on the other hand, to make a hole large enough to accommodate a human body in ordinary California soil is a hard task at some seasons of the year, even with modern tools. However, this is merely suggestive, and primitive man may have had other reasons for burial of his dead in the mounds.

The mortuary customs cannot here be considered in full detail. It will be enough to state that the common practice from the start seems to have been interment rather than cremation, though occasional evidence of the latter has been observed. The particular disposition of the remains varies decidedly, sometimes even in the same mound. Occasionally the body has been laid out at full length with the face either up or down. At other times the arms and legs have been folded tightly against the trunk and the body laid face down. But as a rule the remains lie on the side with the limbs more or less flexed. Group burials of two or more are also not uncommon, the remains lying usually very

snugly, spoon fashion. No attention seems to have been paid to cardinal directions, as is popularly supposed; nor do there appear to be any interments in a sitting posture. The great majority of the remains are not accompanied by artifacts of any kind. Occasionally a male is fitted out with pipes and weapons, while a few females may be supplied with mortar and pestle and sometimes several awls. Children have invariably been accompanied by beads and trinkets made of sea shell. There is also reason for believing that food was placed with the body, pockets of unopened bivalves having on several occasions been found close to the remains.

No careful study has been made of the osteological remains as yet because it is hoped that additional material may be secured from at least a few more mounds. But to all appearances the shellmound peoples were of average build, with some amount of variation in skull form, but with no striking peculiarities.

ORIGIN OF THE PEOPLE.

The first questions naturally asked in connection with the study of these shell heaps concern either the age they represent or the people who made them. Were they the progenitors of the Indian or were they different? Enough has already been stated to make it clear that there is thus far no definite reply to either query. Speculation on such themes, perhaps indirectly fruitful, has long been fascinating pastime; but for even a tentative answer we must await a more thorough investigation of the facts relating not only to these shellmound people but to the prehistoric Americans as a whole.

So far as concerns the San Francisco Bay people, we have seen that there is no great gap either in the evolution of the culture as traced from the bottom of the accumulations to the top, or between the attainments of the last occupants and the culture of the Indian who inhabited Middle California less than a century ago. Moreover, as it is even certain that late Indians lived on some of the sites until a few decades ago, it becomes difficult to reject the opinion that the original migrants who began the refuse accumulations were of his own race, if not his direct ancestors. But it may be well to bear in mind that a

judgment based upon a culture so largely utilitarian is of doubtful value, and possibly a careful study of the skeletal material may lead to a different view.

AGE OF SETTLEMENTS.

A somewhat more definite statement may be ventured regarding the second question, namely as to the time elapsed since the shell heaps were begun. It is of course impossible to fix the absolute age of any of these repositories, but there are a number of things that indicate their relative antiquity. Such facts are for example the general absence of evidence suggesting European contact; the amount of wash or drift that has covered up some of the deposits; the fairly old trees that grow on the tops of two or three of the mounds (pl. 32, fig. 1); the amount of subsidence of the bay region which some of the deposits record, and the enormous volume of sediment which has been deposited in various regions of the bay, in part at least subsequent to the time when some of the largest refuse heaps were abandoned. Add to these the suggestion of the enormous volume of some of the deposits, and their great age, humanly speaking, must be apparent.

If one tries to estimate the duration in terms of years, a difficulty presents itself at once in that it is impossible to know whether the mound people shifted from one site to another, as Darwin observed in Patagonia, or whether they even lived on the bay shore at all seasons of the year. It has been suggested in connection with the presence of bird bones in the deposits that the occupants lived by the water during the winter, but there is no proof that they followed the recent custom of retiring to the hills during the summer. If territorial boundaries were respected in those days as in later times, then, in view of the fact that the immediately surrounding hills are not altogether favorable as summer retreats, it may be assumed, for our purposes, that the mound people remained practically stationary and drew a varying quantity of molluscs from the bay the year round.

For something more satisfactory than a guess let us estimate the age of one of these accumulations on the basis of the probable daily amount of deposition. Mound no. 295, at Ellis Landing, near Richmond (pl. 33, fig. 2), which has a volume approximating

1,260,000 cubic feet, may be used for this purpose. There were on the top of this pile about fifteen house pits, and if we allow an average of six persons to the family or house we may assume a community of ninety or one hundred individuals of mixed age. It has already been pointed out that these people hunted the higher animals and utilized vegetable products, so that they were never entirely dependent on the molluscs. Suppose, however, that in the earliest times, when only the mussel was abundant, they gathered a daily average of fifty shell fish per person, which would of course leave considerably more than fifty for each mature individual and an amount that, supplemented as it was by other things, would probably be sufficient. Actual trial shows that the volume yielded by the total 5,000 shells, crushed down to their present consistency, would be about 1,200 cubic inches. To this amount should be added a quantity of ashes, broken rock and such extra debris as may collect about a camp—possibly sufficient to make up one cubic foot for the daily average. Calculated on this basis it would apparently have required about 3,500 years to accumulate the pile. Even though one may refuse to take these figures at anything like face value, if we consider that the site was possibly not occupied for several centuries, and that it may never have served as permanent residence, it becomes reasonable still to believe that the mound is anywhere from three to four thousand years old.[28]

THE IMPLIED POPULATION.

In view of the astonishment commonly expressed with reference to the great number of shell heaps in the San Francisco Bay group, it may not be out of place in closing to remark briefly on the probable aboriginal population. There are insuperable difficulties in the way of arriving at even an approximately satisfactory answer to the question, and this would still be the case were the original number of mounds present. In the first place, it may safely be assumed that the shell heaps were not all begun at the same time; and, in the second place, it is practically certain

[28] Dall estimates 3,000 years as necessary for the accumulation of some of the Aleutian Island mounds, and the age of some of the kitchen middens in Denmark has been placed at 3,500 years.

that some of the very largest mounds were abandoned long before others. The Spaniards explored the bay region quite thoroughly in the year 1775, and they appear not to have observed Indians living on the larger shellmounds near the shore unless possibly on mound no. 3, at Sausalito, and at Crockett, on the south side of Carquinez Strait;[29] but many informants have pointed out both some of the smaller sites between San Rafael and Petaluma and also some of the larger ones south of San Mateo as having been occupied by the Indians as late as 1870. Precisely how far the buried culture may substantiate these statements remains to be proved. On the one hand, no sign of European influence has so far been encountered in the three large mounds systematically investigated; but, on the other hand, reports are current, mostly referring to long past discoveries, in several of the mounds, that would suggest at least indirect contact with higher civilization. These reported finds include such things as "brick, of Spanish make," from mound no. 3 at Sausalito; "red silk," supposedly from one of the San Pablo mounds[30]; and from no. 232, on Mare Island, even a stone slab, said to have been inscribed with "Egyptian hieroglyphics"; but the only recent and seemingly well authenticated find, coming from near the surface of no. 316, the large Alameda mound previously mentioned, is a small brass medal bearing the date of 1768.[31]

It appears therefore quite impossible to say how many of the middens were occupied at any one time. Nevertheless, if we allow that some of the older mounds have been submerged or obliterated

[29] The report of Portolá's first overland expedition from San Diego to San Francisco Bay, in 1769, says that they judged from the numerous columns of smoke observed that the country about the south end of the bay was well stocked with Indian villages. The party saw and had dealings with the Indians while encamped on San Francisquito Creek. Later, in 1775, Commander Ayala of the *San Carlos*, met or saw natives at two points on the present site of San Francisco and also in the vicinity of Sausalito, where, according to recent hearsay evidence, a populous Indian village existed subsequent to 1838. Cañizares expressly states in his reconnaissance report that he made four visits to an Indian rancheria on the south bank of Carquinez Strait, near the west end, and that he counted there about 400 souls. See *The March of Portolá*, pp. 39-68.

[31] A fragment of a rectangular, three-legged metate like those common to Middle America was also found in or upon one of the mounds at West Berkeley.

[30] Southall, J. C., Recent Origin of Man, p. 550.

and that others have been started in later times to take their places, it is probable that the present number, about four hundred, is not so very far out of the way. If we may then judge at all from the number of house pits found on some of the mounds, the group as a whole may easily average, say five houses to the mound; and estimating six individuals to each house or family we get a population of twelve thousand. Such a figure may seem a little startling at first, because every observer will recognize that the territory in question could not support such a population at the present time. Still there seems to be no inherent reason why under former natural conditions a perfect utilization of all the resources should not have maintained from ten to twenty thousand individuals of mixed age. The figure at all events is not so extraordinary in view of the fact that the estimated total of the aboriginal population for the entire state of California has recently been set by Dr. C. H. Merriam at about two hundred and sixty thousand.[32]

[32] *Amer. Anthropologist* (n. s.), Vol. VII, No. 4, p. 594.

MAP
of
SAN FRANCISCO BAY REGION
showing
DISTRIBUTION
of
SHELL HEAPS

km
miles

LEGEND

- ● MOUNDS STILL PRESENT
- ○ MOUNDS DISAPPEARED
- △ MINOR CAMP SITES

NAPA
SHELLVILLE
PETALUMA
FAIRFIELD
SUISUN
CORDELIA
LAKEVILLE
San Antonio Cr.
NAPA JUNCTION
PETALUMA CREEK
NAPA R.
NOVATO
PETALUMA PT.
VALLEJO
MARE ISL
SAN PABLO BAY
SUISUN BAY
IGNACIO
BENICIA
CARQUINEZ STR
CROCKETT
PORT COSTA
SACRAMENTO & SAN JOAQUIN RVS
RODEO
Rodeo Cr.
MARTINEZ
PINOLE PT.
PINOLE
SAN PEDRO PT.
CONCORD
SAN RAFAEL
SAN PABLO STRAIT
SAN PABLO PT.
Potrero Hill
San Pablo Cr.
Wildcat Cr.
MT TAMALPAIS
RICHMOND
MILL VALLEY
TIBURON PEN.
BROOKS ID.
BERKELEY
BOLINAS BAY
RICHARDSON BAY
RACCOON STR
ANGEL ID.
SAUSALITO
ALCATRAZ ID.
GOLDEN GATE
GOAT ID
OAKLAND
SAN FRANCISCO BAY
SAN FRANCISCO
ALAMEDA
AVISADERO PT (Hunters Pt)
Islais Cr.
San Leandro Cr.
CHABOT L.
SAN LEANDRO
COLMA
HAYWARDS
MUSSEL ROCK
SOUTH SAN FRANCISCO
SAN BRUNO PT
S. P. R. R.
SAN BRUNO
MILLBRAE
San Mateo Pt.
SAN MATEO
Alameda Cr.
Coyote Hills
MONTARA PT.
BELMONT
SANTA CRUZ MTS
REDWOOD
COYOTE R.V.
PILLAR PT
HALF MOON BAY
San Francisquito cr.
PALO ALTO
ALVISO
MAYFIELD
CASTRO
Guadalupe cr.
MOUNTAIN VIEW
PACIFIC OCEAN

40' 35' 122°30' 25' 20' 15' 10' 05' 122°00' West of Greenwich

EXPLANATION OF PLATE 32.

Fig. 1.—Mound no. 75, situated at the edge of the marsh in the mouth of a small side canyon, on the north side of Ross Valley. The mound adjoins a peculiar isolated rock outcrop. Diameter of mound 100×150 ft. through the base; height about 15 ft. View looking north.

Fig. 2.—Mound no. 10, situated on the highland edge of the marsh, below Mill Valley. Dimensions 200×450 ft. through the base; height 20 ft. Diameter of the truncated top 90 ft. View looking southeast.

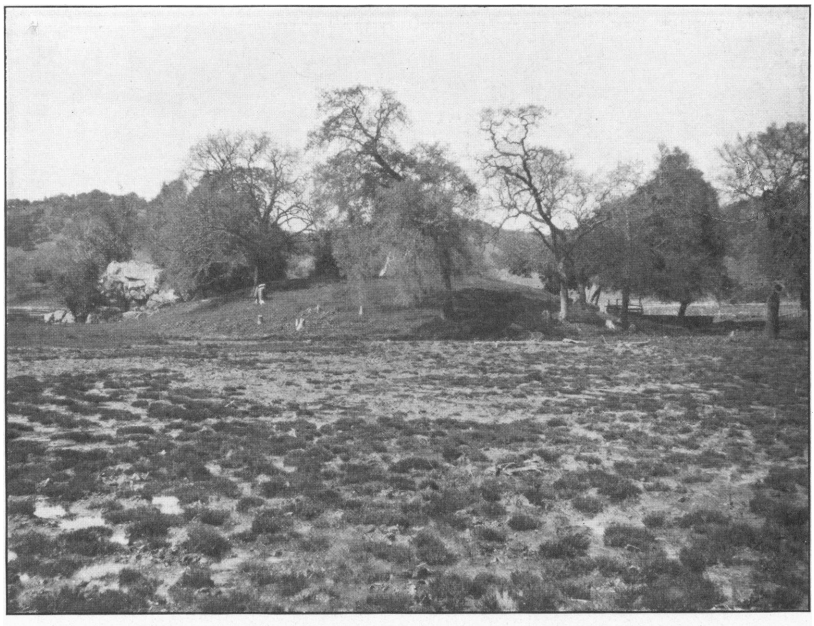


Fig. 1.

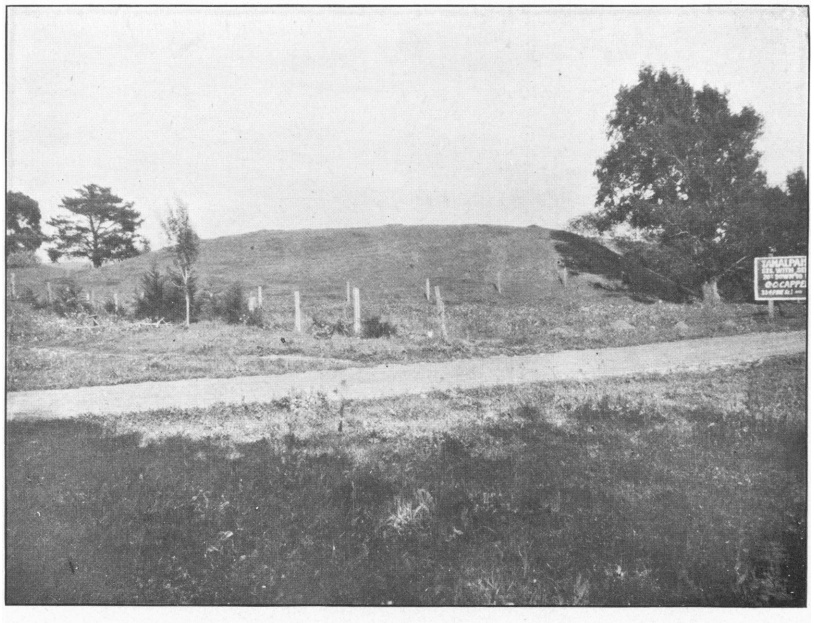


Fig. 2.

EXPLANATION OF PLATE 33.

Fig. 1.—Mound no. 271, situated on the south bank of San Pablo Creek. Dimensions 240×300 ft.; height about 12 ft.; total depth of the shell over 20 ft. The mound has been cultivated for more than fifty years. View looking east.

Fig. 2.—Mound no. 295, situated on the shore edge of the marsh at Ellis Landing, near Richmond. Dimensions 245×460 ft.; height prior to excavation 17 ft.; base of the mound is 11-18 ft. below sea level. View looking southeast across the marsh and bay at flood tide.



Fig. 1.

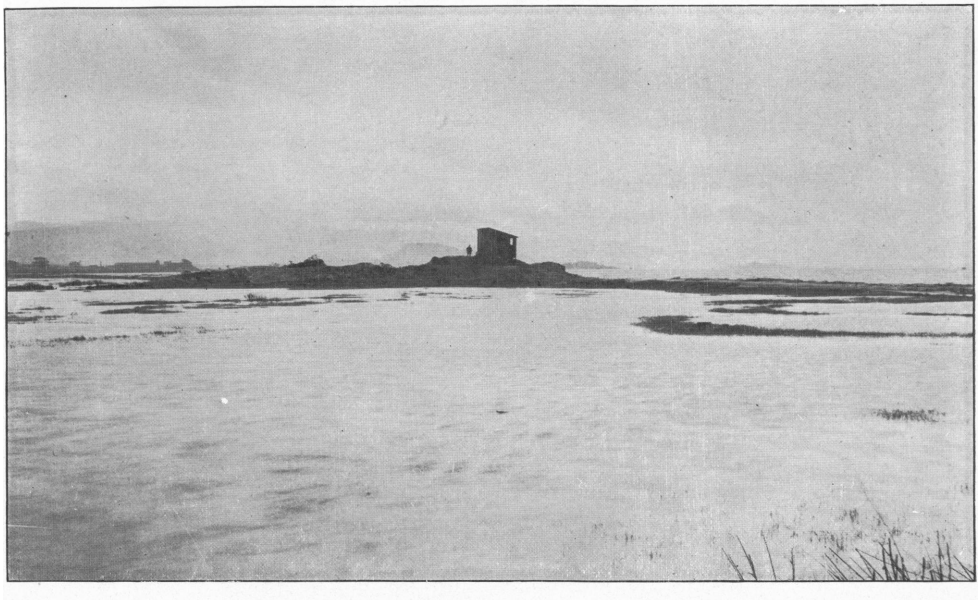


Fig. 2.

EXPLANATION OF PLATE 34.

Fig. 1.—Mound no. 283, situated at Chinese Camp, on the west side of Potrero San Pablo. The deposit lies on a clay slope 7-8 ft. higher than the beach. Present dimensions about 150×200 ft.; height 9 ft. The seaward extension of the mound may possibly lie buried in the tide flat off shore. View looking northwest.

Fig. 2.—Mound no. 290, situated on the shore near the northwestern extremity of Brooks Island. The deposit lies on a slope consisting partly of solid rock, and extends 15 ft. below high tide level. The visible portion extends 210 ft. along the beach and rises 12 ft. above the beach level. View looking southeast.

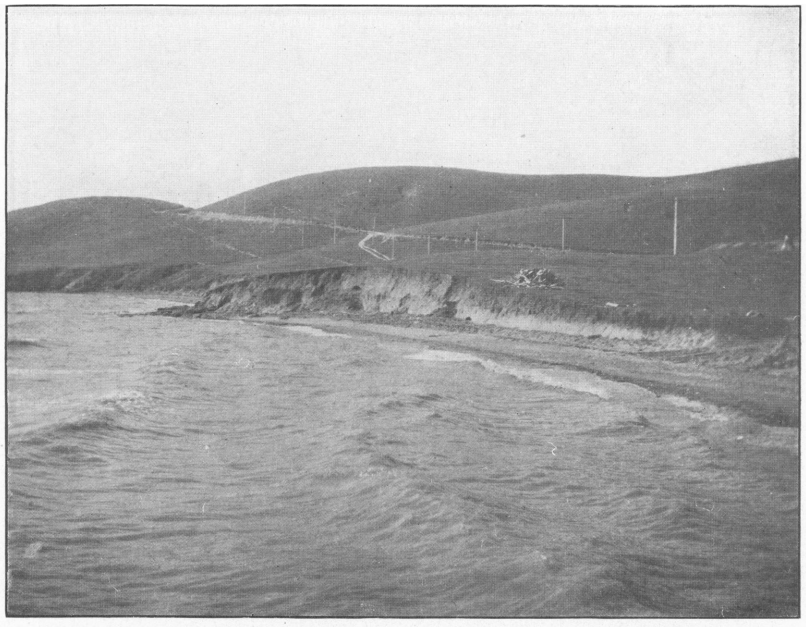


Fig. 1.

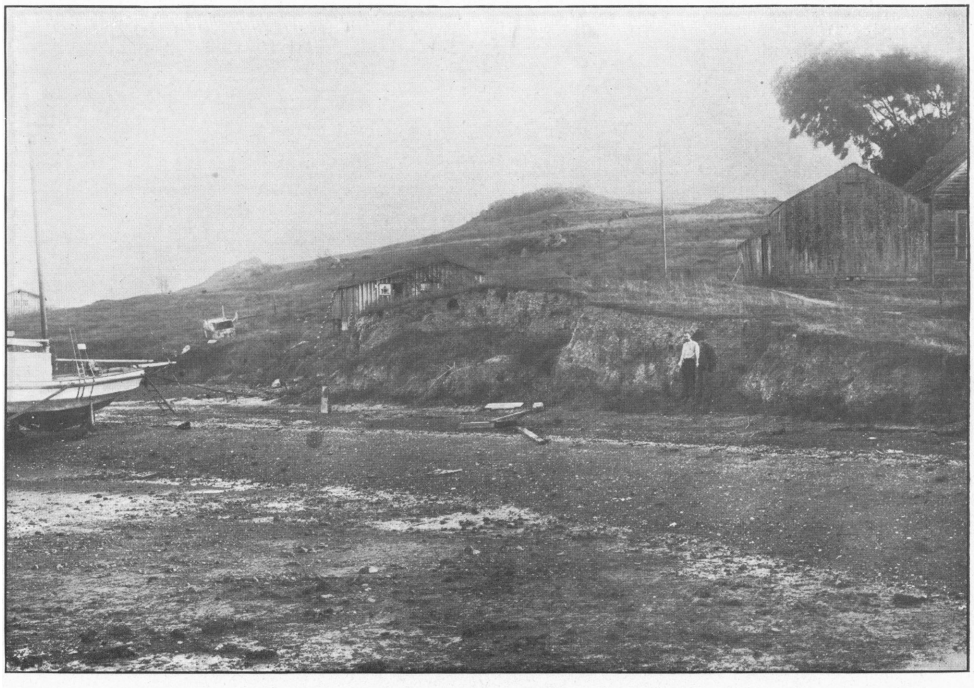


Fig. 2.

EXPLANATION OF PLATE 35.

Fig. 1.—Mound no. 372, situated at the marsh edge, corner of Poplar avenue and H street, San Mateo. Dimensions 150×225 ft. through the base; height may have been as much as 12-15 ft. Made up largely of oyster shells. Shells now being screened and put to various uses. View looking northeast.

Fig. 2.—Illustration of a large sand dune rising about 20 ft. out of the reclaimed tule lands near the western extremity of Bradford Island. This island is encircled by various channels of the San Joaquin River a short distance east of the point where this river joins with the Sacramento, to enter Suisun Bay. Prior to reclamation, the lowlands, which are composed almost entirely of solid peat up to 50 ft. in depth, were continually flooded; but nearly all of these peculiar eminences appear to have been occupied by the aborigines. View looking south.



Fig. 1.



Fig. 2.

AMERICAN ARCHAEOLOGY AND ETHNOLOGY.—Continued.

Vol. 7. No. 1. The Emeryville Shellmound, by Max Uhle. Pages 106, Plates 12, June, 1907. . . . . Price, 1.25

No. 2. Recent Investigations bearing on the Question of the Occurrence of Neocene Man in the Auriferous Gravels of the Sierra Nevada, by William J. Sinclair (in press).

No. 3. The Geography and Dialects of the Miwok Indians, by S. A. Barrett (in press).

No. 4. The Ethnography of the Cahuilla Indians, by A. L. Kroeber (in press).

No. 5. A Mission Record of the California Indians, from a Manuscript in the Bancroft Library, by A. L. Kroeber (in press).

GRAECO-ROMAN ARCHAEOLOGY. (Large Octavo).

Vol. 1. The Tebtunis Papyri, Part 1. Edited by Bernard P. Grenfell, Arthur S. Hunt, and J. Gilbart Smyly. Pages 690, Plates 9, 1902 . . . . . Price, $16.00

Vol. 2. The Tebtunis Papyri, Part 2 (in press).

Vol. 3. The Tebtunis Papyri, Part 3 (in preparation).

EGYPTIAN ARCHAEOLOGY. (Quarto).

Vol. 1. The Hearst Medical Papyrus. Edited by G. A. Reisner. Hieratic text in 17 facsimile plates in collotype, with introduction and vocabulary. pages 48, 1905. (J. C. Hinrichs, Leipzig, 25 Marks) . . . . . Price, $8.00

Vol. 2. The Early Dynastic Cemeteries at Naga-ed-Der. Part I, by G. A. Reisner (in press).

Vol. 3. The Early Dynastic Cemeteries at Naga-ed-Der. Part II. By A. C. Mace. (in press.)

Vol. 4. The Predynastic Cemetery at Naga-ed-Der. The Anatomical Material, by Elliott Smith (in preparation).

Vol. 5. The Cemetery of the Second and Third Dynasties at Naga-ed-Der, by A. C. Mace (in press).

Vol. 6. The Cemetery of the Third and Fourth Dynasties at Naga-ed-Der, by G. A. Reisner (in preparation).

Vol. 7. The Coptic Cemeteries of Naga-ed-Der, by A. C. Mace (in preparation).

ANTHROPOLOGICAL MEMOIRS. (Quarto).

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No. 1. The Ruins of Moche.

No. 2. Huamachuco, Chincha, Ica.

No. 3. The Inca Buildings of the Valley of Pisco.

SPECIAL VOLUMES.

The Book of the Life of the Ancient Mexicans, containing an account of their rites and superstitions; an anonymous Hispano-American manuscript preserved in the Biblioteca Nazionale Centrale, Florence, Italy. Reproduced in fac-simile, with introduction, translation, and commentary, by Zelia Nuttall.

Part I. Preface, Introduction, and 80 Fac-simile plates in colors. 1903.

Part II. Translation and Commentary. (In press).

Price for the two parts $25.00

Facsimile of a Map of the City and Valley of Mexico, by Alonzo de Santa Cruz, Cosmographer of Philip II of Spain. Explanatory text by Zelia Nuttall. Map in 7 sheets, 17×20 inches. (in preparation).

The Department of Anthropology, Its History and Plan, 1905. Sent free on application to the Department, or to the University Press.

ASTRONOMY.—W. W. Campbell, Editor. (Lick Observatory, Mt. Hamilton, Cal.)
Publications of the Lick Observatory.—Volumes I–V completed. Volume VI (in progress).

BOTANY.—W. A. Setchell, Editor. Price per volume $3.50. Volume I (pp. 418) completed. Volume II (in progress).

EDUCATION.—Edited by the Department of Education. Price per volume $2.50.

ENGINEERING.—Edited under the direction of the Engineering Departments. This series will contain contributions from the Colleges of Mechanics, Mining, and Civil Engineering. Volume I in progress.

GEOLOGY.—Bulletin of the Department of Geology. Andrew C. Lawson, Editor. Price per volume $3.50. Volumes I (pp. 428); II (pp. 450), III (475) and IV (462), completed. Volume V (in progress).

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CLASSICAL PHILOLOGY.—Edward B. Clapp, William A. Merrill, Herbert C. Nutting, Editors. Price per volume $2.00. Volume I (in progress).

PHILOSOPHY.—Volume I, completed. Price, $2.00.

PHYSIOLOGY.—Jacques Loeb, Editor. Price per volume $2.00. Volume I (pp. 217) completed. Volume II (pp. 215) completed. Volume III (in progress).

ZOOLOGY.—W. E. Ritter, Editor. Price per volume $3.50. Volumes I (pp. 317) and II (pp. 382) completed. Volume III (in progress)

UNIVERSITY CHRONICLE.—An official record of University life, issued quarterly, edited by a committee of the faculty. Price, $1.00 per year. Current volume No. IX.

Address all orders, or requests for information concerning the above publications to **The University Press, Berkeley, California.**

European orders for numbers of the series in American Archaeology and Ethnology may be addressed to Otto Harrassowitz, Leipzig, or R. Friedländer & Sohn, Berlin.

For Report that goes with these HRIS see
Binder labled Alameda County - Misc. Filed under
Historical Architecture Survey Report Part VII B

4608-0001-9999

Prop 68797

FHWA 900927X

NR: 35

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-Ala-880 P.M. 32.6/34.2

__ LISTED __ DETERMINED ELIGIBLE
X APPEARS ELIGIBLE __ APPEARS INELIGIBLE
(Emeryville Historic Industrial District)

IDENTIFICATION

1. Proposed Name Emeryville Historic Industrial District

2. Historic Name N/A

3. Street or rural address various

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number n/a 5. Present Owner various

Address _____ City _____ Zip Code _____

Ownership is: Public ____ Private X

6. Present Use light manufacturing/warehousing Original Use manufacturing/warehousing

DESCRIPTION

7a. Architectural Style Classical/Industrial and Mission Revival

7b. Description: This is an industrial district which developed over the course of about twenty years, from 1907 to 1930. Its original use was primarily manufacturing, with associated warehousing facilities. Presently, many of the large buildings are primarily warehouses with some light manufacturing. The District contains 29 total structures: 23 contributors and 6 non-contributors. Of the contributors, 18 are in the Classical Style or use a Classical vocabulary and 8 of those use a tri-partite massing--a center pavilion with flanking wings. The predominate material is brick. Two large buildings, the Emeryville Warehouse at 1500 Park and the Shervin-Williams Plant at 1450 Shervin, express a concrete frame, the latter with brick curtain wall infill. Several other buildings, including the P.G.& E. properties at 4245 and 4525 Hollis, are concrete. There are also three Mission Revival structures in the District. The remainder of the buildings are primarily brick industrial designs with no strong stylistic qualities. The primary nature of loss of integrity on the part of contributing buildings is filled-in windows and the substitution or addition of roller doors.

See Continuation Sheet 1.

Photographs on separate sheets and with building inventory forms

8. Construction date:
Estimated 1907-1930 Factual ____
9. Architects various unknown
10. Builders: various unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent X Good X Fair X Deteriorated ____

14. Alterations: As noted in 7b.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site X Moved ____ Unknown ____

18. Related features: As noted in 7b.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

The Emeryville Historic Industrial District identified by this report appears eligible for the National Register of Historic Places under criteria A and C on the local level. The significance of the District is based upon the themes of Economic/Industrial development and Architecture. The period of significance is from 1907, just after the first buildings were built, to 1930, by which time the area within the District boundaries contained all of the contributing structures. The boundaries, described in Item 7b, and shown on the attached map, have been drawn--as much as possible--to include only the structures that fall within the period of significance and retain a high degree of integrity. The structures outside of the District boundaries are, for the most part, replacements for buildings that have burned. While they are much newer, they retain the scale and the function of the originals. Thus the setting outside of the boundaries reinforces the industrial feeling of the area but does not contribute to the District's significance.

The Historical Overview of Emeryville in the text of the HASR describes the economic and industrial history of the area. The development of the District began while the race track, the California Jockey Club, was still operating. Its closing, due to the anti-betting law of 1910, gave impetus to the conscious decision on the part of the city Board of Trustees to establish Emeryville as an industrial city, a turning point in its economic history and development. The earliest buildings date from c.1907--they appear on the 1913 Sanborn map. Of the extant buildings, five were built prior to 1920; thirteen additional (extant) buildings had been added by 1925. This was a period of economic prosperity for the country at large, and Emeryville benefited greatly.

See Continuation Sheets 2 and 3.

Locational sketch map:
See Map C, Sheets 3 & 4 of 17 and attached

20. Main theme of the historic resource:

Architecture 2 Arts & Leisure ____
Economic/Industrial 1 Exploration/Settlement ____
Government ____ Military ____ Religion ____
Social/Education ____

21. Sources: See inventory forms for individual properties and bibliography of overview.

22. Date form prepared: March 30, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Hove Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:District

7b. Description

The boundaries of the district, delineated on the attached map, include the buildings on the north side of 45th Street between the Southern Pacific tracks on the west to Haven on the east, those on the south of 45th Street from the Southern Pacific tracks to and including the Del Monte plant on the north side of Park Avenue, and on the south side of Park between Haven on the west and Emery on the east. At Hollis, the boundary heads north to the middle of the block, including the Morehouse Mustard plant, and continuing west into the next block to include 4250 Horton. At Horton the boundary jogs north to Sherwin, then south on Hubbard to Park taking in 1545 Park and 4067 and 4070 Halleck, and extending west of Halleck to include 1550 on the north side of Park. From the Sherwin-Williams plant north of Sherwin Avenue the boundaries extend north to include 4525-4529 Horton.

The Emeryville Historic Industrial District consists of the following 28 resources.

Resource Number	Inside APE	Address	Date of Construction	Contributor Status
B-14	yes	4070-4076 Halleck	c.1930	C
B-15	no	4224 Holden	c.1930	C
---	no	4333 Holden	c.1945	NC
B-17	no	4202 Hollis	c.1925	C
B-18	no	4221 Hollis	by 1925	C
B-19	no	4224-28 Hollis	c.1929	C
B-20	no	4227 Hollis	by 1930	C
B-21	no	4245 Hollis	1924	C
---	no	4250 Hollis	c.1920	NC
B-22	no	4512 - 4514 Hollis	1923	C
B-23	no	4525 Hollis	1925	C
B-24	no	4250 Horton	c.1925	C
B-25	no	4525-4529 Horton	1924	C
B-29	no	1175-95 Park Avenue	1907	C
B-30	no	1201 Park Avenue	1913	C
B-31	no	1219 Park Avenue	1917	C
B-32	no	1250 Park Avenue	1918	C
B-33	no	1255 Park Avenue	c.1925	C
B-35	yes	1500 Park Avenue	by 1911, 1927	C
B-36	yes	1501 Park Avenue	c. 1935	NC
B-37	yes	1510 Park Avenue	c.1935	NC
B-38	yes	1518 Park Avenue	c.1935	NC
B-39	yes	1526 Park Avenue	c.1925	NC
B-40	yes	1545 Park Avenue	1912	C
B-41	yes	1550 Park Avenue	1917	C
B-50	no	1500 Sherwin	by 1924	C
B-54	no	1290-1266 45th	by 1922	C
B-55	no	1401 45th	by 1913	C
B-56	no	1420 45th	1927	C

Descriptions of the contributors within the APE can be found on the inventory forms for the individual properties. Discussions of contributors outside the APE are included on Continuation Sheets 4-23 of this form.

19. Significance

The history of factory architecture was clearly and succinctly described by one of Albert Kahn's biographers:

> The factory has had varied success in its flirtation with architectural respectability. At the turn of the twentieth century there were very few architects who considered the factory to be worth their notice at all.... By 1912 things had changed, especially in Europe. A number of famous architects and also some on their way to fame expressed their enchantment with the technological age, including the factory as one of its symbols, and backed up their enthusiasm by designing factories. From their enthusiasm grew a body of design theory and accompanying movements. But then in the prosperous twenties the factory returned to the fireside while the other, more elegant stepsisters went to the ball.... During the depression thirties and the years of World War II the factory gained popular attention again, first as a symbol of employment and then as a symbol of patriotism. It became so ubiquitous that it was impossible to ignore, and it has not since entirely lapsed into its neglected state of former days. Yet bookshelves on architecture still yield meager offerings in the field on industrial building.
>
> Certainly the factory has had its role to play, both because of its significant prevalence and because of the particular kinds of design problems and opportunities that it represents....[J]ust before World War I ...in the massive scale to which it had been driven by heavy industry--[the factory] was a relatively new building type and one that was rightly felt to be of great importance to the young country. To many it appeared to be an original and significant building type, which offered new challenges. Thus, if its challenges could be answered with equal originality, it held an unusual degree of promise as the potential father of a new and true architectural genre. (Hildebrand 1974:1-2)

Architecturally the buildings in Emeryville reflect the technology and stylistic trends of the period. Just prior to the turn of the century, Ernest Ransome of San Francisco, designed and had constructed a number of reinforced concrete buildings in California employing his system of reinforcing utilizing twisted bars of square cross section (Hildebrand 1974:32-33). Some years later, the work of Albert Kahn had a national influence on industrial design. "He rigorously analyzed the problem of modern factory design [he built more than two thousand during his long career] and considered such work a legitimate province of the trained architect (Roth 1979:252-253)." His Ford plant at Highland Park, Michigan, which he designed in 1910, frankly revealed its reinforced concrete frame (Roth 1979:251). The Peck and Hills furniture factory (now the Emeryville Warehouse at 1500 Park) and the Sherwin-Williams paint factory both built in the early 1920s employ this "fireproof" technology. Although they followed the Ford plant by over a decade, these buildings represent the latest construction technology. Most of the other buildings in the District are of steel frame construction. Interestingly, the Fisher Body Company plant (now a warehouse at 1255 Park), built in the mid-1920s, utilized wood-frame construction, and thus contrasts sharply with that firm's Kahn-designed, reinforced-concrete Detroit plant. Three buildings in the District, built in 1930, (4070 and 4076 Halleck) are clad with enamel-coated, pressed-metal panels. Thus the District contains the full range of contemporary technology.

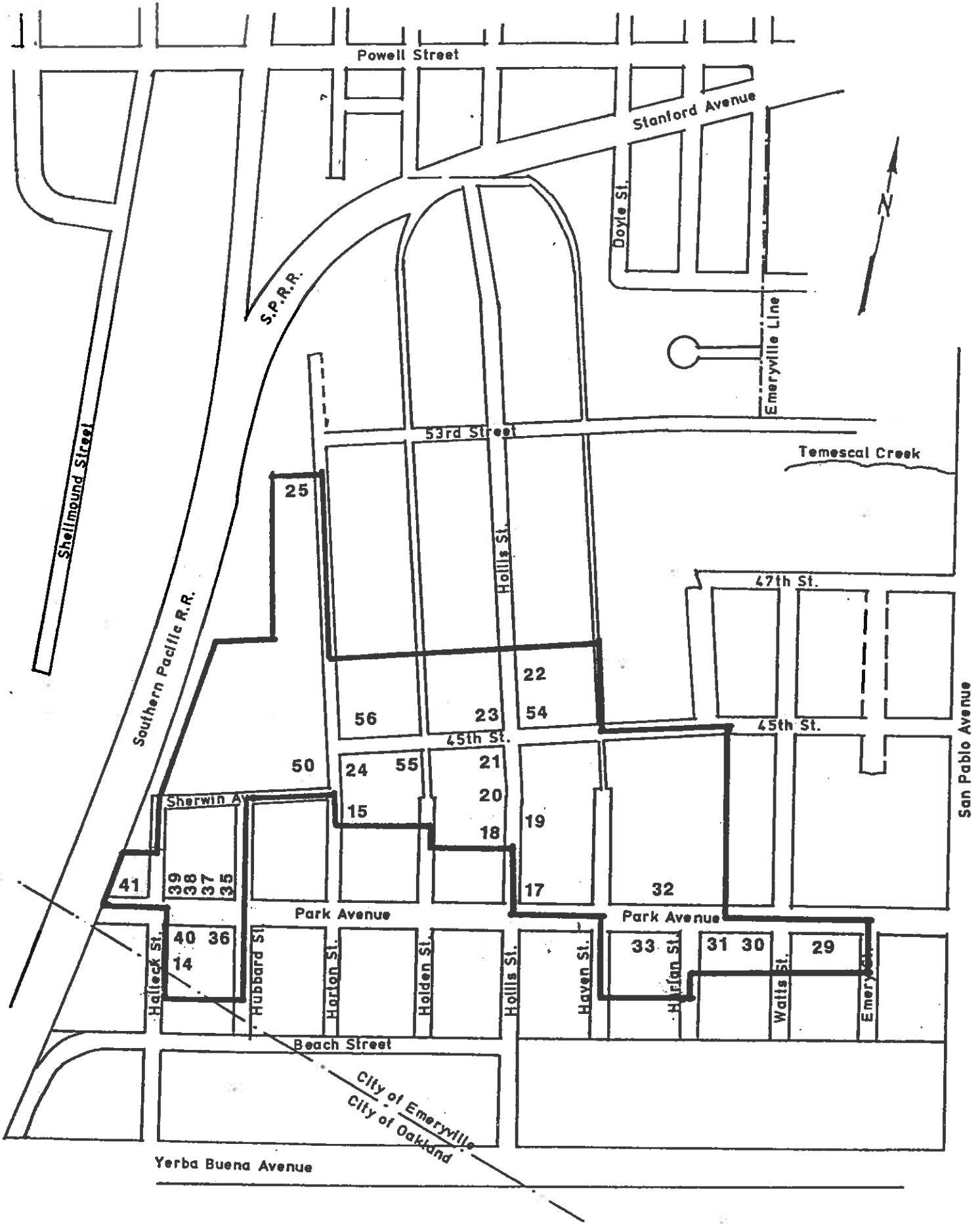
Stylistically, the period (1907-1930) was dominated by historicism which usually applied to public buildings, institutions, or corporate offices. Kahn, as well as Bertram Goodhue and Ralph Adams Cram, utilized Classical, Romanesque, and Gothic vocabularies (among others) in these designs. Although they are factories, many of the brick (steel frame) buildings, in Emeryville reflect this historicized design approach. In Emeryville, however, it is restricted to Classical references. While some structures contain few or no references, Air Reduction Sales Company (now Pelco Distributors at 1550 Park) is so fraught with them that it is difficult to characterize the style in a few words. In addition to the Classical styling, tri-partite massing is characteristic of the District. This is displayed in eight of the Classical buildings and consists of a center pavilion flanked by wings.

19. Significance, continued.

The integrity of the District is excellent. All but four of the structures within the District boundaries fall within the period of significance. Those with some loss of integrity have blocked-up windows but the fenestration pattern is still evident. Despite some shifting of tenancy and use, the District remains industrial with some of the original businesses still occupying the same premises. Sherwin-Williams Paint Company, which moved into Emeryville in the 1920s, is still operating its plant in the same location, as are the Morehouse Mustard Company and the Pacific Gas and Electric Company material manufacturing plant.

Item 19 (continued)

Emeryville's industrial area extends beyond the historic district boundaries, and constitutes it setting. Although differing in age and style from the buildings within the district, the surrounding industrial and warehouse buildings continue the scale, use, and in some cases, the materials, of the historic buildings.



EMERYVILLE HISTORIC INDUSTRIAL DISTRICT

04—ALA—880 Subarea B

Emeryville, California

4608-0001-0002
Prop 83969
NR: 3D



Resource # B-15, Map C, Sheet 4 of 17
4224 Holden Street

Brick. This small structure is at the rear of Morehouse Mustard, facing Holden. Its present occupant is a fire extinguisher company.

part of a District - see

4608-0001-9999

Continuation sheet 5
EMERYVILLE HISTORIC INDUSTRIAL DISTRICT
CONTRIBUTING PROPERTIES OUTSIDE AREA OF POTENTIAL EFFECTS

4608-0001-0003
Prop. 83973
NR: 3D



Resource # B-17, Map C, Sheet 4 of 17
4202 Hollis Street

Brick, Classical vocabulary, c.1925. It was a fish processing facility which was purchased as a research facility by Del Monte when they expanded in the 1930s. In 1967 it was still listed as California Packing Company's (Del Monte) Research Laboratory.

Part of a District. See
4608-0001-9999

4608-0001-0004
Prop. 83978
NR. 3D



Resource # B-18, Map C, Sheet 4 of 17
4221 Hollis Street

Brick, in Classical vocabulary. Built prior to 1925. In 1927, Morehouse Mustard completed a two-story brick addition. The office and warehouse were in the front brick building; the factory in the rear iron-clad frame building. Morehouse still occupies the building.

Part of a District. See
4608-0001-9999

4608-0001-0005
Prop. 83977
NR: 3D

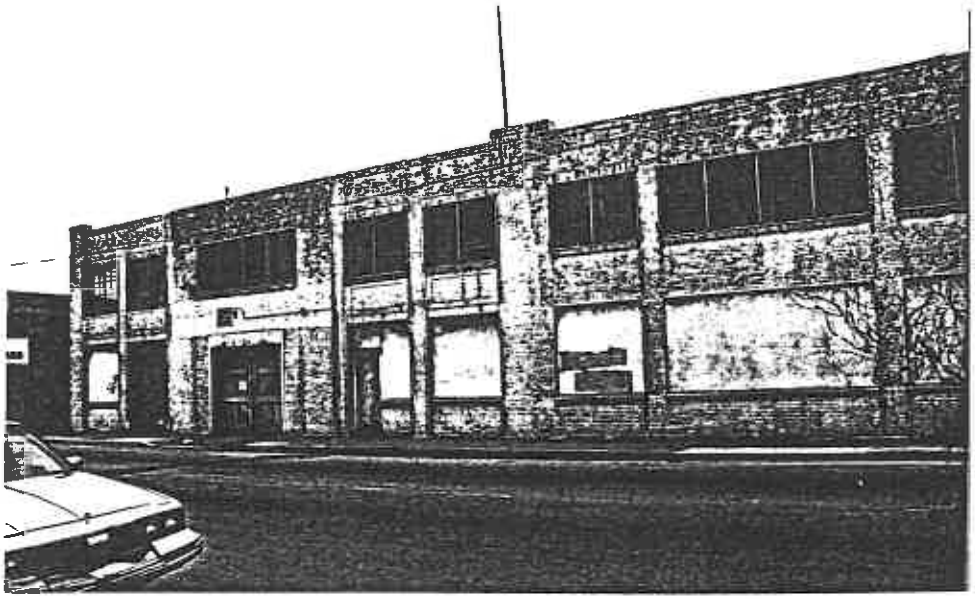


Resource # B-19, Map C, Sheet 4 of 17
4224-28 Hollis Street

Brick. This was a machine shop and warehouse for Gardner Electric Company from 1929 to at least 1943. Some loss of integrity due to blocked windows.

Part of a District. See 4608-0001-9999

4608-0001-0006
Prop839F1
NR.3D

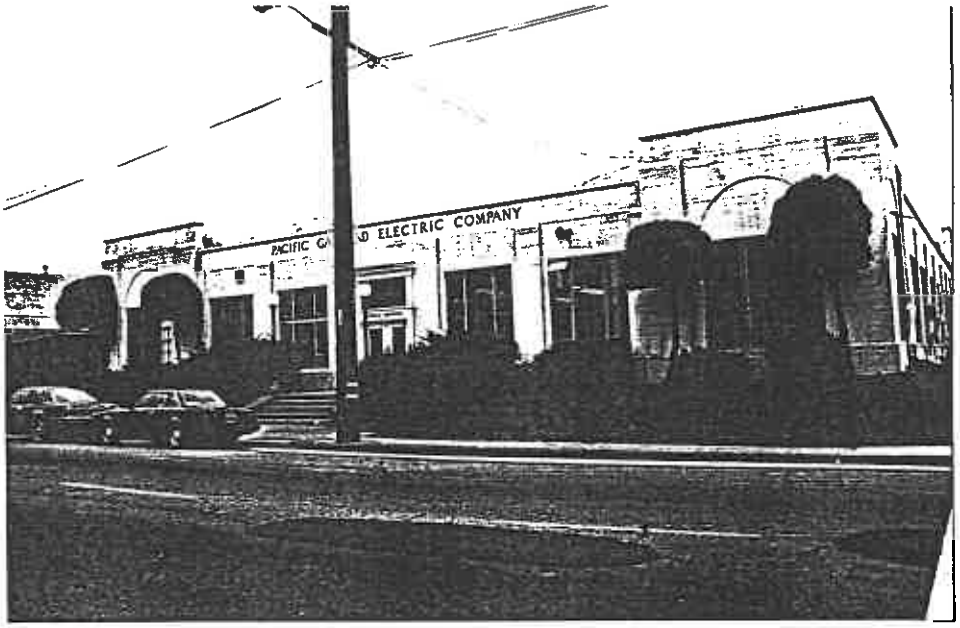


Resource # B-20, Map C, Sheet 4 of 17
4227 Hollis Street

Brick and steel frame, Quonset hut roof. Listed as an electric shop on the 1930 Sanborn Map, the 1933 Directory lists the occupant as Gardner Electric, manufacturers of special transformers and electronic equipment. Later (by 1967) the building served as a warehouse for Pacific Gas and Electric. Some loss of integrity due to blocked windows.

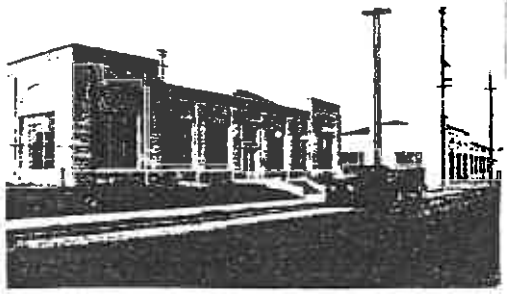
Part of a District. See
4608-0001-9999

4608-0001-0007
Prop 83989
NR:3D



Resource # B-21, Map C, Sheet 4 of 17
4245 Hollis Street

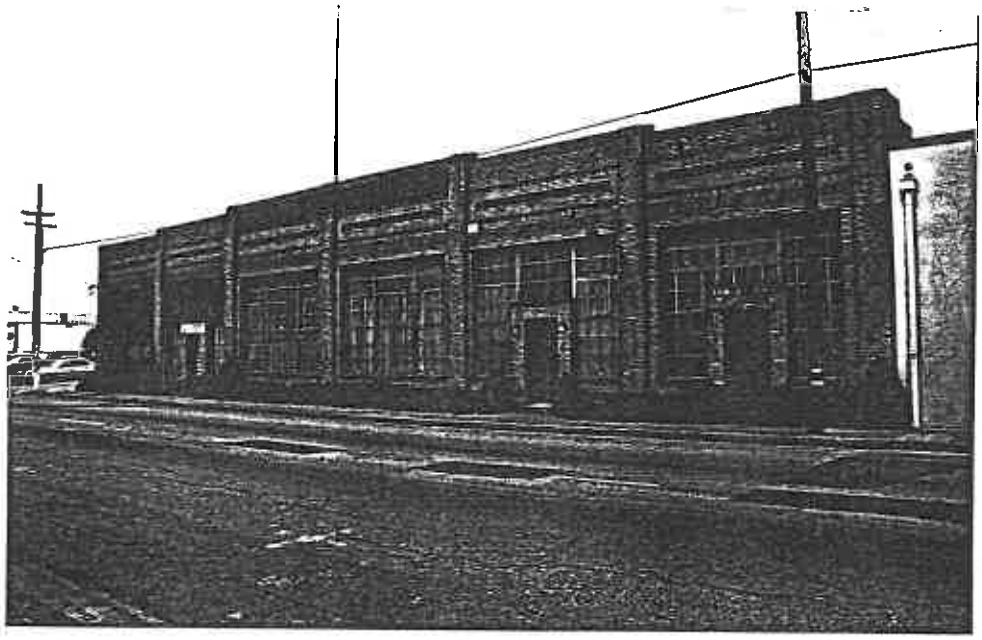
Concrete. Built in 1924 as Pacific Gas and Electric Company's "Laboratories and Testing Plant."



Historical View c. 1940

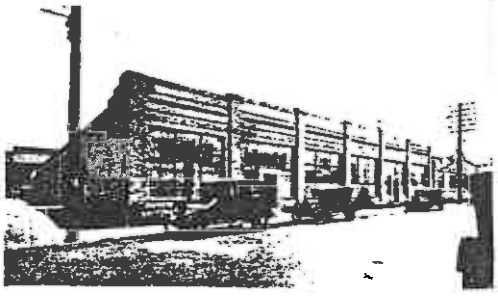
Part of a District - See
4608-0001-99999

4608-0001-0008
Rep 83944
NR: 3D



Resource # B-22, Map C, Sheet 3 of 17
4512 - 4514 Hollis Street

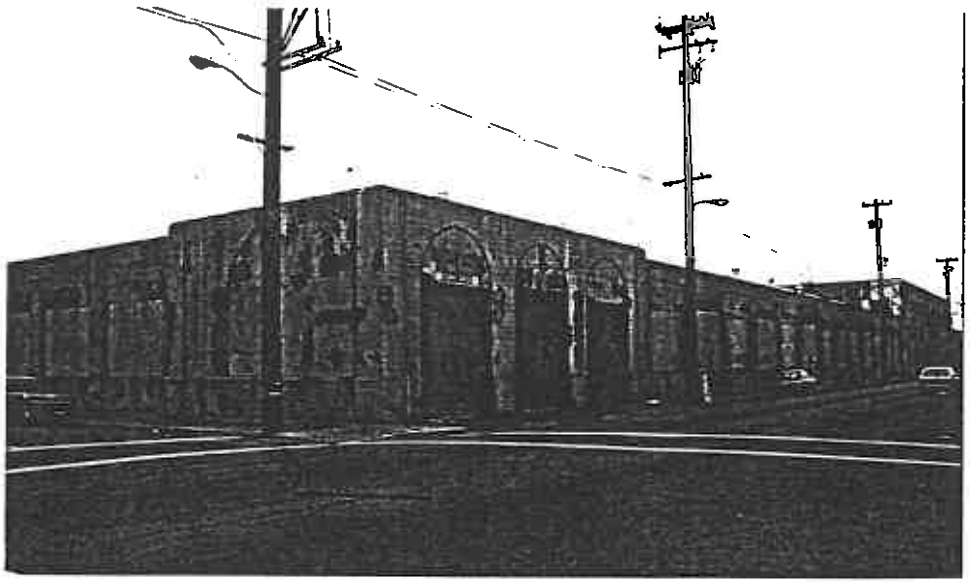
Brick. This structure was built in 1923 by the J. R. Watkins Soap Company at a cost of $40,000. (The company also made extracts, medicinals, and toilet preparations.) In 1924, they added a warehouse and terminal facility. The Cleaning Compound Packing Company occupied at least part of the building in 1930. They were still shown at this address in the 1941 Directory.



Historical View C. 1940

Part of a District See 4608-0001-9999

4608-0001-0009
Prop 83996
NR:3D



Resource # B-23, Map C, Sheet 3 of 17
4525 Hollis Street

Concrete, Classical vocabulary. Built in 1925 as P.G.& E.'s central warehouse. It was the second largest single industrial project in Emeryville that year, having cost $135,000. Additions were made in 1928. Some loss of integrity has resulted from blocked windows.

4608-0001-0010
Prop 84000
NR:3D



Resource # B-24, Map C, Sheet 4 of 17
4250 Horton Street

Rug Brick, Classical. No information available on this structure.

Part of a District - See
4608-0001-9999

4608-0001-0011
Prop 84001
NR 3D



Resource # B-25, Map C, Sheet 3 of 17
4525-4529 Horton Street

Reinforced concrete, Mission Revival. No information available on this structure

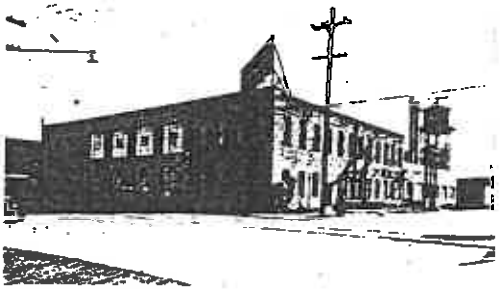
Part of a District - See
4608-0001-9999

4608-0001-0012
Prop 84002
NR:3D



Resource # B-29, Map C, Sheet 3 of 17
1175-95 Park Avenue

Brick, Classical vocabulary. Built in 1907, this two-story building housed the American Rubber Manufacturing Company. The company was founded in Emeryville, in 1906 by N.S. Dodge. The 1911 Sanborn shows 1 1/2 story building, of indeterminable material, on the same site. Linde Air Products was located in a one-story portion at the rear as of 1926.



Historical View, c. 1940

Part of District - See 4608-0001-9904

4608-0001-0013
Prop84003
NR:3D



Resource # B-30, Map C, Sheet 4 of 17
1201 Park Avenue

Brick, Classical. Built in 1913 by the California Cracker Company who carried out $4000 worth of additional construction in 1924. A 1915 publication described it as "one of the newest and best equipped plants on the coast" whose crackers and biscuits were sold throughout the west. By 1941, the premises were occupied by the Oakland Folding Paper Box Company, (previously called the A. N. Hines Company) who by 1967 had moved to 1219 Park. At that time, Dahl Biological Supply was warehousing in this building.



Historical View, c. 1940

Part of a District - See 4608-0001-999c

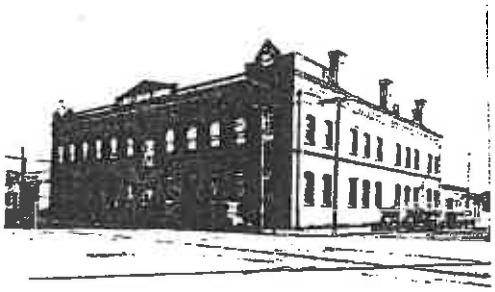
4608-0061-0614

Prop
NR:3D



Resource # B-31, Map C, Sheet 4 of 17
1219 Park Avenue

Brick, Classical. Built in 1917 the building housed the People's Bakery Company. By 1967 this building was occupied by Oakland Folding Box Company, which had previously (since the 1940s, at least) been at 1201 Park.



Historical View, c. 1940

Part of a District - See 4608-0001-9999

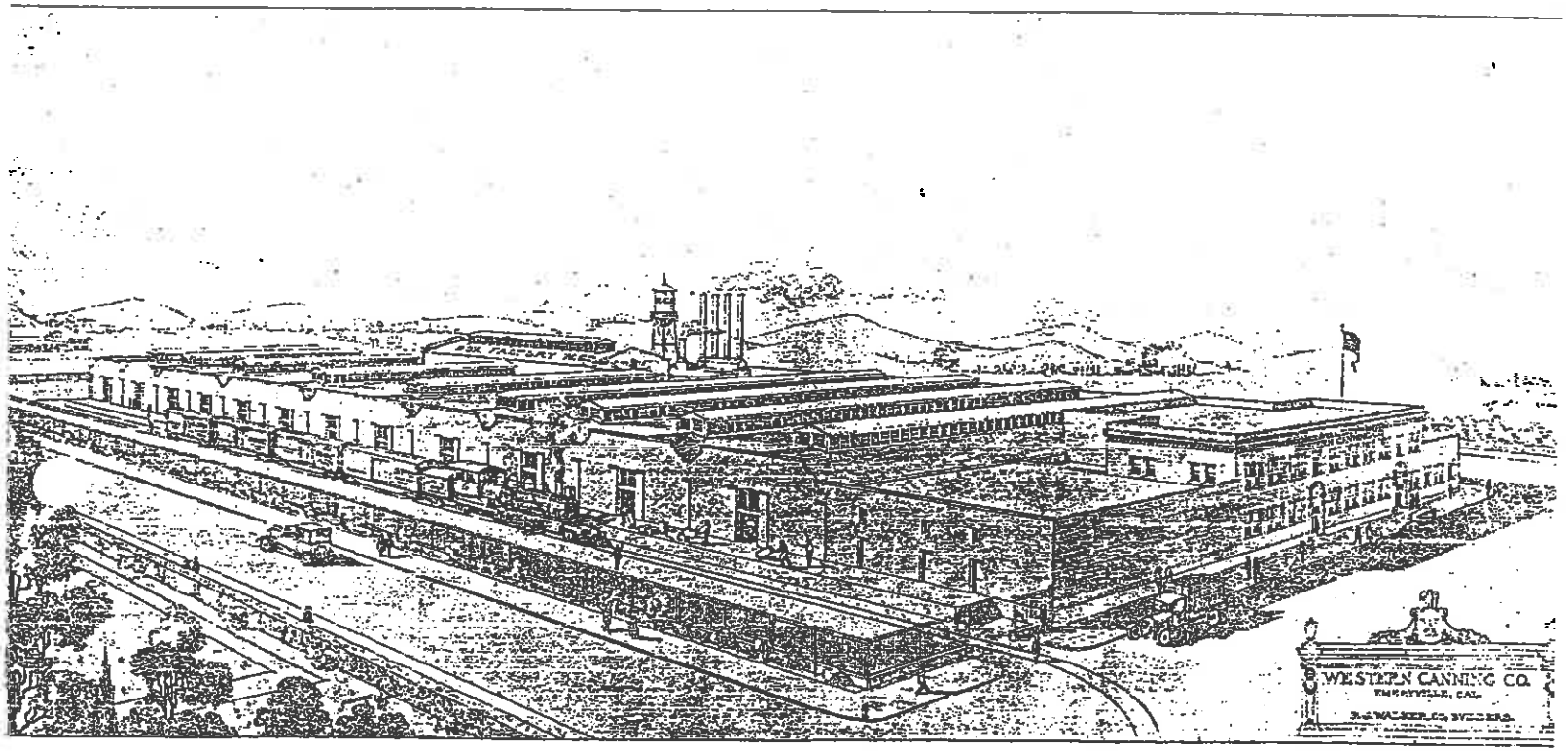
4608-0001-0015
Prop84005
NR:3D



Resource # B-32, Map C, Sheet 4 of 17
1250 Park Avenue

Brick, Classical vocabulary, tri-partite massing. Built in 1919 by a group of Chinese investors at a cost of one million dollars. Upon completion, it was operated by them (Chin Hing, President; Thomas Nom, Vice President and manager; H. P. Chan, Secretary and Treasurer) as the Western Canning Company, producing the "West Best" brand of fruits and vegetables. It was soon sold to Virden Canning Company, packers of meat and fish. In 1927, it was sold to the California Packing Corporation (Del Monte), who started packing peaches. There were 22 small frame dwellings for workers, a kindergarten, and a playground located behind the plant. In 1933, additions were made as the company began packing fruit cocktail. The company added to their lines with Fruits for Salad in 1938, Fruit Cup in 1970, Chunky Mixed Fruit in 1979, Fruit Cup Diced Pear and Pineapple Tidbits in 1986, and Fruit Cup GEL in 1987.

Part of a District. Please see
4608-0001-9999

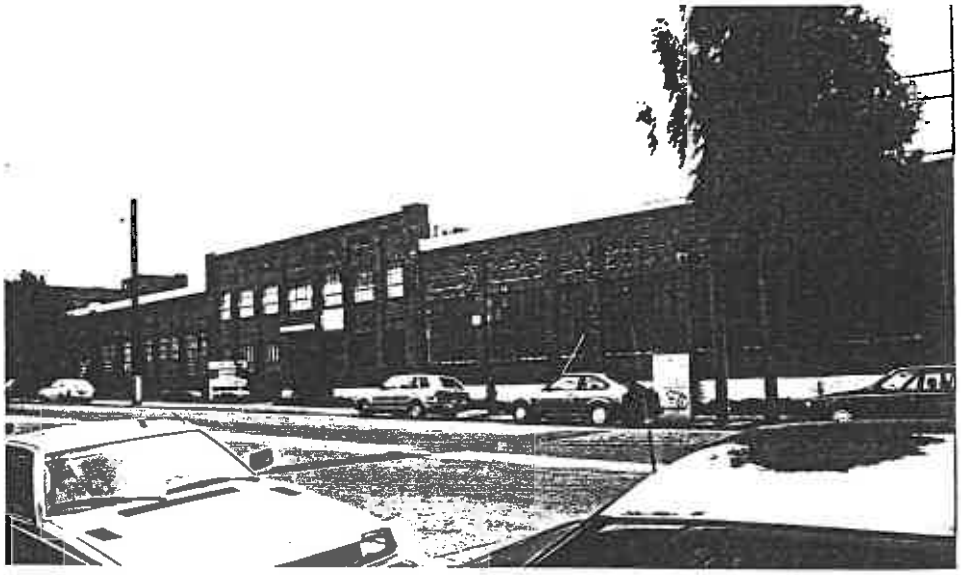


Historical View, 1919



Historical View, c. 1940

4608-0001-0016
Resp. 8400L
NR:3D



Resource # B-33, Map C, Sheet 4 of 17
1255 Park Avenue

Brick, Classical tri-partite massing. Built in the 1920s. New construction for Fisher Body Company totaled $100,00 in 1928. By the time of its completion in 1929, the building had cost $250,000. In 1936, the building was occupied by United Autographic Register Company, commercial printers.

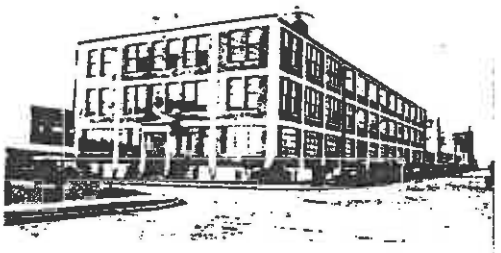
part of a District.
See 4608-0001-9999

4608-0001-0024
Prop 84031
NR. 3D



Resource # B-50, Map C, Sheet 4 of 17
1450 Sherwin Street (Originally Shellmound Avenue)
Sherwin-Williams

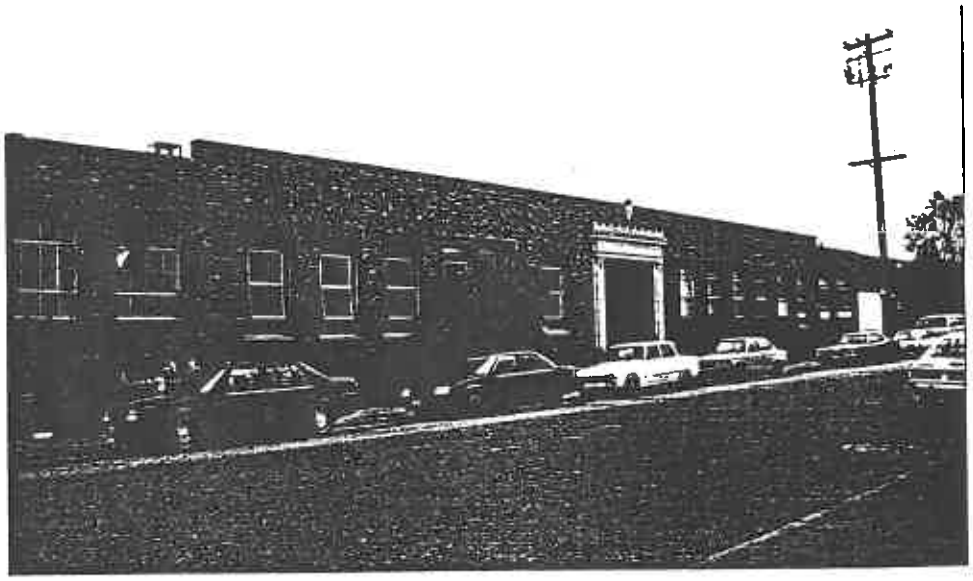
"Fireproof" reinforced concrete with brick curtain wall. Built prior to 1924 when Sherwin-Williams did $7,000 worth of construction. Extensive additions were constructed in 1927, and in 1936, they added a three-story steel-frame and concrete factory and warehouse building. The original entry door, located on Shellmound, was a Classical portico, fully pedimented and supported on columns. The pediment was topped by a three-dimensional paint can and globe--the company's logo. The Plant expanded again in 1939.



Historical View, c. 1940

Part of a district. See 4608-0001-9999

4608-0001-0027
Prop 84034
NR:3D

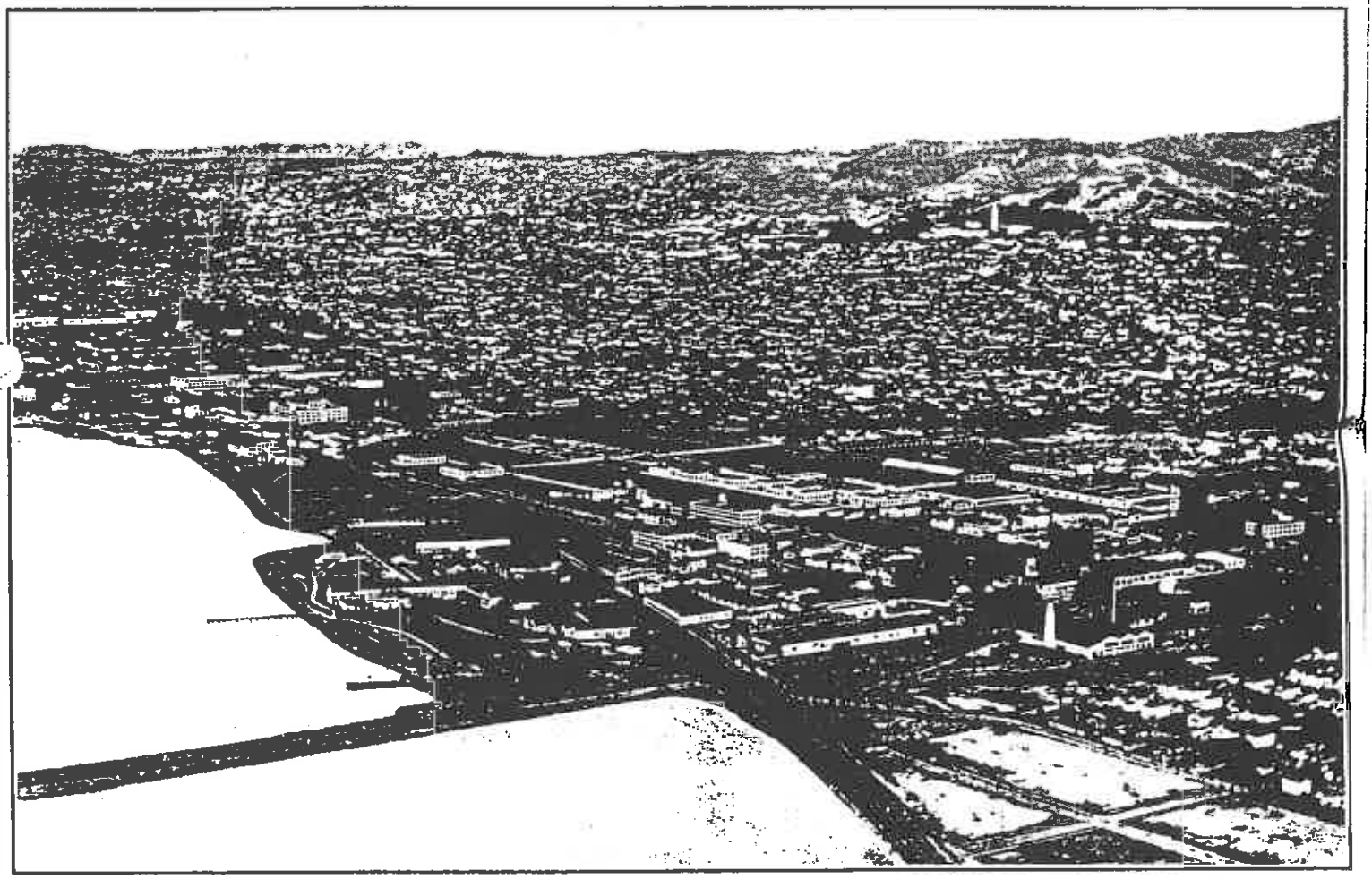


Resource # B-56, Map C, Sheet 4 of 17
1420 45th Street

Brick and terra cotta. Built in 1927 at a cost of $75,000. It was the Kirsch Manufacturing Company's curtain rod plant. A terra cotta cartouche, over the classical terra cotta entry, is decorated with Kirsch's Spencerian script "K."

part of a district
see 4608-0001-9999

"Where They Work and Where They Live"



Aeroplane photo showing in the foreground a portion of Emeryville's factory district; in the background will be seen the residence districts of Emeryville, Oakland and Berkeley

Historical View of Emeryville, c.1940

4608-0001-0001

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-14

Prop 83960
NR: 3D

__ LISTED __ DETERMINED ELIGIBLE
X APPEARS ELIGIBLE __ APPEARS INELIGIBLE
(Contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name N/A

2. Historic Name Part of Westinghouse Pacific Coast Brake Co.

3. Street or rural address 4070 and 4076 Halleck Street

City Oakland Zip Code 94608 County Alameda

4. Parcel Number n/a 5. Present Owner n/a

Address _____ City _____ Zip Code _____

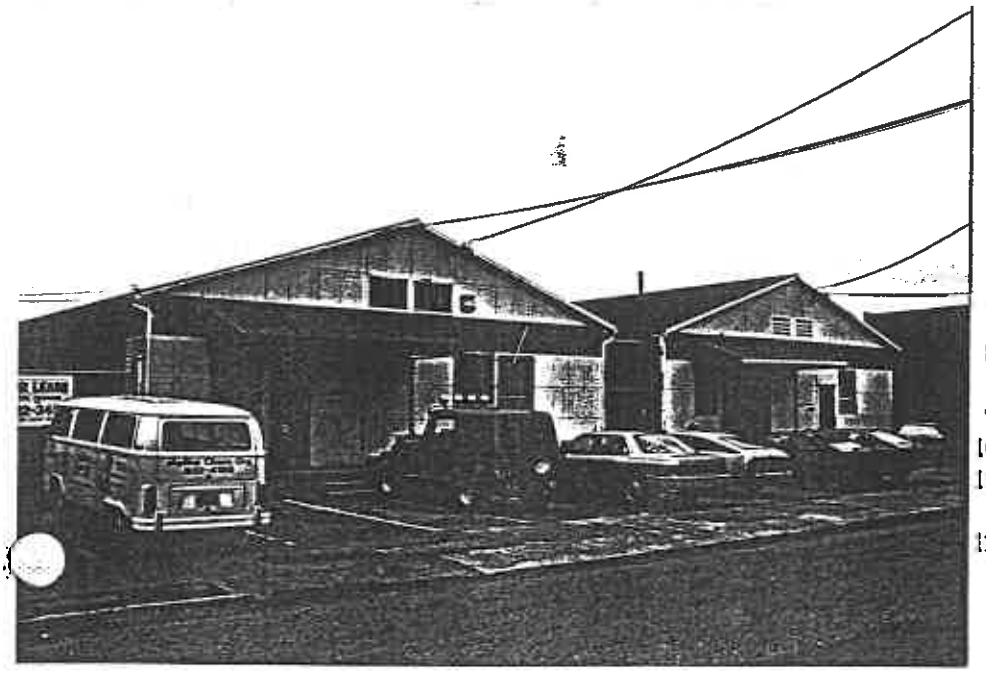
Ownership is: Public ____ Private X

6. Present Use Commercial Original Use Air brake testing and warehousing

DESCRIPTION

7a. Architectural Style N/A

7b. Description: This property consists of two very similar, one-story, front-gable buildings clad in embossed metal panels. The windows are steel frame. Corrugated metal awnings cover a door and 9-light window on the north side of each facade. The south building door is double leafed and half glazed. The north facade also has paired 6/6 double-hung sash, while the south one has a second door and 12/6 sash. The metal panels cladding the buildings are embossed in imitation of framed panels.



8. Construction date:
Estimated 1930 Factual ____
9. Architect unknown
10. Builder: unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent____ Good__X__ Fair____ Deteriorated____

14. Alterations: As noted in 7b.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site__X__ Moved____ Unknown____

18. Related features: Equipment stored in chain link fence enclosure at rear.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

Westinghouse Pacific Coast Brake Co. built these warehouses c.1929 in expansion of their plant at 1545 Park Avenue. The building at 4076 was the air brake testing building; that at 4070 was warehouse space. In 1967, the buildings housed the Northern Can Company warehouse (4070) and King's Imports, Novelties and Toys (4076).

These structures appear eligible for the National Register of Historic Places as contributors to the Emeryville Historic Industrial District. A discussion of these structures in relationship to the District can be found on the District form.

Locational sketch map:
See Map C, Sheet 4 of 17

20. Main theme of the historic resource:

Architecture 2 Arts & Leisure____
Economic/Industrial 1 Exploration/Settlement____
Government____ Military____ Religion____
Social/Education____

21. Sources: Sanborn Map, 1951 update of 1913.

22. Date form prepared: April 3, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Howe Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:B-14

4608-0001-0017
Prop84007

NR:3D

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-35

___ LISTED ___ DETERMINED ELIGIBLE
_X_ APPEARS ELIGIBLE ___ APPEARS INELIGIBLE
(Contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name Emeryville Warehouse Company

2. Historic Name Peck & Hills Company factory and warehouse

3. Street or rural address 1500 Park Avenue

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number n/a 5. Present Owner n/a

Address _____ City _____ Zip Code _____

Ownership is: Public ____ Private _X_

6. Present Use Warehouse Original Use Warehouse

DESCRIPTION

7a. Architectural Style Industrial

7b. Description: This is a seventeen-bay, three-story, poured-concrete structure with huge steel sash windows, fixed, except for the center, awning sections. The Hubbard Street elevation is divided into three sections with a five-bay center pavilion flanked by six-bay wings. Classical styling is achieved by low pedimented parapets at the ends and over the center pavilion. The entry door on the Park Avenue end is capped with a pedimented hood. The window spandrels on the Park Avenue facade are accented by recessed panels. Overhead, roller doors have been inserted in the Hubbard Street side.



8. Construction date:
Estimated ____ Factual 1922,1926
9. Architect unknown
10. Builder: unknown
11. Approx. property size
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent____Good_X_Fair____Deteriorated____

14. Alterations: As noted in 7b.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site_X_ Moved____Unknown____

18. Related features: None noted.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

In 1907, Peck & Hills Furniture Company occupied a wood frame structure located where the central, four-story section is today. In 1922, they built a new three-story, fireproof (reinforced concrete) addition, and in 1923 spent $40,000 more on new construction. Again, in 1926 they spent $75,000 on an addition to their warehouse and salesroom. By 1933, Peck and Hills had moved to a downtown Oakland location. In 1967, the structure was occupied by several tenants including Beauty Line Plastic Store Fixtures, Modern Furniture, Sherwin-Williams Chemistry Department and the Emeryville Warehouse, which name the building presently bears.

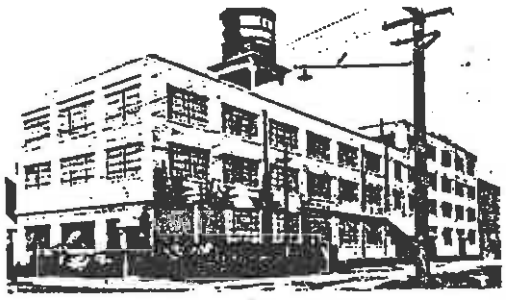
This structure appears eligible for the National Register of Historic Places as a contributor to, and key element in, the Emeryville Historic Industrial District. One of the concrete-frame structures in the District, this building also incorporates the District-defining qualities of Classical styling and tri-partite massing. (See District inventory form for a fuller discussion.)

Locational sketch map:
See Map C, Sheet 4 of 17

20. Main theme of the historic resource:

Architecture_2__Arts & Leisure____
Economic/Industrial_1__Exploration/Settlement____
Government____Military____Religion____
Social/Education____

21. Sources: Sanborn Maps, 1911, 1913.
Oakland Tribune Yearbooks, 1924, 1925, 1928.
Oakland City Directories, 1924, 1926, 1928, 1933, 1934, 1937, 1941, 1943, 1967.
Emeryville Historical Society paper
The History of Park Avenue, Emeryville, p. 9.



Historical view, c. 1940

22. Date form prepared: April 3, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Hove Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:8-35

4608-0001-0018
Prop
NR: 621

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-36

___ LISTED ___ DETERMINED ELIGIBLE
___ APPEARS ELIGIBLE X APPEARS INELIGIBLE
(Non-contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name N/A

2. Historic Name N/A

3. Street or rural address 1501 Park Avenue

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number 49-617-5-7 5. Present Owner E. L. Buttner, Trustee

Address 600 West Grand City Oakland Zip Code 94612

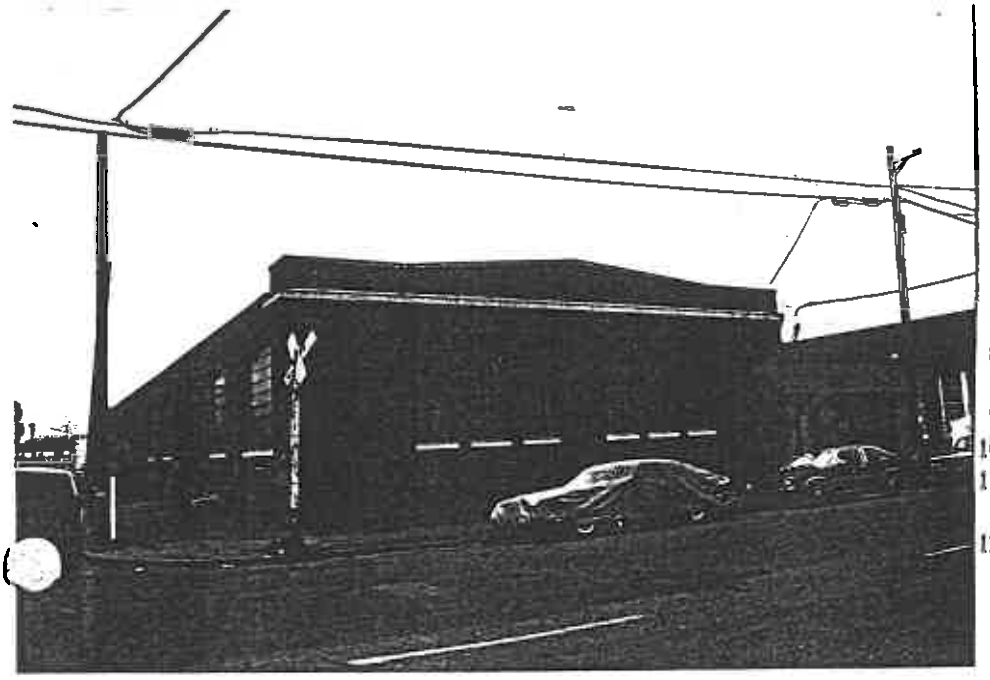
Ownership is: Public ____ Private X

6. Present Use Warehouse Original Use Warehouse

DESCRIPTION

7a. Architectural Style Brick industrial

7b. Description: Subtle Classical styling, in the form of a pedimented parapet, distinguishes this one story brick structure. The parapet rises above a concrete entablature line and is capped by a concrete cornice. Concrete sills support glass brick windows grouped in two recessed bays. The east elevation contains multiple roller doors at truck bed height.



8. Construction date
Estimated 1935 Factual ____
9. Architect unknown
10. Builder: unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent X Good ___ Fair ___ Deteriorated ___

14. Alterations: None noted.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site X Moved ___ Unknown ___

18. Related features: None.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

In 1930, this site was occupied by a building made of corrugated iron on studs. By 1967 Boye Needle Company was occupying the building.

This structure does not appear eligible for the National Register of Historic Places. It does not possess sufficient architectural merit, especially in the context of Emeryville, and was built after the period of significance of the Emeryville Historic Industrial District.

Locational sketch map:
See Map C. Sheet 4 of 17

20. Main theme of the historic resource:

Architecture 2 Arts & Leisure ___
Economic/Industrial 1 Exploration/Settlement ___
Government ___ Military ___ Religion ___
Social/Education ___

21. Sources:
Oakland City Directory, 1967.

22. Date form prepared: April 3, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Hove Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:B-36

4608-0061-0019

Prop 84018

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-37

___ LISTED ___DETERMINED ELIGIBLE NR.621
___ APPEARS ELIGIBLE _X_ APPEARS INELIGIBLE
(Non-contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name N/A

2. Historic Name N/A

3. Street or rural address 1510 Park Avenue

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number n/a 5. Present Owner n/a

Address _____ City _____ Zip Code _____

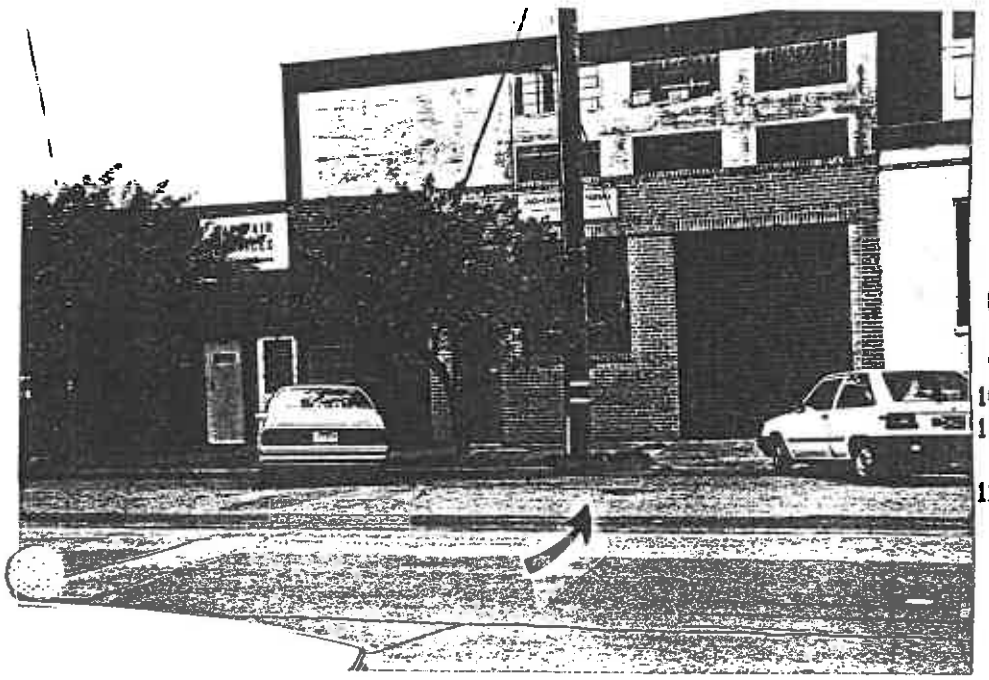
Ownership is: Public ____ Private _X_

6. Present Use Commercial Original Use Commercial

DESCRIPTION

7a. Architectural Style Brick industrial

7b. Description: This single-story, brick building with 4/4 double-hung wood sash is connected to its neighbor 1518 Park Avenue (see Resource No. 38). Entry is gained through a single leaf door and a roller door in the eastern bay. It has flat arches above the fenestration and a cornice consisting of a single header course.



8. Construction date:
Estimated 1930 Factual ____
9. Architect unknown
10. Builder: unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent____Good X__Fair_____Deteriorated____

14. Alterations: None noted.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site__X__ Moved____Unknown____

18. Related features: None noted.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

In 1930 a one-story, reinforced-concrete building occupied this site. It could have been this structure, which may have been faced in brick at a later date. In 1936, 1514 Park was the address of Nasco Soap Products. The 1967 Directory lists Decora Compressors and Spray Paint at 1516 Park indicating a number change at some point. (1518 Park, the next property, was listed with a different occupant.)

Within the boundaries of the Emeryville Historic Industrial District, this structure is a non-contributor as its integrity has been seriously compromised by changes to the facade.

Locational sketch map:
See Map C, Sheet 4 of 17

20. Main theme of the historic resource:

Architecture____Arts & Leisure____
Economic/Industrial_1__Exploration/Settlement____
Government____Military____Religion____
Social/Education____

21. Sources: Sanborn Map 1913 updated to 1951.

22. Date form prepared: April 3, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Hove Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:B-37

4608-0001-0020
Prop 84019

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-38

___ LISTED ___ DETERMINED ELIGIBLE NR: 621
___ APPEARS ELIGIBLE _X_ APPEARS INELIGIBLE
(Non-contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name N/A

2. Historic Name N/A

3. Street or rural address 1518 Park Avenue

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number 49-1035-1 5. Present Owner Eugene Friend et al.

Address 535 Mission Street City San Francisco Zip Code 94105

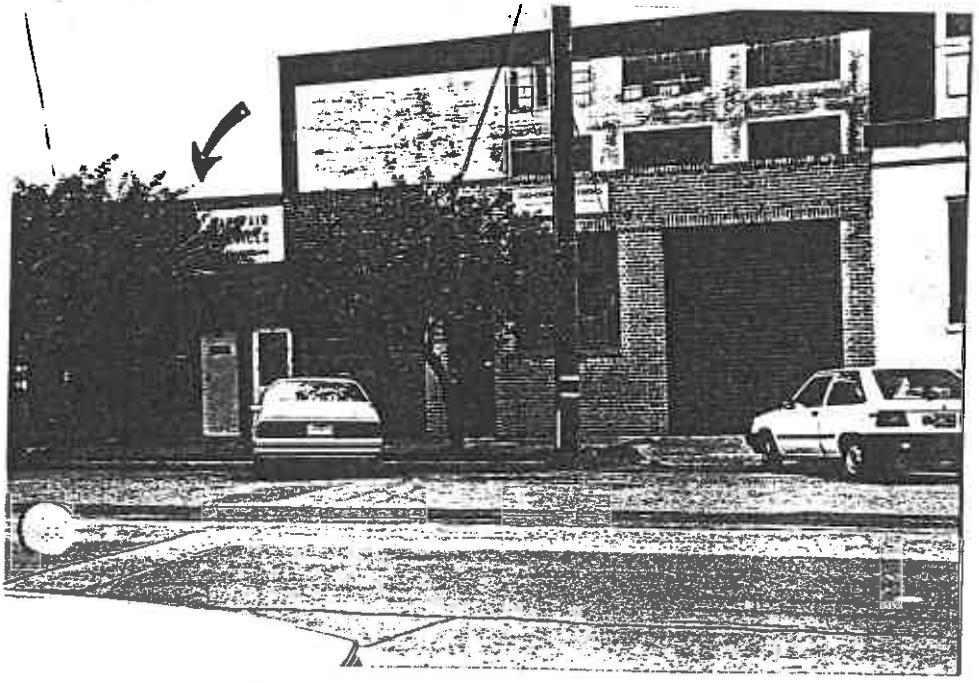
Ownership is: Public ____ Private _X_

6. Present Use Commercial Original Use Industrial

DESCRIPTION

7a. Architectural Style Brick industrial

7b. Description: This is a single-story, brick building with a plywood inset. There are two single-leaf doors in the inset, flanked by two windows. The window on the west is aluminum sliding sash, while that on the west is nine-pane steel sash. The windows on the west elevation are 1/1 double-hung wood sash.



8. Construction date:
Estimated 1935 Factual ____
9. Architect unknown
10. Builder: unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent____Good__X__Fair____Deteriorated____

14. Alterations: As noted in 7b.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site__X__ Moved____Unknown____

18. Related features: None noted.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

In 1950, this building was occupied by Voglesong Products and in 1967 by Healthcraft Corporation.

Within the boundaries of the Emeryville Historic Industrial District, this structure is a non-contributor as its integrity has been seriously compromised by changes to the facade.

Locational sketch map:
See Map C, Sheet 4 of 17

20. Main theme of the historic resource:

Architecture 2 Arts & Leisure____
Economic/Industrial 1 Exploration/Settlement____
Government____Military____Religion____
Social/Education____

21. Sources: Sanborn Map 1913 updated to 1951.
Oakland City Directories, 1941, 1967.

22. Date form prepared: April 3, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Howe Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:B-38

4668-0001-0021

Prop 84021

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-39

__ LISTED __DETERMINED ELIGIBLE NR:621
__ APPEARS ELIGIBLE __X__ APPEARS INELIGIBLE
(Non-contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name N/A

2. Historic Name N/A

3. Street or rural address 1526 Park Avenue

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number 49-1035-2 5. Present Owner Hattie Lestrange, et al.

Address 957 Arlington Way City Berkeley Zip Code 94707

Ownership is: Public ____ Private X

6. Present Use Commercial Original Use Commercial

DESCRIPTION

7a. Architectural Style N/A

7b. Description: This is a large brick building with a stucco facade. The 1/1 double-hung sash windows are covered by wooden screens. The original entry door has been altered by the insertion of horizontal wood siding and a smaller door.



8. Construction date:
Estimated 1925 Factual ____
9. Architect unknown
10. Builder: unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent___ Good X Fair___ Deteriorated___

14. Alterations: As noted in 7b.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site X Moved___ Unknown___

18. Related features: None noted.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

The 1930 update of the 1913 Sanborn Map for this area shows this structure as a Chinese store. Modifications to the windows and door constitute a serious loss of integrity for this simple building.

This structure, of no architectural merit, and lacking in integrity, does not appear to be eligible for the National Register of Historic Places. Within the boundaries of the Emeryville Historic Industrial District, this building is a non-contributor. Further, its former use as a store disqualifies the building for the industrial theme of the District.

Locational sketch map:
See Map C. Sheet 4 of 17

20. Main theme of the historic resource:

Architecture___ Arts & Leisure___
Economic/Industrial___ Exploration/Settlement___
Government___ Military___ Religion___
Social/Education___

21. Sources: Sanborn Map 1913 updated to 1930.

22. Date form prepared: April 3, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Hove Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:B-39

4608-0001-0022
Prop. 84029

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-40

__ LISTED __ DETERMINED ELIGIBLE NR'3D
X APPEARS ELIGIBLE __ APPEARS INELIGIBLE
(Contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name Trader Vic's

2. Historic Name Westinghouse Pacific Coast Brake Co. Machine Shop (1930)

3. Street or rural address 1545 Park Avenue

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number 49-617-5-6 5. Present Owner Trader Vic's

Address same City _____ Zip Code _____

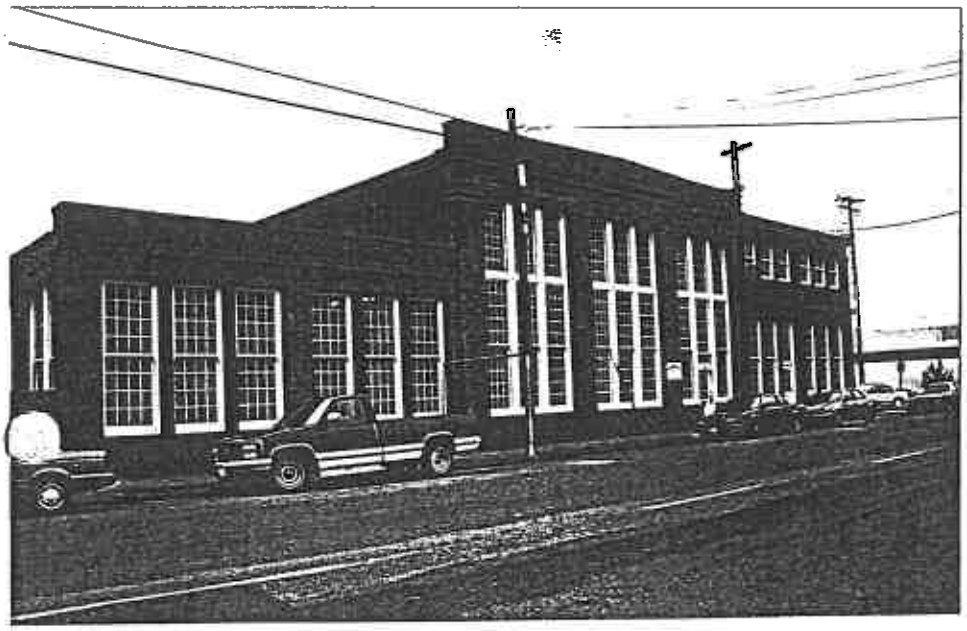
Ownership is: Public ____ Private X

6. Present Use Warehouse Original Use Manufacturing

DESCRIPTION

7a. Architectural Style Classical Revival Industrial

7b. Description: This large warehouse has a three-part facade consisting of a tall center pavilion flanked by wings. The east wing is single story with two sets of grouped (triple) tall 16/16 wood double-hung sash windows with lambs-tongue drops on the meeting rails. The west wing has the same fenestration on the first story and 1/1 double-hung sash on the second. The three-bay center pavilion has grouped, 20/20 double-hung wood sash topped by 24-light fixed pane windows. A nine-light door, topped by a transom, is centered in the western group of windows. Classical in style, the building has a full entablature consisting of a concrete architrave, brick frieze band, and concrete cornice, topped with a pedimented parapet. The entablature, without the parapet, accents the east wing, while the second story acts as the frieze on the west wing. The classical motif is continued in the piers which are topped with capitals. The fenestration pattern of the facade is carried around the sides of the structure. Overhead door bays on the west elevation allow for warehouse functions.



8. Construction date:
Estimated ____ Factual 1912
9. Architect unknown
10. Builder: unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent X Good ___ Fair ___ Deteriorated ___

14. Alterations: The second story on the west wing may be a 1927 addition.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site X Moved ___ Unknown ___

18. Related features: None noted.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

Oakland Tribune Yearbooks indicate that the Westinghouse Pacific Coast Brake Co. plant was at this address in 1925, and that additional warehouse space was added in 1927. The factory produced air brakes, compressors and pneumatic appliances. This business was listed at this address in the 1950 Directory together with the Alvord Company. Trader Vic's had occupied the structure by 1967.

This structure appears eligible for the National Register of Historic Places as a contributor to and because of it high artistic merit, a defining element in the Emeryville Historic Industrial District. For the same reason, it also appears individually eligible under Criterion C. See District inventory form and "Historical Background" for further discussion.

Locational sketch map:
See Map C, Sheet 4 of 17

20. Main theme of the historic resource:

Architecture 1 Arts & Leisure ___
Economic/Industrial 2 Exploration/Settlement ___
Government ___ Military ___ Religion ___
Social/Education ___

21. Sources: Sanborn Map 1913 updated to 1951.
Oakland Tribune Yearbooks, 1926, 1928.
Emeryville Herald 33rd. Anniversary Edition, 1929.
Oakland City Directories, 1941, 1967.
"History of Park Avenue," MS, Don Hausler, p. 9.



Historical view, c. 1940

22. Date form prepared: April 3, 1990
By: Bonnie W. Parks and Denise O'Connor
Organization Caltrans
Address 650 Howe Avenue
City Sacramento Zip Code 95825
Phone 920-7683 Ref. # 04-Ala-880:B-40

4608-0001-0023

Prop 84030

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ARCHITECTURAL INVENTORY/EVALUATION FORM
04-ALA-880 P.M. 32.6/34.2

RESOURCE NUMBER B-41

___ LISTED ___ DETERMINED ELIGIBLE NR-3D
_X_ APPEARS ELIGIBLE ___ APPEARS INELIGIBLE
(Contributor, Emeryville Historic Industrial District)

IDENTIFICATION

1. Common Name Pelco Distributors

2. Historic Name Air Reduction Sales Co.

3. Street or rural address 1550 Park Avenue

City Emeryville Zip Code 94608 County Alameda

4. Parcel Number 49-1036-3 5. Present Owner Pelligrini Refrigeration & Restaurant Equipment

Address same City Zip Code

Ownership is: Public ____ Private _X_

6. Present Use Warehouse Original Use Warehouse

DESCRIPTION

7a. Architectural Style Brick industrial with historicist (Classical/neo-baroque) references

7b. Description: This is a two-story, brick warehouse with a three-part facade consisting of a center section with a gabled parapet, with flanking, three-bay wings. The center section has three, 36-light steel sash windows on the first floor and two small 2-light windows with vertical emphasis on the second floor. The bays of the wings are marked by pilasters. The east wing has pedimented parapets topping each bay, while the west wing lacks the pediments. Decorative tiles are set into the brick of the parapets on both wings. The east wing originally had paired steel sash in each bay of the second story and the first two bays of the first story, however, the second story windows have all been altered--two by being filled in and one by being partially filled in. The smaller, west wing has single 24-light steel sash windows in each bay of the second story and a single 36-light window in the first bay of the first floor. The window on the second story of the east elevation has also been filled in.

Behind the single-loaded, two-story front section just described, is a one-story extension with the same detailing--pilasters and tiles in the parapet. An awning that spans the extension covers steel sash and a loading dock. There are two associated buildings at the rear of the property--an older brick one and a new concrete one.



8. Construction date:
Estimated ____ Factual 1917
9. Architect unknown
10. Builder: unknown
11. Approx. property size
n/a
12. Date(s) of photograph(s)
February 1990

13. Condition: Excellent___ Good X Fair___ Deteriorated___

14. Alterations: As noted in 7b.

15. Surroundings: Commercial, light manufacturing/warehouse

16. Threats to site: Public Works Project

17. The structure is: On its original site X Moved___ Unknown___

18. Related features: As noted in 7b.

SIGNIFICANCE

19. Historical and/or architectural importance, events and persons associated with the site:

This plant apparently began as Air Reduction Sales and the same company still occupied the building in 1950. By 1967, the building was occupied by Gojer Inc., soap manufacturers.

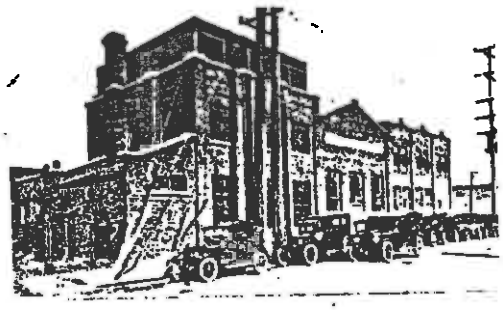
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Locational sketch map:
See Map C. Sheet 4 of 17

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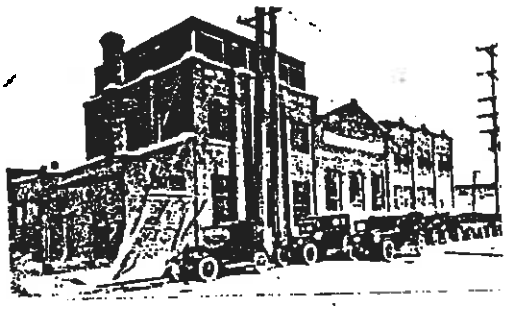
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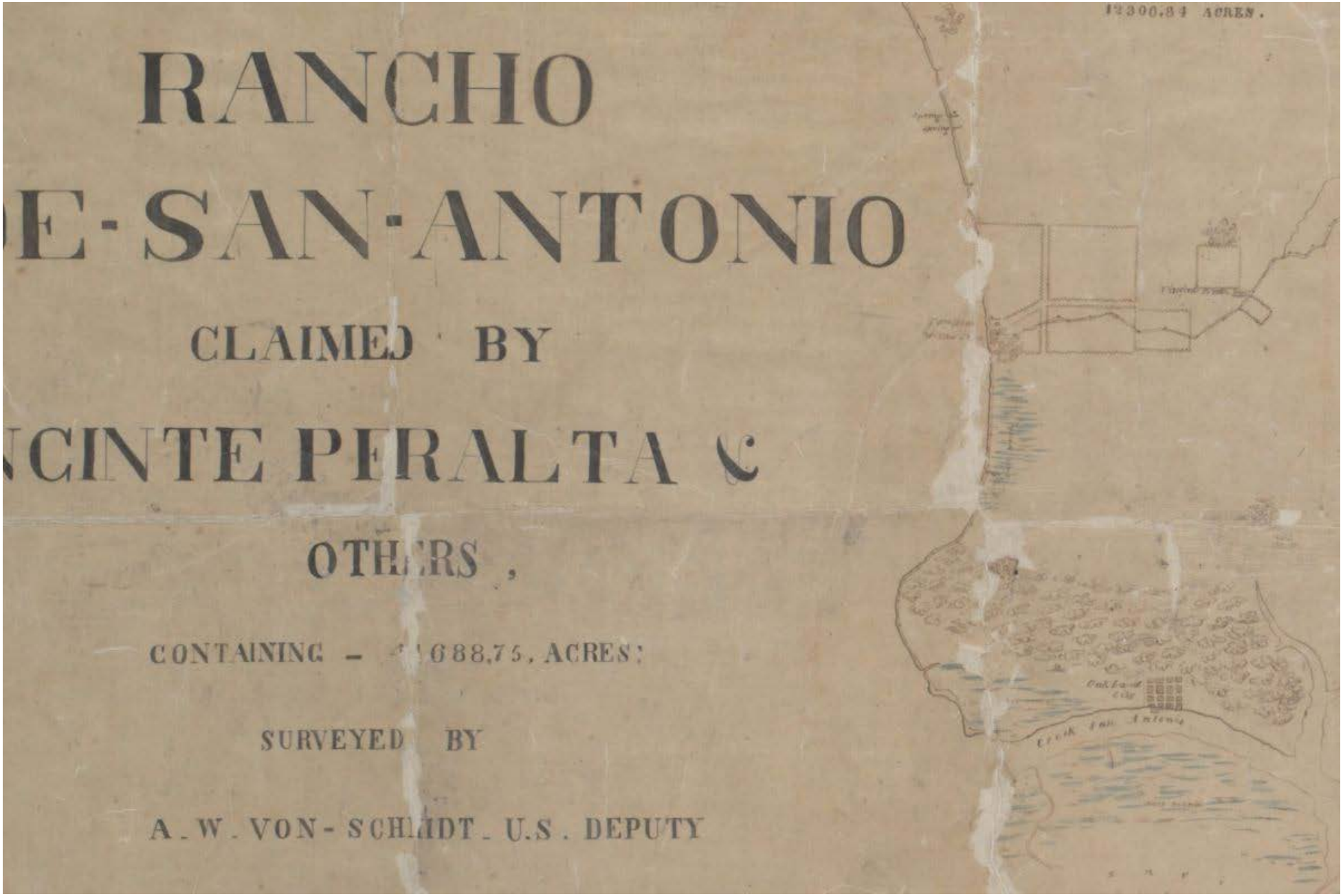
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Government____Military____Religion____
Social/Education____

21. Sources: Emeryville Herald 33rd Anniversary Edition, 1929.
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Phone 920-7683 Ref. # 04-Ala-880:B-41


12300.84 ACRES.
RANCHO
E-SAN-ANTONIO
CLAIMED BY
NCINTE PERALTA &
OTHERS,
CONTAINING - 44688.75, ACRES;
SURVEYED BY
A. W. VON-SCHMIDT. U.S. DEPUTY



Courtesy of UC Berkeley, Bancroft Library

http://content.cdlib.org/ark:/13030/hb6z09p0fz/?order=1

Title: Plan of Rancho de-San-Antonio [Alameda County, Calif.] : claimed by Vincinte [sic] Peralta & others, containing 44,688.75 acres / surveyed by A.W. Von Schmidt, U.S. Deputy Surveyor

Description: 4362 S18Pen-and-ink and watercolor on tracing paper.From: U.S. District Court. California, Northern District. Land case 100 ND, page 2216; land case map F-219 (Bancroft Library). Vincente Peralta, et al., clmts."This map of the initiatory survey of the tract in question made ... 1852 ... "Shows drainage, boundaries, settlements, etc.Relief shown by shading.

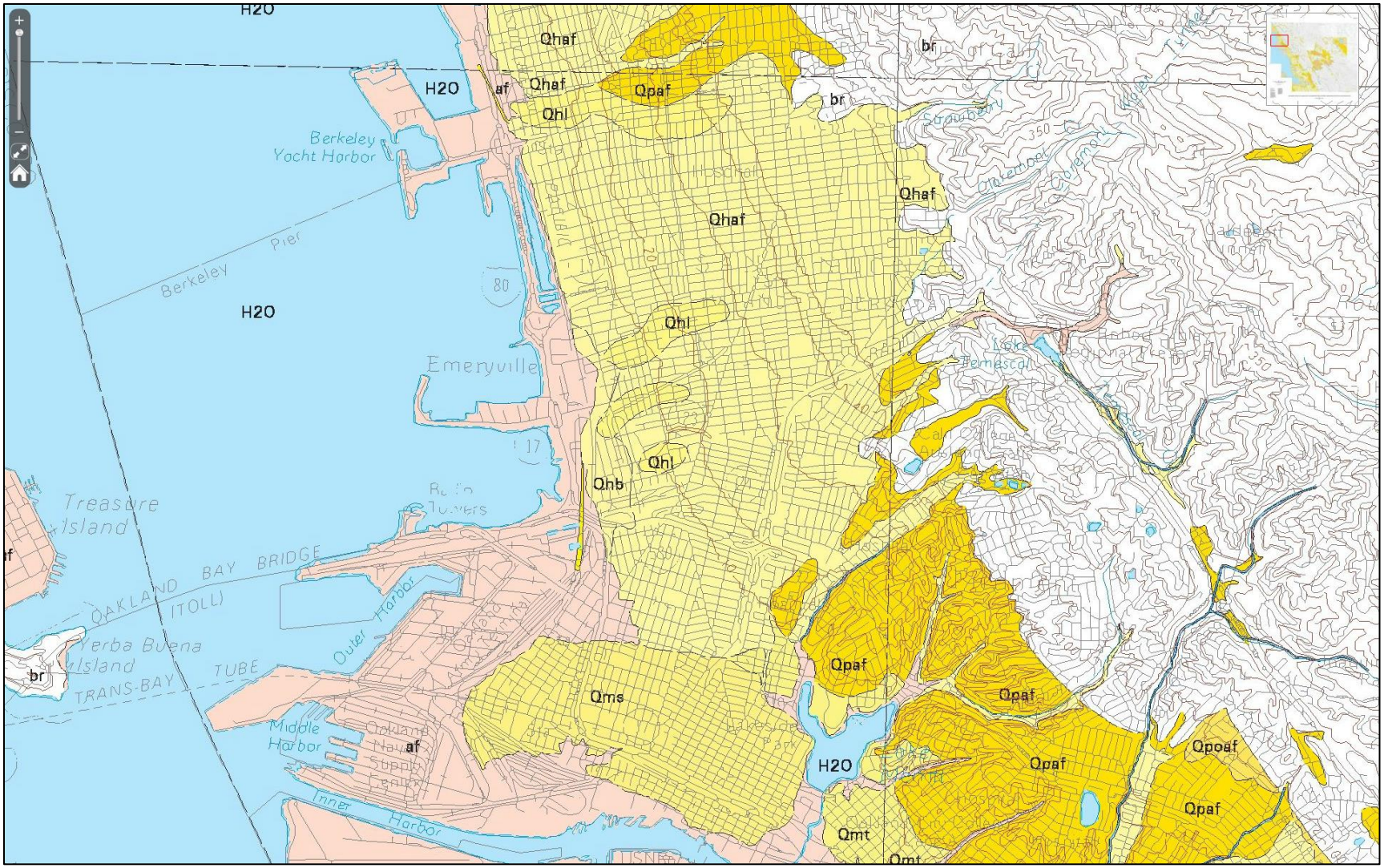
Creator/Contributor: Von Schmidt, A. W. (Allexey Waldemar), b. 1823?, author

United States. District Court (California : Northern District). Land case. 100, Related Name Indexing Term

Date: [1852]

Contributing Institution: UC Berkeley, Bancroft Library

calisphere



Title: *Sheet 1 of 2: Quaternary geology of Alameda County and surrounding areas, California: derived from the digital database open-file 97-97.*

Source: http://ngmdb.usgs.gov/ngm-bin/pdp/zui_pdpViewer.pl?id=42922. Accessed 3 November 2015.

California Prehistory

Colonization, Culture, and Complexity

EDITED BY
TERRY L. JONES AND KATHRYN A. KLAR

Published in Cooperation with the
Society for California Archaeology



A Division of
ROWMAN & LITTLEFIELD PUBLISHERS, INC.
Lanham • New York • Toronto • Plymouth, UK

AltaMira Press
A division of Rowman & Littlefield Publishers, Inc.
A wholly owned subsidiary of The Rowman & Littlefield Publishing Group, Inc.
4501 Forbes Boulevard, Suite 200, Lanham, MD 20706
www.altamirapress.com

Estover Road, Plymouth PL6 7PY, United Kingdom

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British Library Cataloguing in Publication Information Available

Library of Congress Cataloging-in-Publication Data

California prehistory : colonization, culture, and complexity / edited by Terry L. Jones and Kathryn A. Klar.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-7591-0872-1 (cloth : alk. paper)
ISBN-10: 0-7591-0872-2 (cloth : alk. paper)
1. Paleo-Indians—California. 2. California—Antiquities. I. Jones, Terry L. II. Klar, Kathryn.
E78.C15C297 2007
979.4'01—dc22

2006034418

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CHAPTER 8

Punctuated Culture Change in the San Francisco Bay Area

RANDALL MILLIKEN, RICHARD T. FITZGERALD, MARK G. HYLKEMA, RANDY GROZA, TOM ORIGER, DAVID G. BIELING, ALAN LEVENTHAL, RANDY S. WIBERG, ANDREW GOTTSFIELD, DONNA GILLETTE, VIVIANA BELLIFEMINE, ERIC STROTHER, ROBERT CARTIER, AND DAVID A. FREDRICKSON

THE SAN FRANCISCO BAY AREA SUPPORTED A DENSE hunter-gatherer population over thousands of years, a population that has left a rich and varied archaeological record. When Spanish settlements were established in 1776, the Bay Area was a place of incredible language diversity. Seven languages were spoken—Southern Pomo, Wappo, Patwin, Coast Miwok, Bay Miwok, Karkin Costanoan, and San Francisco Bay Costanoan (Figures 8.1, 8.2). The diverse ecosystem of the bay and surrounding lands supported an average of three to five persons per square mile, but reached over six persons per square mile in the Los Altos–Palo Alto vicinity in the South Bay and 11 persons per square mile in the Petaluma River basin in the North Bay (Milliken 1995a:19–21).

At Spanish contact, the Bay Area people were organized into local tribelets that defended fixed territories under independent leaders (Kroeber 1932). Typically, individual Bay Area tribelets included 200 to 400 people distributed among three to five semipermanent villages, within territories approximately 10 to 12 miles in diameter (Milliken 1995a). Bean and Lawton (1973) describe aspects of contact period regional organization as follows:

> Within the aboriginal social-religious institutions ... smoothly articulated intergroup relationships were regulated by ... secret societies or cults, confirming and demonstrating who had economic and political privileges, always supported in a ritual and cosmological referent of some sort. These institutions were responsible for distributing energy within the various subsystems, so that temporal or spatially related inequities in food and other economic goods could both be alleviated or maintained, depending on the particular needs of the corporate group. (Bean and Lawton 1973)

The distribution of artifacts in protohistoric sites—clamshell disk beads, distinctive *Haliotis* pendants, flanged steatite pipes, chevron-etched bone whistles and tubes, elaborately finished stone "flower pot" mortars, and needle-sharp coiled basketry awls—reflects the relative complexity of the native world at the Spanish arrival.

In 1984 both Moratto and the Chartkoffs dated the appearance of complex hunter-gatherer societies in the Bay Area to about 4,000 years ago, and both argued that complexity increased from that time forward. Both authors looked to population growth as a stimulus for resource intensification, increased cooperation, and social stratification (Chartkoff and Chartkoff 1984:227–237; Moratto 1984:276, 281–283). Moratto (1984) differed from the Chartkoffs (1984) by incorporating "language group migration" into his explanatory model. He posited that proto-Utians (ancestors of all Costanoan and Miwok-speaking groups) entered the East Bay about 4,500 years ago and then expanded throughout the Bay Area at the expense of forager groups who spoke Hokan languages. Subsequent development took place, he suggested, through internal change within the Utian population, with final Augustine Period development driven by indirect influence from Wintuan populations expanding into the North Bay (Moratto 1984:283). Chartkoff and Chartkoff (1984:205) rejected the importance of language group migration as an explanation, and instead asserted that new kinship systems were the innovation that freed people to increase status differentiation and develop rational regional institutions (Chartkoff and Chartkoff 1984:149–150).

The San Francisco Bay Area archaeological record as of the early 1980s has been summarized by Moratto (1984:227–237, 252–283). As ground disturbance has continued in the Bay Area since then, so too has archaeological fieldwork. Large-area survey, common in rural California, seldom takes place in the urban Bay Area. Instead, sites are usually encountered prior to or during

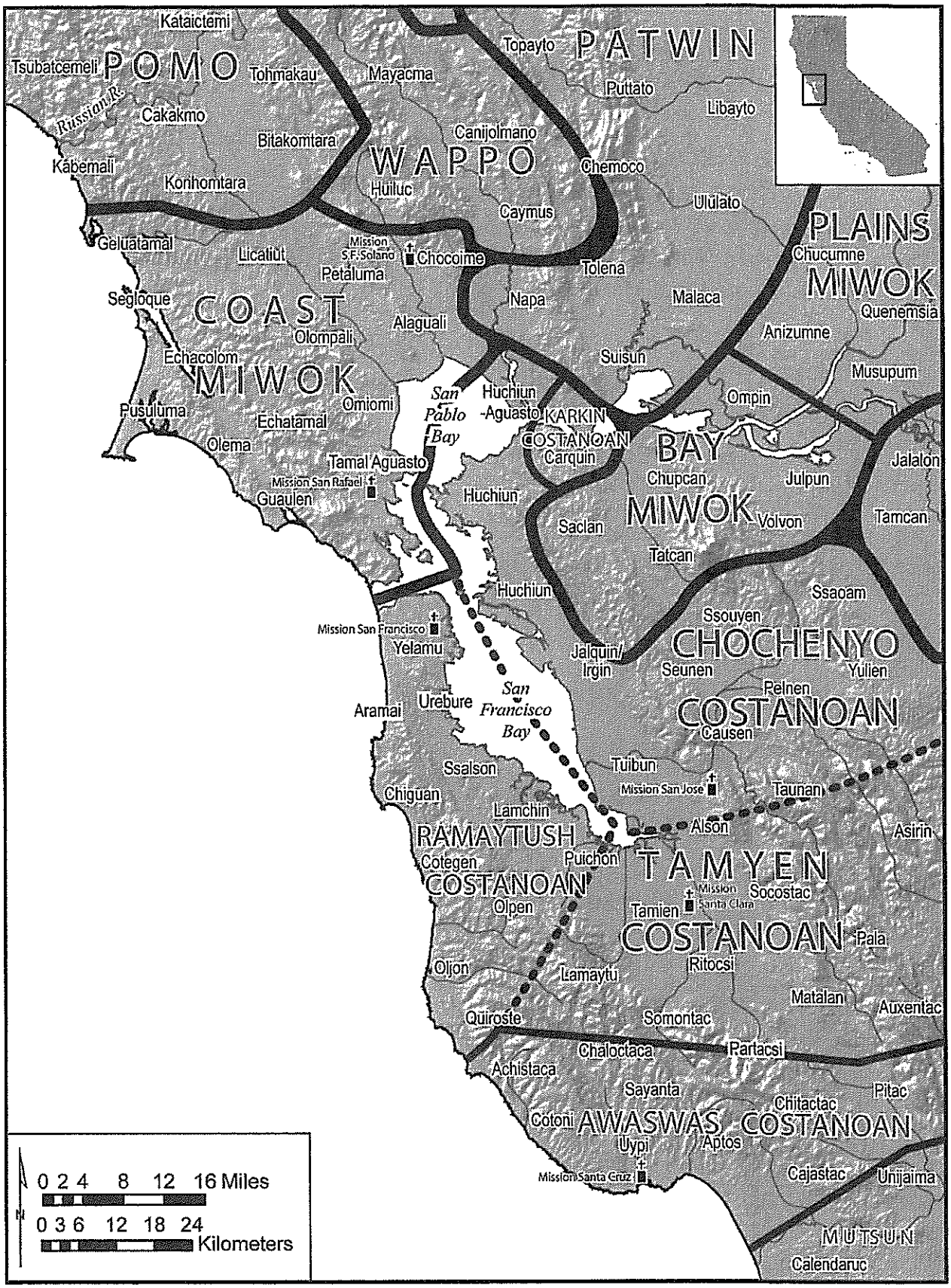


Figure 8.1. San Francisco Bay Area language groups and local, multivillage tribal communities.

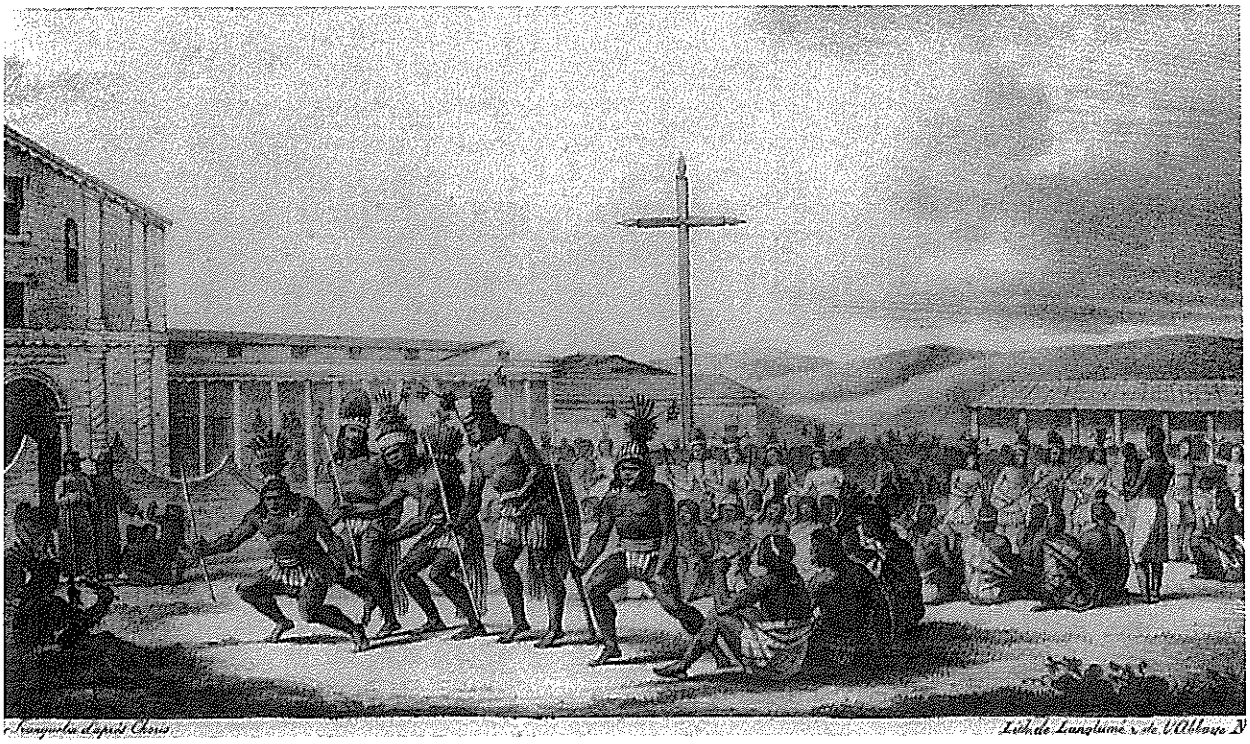


Figure 8.2. Dancers and audience in the plaza of Mission Delores (San Francisco) in October 1816, by L. Choris. (Courtesy of the Bancroft Library, University of California–Berkeley.)

and alteration for new home and industrial park development, urban redevelopment, highway construction, or linear underground utility installation. Figure 8.3 shows the locations of 200 prehistoric Bay Area sites with dated components critical to the interpretation of San Francisco Bay Area prehistory. Of the 200 sites, 93 (46 percent) were first studied prior to January 1, 1983, while the other 107 (54 percent) have been reported since that date. Santa Clara and San Francisco Counties have seen the greatest relative amount of post-1982 study, while Marin and Contra Costa Counties have seen relatively little (Table 8.1).

The initial sections of this chapter update topical themes—chronological and taxonomic issues, settlement systems, subsistence patterns, mortuary patterns, and physical anthropology. The final section takes a sequential approach. It describes cycles of change in Bay Area prehistory—population growth, economic intensification, symbolic integration, conflict, then crash—along a trajectory of generally increasing cultural complexity.

CHRONOLOGICAL AND TAXONOMIC ISSUES

A Hybrid Cultural Taxonomy

The San Francisco Bay Area is the meeting ground of two different systems for organizing the archaeological record into coherent units of observation and comparison.

- The Early-Middle-Late Period nomenclature of Beardsley (1954), dubbed the Central California Taxonomic System (CCTS) by Gerow (1968), is used by South Bay archaeologists (Bellifemine 1997; Cartier et al. 1993; Hylkema 2002) and some Central Bay archaeologists (Broughton 1999; Lightfoot and Luby 2002).
- The *Archaic-Emergent* temporal structure of Fredrickson (1973, 1994a), with specific cultural configurations identified by economic patterns, stylistic aspects, and temporally constricted regional phases, is used by North Bay archaeologists (Stewart 2003; White et al. 2002) and some Central Bay archaeologists (Meyer and Rosenthal 1997).
- A hybrid system, marking large blocks of time with the Early-Middle-Late Period structure and differentiating units of culture with Fredrickson's pattern, aspect, and phase concepts, is used by some Central Bay archaeologists (cf. Banks and Orlins 1985:28–51; Wiberg 1996a:123–128, 1997:9–17).

The third alternative, the hybrid system using the Early-Middle-Late Period *temporal sequence* (with all earlier post-Pleistocene times lumped as the Early Holocene) and the pattern-aspect-phase *cultural sequence*, is used in this chapter (Figure 8.4). The hybrid

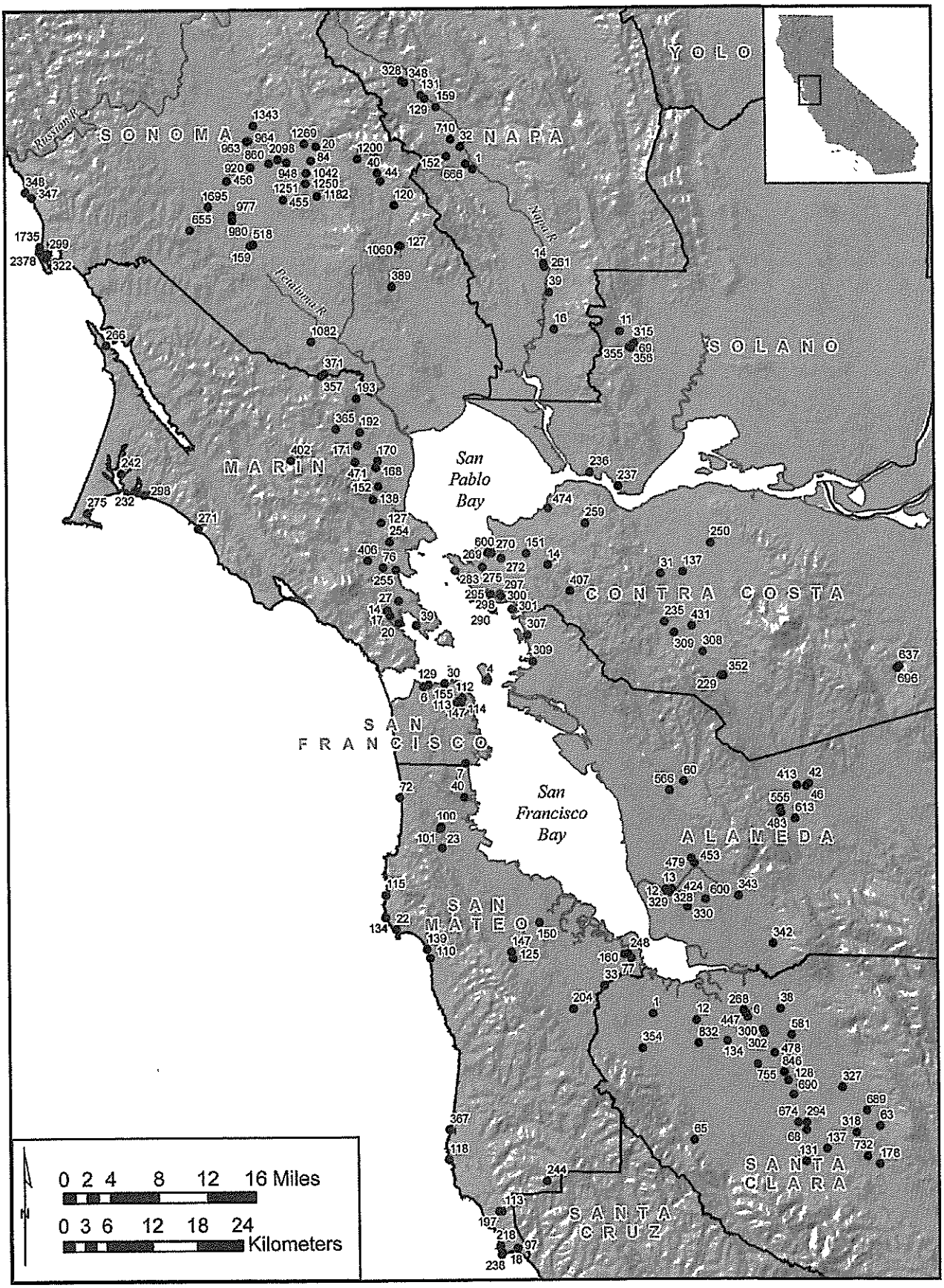


Figure 8.3. Archaeological sites and locations of the San Francisco Bay Area.

able 8.1. Counts of Sites Mapped on Figure 8.3 by County, Differentiating Pre- and Post-January 1, 1983, Reports nd Noting Density of Reported Sites

County	Sites Mapped on Figure 8.3	Pre-Jan. 1983 Reports	Post-Jan. 1983 Reports	Bay Area Land (square miles)	Square Miles per Mapped Site
Alameda	21	12 (57%)	11 (43%)	780	37
Contra Costa	28	21 (75%)	7 (25%)	580	21
Marin	28	21 (75%)	7 (25%)	588	21
Napa	14	6 (43%)	8 (57%)	500	36
San Francisco	10	2 (20%)	8 (80%)	91	9
San Mateo	26	9 (35%)	17 (65%)	531	20
Santa Clara	30	6 (20%)	24 (80%)	760	25
Solano	7	3 (43%)	4 (57%)	170	24
Sonoma	36	13 (36%)	23 (64%)	740	20
Total	200	93 (46%)	107 (54%)	4,740	24

axonomic system has the advantage of allowing the dentification of regional aspects within larger cultural patterns, as well as allowing subdivision of cultural patterns into short sequential phases of 200- to 300-ear duration, when data are available. In deference to North Bay nomenclature, however, Archaic-Emergent equivalents to the Early, Middle, and Late Periods are electively added below in parentheses.

Patterns, Phases, Aspects, and Localities

Definitions for the concepts of pattern, phase, and aspect are explained here as we use them in this chapter, following Fredrickson (1973, 1994a). The term *locality* s explained both as Fredrickson (1973, 1994a) used it nd in the different way we use it in this chapter.

Patterns are units of culture marked by distinct underlying economic modes, technological adaptations, nd ceremonial practices (Fredrickson 1994a:39–47). Separate patterns could co-occur in restricted geographical areas. For instance, during the Early Period (Middle Archaic) the range of Mendocino Pattern nobile foragers overlapped the territories of Lower Berkeley Pattern sedentary villagers in the northernmost portions of the San Francisco Bay Area.

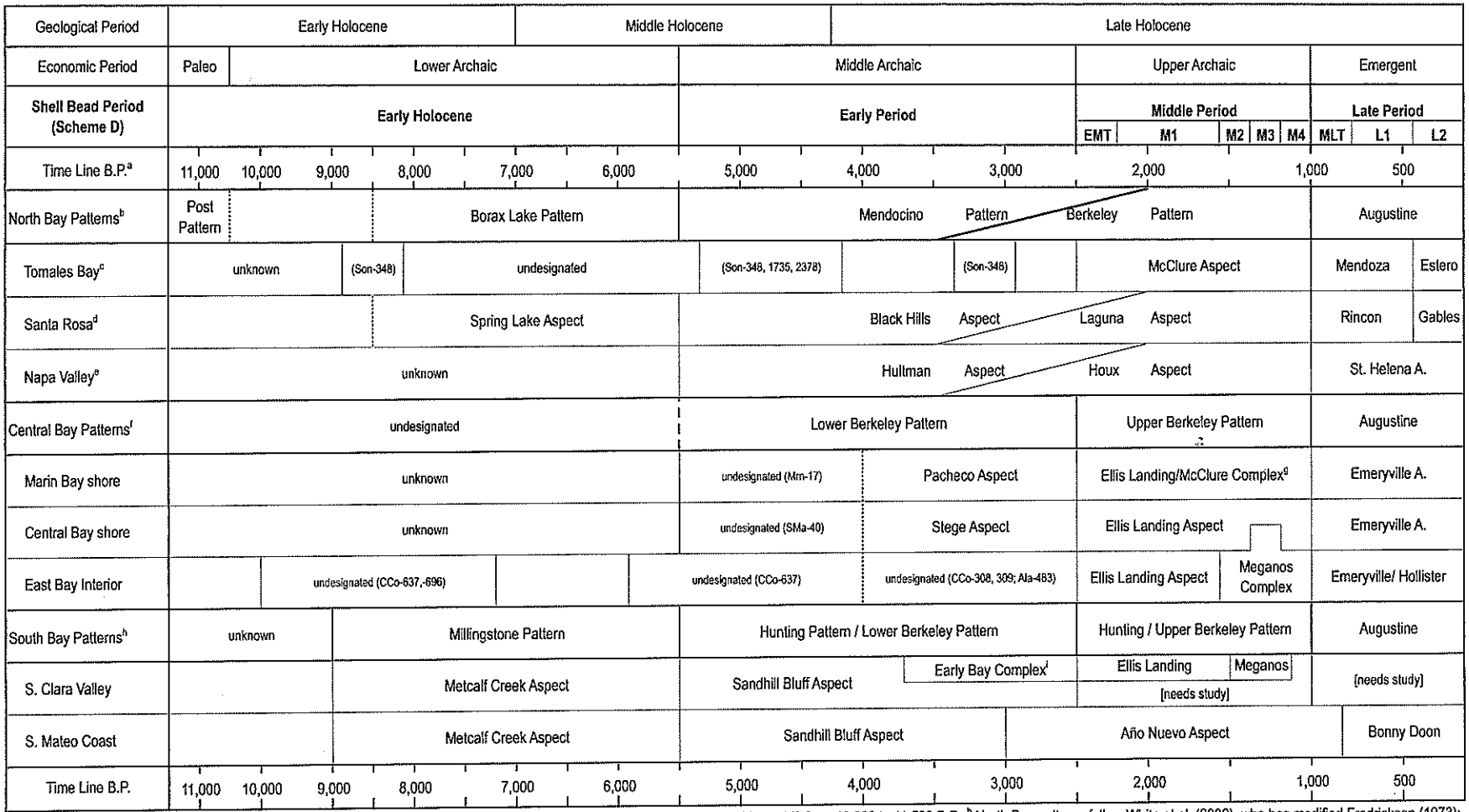
Phases, following terminology developed by Willey and Phillips (1958), are the smallest units of related site components "spatially limited to the order of magnitude of a locality or region and chronologically limited to a relatively brief interval of time" (Fredrickson 1994a:34). Phases in most parts of California, and most areas of the world, tend to be anywhere from 500 to many thousands of years long. But Bennyhoff (1994c:74) isolated sequences of short cultural phases of 200- to 300-year duration for many parts of the Late Holocene San Francisco Bay Area. Names of the local phases, such as Castro and River Glenn, derive from type sites (Bennyhoff 1986; Fredrickson 1973, 1994a). We consider documentation of such named phases crucial for future comparative research, but beyond the scope of the current overview (for phase seriation of artifacts, see Moore [1982]).

Aspect is the term Fredrickson coined to identify a local variation of one of his major economic patterns. "A sequence of phases within a single district is referred to herein as an *aspect.* Both phases (during a single time interval) and aspects (usually covering several time intervals) are district representatives of a pattern, a generalized cultural configuration usually encompassing one or more regions" (Fredrickson 1994a:35). Under the hybrid taxonomic system, Beardsley's (1954) Bay Area Stege, Ellis Landing, and Fernandez facies are considered to be San Francisco Bay Aspects of the more widely distributed Lower Berkeley, Upper Berkeley, and Augustine Patterns. Also under the hybrid system, the long phases of the South Bay chronology, such as Metcalf Creek and Sandhill Bluff, become aspects of a pertinent pattern (Figure 8.4).

Locality, according to Fredrickson (1973), is a "geographical space which exhibits complete cultural homogeneity at any given time." For purposes of inquiry, research, and comparison, the Bay Area has been divided into 18 localities in this chapter. Fredrickson's locality could change shape over time. In contrast, the localities of this chapter, such as "the San Mateo Coast," the "Santa Rosa Plain," and "the Livermore Valley," are fixed geographic areas, approximately 16 miles in diameter. We can be fairly certain that before the Spanish arrival, contemporaneous archaeological sites within each locality would have been created by people who interacted directly with one another, whether or not they shared a specific culture.

Shell Bead Horizons and Dating Scheme D

The cultural patterns, aspects, and phases of the Bay Area are anchored in time by Dating Scheme D, a pan-



Note: [a] Time periods here are based on calibrated radiocarbon dates and absolute time, causing the Pleistocene/Holocene divide to shift from 10,000 to 11,500 B.P.; [b] North Bay patterns follow White et al. (2002), who has modified Fredrickson (1973); [c] Tomales Bay aspects follow Beardsley (1954) with components at Duncans Landing noted (Kennedy 2005); [d] Santa Rosa aspects follow Fredrickson (1989); [e] Napa Valley aspects follow Fredrickson (1984:515); [f] Central Bay aspects follow Bennyhoff (1994c:74); [g] Marin bayshore Upper Berkeley Pattern components suggest a complex of Ellis Landing and McClure Aspect elements (Goerke and Cowan 1983:63); [h] Patterns and aspects in the South Bay, encompassing San Jose, Santa Teresa, and Point Año Nuevo localities, are from Hylkema (2002); [i] Early Bay Complex is distinguished at University Village site (SMa-77) because it mixes central bay Stege Aspect (Ala-307) ornaments and tools with a flaked tool assemblage typical of the south bay Sandhill Bluffs Aspect.

Figure 8.4. Concordance of archaeological time periods, patterns, and aspects in the San Francisco Bay Area.

entral California sequence of directly dated *Olivella* hell bead horizons. Scheme D is the fourth radiocar-)on-based sequence available for central California. The first such scheme, here called Scheme A, was ntroduced in 1958 by R. F. Heizer on the basis of 17 adiocarbon dates. In 1984, central California archae-)logists, including the Chartkoffs and authors in the Moratto volume, relied on Dating Scheme A. It is a long" chronology, placing the beginning of the Late Horizon (Late Period) at A.D. 300 to 500 (uncalibrated adiocarbon years).

Dating Scheme B was introduced by Bennyhoff and Hughes in their 1987 *Olivella* shell bead monograph. t was based on 180 central California radiocarbon lates from charcoal, collagen, and shell; the dates were neither calibrated nor corrected for the marine reser-'oir effect. Scheme B moved the Middle/Late Period Transition (MLT) forward to A.D. 700 to 900. Elsasser 1978:41) proposed a compromise between Schemes A and B that was labeled Scheme C by Bennyhoff and Hughes (1987:147).

Dating Scheme D was developed by Groza (2002) n consultation with a consortium of archaeologists nd in cooperation with the Indian community. It was initially based on 103 AMS radiocarbon dates on well-provenienced *Olivella* beads representing 10 of Bennyhoff's 11 bead horizons (Early/Middle Transi-ion beads were not sampled). The new radiocarbon lates shift many shell bead horizons forward in time s much as 200 years. (See Chapter 17, Figure 17.2 for a representation of the Scheme D Late Holocene time periods in relation to the southern California tempo-al sequence.)

The notation used in this chapter for the Scheme D shell bead horizons is new. Bennyhoff and Hughes (1987) labeled 11 Scheme B shell bead horizons within the Early, Middle, and Late Periods as *phases,* the same term Bennyhoff (1986) elsewhere applied to regionally restricted cultural units. We use the term *bead horizon* instead of *phase* for the short time periods marked by trade of particular bead types across wide areas of central California, in order to clearly separate units of time and units of culture. In our nomenclature, the Early Period/Middle Period Transition bead horizon (marked by split-beveled *Olivella* beads) can be noted as the EMT. Bead horizons of the subsequent Middle Period are labeled M1, M2, M3, and M4; each has its own signature shell bead array. The MLT (Middle Period/Late Period Transition) and Late Period bead horizons L1 and L2 follow. (No shorthand is used for the Early Period, since it has yet to be divided into shorter bead horizons.) We reiterate that the bead horizons are units of *time*, with no cultural implications other than the fact that they are defined by widely traded shell bead types.

Summary: A Complex Taxonomy for a Complex Prehistory

The large number of separate prehistoric Bay Area cultural aspects are shown in Figure 8.4. The figure is a nightmare of detail to novices and archaeologists with "lumper" predilections, yet it represents real and significant variation in time and space. Aspect-defining artifacts for three localities in or near the San Francisco Bay Area are illustrated in Figures 8.5 (Santa Rosa Locality), 8.6 (San Mateo Coast Locality), and 8.7 (Los Vaqueros Locality, east edge of the Central Bay Area). See pages 119–123.

SETTLEMENT SYSTEMS

Since the 1980s Bay Area researchers have sought to interpret settlement systems within Binford's (1980) forager-collector model, which posits two extremes of hunter-gatherer behavior: mobile small bands versus storage-oriented central place villagers (cf. Polansky 1998). T. F. King (1974b) suggested synchronic variations along the forager-collector cline in the Bay Area during the Middle Period, with inhabitants of bay shore Marin County living in sedentary villages nestled in rich heterogeneous environments, in contrast with inhabitants of the Fremont Plain, who moved seasonally between marsh edge villages and camps in upland oak groves.

Years earlier, Beardsley (1955:138–139) contrasted the *central-based wandering model,* in which a community "spends part of each year wandering and the rest at a settlement or central base to which it may or may not consistently return in subsequent years" with the *semipermanent sedentary model,* in which a community "can be identified with a village that establishes itself in successive locations, occupying each for several years." More recently, Banks and Orlins (1981) presented a version of the central-based wandering model on the basis of historic evidence for San Francisco Peninsula tribelets at the time of the Spanish arrival. Tribelet populations on that landscape were divided among three to five specific villages, some or all of which relocated more than once a year. Because the system was used by territorially restricted groups in a densely populated landscape, it should not be confused with a mobile forager strategy. Banks and Orlins (1981) called it a *periodically mobile home base* model.

North Bay

In the North Bay, a concept of concurrent landscape use by settled collectors and wide-ranging mobile foragers was introduced by Wickstrom (1986) for part of the Late Holocene in the Santa Rosa Locality. Jones and Hayes (1989:16–18; 1993) refined the Santa Rosa Locality land-use sequence. They classified site components into site types (task-specific locations, residential camps, and semipermanent villages), then stratified them by time (primarily using obsidian hydration) and environmental zones (Jones and Hayes 1989:229). The pattern that emerged suggested Paleo-Indian forager use of lacustrine zones, followed by Lower Archaic (Early Holocene) and Middle Archaic (Middle Holocene and Early Period) forager residential camps along marshes and on grasslands, succeeded by Upper Archaic (Middle Period, i.e., after 500 cal B.C.) "concurrent use" by people using forager residential camps and people using semipermanent collector villages, finally leading to Emergent (Late Period, i.e., post cal A.D. 1000) semipermanent collector villages in oak woodlands, with residential camps along marshes.

Fredrickson (1989a) offered an analysis of changing North Bay settlement and chronology similar to that of Jones and Hayes (1989), but specific to the Laguna de Santa Rosa area along the west side of the Santa Rosa Plain. He proposed that overlapping use of the Laguna area by foragers (Black Hills Phase of the Mendocino Pattern) and collectors (Laguna Phase of the Berkeley Pattern) occurred between 1500 cal B.C. and cal A.D. 1. Later, Jones and Hayes (1993) redated the period of forager-collector overlap to cal A.D. 500 to 1000.

South Bay

In the 1970s King and Hickman (1973) proposed that Late Period settlement in the Gilroy-Hollister area (south of the San Francisco Bay Area) utilized valley-edge logistical centers, with special task locations in the higher uplands and along marsh edges. In the 1980s prehistorians tested the applicability of the model to the San Jose Locality at the south end of San Francisco Bay and the inland Santa Teresa Locality between San Jose and Gilroy (see Elsasser 1986). Bergthold (1982) showed that the large residential villages of the northern Santa Clara Valley were typically out in the center of the valley along perennial streams, but she lacked the temporal evidence necessary for documenting change or continuity of settlement pattern over time. Cartier et al. (1993:54) revisited Bergthold's model with new temporal evidence, suggesting that some settlement shifts occurred in the Santa Teresa Locality about 2,000 years ago and arguing for a population drop in the San Jose Locality at the end of the Middle Period.

Early mobile forager land use gave way to semisedentary collector land use in the South Bay by the outset of the Middle Period (Upper Archaic) at about 500 cal B.C., according to a recent synthesis by Hylkema (2002:233, 250). By cal A.D. 700 that collector pattern was trending toward the more complex social organization that would lead to the rich midden central sites of the Late Period. Meanwhile the forager system persisted through the Middle Period on the nearby San Mateo coast to the west; it did not change to the collector mode until the Late Period, after cal A.D. 1200. When coastal area people did shift to a collector economy (with mortar and pestle predominance at central sites), they developed a specialized transhumance pattern between upland meadows and coastal terrace—summer hunting for juvenile deer in the uplands, then winter otter and harbor seal hunting on the coast (Hylkema 2002:255).

Central Bay

Central Bay settlement pattern studies have been time stratified and locality based. Banks and Orlins (1981) used the "periodically mobile home base" model that we mentioned above to explain how so many Middle Period residential sites could have been generated in the Richmond Locality of the East Bay. They documented 28 residential sites within a 10 kilometer circle, each containing at least two meters of cultural deposit, and inferred that they were generated by people who utilized only two or three of the sites as semipermanent villages at any one time. The problem for archaeologists, they pointed out, is that sites used as residences during one generation may have been used as special activity locations by other generations, making locality-wide settlement patterns nearly impossible to interpret.

Parkman (1994:45) built a model of "the semisedentary and seasonal nature of the settlement of the southern Alameda County bay shore, an area that is characterized by a broad plain separating the bay shore and bay hills." He pointed out an increase in deer (found in the hills) relative to elk at bay shore sites during the Late Period (citing Hildebrandt et al. 1984; Watts 1984) and argued that Middle Period elk hunters were not as logistically oriented as the Late Period people, who brought deer and processed vegetal foods

back from inland foothills to bay shore residential villages during the spring and fall.

Wilson (1999) presented a more complex settlement pattern analysis for the Fremont Plain, modeling differing land use over five time periods—Early, EMT, Middle, MLT, and Late—broken into components using obsidian hydration, radiocarbon dates, and seriated artifacts from eight residential/cemetery sites. He posited light initial residential occupation at the end of the Early Period at ALA-343, six kilometers inland from the bay marshes. He inferred that the bay marsh edge was first settled at the Patterson Mound (ALA-328) at the end of the Early Period, around 600 cal B.C. (Wilson 1999:5). He viewed the Middle Period as a time of competition between two unrelated groups, a marsh-oriented people at ALA-328 and an inland people at ALA-343 who "began challenging ALA-328 for area dominance" (Wilson 1999:6). He inferred that the Late Period was a time of peace and locality-wide integration, on the basis of an increase in identified site components along the bay shore marsh and farther inland. Wilson's study could be strengthened by tracking possible settlement shifts through the four phases of the Middle Period. Nevertheless, the study provides a rare, time-sensitive analysis of site distributions and discusses sites in terms of human communities.

Late Period population and settlement increase around San Francisco Bay has generally been accepted (see Elsasser 1978:43), but some scholars have argued that it actually decreased (Beardsley 1954:84–86; Banks and Orlins 1981; Jones 1992:12–15; Hildebrandt and Jones 1992:378; Holson et al. 2000:24–28). Lightfoot and Luby (2002) examined settlement patterns within a 15 by 15 kilometer area of the Richmond Locality. Most of the sites in their sample were bay shore sites with Middle Period components. Late Period components, on the other hand, were fewer in number and more evenly distributed between bay shore locations and locations three to five kilometers inland. "Some sites that served as mounded villages in the Middle Period were apparently deserted and then later re-used as special-purpose places in the Late Period where individuals continued to be buried and where occasional gatherings and ceremonies took place" (Lightfoot and Luby 2002:277). They concluded that the Middle Period was a golden age of shell mound communities and that population dropped during the Late Period, concurrent with the shift of central sites away from the bay shore (Lightfoot and Luby 2002:276–277).

In order to see if a general shift inland occurred everywhere around the bay, we collated evidence for bay shore and inland habitation at four localities. Our results support a view of decreased bay shore strand occupation in the Richmond Locality. But the decrease occurred after Bead Horizon M1 within the Middle Period rather than at the beginning of the Late Period (Table 8.2). Elsewhere, increased Late Period bay shore occupation is indicated in the San Rafael and Fremont Localities, while Middle to Late Period stability is suggested in the San Jose Locality. All in all, data on settlement shifts are inconclusive due to (1) small sample sizes, (2) geographic bias in past archaeological testing programs, and (3) varying geomorphic processes of site burial.

SUBSISTENCE PATTERNS

Late-twentieth-century research interest in subsistence behavior—from least effort modeling to patch utilization theory to optimal foraging theory—has generated new studies and new insights about Bay Area prehistory. In this section we review selected studies on mammal, shellfish, and plant harvest.

Mammal Harvesting Patterns

Late Holocene faunal exploitation in the South Bay over the past 4,000 years has been characterized as a deer economy by Hildebrandt et al. (1984), utilizing the principles of optimal foraging theory (see Broughton 1999:5–12 for theoretical considerations). Since 1990 numerous faunal studies have been undertaken using intensification theory. Hildebrandt and Jones (1992) studied 11 bay shore sites to document a shift from large-bodied pinniped, especially northern fur seal, dominance in the Early Period (2500 to 500 cal B.C.), to terrestrial large mammal dominance in their Middle Period (500 cal B.C. to cal A.D. 1 [actually the EMT]), to an increase in sea otter and harbor seal in their Late Period (post cal A.D. 1, encompassing most of the Middle and Late Periods). Hylkema (2002:254) noted a shift from large sea mammal exploitation to sea otter exploitation along the San Mateo coast at a later date, the onset of the Late Period.

The concept of the broad-spectrum coharvesting exploitative strategy—short-term local shifts from one resource to another as a flexible adaptive response to resource explosions and crashes—was offered by Simons (1992:73–103) as a description of the central California mode of animal harvest for the entire late Holocene. He documented an increase in the harvest of sea otters, relative to large artiodactyls, on the bay shore during the Middle Period, followed by a rebound of deer exploitation during the Late Period.

Table 8.2. Counts of Site Components (Stratified by Distance from the Bay Shore) at Four Example Localities, Together with Total Count of All Documented Components at the 200 Sites Mapped on Figure 8.3

Locality	*Bead Horizon Phase*									
Distance from Bay	Early 3,000 yrs	EMT 300 yrs	M1 600 yrs	M2 200 yrs	M3 200 yrs	M4 250 yrs	MLT 200 yrs	L1 300 yrs	L2 250 yrs	Total
San Rafael Locality (25 sites)										
0–2 km	2	1	6	1	1	4	4	7	6	32
2–10 km	1	1	0	0	0	1	0	0	2	5
10–16 km	0	0	0	0	0	0	0	0	0	0
% for locality	8	5	16	3	3	14	11	19	22	*100*
Richmond Locality (29 sites)										
0–2 km	5	9	10	7	4	3	3	4	6	51
2–10 km	0	0	1	4	4	3	1	3	3	19
10–16 km	0	0	0	0	0	0	0	0	0	0
% for locality	7	13	16	16	11	9	6	10	13	*100*
Fremont Locality (16 sites)										
0–2 km	0	2	3	3	2	2	2	5	4	23
2–10 km	0	0	1	0	3	1	2	0	1	8
10–16 km	0	0	0	0	0	0	0	0	0	0
% for locality	0	6	13	10	16	10	13	16	16	*100*
San Jose Locality (20 sites)										
0–2 km	1	0	1	0	2	1	3	4	2	14
2–10 km	2	3	4	4	6	4	1	3	1	28
10–16 km	1	0	1	0	0	0	1	2	0	5
% for locality	9	6	13	9	17	11	11	19	6	*100*
Total Bay Area (200 sites)										
Components	61	56	86	60	67	64	67	105	101	667
% of Total	9	8	13	9	10	10	10	16	15	*100*

Hylkema (1991:377; 2002:257) suggested that otters were harvested for their pelts rather than their meat, based on the relative completeness of sea otter skeletal remains at Late Period site SMA-115 on the coast just south of San Francisco. Broughton (1994b) argued that foraging efficiency declined through the Late Holocene on the basis of increasing ratios of otter to deer in 18 temporally discrete Middle and Late Period site components from three localities around the bay. He interpreted the increase of sea otter bone as evidence of deer population decline that may have been partially related to human-deer competition for acorns. When sorted by time, Broughton's components reveal that the shift to otter predominance took place suddenly at the M1/M2 divide, about cal A.D. 425 to 475, when a new cultural pattern, the Meganos Aspect, was spreading into the East Bay. The suddenness of the otter bone increase leads us to suggest a cultural interpretation, that the new group may have desired sea otter pelts for cloaks or vests.

A buffer zone patch exploitation model was offered by Broughton (1999) to explain an artiodactyl rebound at the Emeryville shell mound (ALA-309) following many years of relative increase in small mammal remains at the site. Broughton dated the beginning of the rebound at cal A.D. 1, and he noted a gradual increase in the deer-to-small mammal ratio up to cal A.D. 1250. He posited the existence of buffer zones between the habitation areas of neighboring tribal communities, zones where deer could thrive and be available for people willing to travel great distances to hunt them and carry them back to their core tribal areas (Broughton 1999:64–65). Broughton's conclusion is based on the study of a trench sample from a single site. Valente (1998b:212), in a single site study at MRN-254, found the opposite type of fau-

nal assemblage change, from a Middle Period cervid economy to a more diversified Late Period economy that included waterfowl, deer, and carnivores. Future studies of change and continuity in faunal exploitation patterns will have to rely on comparative study of multiple sites within localities, in order to overcome the problems of limited and anomalous component samples.

Differences in faunal assemblages over the past 2,500 years are attributable to geography and habitat, not intensification over time, concludes a recent comparative study by Simons (2004:408–422). He compared the faunal assemblages of the inland Santa Clara Valley, the East Bay, and western Solano County. He found that intensive cottontail rabbit harvesting was important throughout the Middle and Late Periods everywhere but in Solano County. He noted that fractions of deer, elk, and pronghorn varied with geography but not time, a pattern that supports his 1992 broad-spectrum coharvesting model.

Intensification of Shellfish Harvesting

A shift from oyster harvesting to mussel harvesting and then clam digging was noted on the central and northern bay shore very early (Gifford 1916). Bennyhoff (in Elsasser 1978:39; in Moratto 1984:262) seriated the shifts to the Middle Period, oyster giving way to mussel at the M1/M2 break (about cal A.D. 430), and mussel giving way to clam at the M3/M4 break (about cal A.D. 800). Moratto (1984:259) favored sedimentation as the explanation for the shifts. Jones (1992:4) reopened the possibility that the shifts reflected oyster overexploitation. Broughton (1999:71) too argued that oysters and mussels were overharvested, forcing people to dig clams out of the mud. Story et al. (1966:48) suggested that an oyster bed near San Mateo had been smothered by sedimentation at about cal A.D. 250–350, just prior to Bennyhoff's suggested oyster-mussel shift. Gottsfield (in Pastron et al. 2004:79–80) documented a sudden shift from mussel exploitation to clam exploitation at the Mission Bay site cluster (SFR-112, 113, 114, 147, 155) on the northern San Francisco Peninsula at approximately cal A.D. 100–160. A possible correlation between this foraging shift, the bay sedimentation event, and a cultural disruption at the M1/M2 boundary (the Meganos intrusion discussed below) deserves future study.

In the South Bay, clams were never an important dietary element; mussel and oyster harvesting persisted through the Late Period (Bickel 1976:37; Cartier 1996; Rosenthal 2001). Roop et al. (1982) and later Cartier et al. (1993:168–171) have noted large amounts of coastal shellfish (relative to bay shellfish) in sites of the Santa Teresa Locality, more than 16 kilometers south of the bay, in contrast to the preponderance of bay shore shellfish in sites of the bay shore San Jose Locality.

A sudden intensification of tiny horn snail (*Cerithidea* spp.) harvest, relative to the oyster and mussel harvest, occurred along the South Bay shore at the outset of the Late Period. Hylkema (2002:252) suggested that increasing populations began to gather horn snails during off-months when mussels were inedible. An alternative social intensification model might suggest that surplus labor was being spent in the Late Period to gather the snails as luxury food items, regardless of high collection costs.

Plant Harvesting Intensification

The accepted paradigm of plant harvesting—that acorns were not added to small seeds as important carbohydrates until 4,000 years ago—has been called into question in the past 10 years with the aid of macrobotanical recovery from midden and features. Wohlgemuth (2004:144–145) synthesized recent macrobotanical studies to present a comparative view of plant harvesting intensification in central California. Acorn use is well documented in the Early Holocene (Lower Archaic), but small seed use is not. Millingslabs and handstones, the original paradigm infers, were used to process small hard seeds and nuts, whereas mortars and pestles were used to make flour from acorns (Fredrickson 1973; Moratto 1984:264; see also Basgall 1987). We now know that mortars were in use at least 5,700 years ago in the Bay Area (Rosenthal and Meyer 2004a:34–35; Wohlgemuth 2004:143).

Passive acorn leaching is evidenced during the Early Period (Middle Archaic), along with peak use of bulbs and some use of small seeds, in pits at SOL-391 near Fairfield. Pounding acorns for flour increased during the Middle Period (Upper Archaic). Use of small seeds, including green-phase seeds, increased greatly in the Late Period (Emergent Period) at the Fairfield site and at most other sampled localities in west-central California. At a few sites on the immediate shore of San Francisco Bay (ALA-309, 310, 604), however, sparse amounts of acorn and small seeds were recovered from Middle Period components, and neither acorn nor small seeds were recovered from Late Period components (Wohlgemuth 2004:114–120).

Wohlgemuth's (2004:70) bay shore data were strongly weighted to the EMT and M1 basal levels of

one site, ALA-309 (Emeryville). Popper and Martin (Wiberg 2002:9–11) report remarkably high amounts of goosefoot, along with acorn and several other seeds, at EMT site SCl-478 (Skyport Plaza), only four kilometers south of the bay shore in the San Jose Locality (see also Legare 1998 for MRN-254). Obviously a larger comparative sample is needed, as is a rigorous study of burned small seed preservation problems, in order to refine our understanding of plant food resource use in the past.

MORTUARY PATTERNS AND SYMBOLIC EXPRESSIONS

Evidence of ritual treatment of the dead is one of the few archaeological windows for viewing the emergence of social complexity in the past. Despite the fact that professional archaeologists avoid excavating burials in the Bay Area whenever possible, more burials have been scientifically removed over the 25 years since 1982 (approximately 3,750) than were removed over the previous 100 years (approximately 3,570), due to ongoing urban development. In this section we discuss the themes pertinent to social complexity—mortuary contents, mortuary structure, relative grave wealth, and interpretation of change in mortuary structure and wealth over time.

Status Goods and Surplus Labor

The full array of artifacts that prehistoric Californians placed in the graves of their deceased is too extensive to recount here (Beardsley 1954:80–101; Bickel 1976; Fredrickson 1974b; Moratto 1984:264–265, 275–276; Leventhal 1993). Ornamentally shaped stone mortars may be the most expensive items found as grave offerings. Fully shaped examples appear after cal A.D. 1200 (Bellifemine 1997; Leventhal 1993:222; Wilson 1993). Beardsley (1954:31) found that some ornamental mortars weighed 80 pounds and had been carried over 30 miles to their final disposition site. Transportation is the least of the costs for the creation of a fully shaped show or flower pot mortar, however. Leventhal and Seitz (1989:156–165) determined that it took 17.2 hours and 46,000 blows just to create a small five centimeter mortar cup on a granodiorite boulder. Leventhal (1993:225–226) writes, "The energy output . . . must have made these large, finely made objects highly desirable commodities, especially for wealthy families."

Shaped marine shell beads are another category of items placed with burials that were costly to manufacture or obtain. Thousands of beads went into the ground as mortuary offerings each year during most time periods. Raw material was obtainable only along the coast. Each shaped bead, cut from the hard wall of *Olivella, Haliotis,* or clamshell, represented almost an hour of production activity. C. King (1974b:84) argued that high-labor beads circulated in centralized political systems where it was important to control flows of subsistence goods from community food stores; less expensive decorative beads (of larger diameter, less careful edge finish, or made from softer materials such as steatite), on the other hand, circulated in economic systems where centralized control was not an issue (see Chapter 17 for discussions of recent studies on Santa Barbara Channel shell bead manufacture and trade and the implications for the Bay Area).

Beautifully manufactured blades of obsidian and chert or carefully shaped elongate elk femur artifacts distinguished occasional burials during some bead horizons of the Middle Period. Late Period mortuaries contain steatite pipes with elaborate flanges, elongated flanged stone pestles, stone plummets (charmstones), and a wide array of distinctive *Haliotis* ornaments. Destruction and burial of wealth items in Middle and Late Period mortuaries intentionally or unintentionally prevented the depreciation of wealth item values that would have accompanied their accumulation among the living. Wealth destruction also indicates that surplus time and specialized labor were available to replenish the supply.

Cemeteries versus Dispersed Graves

Four modes of mortuary location and organization have been described in the Bay Area. The first, and seemingly most common, is the noncemetery pattern, where people were buried in a dispersed informal way under house floors and at other places in or adjacent to a village. The other three are dedicated cemeteries where interments were placed in some formal structure: (1) cemeteries in rich midden adjacent to villages, (2) cemeteries away from villages in sterile or near-sterile sediments, and (3) possible dedicated cemetery mounds with formal burials and some dietary residue from feasting.

Both dispersed and compact mortuaries in rich midden sites were well documented prior to 1984 (T. King 1970, 1974b:38; Fredrickson 1974b:62–63). Since then, many off-village cemeteries have been documented in East Bay and Santa Clara Valley Middle Period and MLT sites. One example is the multicomponent Rubino site (SCL-674) in the Santa Clara Valley, regarding which Pastron (1999:iv) stated, "The intensity of occupation at the site was at no time

commensurate with the extensive number of burials interred there." The Mazzoni site (SCL-131), another nonvillage cemetery in the Santa Clara Valley, is remarkable for its lack of grave offerings. A cache of obsidian blades at the cemetery may "represent a conspicuous, highly valued commodity, offered, not cached . . . [in] homage to a sacred plot" (Pastron and Walsh 1989:86); obsidian hydration rims suggest the cache was buried during poorly documented Bead Horizon M4. In the East Bay, a number of nonmidden cemeteries, each representing one or two upper Middle Period bead horizons (M2, M3, M4), have now been recognized (Bennyhoff 1994c:66).

Leventhal (1993) proposed that bay shore mounds were dedicated burial and funerary sites. He argued that the Ryan Mound (ALA-329) in the Fremont Locality had been created by "large groups of people purposefully engaged in mound-building activities as part of the commemoration, ritual obligation and specialized treatment for mostly a distinctive class of people" (Leventhal 1993:259). The mound, occupied continually during Bead Horizons M4 through L2, contained little shell, but typically large amounts of waterfowl bone. Leventhal (1993:251–252) interpreted the dietary remains as the product of feasts and cemetery offerings left after groups gathered to honor the elite dead. Lightfoot (1997) summarized the more commonly accepted view that the bay shore mounds are multipurpose sites, used repeatedly as residential locales, ceremonial centers, and long-term repositories for the dead.

Luby and Gruber (1999:101) incorporated part of Leventhal's thesis, that bay shore mounds were places where feasting occurred as part of mortuary ritual. Luby (1992) described a shift of mortuary patterning at the Patterson Mound (ALA-328) in the Fremont Locality, from an organized submound cemetery (presumably off-village) to a midden mound village with dispersed inhumation. That shift occurred over a short period of time, between the beginning and end of the EMT (500 to 200 cal B.C.). Luby (2004) recently interpreted the shift as a reflection of cultural change, from explicit social inequality to public expression of an egalitarian ideal.

Statistical Analysis of Mortuaries

Only three mortuary studies have been carried out since 1984 that take a quantitative approach to the structure of a Bay Area cemetery. Cartier et al. (1993) developed a statistical method to quantify social inequality on the basis of the range of wealth within a given mortuary component. This methodology attempted to score the value of each type of item found in grave lots; uncommon and exotic items and those representing large investments of production time were given high scores. The total score for a given grave was called the grave association (GA) score. Using GA score distributions, they highlighted distinctions along a cline from the poorest mortuary (SCL-128, Holiday Inn) to the richest mortuary (SCL-690, Tamien Station) in their study area. Wealth was most evenly distributed in the richest cemetery, Tamien Station (SCL-690, predominately an MLT site). Inequality was highest in the poorest site, the Holiday Inn site (SCL-128, mixed M2, M3, L1, L2 components).

Bellifemine (1997) utilized multivariate analysis to demonstrate a high degree of spatial organization in the largely L1 cemetery at SCL-38 (Yukisma site), a dark midden site where 244 individuals were recovered with 32,000 beads and other associated artifacts. She made the following observations about the cemetery:

> The central cluster is strongly associated with males and cremations, while four of the other clusters (two in the middle ring, two in the outer) have a balanced sex ratio. This last could indicate lineal groups, clans, or moieties, and later DNA analysis could verify this patterning. Furthermore, there are preferential areas for youths, elders, and infants in the intermediate and peripheral regions. . . . There is also a correlation between the artifact frequency sets and the spatial clustering. (Bellifemine 1997:260)

Mortars and pestles in the SCL-38 mortuary tended to co-occur in burials with beads, whereas utilitarian bone artifacts tended to co-occur with bone tubes and whistles (Bellifemine 1997:260). Four artifact types were restricted to the rich central cemetery area: charmstones, stone beads, type K *Olivella* beads, and type M *Olivella* beads. If this pattern holds at other sites, it could be used to refine the GA scoring system proposed by Cartier et al. (1993).

The third statistical approach to a Bay Area mortuary was that of Luby (1992, 2004), as part of his study of the submound and midden mortuaries of the Patterson Mound (ALA-328) during the EMT. Of 100 graves in the basal strata of the site that included both mortuaries, 30 were randomly selected and scored for burial attributes. Cluster analysis, specifically unweighted pair–group cluster analysis, was applied to the sample, illuminating two distinct groups of similar burials: (1) a statistical cluster containing a small but diverse array of accompaniments, primary inhuma-

tion, and cremation, that included most of the sterile sediment submound burials, and (2) a statistical cluster of dispersed interments in the midden just above the submound burials, with very few accompaniments and no cremations. Based on this study, Luby (2004) argued for the decline in publicly expressed social inequality at the beginning of the Middle Period.

The Meaning of Mortuary Wealth

By 1984 most scholars agreed that formal cemeteries with differential grave wealth, reflecting the emergence of status ascription and hierarchical social control, appeared late in Bay Area prehistory. But disagreement existed regarding the precise time of that emergence. T. F. King (1974b:38) argued for status ascription's first appearance at the beginning of the Middle Period (Upper Archaic), while Fredrickson (1974b:62–63) did not see it until the beginning of the Late Period (Emergent). Recent studies indicate that cemetery wealth differentiation did not develop steadily over time and space. Milliken and Bennyhoff (1993) illustrated an increase in mortuary wealth and wealth differentiation, expressed by shell bead numbers and concentration, from the Early Period to the Middle Period, followed by a marked increase during the MLT, then a steady decline through Bead Horizons L1 and L2 of the Late Period (Hylkema 2002:258–261; Wiberg 1996a:376–380). They offered two alternative explanations for the Late Period drop in mortuary bead counts and concentration: (1) bead inflation as certain bead types became accessible to most families in a culture (cf. King 1990:95, 118 for the Santa Barbara Channel) or (2) a shift from show-off behavior (conspicuous destruction of wealth through funerary offering by a limited numbers of rich families) to conspicuous gifting behavior (redistribution of beads by rich families to poorer families at funerary or mourning ceremonies).

A mortuary pattern that seems on the surface to suggest social equality may mask more subtle aspects of social control, writes Luby (2004). A simple and undifferentiated mortuary pattern, such as the terminal EMT midden inhumations at ALA-328, may mask the presence of a strong aggrandizer leadership if that leadership accepts an egalitarian ideal. A decrease in mortuary inequality over time may reflect emergence of a corporate mode of inequality, where collective ritual, kinship affiliation, public mound construction, and suppressed display of economic differences are emphasized (Luby 2004:18).

With the new concepts of conspicuous gifting and egalitarian ideal in mind, we are reminded of Fredrickson's (1974b:65) argument that the people who brought the Late Period Augustine Pattern into the Walnut Creek Locality had an incipient social ranking system. Status and prestige were obtained and controlled through membership in a new regional ceremonial system that was marked in graves by unique status markers, especially "banjo" *Haliotis* ornaments (Fredrickson 1974b:65–66, see also Chartkoff and Chartkoff 1984:237; Leventhal 1993:230–236).

We conclude the review of mortuary studies with a caution that there may have been periods, as yet undocumented, when access to symbols of wealth and power was impeded. Mortuaries lacking grave associations are difficult to place in time. In large, multicomponent bay shore mounds, such as the Emeryville shell mound, any short time periods of burial without any grave associations would be impossible to recognize. Inability to recognize and study the temporal patterning of wealthy-poor mortuary assemblages may be inhibiting us from recognizing evidence of punctuated change in the past.

PHYSICAL ANTHROPOLOGY

Physical anthropology research in the Bay Area prior to the 1980s focused on biological distance between populations (Breschini 1983:52–55). More recent bioarchaeological studies have explored additional research issues, including skeletal evidence for dietary stress and signs of interpersonal violence and warfare.

Physical Types and Genetic Populations

As proposed by Gerow (1968), a single physical type prevailed among all central California peoples throughout the Late Holocene, with the exception of the divergent Windmiller people of the delta. The central California type was characterized by a broad-headed (mesocephalic) cranium in combination with relatively small postcranial morphology (Wallace and Lathrop 1975). The Early Period Windmiller people, on the other hand, were longheaded (dolichocephalic) and taller. Gerow (1993) later suggested that the Windmiller people were migrants into California with affiliation to archaic populations of the eastern United States and lowland eastern Mexico. Whatever their origin, the Delta people became smaller and wider-faced over time. By the Late Period they were morphologically similar to other central California peoples, including Bay Area groups (Gerow 1968:96–98).

Breschini (1983:56–61) distinguished a Penutian (Wintuan and Miwok) cranial type from a Hokan (Shasta and Salinan) type using discriminate analysis

on small samples from geographically discrete areas. He argued that Bay Area Costanoan speakers exhibited metric cranial characteristics intermediate between Hokan and Penutian extremes, concluding that the Costanoan speakers are a genetic mix of the two. This conclusion is controversial in light of ongoing debate among linguists regarding the reality of either the Hokan or Penutian language stocks (Chapter 6 in this volume). The differences Breschini found may track the effects of genetic drift rather than migration events (Cartier 1993:90; Suchey 1975). It is also important to recognize that Breschini's interpretations were based on an extremely small sample of metric data.

Despite concerns about overinterpretation, osteologists have continued to measure skeletal attributes that may illustrate population differentiation and mixing. In an intriguing study in the Green Valley area of the Napa Locality, Wiberg (1992:236) contrasts the 2600 to 500 cal B.C. cemetery population at SOL-315 with the cal A.D. 600 to 1900 population at adjacent site SOL-355: "Osteometric data indicate earlier site inhabitants were more narrow-headed and postcranially smaller than later [ones]" suggesting to Wiberg a shift from Yukian or Hokan people to Penutian people at 500 cal B.C.

Stark shifts in physical type have also been noted in the East Bay. Early Period Livermore Valley people were significantly larger than subsequent Middle Period and Late Period people (Wiberg 1996a:377–379). On the Fremont Plain, Hall et al. (1988) reported that the individuals of the Meganos extended burial population at ALA-343 (M3 Bead Horizon) were larger and higher-vaulted than typical Bay Area people, but somewhat smaller than Windmiller populations. That pattern supports Bennyhoff's (1994d:83) hypothesis that the Meganos culture carriers were intermarried Berkeley and Windmiller Pattern people. Given all these findings, a new regional comparative study of cranial and postcranial attributes, by bead horizon and locality, seems warranted.

Osteology and Health

Bay Area mortuary populations have not been studied for evidence of progressive dietary stress over time to the extent that Santa Barbara Channel and Sacramento Valley populations have. Relevant data are scattered in site reports and local overviews (cf. Holson et al. 2000:524–535; Jurmain 1993; Roop et al. 1982). In a synchronic comparative study of Livermore Valley skeletal populations, Wiberg (1996a:267–284, 383) found evidence for increased upper respiratory tract infections among Late Period women, perhaps reflecting work activity in aggregated groups and exposure to fire smoke. Almost twice as many women as men exhibited carious dental lesions (during all time periods), and Late Period women showed increased cribra orbitalia, a skeletal pathology thought to result from iron-deficiency anemia (Wiberg 1996a:383). In a recent study Bartelink (2006) used stable isotope data from human bone collagen to document significant regional differences in diet and health between three different prehistoric Bay Area populations.

Evidence for Warfare

Osteological evidence for warfare and other expressions of interpersonal violence occur in four forms: (1) healed bone fractures and puncture wounds, (2) direct evidence of violent death (e.g., embedded projectile points), (3) postmortem modification of skeletal material, and (4) the haphazard disposal of the dead on burned house floors or in nonformal burial pits. Hylkema (2002:260) discussed evidence for violent death at many East and South Bay sites. Strother (2003) presented a detailed summary of evidence for violent death at nine East and South Bay sites with components dating to the Middle and Late Periods.

Well-documented evidence of violence has been reported at the EMT/M1 Skyport Plaza site (SCL-478) in northern San Jose, where Wiberg (2002) documented extended burials that "appear to be linked with evidence of violence and special mortuary treatment, i.e. partial dismemberment (trophy taking) and interment in multiple graves." Pesnichak and Evans (2005:14), reporting on a subsequent excavation in a different part of SCL-478, noted victims of violent death lying on house floors, perhaps with burned roofs; they concluded that the distribution of the skeletons and their demographic mix clearly showed that the inhabitants of SCL-478 had been attacked. At the Rubino site (SCL-674), polished forearm elements were recovered that exhibited cut marks along the shaft; it was another EMT/M1 mortuary (Grady et al. 1999).

The burial population of the Late Period Hillsdale site (SCL-294) in the Santa Teresa Locality of San Jose exhibited higher rates of healed fractures and penetration wounds, 17 percent of the total population, than reported anywhere else in North America; healed wounds were 50 percent higher in females than males (Richards 1988:120-122). Elsewhere, at several Middle Period and Late Period sites in the Fremont and San Jose Localities, Jurmain (1990) reported numerous examples of forearm trauma (usually on the left arm),

interpreted as the result of parry fractures. Additionally, multicomponent Early, Middle, and Late Period sites CCO-474 in the Richmond Locality and ALA-613 in the Livermore Locality yielded a catalog list of evidence for violent interactions, including scalping, sharp-force trauma to the neck, embedded projectile points, parry fractures, and modified human bone artifacts (Strother et al. 2005; Estes et al. 2002).

Taken as a whole, reports seem to support Chartkoff and Chartkoff's (1984:236) prediction of increased violence over time, corresponding with increased resource stress and territoriality. However, some Bay Area mortuary assemblages show little or no evidence of violent death. For instance, the mortuary population of 131 skeletons at the Kenwood II site (SCL-689) in the Santa Teresa Locality south of San Jose exhibited no signs of interpersonal violence (Clark and Reynolds 2003:8). A comprehensive study is needed, quantifying amounts of violence on a horizon-by-horizon and locality-by-locality basis, in order to reconstruct and explain changing patterns of intergroup conflict.

THE BAY AREA CULTURAL SEQUENCE IN BRIEF

This section describes a series of cultural changes in the San Francisco Bay Area over the past 10,000 years. We skip discussion of occupation during the 11,500 to 8000 cal B.C. time frame, when Clovis big-game hunters, then initial Holocene gatherers, presumably lived in the area. Evidence for those periods has not yet been discovered, presumably because it has been washed away by stream action, buried under more recent alluvium, or submerged on the continental shelf (Rosenthal and Meyer 2004a:1). We do have enough evidence to document an in-place forager economic pattern beginning at 8000 cal B.C., followed by a series of five cycles of change that began at approximately 3500 cal B.C., all described in subsections below.

The Early Holocene (Lower Archaic), cal 8000–3500 B.C.
An opaque portrait of a generalized mobile forager pattern, characterized by the millingslab and handstone and by a variety of large wide-stemmed and leaf-shaped projectile points, emerges around the edges of the San Francisco Bay Area during the Early Holocene Period (including part of the geological Middle Holocene). The earliest Bay Area date for a millingstone component is 7920 cal B.C., obtained in the mid-1990s from a discrete charcoal concentration beneath an inverted millingslab at CCO-696 at Los Vaqueros Reservoir in the hills east of Mount Diablo (Meyer and Rosenthal 1997). The date came from the deepest component at CCO-696 (390–415 centimeters), which also contained a wide-stemmed projectile point of Napa Valley obsidian with a mean hydration band of 6.9 microns. Archaeobotanical remains from CCO-696 suggested an economy focused on acorns and wild cucumbers (Wohlgemuth 1997).

The earliest documented grave in west-central California was recovered in the 1990s at CCO-637 (within a few hundred meters of CCO-696 at Los Vaqueros Reservoir), where a single radiocarbon date of 6570 cal B.C. was returned from a loosely flexed burial (Meyer and Rosenthal 1998). A 325-centimeter-deep component at CCO-696 yielded a tightly flexed burial that returned a date of 5490 cal B.C. The millingstone assemblage at Los Vaqueros reservoir has yet to be assigned a phase or aspect name (Figure 8.4).

In the South Bay, SCL-178, the Metcalf Creek site, gives its name to the Metcalf Creek Aspect (or Phase), the millingstone pattern cultural expression in the Santa Clara Valley and adjacent coast. Findings from Metcalf are discussed in more detail in Chapter 9. Another Metcalf Creek Aspect millingstone site, SCL-65 (the Saratoga site), produced two flexed burials beneath cairns of millingstones dating between 5400 and 4900 cal B.C. (Fitzgerald 1993). Local Franciscan chert dominates the Early Holocene Santa Clara Valley components (Hylkema 2002:235).

The earliest radiocarbon dates in the North Bay come from the Duncan's Landing site (SON-348/H), a rock shelter that has produced a basal date of ca. 7000 cal B.C. (see Chapter 4 in this volume; Kennedy et al. 2005). The deposit was predominately mussel shell, with limited quantities of fish, bird, and pinniped, with limited numbers of obsidian flake tools and no milling equipment (Schwaderer 1992). A wide-stemmed projectile point from the site produced a hydration reading of 7.5 microns (Borax Lake obsidian), suggesting manufacture about 8,000 years ago. Farther inland, the Spring Lake site (SON-20) in a small valley just east of Santa Rosa has yielded stone millingslabs as well as large wide-stemmed projectile points and other flaked stone tools, a large proportion made from Borax Lake obsidian from distant Lake County. SON-20 is the type site of the Spring Lake Aspect of the Borax Lake Pattern, again thought to represent a mobile forager economic pattern (Fredrickson 1989a:22-23).

The Early Period (Middle Archaic), 3500 to 500 cal B.C.
New ground stone technology and the first cut shell beads in mortuaries signal sedentism, regional sym-

›olic integration, and increased regional trade in the 3ay Area, beginning at 3500 cal B.C. The earliest cut ›ead horizon—the *Olivella* grooved rectangle (Velanoweth 2001), bracketed 3400 to 2500 cal B.C.; in he Bay Area it is represented so far by a single bead rom the San Bruno Mound (Clark 1998:127, 156). Double-perforated *Haliotis* rectangle beads are first locumented in the Bay Area in the 5,590-year-old ;unnyvale Red Burial (SCL-832), which also contained red ocher and exhibited preinterment burning Cartier 2002). The earliest known *Olivella* rectangle ›eads with drilled perforations date to 4,800 years .go in a burial that contained red ocher and also :xhibited preinterment burning from CCO-637 at .os Vaqueros reservoir (Rosenthal and Meyer 2000). Rectangular *Haliotis* and *Olivella* beads are the mark:rs of the Early Period bead horizon; they continued n use at least until 2,800 years ago (Ingram 1998; Wallace and Lathrop 1975:19 for ALA-307; Gerow .968 for SMA-77).

The mortar and pestle are first documented in the 3ay Area shortly after 4000 cal B.C. Pestles utilized vith wooden mortars have been dated to 3800 cal B.C. n the Los Vaqueros reservoir area (CCO-637; Meyer ınd Rosenthal 1997). By 1500 cal B.C. cobble mortars ınd pestles were used to the exclusion of millingslabs ınd handstones at the West Berkeley site on the east :hore of San Francisco Bay (Wallace and Lathrop .975:19) and in deeply buried components at CCO-308 in the San Ramon Valley (Fredrickson 1966) and ALA-483 in the Livermore Valley (Wiberg 1996a:373). Millingstone and mortar assemblages may or may not ıave been contemporary at two East Bay sites with ›oor component differentiation (CCO-474 [Estes et ıl. 2002]; ALA-613).

In the central Bay Area, the Lower Berkeley Pattern, narked by mortars and pestles and a burial com›lex with ornamental grave associations, represents ı movement from forager to semisedentary land use ıt shell mounds like West Berkeley (ALA-307), Ellis .anding (CCO-295), and Pacheco (MRN-152). El:iptical house floors with postholes, dating to 1500 :al B.C., were discovered in 2005 at the Rossmoor site (CCO-309) in the Walnut Creek Locality; they clearly ;uggest sedentism or semisedentism in the interior East Bay (Price et al. 2006).

At the north end of San Francisco Bay, variations of nobile band (forager) economies persisted for much ›f the Early Period (Middle Archaic). The generalzed Early Holocene Borax Lake Forager Pattern (rich n obsidian flaked stone) gave way to more localized forager lifeways of the Mendocino Pattern, the chert-using Black Hills aspect of the Santa Rosa Locality, and the obsidian-using Hultman Aspect in the Upper Napa Valley. The collector-oriented Lower Berkeley Pattern, with its cobble mortars and flexed burials in residential midden sites, spread into the Napa Valley at about 1500 cal B.C. and to the Santa Rosa Locality by 1000 cal B.C. (Bennyhoff 1994b:52). For much of the Early Period, the lowland sedentary collectors lived side by side with the upland mobile foragers who occasionally visited lowland marshes.

Lower Middle Period (Initial Upper Archaic), 500 cal B.C. to cal A.D. 430

A major disruption in symbolic integration systems is clear in the record by about 500 cal B.C., the end of the Early Period (although disruption may have begun a few hundred years earlier). The ubiquitous rectangular shell beads, in use for 3,000 years, disappeared from not only the Bay Area but the Central Valley and southern California as well. Split-beveled and tiny saucer *Olivella* beads, the first examples of a whole new suite of decorative and presumed religious objects, appeared during the EMT (Elsasser 1978:39). However, EMT mortuaries around the Bay contained few accompaniments, and spire-lopped *Olivella* beads were more common than the cut beads (Luby 2004). The first rich black midden sites are noted in the Napa Valley in EMT sites (Bennyhoff 1994b:52). New sites were occupied at Bodega Bay (Kennedy 2005). Cobble mortars and Excelsier leaf-shaped projectile points appeared on the Santa Rosa Plain (Figure 8.5).

Bead Horizon M1 of the Middle Period (Upper Archaic, 200 cal B.C. to cal A.D. 430), developing out of the EMT, marks a cultural climax on San Francisco Bay. *Olivella* saucer beads became common and new circular *Haliotis* ornaments appeared. New bone tools and ornaments also appeared, among them barbless fish spears, elk femur spatulae, tubes, and whistles (Elsasser 1978:39). Basketry awls (split cannon bones) with shouldered tips, indicating coiled basketry manufacture, appeared in the Central and North Bay (Bennyhoff 1986:70; Bieling 1998:218).

Mortars and pestles continued to be the sole grinding tools during Bead Horizon M1 in the Central Bay, while mixed mortars and millingslabs continued in use around the peripheries. Net sinkers, a typical Early Period marker all around the bay, disappeared at most sites but continued in use well into the Middle Period at SFR-112 (Pastron and Walsh 1988a:90). The pure millingslab/handstone-oriented forager economy,

however, continued along the Pacific coast of San Mateo County (Hylkema 2002:261).

Upper Middle Period (Late Upper Archaic), cal A.D. 430 to 1050

A dramatic cultural disruption occurred in central California at about cal A.D. 430. The *Olivella* saucer bead trade network suddenly collapsed, 53 of 103 known M1 sites were abandoned, sea otter bones spiked in the remaining sites, and the Meganos extended-burial mortuary pattern began to spread in the interior East Bay (Bennyhoff 1994a, 1994d). These changes co-occurred with the inception of a series of *Olivella* saddle bead horizons—M2, M3, and M4—that would mark central California bead trade until cal A.D. 1000 (Groza 2002). "A Castro phase inhabitant, decked out in Saucer beads and black *Haliotis* ornaments, would have seen a Sherwood phase inhabitant, wearing ear spools, saddle bead appliqué, and red *Haliotis* rectangles, as different, even if few past archaeologists did," wrote Bennyhoff (1986:69), contrasting people of specific lower Middle Period (M1 Bead Horizon) and upper Middle Period (M3 Bead Horizon) cultural phases of his Alameda district.

The first sign of the Meganos complex, characterized by dorsal extended burials, appeared at ALA-413, the Santa Rita village site in the Livermore Valley. There, a 30-year-old man was buried at the end of Bead Horizon M1 with approximately 30,000 *Olivella* saucer beads (the largest documented California bead lot), quartz crystals, and bead appliquéd bone spatulae (Wiberg 1988). Unlike the deeper flexed interments at the site, this individual was buried in dorsally extended Meganos style. One associated saucer bead provided a median AMS intercept of cal A.D. 388 ($\Delta R = 225 \pm 35$; Groza 2002:158). Within a few years the saucer beads disappeared as burial accompaniments, replaced by rough-edged full saddle *Olivella* beads with remarkably small perforations, markers of Bead Horizon M2a. Six full saddle *Olivella* beads have been directly dated so far, from flexed burials at ALA-329 and CCO-269 along the bay shore, and from extended burials at ALA-413 and CCO-151 farther inland. All six have calibrated median intercepts in the narrow cal A.D. 420–450 time range (Groza 2002).

Bead Horizon M2b is marked by mixed *Olivella* saddle beads with tiny 1.0- to 1.5-millimeter perforations that date to cal A.D. 430–600. The Meganos mortuary style continued to spread westward during M2b. A number of new items appeared in Central Bay sites during the M2a and M2b horizons, including beautifully fashioned show blades, fishtail charmstones, new *Haliotis* ornament forms, and mica ornaments (Elsasser 1978:39:Fig. 3). The earliest evidence for inland manufacture of *Olivella* wall beads is found on the Santa Rosa Plain (Tamez 1978).

The climax of upper Middle Period stylistic refinement occurred during Bead Horizon M3 (cal A.D. 600 to 800). It is marked by small, delicate square saddle *Olivella* beads in burials, occasionally with small, poorly shaped *Olivella* saucer beads, often in off-village single component cemeteries. Single-barbed bone fish spears, ear spools, and large mortars first appear during M3. Wohlgemuth (2004:146) notes an increase in seed recovery from middens dated to this time. The Meganos mortuary complex spread during M3 from the interior almost to the Bay at the Fremont BART site (ALA-343), and into the Santa Clara Valley at Wade Ranch (SCL-302). It did not, however, reach the West Bay or the North Bay.

Bead Horizon M4 (cal A.D. 800 to 1050) may be a period of postclimax culture in parts of the Bay Area. It is marked by a devolution of the *Olivella* saddle bead template into a variety of wide and tall bisymmetrical forms, and by the appearance of distinctive *Haliotis* ornament styles (unperforated rectangles and horizontally perforated half ovals). Grave accompaniments are completely lacking at the Santa Teresa Locality Mazzoni site (SCL-131) in the South Bay, and few other mortuaries can even be dated to this time period.

Initial Late Period (Lower Emergent), cal A.D. 1050 to 1550

The lifeways in place at the Spanish entry emerged during the time of the Late Period shell bead horizons. Culture moved up a notch in complexity, from that of collectors who buried their dead with diverse, numerous, but fairly simple ornaments to collectors who invested large amounts of time in the creation of finely wrought wealth objects. The Late Period was called the Emergent Period by Fredrickson (1973, 1994c:100–101), in recognition of the appearance of a new level of sedentism, status ascription, and ceremonial integration in lowland central California. Scheme A dated the beginning of the Late Period to cal A.D. 300, but it is now clear that the Middle/Late Transition (MLT) bead horizon, marking the beginning of the Late Period, began at cal A.D. 1000. During the MLT, fully shaped show mortars, new *Olivella* bead types, and a new array of multiperforated and bar-scored *Haliotis* ornaments appeared at such sites as CCO-308

(Fredrickson 1973), ALA-42 (Wiberg 1997), and SCL-590 (Hylkema 2006). These items are initial markers of the Augustine Pattern. The classic Augustine Pattern markers appeared in Bead Horizon L1 (after cal A.D. 1250); among them were the arrow, the flanged pipe, the *Olivella* callus cup bead, and the banjo effigy ornament (Bennyhoff 1994c).

The first arrow-sized projectile point types in the Bay Area were the Stockton serrated series, a unique central California type (Bennyhoff 1994b:54; Hylkema 2002:49; Justice 2002:352). Surprisingly, they did not appear until after cal A.D. 1250. Biface and debitage production dropped significantly at Napa Valley Glass Mountain quarries with the appearance of the bow and arrow (Gilreath and Wohlgemuth 2004:14). At the same time, Napa Valley obsidian manufacturing debris increased dramatically in the interior East Bay. "Technological organization is defined by acquisition of large Napa Valley flakes that were treated as cores to produce small points, preforms, and miscellaneous simple flake tools," wrote Bieling (1997:76). In the San Jose and Point Año Nuevo Localities of the South Bay, however, debitage and casual tools continued to be derived from local Franciscan chert, and finished projectile points of Napa Valley obsidian continued to be imported from the north (Bellifemine 1997:124–136; Clark and Reynolds 2003:8; Hylkema 2002:250). Jackson and Ericson (1994) argue that Late Period North Bay obsidian exchange was regulated by social elites.

More evidence of increasing social stratification is provided by mortuary evidence. Partial cremation, often associated with the wealthiest grave offerings, appeared, or in some places reappeared. Although numbers of shell beads with burials actually dropped (Milliken and Bennyhoff 1993:392), the overall array of uncommon wealth items increased in high-status burials and cremations (Fredrickson 1994b:62). Fredrickson (1974b:66) and Bennyhoff (1994b:70, 72) suggested that the mortuary pattern, including signature *Haliotis* "banjo" effigy ornaments, reflected a new regional ceremonial system that was the precursor of the ethnographic Kuksu cult, a ceremonial system that unified the many language groups around the Bay during Bead Horizon L1.

Terminal Late Period: Protohistoric Ambiguities

The signature *Olivella* sequin and cup beads of the central California L1 Bead Horizon abruptly disappeared at around cal A.D. 1500 to 1550. Clamshell disk beads, markers of the L2 Bead Horizon, began to spread across the North Bay at that time, but were not initially traded south of Carquinez Strait. From cal A.D. 1500 to cal A.D. 1600 or 1650, the only shell beads in South Bay and Central Bay mortuaries were *Olivella* lipped and spire-lopped beads, and they occurred in far smaller numbers than the bead offerings of the L1 Horizon (Milliken and Bennyhoff 1993:392). While site distributions did not change remarkably, L2 components often seem to be thin signatures on the surface of rich L1 middens.

The North Bay was the seat of innovation during the L2 Horizon in the Bay Area. The toggle harpoon, hopper mortar, plain corner-notched arrow-sized projectile point, clamshell disk beads, magnesite tube beads, and secondary cremation all appeared in the north first. The toggle harpoon, known earlier in northwest California, replaced the multibarbed fish spear. The hopper mortar appeared on the Santa Rosa Plain and the Napa Valley for the first time, but did not spread to the Central or South Bay (Bennyhoff 1994b:54; Wickstrom 1986). Simple corner-notched points replaced Stockton serrated points in the North Bay and began to appear in the Central Bay, while Desert side-notched points spread into the South Bay from the Central Coast (see Hylkema 2002; Jackson 1986, 1989a; Jurmain 1983).

Clam beads were not manufactured in volume on the coast. Some manufacture did occur at Point Reyes (King and Upson 1970:131), but at Bodega Bay, known ethnographically as a collecting point for clamshells, only one bead blank and several drills were recovered during controlled-volume sampling at five separate sites (Kennedy 2005). Evidence of a thriving clam disk manufacturing industry does appear on the Santa Rosa Plain some 30 kilometers inland (Keswick 1990; Wickstrom 1986), as well as at NAP-539, 80 kilometers inland in the Berryessa Valley (Hartzell 1991), and YOL-69 (Wiberg 2005), 115 kilometers inland in the lower Sacramento Valley. The earliest date for clam disks south of Carquinez Strait, cal A.D. 1670, was obtained from a charcoal lens at CCO-309 (V. M. Fredrickson 1968).

Why did shell bead types, mortuary wealth distributions, and some technological artifact types change after cal A.D. 1500? Had population shot past carrying capacity due to success of regional organization during the L1 Horizon, spawning conflict and wealth contraction? Were populations on the move, forcing or marrying their way into neighboring lands? Did European-introduced epidemics spread across the continent following Spanish explorations in Mexico, causing population crashes and cultural disturbances (Erlandson

and Bartoy 1995; Preston 1996)? Whatever the cause, indications are that another upward cycle of regional integration was commencing when it was interrupted by Spanish settlement in the Bay Area in 1776.

CONCLUSION: WHAT DROVE CHANGE IN BAY AREA PREHISTORY?

In conclusion, some brief comments are offered regarded two common explanatory themes for past change in Bay Area prehistory: linguistic group migration and population pressure. Gerow (1968:98) and Breschini (1983:64–70, 98–101) posit an east-to-west spread of the mortar-based collector economy into the Bay Area during the Early Period, carried by proto-Penutian speaking peoples from the delta. Moratto (1984:207, 280, 550–557) agrees, but suggests that the invading Penutian groups were proto-Utians (ancestral Miwok-Costanoans), already differentiated from other Penutian groups. Bennyhoff (1994c:83) argues, alternatively, that the proto-Utians had come into the central San Francisco Bay Area somewhat earlier and developed the Early Period Berkeley Pattern in place (Bennyhoff 1986:67, 1994b:66). Fredrickson (1989a) concurs with Bennyhoff, positing a Lower Berkeley Pattern spread from the Central Bay into the North Bay after 1500 cal B.C. and tying it to a proto-Miwok separation from proto-Costanoan (Ohlone). An alternative argument can be made for a later arrival of the Utians, with a proto-Costanoan entry into the Bay Area during the Early Period, and the Miwokans remaining on the Sierran side of Sacramento Valley until a later date.

It was the general consensus in 1984 that Miwokan speakers expanded eastward from the North Bay into the Sacramento Valley at the EMT (500 to 200 cal B.C.), forcing the Windmiller Pattern people south into the San Joaquin Valley (Bennyhoff 1994c:66; Fredrickson 1984:511; Moratto 1984:210; Wiberg 1993:265). Under the alternative model, the Miwokans actually moved westward into the North Bay during or just prior to the EMT.

The Meganos extended burial practice in the East Bay, also found in the Stockton vicinity, seems to have its antecedent in the Early Period Windmiller Pattern of the Sacramento–San Joaquin Delta. The language of the people who carried the Windmiller and Meganos cultures has been suggested as an extinct subgroup of Utian (Moratto 1984:201–211) or as proto-Yokutsan (James Bennyhoff, personal communication to Randall Milliken, 1980). Whatever their language, their cultural pattern was pushed from the East Bay to the San Joaquin Valley at the end of the Middle Period, probably by speakers of proto-San Francisco Bay Costanoan. But what change stimulated such an expansion-retraction?

No change was more dramatic than the appearance of the Augustine Pattern, beginning in the MLT and consolidating in the L1 Bead Horizon. Bennyhoff (1994c:66–67) argues that it arose through stimulation from Patwin speakers newly arrived into the Sacramento Valley from Oregon, bringing with them the bow, the flanged pipe, preinterment grave pit burning, and other new traits. It is a challenge to linguistic group–based explanation that the key traits of the Augustine Pattern were shared by Plains Miwoks, Patwins, Bay Miwoks, San Francisco Bay Costanoans, Coast Miwoks, Wappos, and southern Pomos at the time of Spanish settlement. Perhaps the Augustine Pattern, with its inferred shared regional religious and ceremonial organization, was developed as a means of overcoming insularity, not in the core area of one language group but in an area where many neighboring language groups were in contact.

Finally we turn to the question of population pressure, often offered as an explanation for the rise of cultural complexity in the past. Under hunting and gathering conditions, human populations have an "intrinsic rate of natural growth" in the general range of 1 percent to 3 percent per year, which allows them to double in size within a century, unless the growth rate is somehow checked (Richardson et al. 2001:396–397). Bay Area population pressure must have been incessant in all times in the past, with the exception of the initial centuries of colonization during the Terminal Pleistocene. We presume that Bay Area populations cyclically approached and overran their carrying capacity, crashed (probably through warfare, since humans have only one important predator), and quickly rebounded. Only technological or social innovations allowed the carrying capacity to be raised, and such innovations, we suggest, did not always occur.

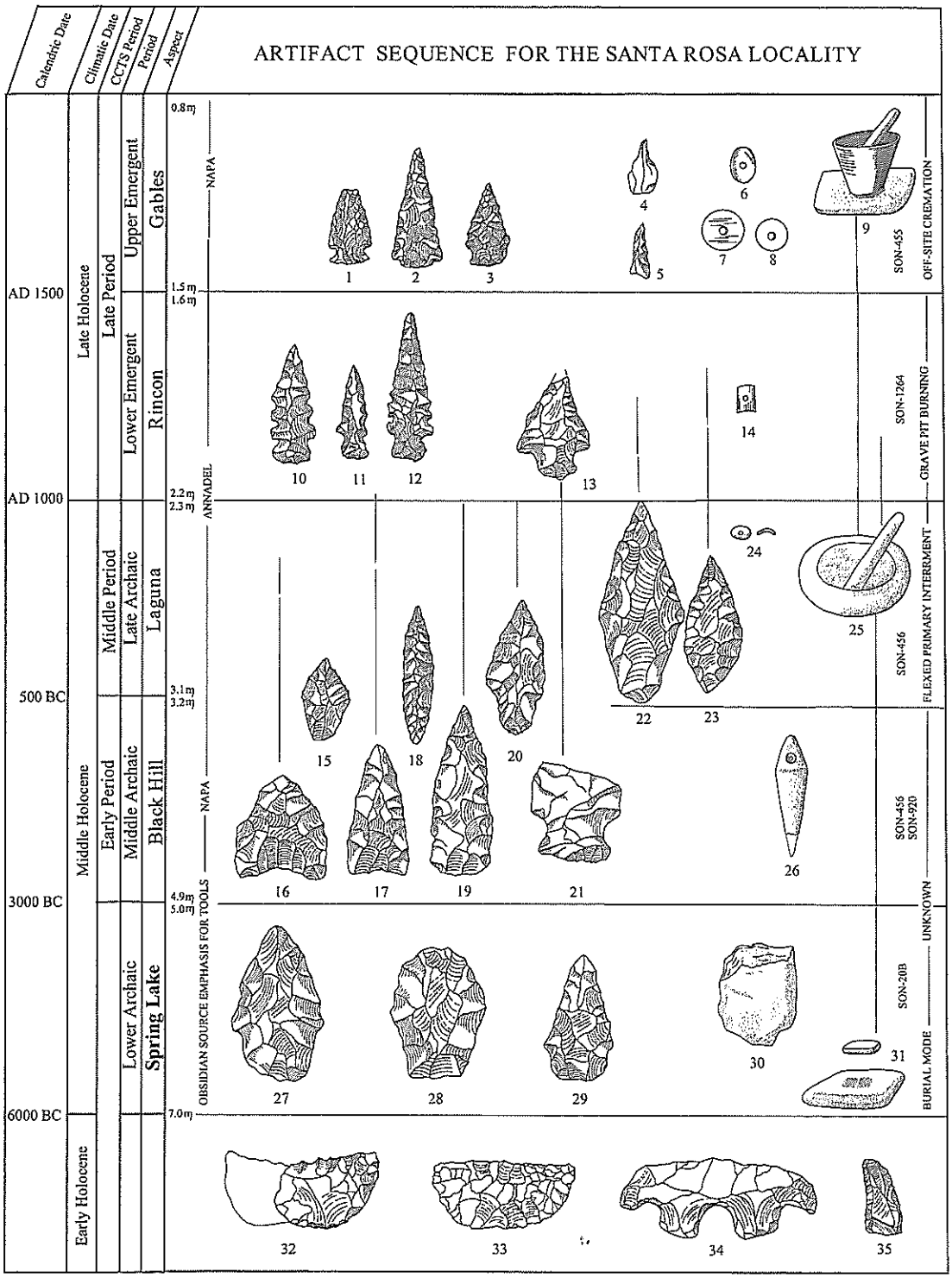


Figure 8.5. Artifact sequence for the Santa Rosa Locality. Key: (1–3) obsidian corner-notched arrow points; (4–5) chert bead drills; (6) *Olivella* lipped bead; (7–8) clamshell disk beads; (9) hopper mortar and pestle; (10–12) obsidian serrated, corner-notched projectile points; (13) side-notched spear point or hafted knife; (14) *Olivella* rectangular bead; (15) obsidian small, diamond-shaped projectile point; (16–17) obsidian (or chert) concave-based projectile points; (18) obsidian (or chert) narrow, leaf-shaped projectile point; (19-20) chert stemmed projectile points; (21) chert side-notched spear point or hafted knife (chert earlier, obsidian later); (22–23) obsidian shouldered, lanceolate projectile points; (24) *Olivella* saddle-shaped bead; (25) bowl mortar and pestle; (26) blue schist charmstone (biconically drilled); (27–28) obsidian wide-stemmed projectile points; (29) obsidian small-stemmed projectile point; (30) basalt unifacial cobble tool; (31) millingslab and handstone; (32) obsidian (Napa) butterfly form crescent; (33) chert lunate form crescent; (34) chert zoomorphic form crescent; (35) high-quality chert unifacial tool. (Only projectile points drawn to relative scale. Drawings by Nelson Thompson.)

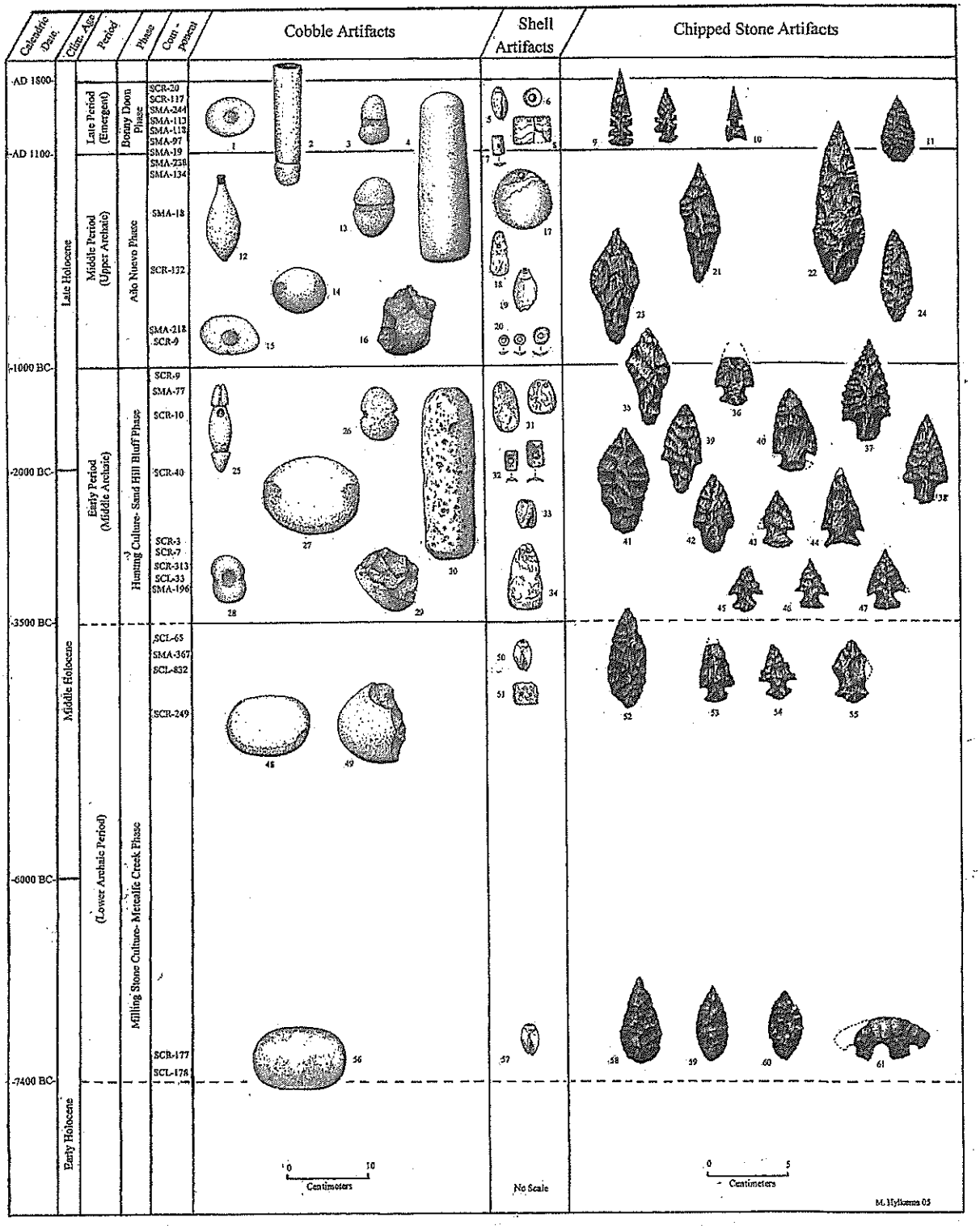


Figure 8.6. Artifact sequence for the San Mateo coast and Santa Cruz Localities.

Key: (1) sandstone bi-pitted cobble, SMA-134;
(2) chlorite schist tobacco pipe, SCR-117;
(3) Andesitic grooved sinker, SMA-238;
(4) sandstone pestle, SCR-20;
(5) *Olivella biplicata* type A1 series bead, SMA-244;
(6) steatite disk bead, SMA-244;
(7) *Olivella* M1a thin rectangle bead, SCR-20;
(8) *Haliotis* type RC5e ornament SMA-238;
(9) Napa obsidian Stockton-serrated points, SMA-244;
(10) Monterey chert desert side-notched point, SCR-20;
(11) Napa obsidian lanceolate point, SMA134;
(12) Andestic piled charmstone, SCR-132;
(13) sandstone grooved sinker, SCR-132;
(14) granitic shaped handstone, SCR-132;
(15) sandstone bi-pitted cobble, SCR-132;
(16) basaltic cobble chopper, SMA-218;
(17) *Haliotis* type CA3h ornament, SCR-10;
(18) *Haliotis* type OB3 ornament, SCR-9;
(19) *Olivella biplicata* type A1 series bead, SMA-18;
(20) *Olivella biplicata* type G series beads, SMA-218;
(21) Monterey chert Año Nuevo long-stemmed point, SCR-9;
(22) Napa obsidian lanceolate point, SMA-97;
(23) Monterey chert Año Nuevo long-stemmed point, SMA-218;
(24) Napa obsidian lanceolate point, SMA-18;
(25) serpentine perforate charmstone, SCR-93;
(26) sandstone edge-notched sinker, SMA-77;
(27) granitic handstone SCR-9;
(28) granitic bi-pitted cobble, SCR-7;
(29) quartzitic cobble chopper, SCR-7;
(30) sandstone pestle, SCR-40;
(31) *Haliotis* type SC3 and FA5 ornaments, SMA-77;
(32) *Olivella biplicata* L series rectangle beads, SMA-77;
(33) *Olivella biplicata* type B series barrel bead, SCR-38;
(34) *Haliotis* type OK5 ornament, SMA-77;
(35) Monterey chert Año Nuevo long-stemmed point, SMA-218;
(36) Monterey chert notched point, SCR-9;
(37) Franciscan chert Rossi square-stemmed point, SCR-9;
(38) Monterey chert Rossi square-stemmed point, SCR-7;
(39) Monterey chert shouldered contracting-stemmed point, SCR-40;
(40) chalcedony notched point, SCR-7;
(41) Monterey chert contracting-stemmed biface, SCR-7;
(42) Monterey chert shouldered contracting-stemmed point, SCR-7;
(43-47) Franciscan chert notched points SCR-7;
(48) sandstone handstone, SCL-65;
(49) quartzitic cobble chopper, SCR-177;
(50) *Olivella biplicata* A1 series bead, SCL-832;
(51) *Haliotis* type H2a bead, SCL-832;
(52) Monterey chert biface, SMA-196;
(53) Monterey chert notched point, SCR-249;
(54) Monterey chert notched point, SCR-313;
(55) Monterey chert notched point, SCL-65;
(56) sandstone handstone, SCL-178;
(57) *Olivella biplicata* type A1 series bead, SCL-178;
(58-60) Monterey chert lanceolate points, SCR-177;
(61) Monterey chert eccentric crescent, SCR-177.
(Some artifacts not drawn to scale. Artifacts depicted are represented at multiple sites. Drawings by Mark G. Hylkema.)

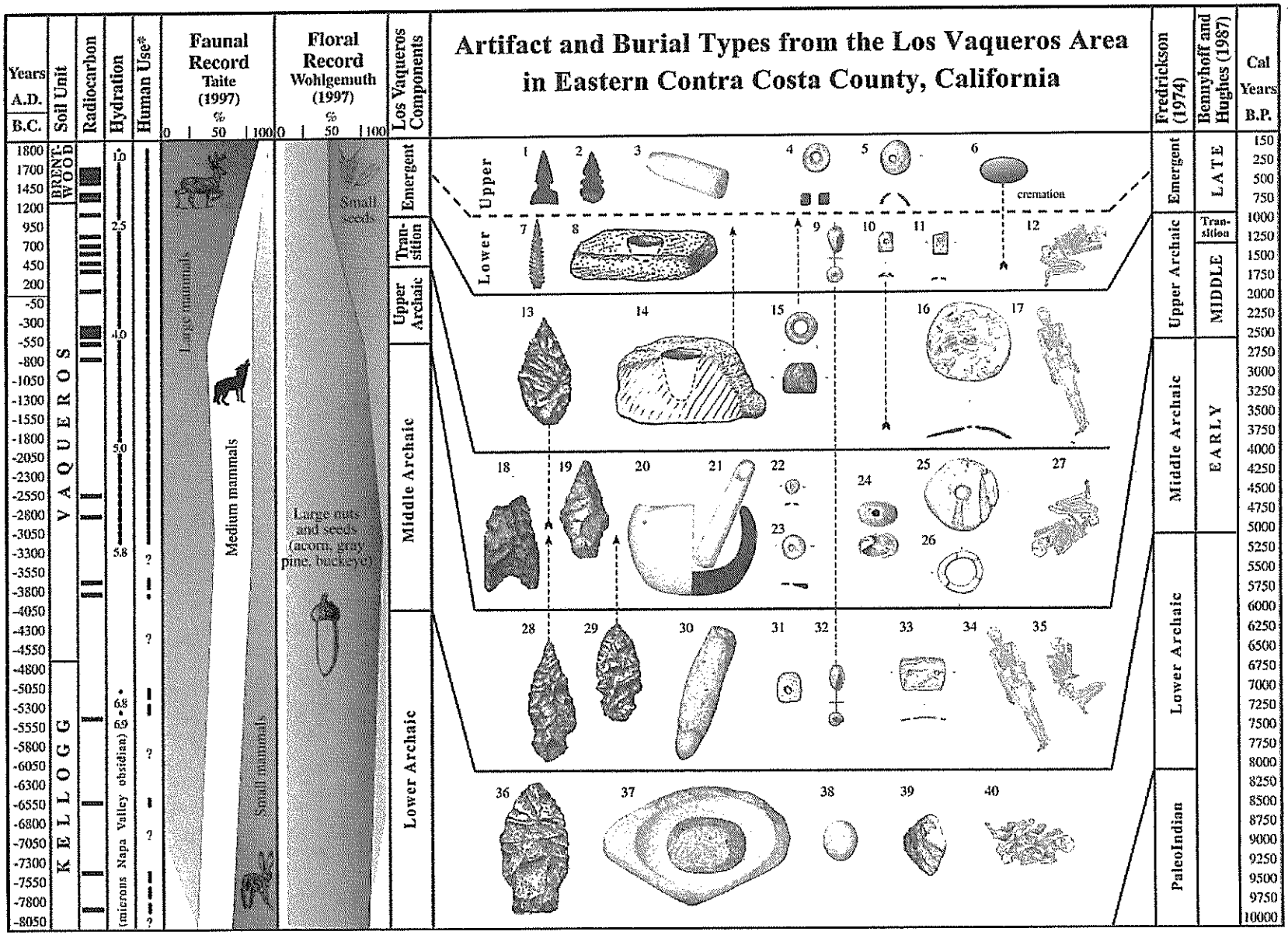


Figure 8.7. Artifact sequence for the border area between the Livermore Locality and the San Joaquin Valley.

Key: (1) Panoche side-notched and desert side-notched projectile points (mainly cryptocrystalline rock);
(2) Stockton side-notched and corner-notched projectile points made only of obsidian;
(3) small cylindrical pestles;
(4) clamshell disk beads;
(5) lipped *Olivella* beads, Type E;
(6) cremation of human remains;
(7) Stockton stemmed projectile points made only of obsidian;
(8) small block mortars;
(9) spire-lopped *Olivella* beads, Type A1b;
(10) thin rectangular *Olivella* beads, Type M1;
(11) thin rectangular *Olivella* beads, Type M2;
(12) tightly flexed burials with variable orientations;
(13) shouldered lanceolate projectile point made of obsidian;
(14) bedrock mortars (Upper Archaic Period cups larger than Emergent Period cups;
(15) steatite beads;
(16) *Haliotis* ornaments, Type CA4fm;
(17) ventrally extended burials primarily with northern orientations;
(18) concave-base projectile points made of chert and obsidian;
(19) contracting-stemmed projectile point made of chert;
(20) shaped and cobble bowl mortars;
(21) shaped and cobble pestles;
(22) saucer *Olivella* beads, Type G1 and G2;
(23) *Macoma* clam disk beads;
(24) split *Olivella* beads, Type C;
(25) *Haliotis* ornaments, Type C1C;
(26) *Haliotis* ornaments, Type C2C;
(27) tightly flexed burials, primarily with southwest orientation;
(28) side-notched projectile point made of chert (CCO-637, Burial 7, 3850 cal B.C.);
(29) side-notched projectile point made of chert (CCO-637, Burial 5, 3720 cal B.C.);
(30) cobble pestles with convex parabolic end wear;
(31) thick rectangular *Olivella* beads;
(32) spire-lopped *Olivella* beads, Type A1a;
(33) *Haliotis* ornament, Type uBA7;
(34) fully extended and semiextended burials, primarily with northwest orientations;
(35) loosely flexed burials, primarily with northwest orientations;
(36) wide-stemmed projectile point made of obsidian (CCO-696, 6.9 microns Napa Valley);
(37) millingslabs and oval bifacial handstones;
(38) small round handstones;
(39) cobble-core tools;
(40) cairn burial (CCO-696, Burial 160, 5540 cal B.C.).
Approximate timing and duration of human use in the project area based on combined radiocarbon and obsidian hydration evidence. Courtesy of Jack Meyer.

Ballena Press Anthropological Papers No. 43
Series Editor: Thomas C. Blackburn

A TIME OF LITTLE CHOICE

The Disintegration of Tribal Culture in the San Francisco Bay Area 1769-1810

by

Randall Milliken

A BALLENA PRESS PUBLICATION

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Ballena Press Anthropological Papers Editors:
Sylvia Brakke Vane
Thomas C. Blackburn
Lowell John Bean

Library of Congress Cataloging in Publication Data

A time of little choice: the disintegration of tribal culture in the San Francisco Bay area, 1769-1810 / by Randall Milliken.
p. cm. -- (Ballena Press anthropological papers : no. 43)
Includes bibliographical references and index.
ISBN 0-87919-132-5 (alk. paper) : $32.95 --
ISBN 0-87919-131-7 (pbk. : alk. paper) : $24.95
1. Indians of North America--California--San Francisco Bay Area--History--18th century. 2. Indians of North America--California--San Francisco Bay Area--History--19th century. 3. Indians of North America--Missions--California--San Francisco Bay Area. 4. Catholic Church--Missions--California--San Francisco Bay Area--History--Sources. I. Title.
E78.C15M55 1995
979.4'601--dc20

95-22975
CIP

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Ballena Press
823 Valparaiso Avenue
Menlo Park, CA 94025

Orders: Ballena Press Publishers' Services
P. O. Box 2510
Novato, CA 94948

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Printed in the United States of America.

on upper San Anselmo Creek to the west. The Habastos went to Mission San Francisco between 1800 and 1810. Many of them returned to their homeland as Mission Indians when Mission San Rafael was founded in late 1817.

Huchiun (Costanoan language). Huchiun lands seem to have extended over a large area along the East Bay shore, from Temescal Creek opposite the Golden Gate north at least to the lower San Pablo and Wildcat Creek drainages in the present area of Richmond. East Bay people who came to Mission San Francisco before 1787 were said to be from numerous specific villages in "Yacomui." The most commonly mentioned villages were Genau and Josquizara. Yacomui probably referred to "Easterners" in the Costanoan language of the San Francisco area (Heizer 1974:43). Family reconstitution evidence and one direct statement indicate that Genau was a Huchiun village (SFR-B 188-191, 194, 201, 203, 450, 541). The first explicit reference to the Huchiun involved an individual who was baptized in 1787 "from the village of Junchaque of the Juchiun nation" (SFR-B 581). The first large groups of Huchiuns came to Mission San Francisco in the fall of 1794. Missionary Antonio Dantí identified them as "Jutchiunes—All from the northeast of the mission" (SFR-B 1628). Between 1800 and 1805 they appeared in mixed groups with Huchiun-Aguastos. The missionaries were inconsistent in their identification of nuclear family members as Huchiun or Huchiun-Aguasto. Either it did not matter, because the two groups were a single tribe, or the missionaries found it impossible or unimportant to differentiate them. In addition to 384 Huchiun converts there were 95 Huchiun-Aguastos (see below).

Sometime before 1820 Mission San Francisco founded a cattle ranch in the Richmond, San Pablo area which they called "San Ysidro of the Juchiunes" (SFR-B 5875, 5879). That mission ranch, taken over during the 1820s by the Castro family, became the Mexican rancho called "San Pablo, alias Los Cuchiyunes." Temescal Creek in north Oakland, directly across the bay from San Francisco, was known in the Mexican era as the "Arroyo del Temescal o Los Juchiyunes" (Land Case Map E-214, Bancroft Library, Berkeley).

Huchiun-Aguasto (Costanoan language). The Huchiun-Aguastos held lands in the East Bay on the southeast shores of San Pablo Bay. The first member of the group identified in San Francisco baptismal records was Blandina Guaiamay from "the village of Ssogoreate on the port of the Assumption near the outlet of the great river of Our Father San Francisco, of the family of the Aguasajuchiun" (SFR-B 708). Groups of Huchiun-Aguastos went to Mission San Francisco between 1803 and 1811, usually with Carquins or Huchiuns. Many of the 384 Mission San Francisco people baptized merely as "Huchiuns" were

REPORT

Remedy Implementation Completion Report

The Sherwin-Williams Company
1450 Sherwin Avenue
Emeryville, California

Prepared For:

The Sherwin-Williams Company
101 Prospect Avenue NW
Cleveland, OH 44115

Prepared By:

CDM Smith Inc.
100 Pringle Avenue, Suite 300
Walnut Creek, California 94596

July 25, 2012

CDM Smith

Remedy Implementation Completion Report

The Sherwin-Williams Company
1450 Sherwin Avenue
Emeryville, California

July 25, 2012

Prepared For:

The Sherwin-Williams Company
101 Prospect Avenue NW
Cleveland, OH 44115-1075

CERTIFICATION:

This document was prepared under the direction and supervision of qualified, registered professionals.



David K. Cline, P.E.
CDM Smith Inc.



Pawan K. Sharma, P.E.
CDM Smith Inc.

Envirocon

July 25, 2012

Mr. Larry Mencin
Sherwin-Williams
1450 Sherwin Ave.,
Emeryville, CA 94608

RE: Certification Letter for the Remedy Implementation Completion Report
The Sherwin-Williams Company: 1450 Sherwin Avenue,
Emeryville, California

Dear Mr. Mencin:

The intent of this letter is to summarize the design components and remedial activities performed by Envirocon in executing our contract for The Sherwin-Williams Company (S-W) property located at 1450 Sherwin Avenue in Emeryville, California and in doing so, certify that these activities were performed in accordance with the Remedial Design and Implementation Plan.

- Design Assistance with formalizing the Final Remedial Design Implementation Report (RDIP), dated June 29, 2011, included:

    - Heave Management Plan and Earthwork Requirements, prepared by TRC Solutions, dated January 24, 2011: *Geotechnical Recommendations, Remedial Design and Implementation Plan (RDIP), Former Sherwin-Williams Coating Facility, Emeryville, California*;

    - Temporary Shoring Design along Horton Street and Building 31 to support excavation to depths of -11 FT NAVD88, prepared by Condon Johnson, dated February 10, 2011: *Temporary Shoring Plans;*

    - Dust and Vapor Control Plan to mitigate public concerns at the Site perimeter, prepared by KUMA Corporation, dated May 2011: *Dust and Vapor Control Plan V1.6;*

    - Noise and Vibration Monitoring and Mitigation Plan to compare background levels to high energy construction equipment; prepared by Eilar Associates, Inc., dated January 20, 2011, *Noise and Vibration Monitoring Plan*;

- Stability Analysis to support the excavation(s) of each: Slurry Wall Extension, Slurry Wall Breaches, and the Interceptor Trench, prepared by Envirocon, dated October 25, 2011: *Trench Stability Calculation for SWE* (Submittal No. 004.c.1), November 7, 2011: *Trench Stability Calculations for Slurry Wall Breaches* (Submittal No. 011.b), and November 23, 2011: *Interceptor Trench Stability Calculations* (submittal No. 014.f);

- Excavation Design Plan developed to incorporate boring logs from historical and recent data into a 3-dimensional excavation plan that could be utilized to segregate the excavation into 8 separate categories; prepared by Envirocon, dated March 19, 2011: *Excavation Design Plan*(s).

- Pre-mobilization activities including submittal of workplans and acquiring construction related permits;

- Installation and operation of a temporary soil vapor extraction and treatment system to remove volatile organics from excavation area vadose zone soils;

- Relocation of high-pressure natural gas line from adjacent to the excavation, under the western sidewalk along Horton Street, to the other side of the street;

- Removal and offsite disposal of aboveground and underground structures, pipes, and debris containing arsenic, lead, and/or organic contaminants, primarily consisting of the raised cap and former water treatment plant;

- Excavation and offsite disposal of vadose zone soil containing arsenic, lead, and/or organic contaminants to support future potential residential use of the Site;

- Excavation and offsite disposal of saturated zone soil containing arsenic, lead, and/or organic contaminants to support long-term protection of groundwater underlying the Site;

- Excavation dewatering, onsite treatment, and discharge to sanitary sewer;

- Backfill of excavation areas to control groundwater movement within the Site;

- Placement of backfill and gravel cover to re-grade the Site to facilitate storm water drainage;

- Extension of the existing slurry wall along the southwestern portion of the Site;

Envirocon

- Installation of a membrane barrier and interceptor trench to prevent movement of groundwater from the S-W property to the Novartis property;

- Removal of portions of the existing slurry wall to facilitate groundwater movement from the Site to offsite, downgradient (western) areas;

- Abandonment of a former underground storage tank (UST) at the Site.

The remedial activities listed above including those items specifically identified to support the design assistance were, to the best of my knowledge and belief, performed in general accordance with the Final Remedial Design and Implementation Plan (RDIP) and its associated documents including Department of Toxic Substances Control (DTSC) approved variances, as described and documented in the Remedy Implementation Completion Report prepared by CDM Smith, dated July 25, 2012.

Further, my review of the project data and quality control procedures and my assessment of the persons directly responsible for gathering QA/QC information pertaining to construction of the remedy elements associated with the RDIP indicate that these activities were, to the best of my knowledge and belief, conducted in general accordance with applicable industry standards and the Site specific Quality Control/Quality Assurance Project Plan.

Respectfully submitted,



Tino Maestas, P.E.
Senior Engineer
Envirocon, Inc.

Cc Peter Joy, Envirocon Director of Operations
Jeff Rankin, Envirocon Project Director

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Attachment K4	Former UST Excavation Analytical Reports (on disc with DTSC submittal only)

Executive Summary

This Remedy Implementation Completion Report (Completion Report) has been prepared for The Sherwin-Williams Company (S-W) property located at 1450 Sherwin Avenue in Emeryville, California and a portion of the adjacent former Rifkin property, located at 4525 – 4563 Horton Street, to which hazardous substances have migrated from the S-W property. Collectively the S-W property and this portion of the former Rifkin property are referred to as the "Site" within this document. The Site consists of approximately 10 acres. Novartis Vaccines and Diagnostics, Inc. (Novartis) is the current owner of the former Rifkin property.

This Completion Report is consistent with the description of report contents presented in Section 14.2.1 of the Remedial Design Implementation Plan (RDIP), dated June 29, 2011 (CDM, 2011), and with the Department of Toxic Substances Control (DTSC) Imminent and Substantial Endangerment Determination and Order and Remedial Action Order No. 05/06-007 (the Order) and the Remedial Action Plan (RAP), dated May 10, 2006 and June 14, 2010, respectively (DTSC, 2006 and CDM, 2010). The RAP and RDIP were approved by DTSC in their letters dated June 14, 2010 and June 30, 2011, respectively (DTSC, 2010 and DTSC, 2011a). DTSC had previously provided conditional approval to proceed with soil excavation after partial review of the RDIP in their letter dated June 8, 2011(DTSC, 2011b). The RAP and RDIP provide summaries of the Site location, background, geology/hydrogeology, and history, and previous project remedial investigation results and actions.

The remedy implementation has achieved the project remedial action objectives (RAOs). The following presents the RAOs that were established for the Site in the RAP and remedy component that fulfills the RAO:

Remedial Action Objective (RAO)	*Remedy Component*
▪ Minimize direct contact/ingestion by humans with Site soil containing chemicals of concern (COCs) at concentrations exceeding the cleanup goals.	▪ Removal of vadose zone soil with COC concentrations above cleanup goals. ▪ Development and recording of the land use covenant (LUC). ▪ Monitor for unknown contamination in areas outside existing removal areas, as identified in the project operation, maintenance and monitoring (OM&M) plan and/or subsequent DTSC-approved modifications. ▪ Monitor soil gas conditions, as identified in the OM&M plan and/or subsequent DTSC-approved modifications.
▪ Minimize migration of and/or inhalation of airborne dust by humans from the Site containing COCs at concentrations exceeding the cleanup goals.	▪ Removal of vadose zone soil with COC concentrations above cleanup goals. ▪ Development and recording of the LUC, controlling intrusive activity at the S-W property.

Remedial Action Objective (RAO)	*Remedy Component*
▪ Minimize exposure to and inhalation by humans of volatile organic COCs at concentrations in indoor air exceeding the cleanup goals.	▪ Removal of vadose zone soil with COC concentrations above cleanup goals. ▪ Development and recording of the LUC. ▪ Monitor for unknown contamination in areas outside existing removal areas, as identified in the OM&M plan and/or subsequent DTSC-approved modifications. ▪ Monitor soil gas conditions, as identified in the OM&M plan and/or subsequent DTSC-approved modifications.
▪ Minimize risk to down-gradient ecological receptors from off-site groundwater migration containing COCs at concentrations exceeding the cleanup goals.	▪ Removal of saturated zone soil with COC concentrations identified as source material. ▪ Backfill to control groundwater movement. ▪ Installation of slurry wall breaches and extension; maintain key portions of existing slurry wall. ▪ Monitor groundwater conditions, as identified in the OM&M plan and/or subsequent DTSC-approved modifications.
▪ Minimize on-site human contact with groundwater containing COCs at concentrations exceeding the cleanup goals.	▪ Removal of saturated zone soil with COC concentrations identified as source material. ▪ Development and recording of the LUC.

Vadose zone soils with chemicals of concern above cleanup goals have been removed. Confirmation samples were collected from the vadose zone excavation sidewalls to demonstrate conformance with the cleanup goals as established in the RAP.

The remedy implementation occurred between March 2011 and April 2012, and consisted of the following key components:

- Installation and operation of an air monitoring system and air sampling program to evaluate the effectiveness of Site controls in maintaining the safety of the surrounding community.
- Installation and operation of a temporary soil vapor extraction and treatment system to remove volatile organics from the most impacted vadose zone excavation area.
- Relocation of a high-pressure natural gas line, from under the western sidewalk of Horton Street (i.e., adjacent to the excavation) to the other side of the street.
- Removal and offsite disposal of aboveground and underground structures, pipes, and debris containing arsenic, lead, and/or organic contaminants, primarily consisting of the raised cap and former water treatment plant.

- Excavation and offsite disposal of vadose zone soil containing arsenic, lead, and/or organic contaminants to support future potential residential use of the Site.
- Excavation and offsite disposal of saturated zone soil containing arsenic, lead, and/or organic contaminants to support long-term protection of groundwater.
- Excavation dewatering, and onsite pre-treatment and discharge to sanitary sewer of extracted water.
- Backfill of excavation areas to control groundwater movement within the Site.
- Placement of backfill and gravel cover to re-grade the Site to facilitate storm water drainage.
- Extension of the existing slurry wall along the southwestern portion of the Site.
- Installation of a membrane barrier and interceptor trench to prevent movement of groundwater from the S-W property to the Novartis property.
- Removal of portions of the existing slurry wall to control groundwater movement from the Site to offsite, downgradient (western) areas.
- Abandonment of a former underground storage tank (UST) at the Site.
- Abandonment of selected existing groundwater wells no longer required for the project.
- Installation of new groundwater wells required for the post-remedy implementation groundwater monitoring program.

The remedy implementation was completed by S-W's contractors, Envirocon Inc., Waste Solutions Group, and CDM Smith Inc., and their subcontractors.

This Completion Report provides summaries of the completed remedy components; documents variances in their implementation from that described in the RDIP; presents actual amounts and dispositions of waste; presents the results of the air monitoring and sampling; presents selected photographic documentation of pre- and post-remedy Site conditions; and, presents locations and plans for protection and monitoring of installed remedy components.

Variances from the RDIP are identified in this Completion Report with reference to the RDIP sections. For reference, the RDIP Table of Contents is included with this Completion Report as Attachment A.

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Section 1

Documentation of Results

1.1 Locations and Quantities of Excavated Soil

The Asbuilt Drawings in Attachment B illustrate the final spatial boundaries of the excavation areas. Based on the actual weigh tickets returned from receiving landfills, 149,708 tons of soil and debris were removed from the Site. Of this amount, approximately 139,600 tons were removed to support the remedy; the preliminary estimate for waste disposal amount during remedy planning was 106,200 tons. The larger final quantity for soil removal to support the remedy is due to (1) the expanded excavation boundary in the main excavation area and (2) higher amounts of debris/concrete encountered resulting in relatively higher density to the excavation volume removed.

The approximately 20,148 tons of additional soil and debris removed from the Site were from activities that developed from the remedy implementation but did not directly support the RAOs, including:

- removal of underground utility pipes and overlying soils encountered during excavation, slurry wall extension, and activities pertaining to slurry wall breaches,
- removal of pavement, vadose zone soil, and buried concrete foundations within the northern portions of the S-W property to support storm water drainage, and
- removal of the water treatment plant (WTP), and underlying vadose zone soils, after completion of dewatering activities.

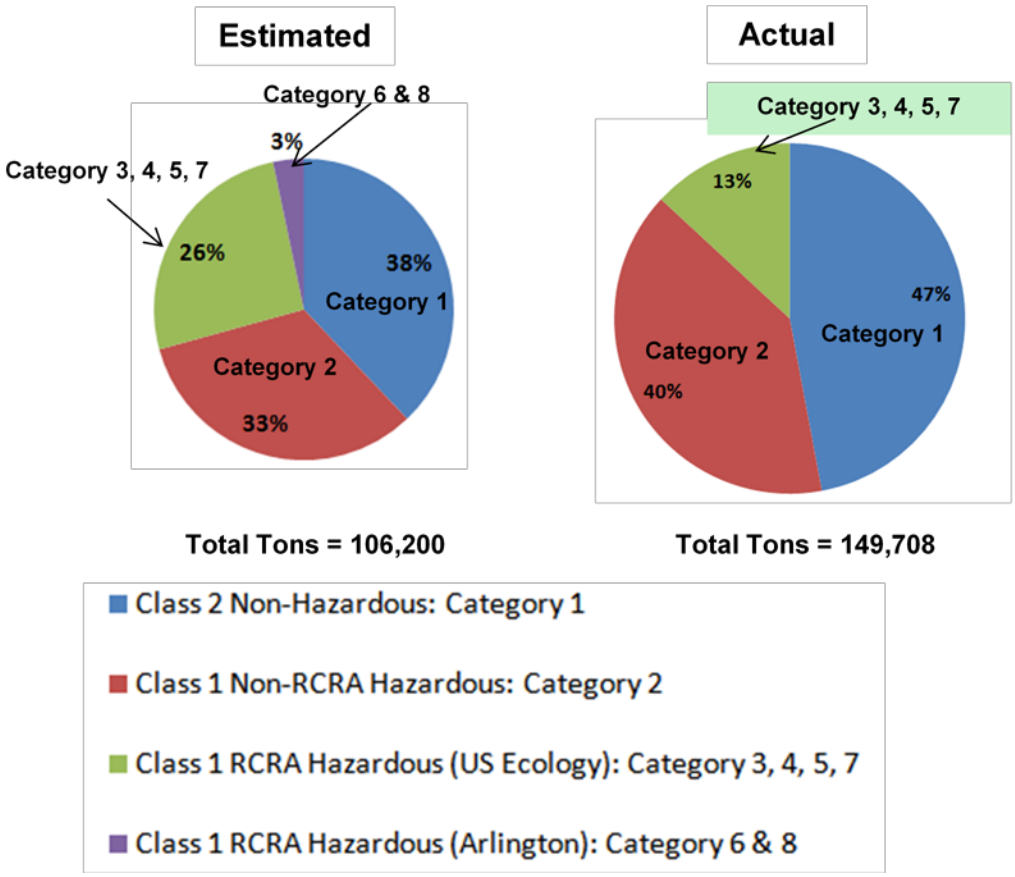
1.2 Amounts Disposed by Waste Characterization Profile

The RDIP identified eight possible project waste categories from the excavation, based on evaluation of in place sample results and state/federal hazardous waste regulations. The U.S. EPA waste classification for each category is described as follows:

- Category 1 - Class 2, non-hazardous waste.
- Category 2 - Class 1, non-RCRA hazardous waste.
- Categories 3 through 8 - Class 1, RCRA hazardous waste of various types.

The RDIP estimated amounts of materials for each of these eight categories. The materials for Categories 1 through 5 and 7 (see below) were transported to their designated facilities listed in the RDIP. Anticipated RCRA hazardous waste containing metal and organic underlying hazardous constituents with total volatile organic compounds at or greater than 500 mg/kg (Category 6 and 8) were not identified during stockpile characterization. No material was transported to the designated disposal facility for these two categories (in Arlington, OR). Hazardous waste was shipped under manifests with S-W EPA generator identification number CAD003934601. Non-RCRA and RCRA waste manifests are presented in Attachment J1 and Attachment J2, respectively.

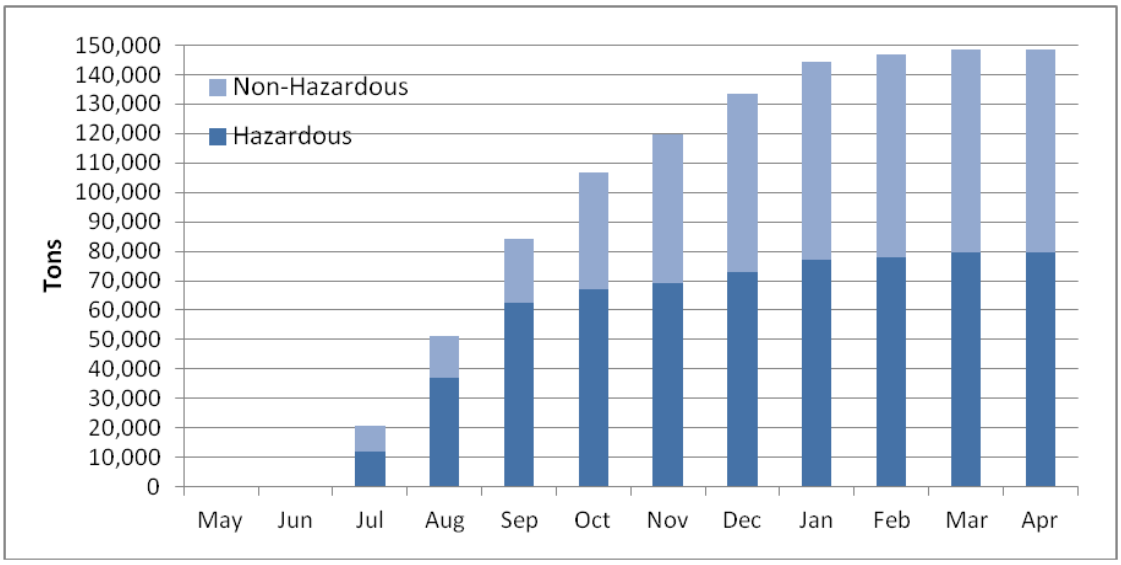
The two pie charts shown below reflect the percentages of waste disposal by category, as estimated in the RDIP and the actual disposition.



Final waste amounts removed from the Site are presented by their waste characterization results below and are based on reported weights received by the disposal facilities.

Waste Characterization	*Project Waste Category*	*Amount (Tons)*
Class 2 Non-Hazardous	1	69,671
Class 1 Non-RCRA Hazardous	2	60,650
Class 1 RCRA Hazardous (US Ecology)	3, 4, 5, 7	19,387
Class 1 RCRA Hazardous (Arlington)	6 & 8	0

The following chart presents excavated materials transported offsite (in accumulated tons by month):



The following summarizes total truck loads and rail cars by waste type:

Total trucks with non-hazardous waste loads out:	2,670
Total trucks with non-RCRA hazardous waste loads out	302
Total trucks with RCRA hazardous waste loads out:	4
Total rail cars with RCRA hazardous waste loads out	180
Total rail cars with non-RCRA hazardous waste loads out:	502

1.3 Soil Vapor Extraction and Treatment

In accordance with the RDIP and the Bay Area Air Quality Management District (BAAQMD) operation permit, the soil vapor extraction and treatment (SVET) system was operated prior to excavation activities. The extraction wells were installed between April 25 and 29, 2011 under an Alameda County Public Works Agency (ACPWA) permit, and the treatment system assembled during that same timeframe. The wells and treatment system were built in accordance with the RDIP. Startup of the system occurred May 2, 2012 and it operated for approximately six weeks until total VOC levels in the soil gas stabilized and DTSC approved the commencement of excavation activities. The wells were abandoned under an ACPWA permit by removal during excavation. Site permits are included in Attachment F.

Attachment D1 presents a summary of the daily total flow rate and total VOC measurements during the SVET operation. Total VOC measurements were one to three orders of magnitude higher than that anticipated in the RDIP. The constructed treatment system was able to handle this additional mass rate. Per the BAAQMD permit, bi-weekly samples were collected from the SVET system effluent stream. No VOCs were detected in any of these samples and reporting limits were below permit requirements. Site permits are included in Attachment F.

1.4 Air Quality Monitoring Results

Throughout the remediation activities, as described in RDIP Section 14, air quality on and surrounding the Site was monitored and the results submitted to DTSC in weekly and monthly reports, and in daily reports for the first several weeks. Air quality monitoring reports submitted were posted to the DTSC website where they are available for review (DTSC Envirostor, 2012) and are provided in Attachment C.

The airborne concentrations of Total Volatile Organic Compounds (TVOC) and Respirable Particulate Matter of 10 microns or less (RPM10) for the air monitoring stations were below the project action levels as presented in the charts in Attachment D2.

RPM10 readings from the air monitoring stations ranged from 0.0 micrograms per cubic meter ($\mu g/m^3$) to 432 $\mu g/m^3$ and averaged less than acute RPM10 action levels for any 4-hour period as established for the phases of the excavation: raised cap removal, vadose zone soil removal, and saturated soil removal. During the monitoring, the running average for RPM10 readings from the start of the project was less than the subchronic RPM10 action level (see charts in Attachment D2).

TVOC readings from the air monitoring stations ranged from 0.0 parts per million volume (ppmv) to 12.8 ppmv and averaged less than 1.80 ppmv for any one 24-hour period, which is less than the acute TVOC action level. During the monitoring, the running average for TVOC readings from the start of the project was less than the subchronic TVOC action level (see charts in Attachment D2).

Shortly after startup it was determined the perimeter misters, being used for odor and vapor control, located adjacent to the air monitoring stations were impacting the RPM10 readings. The very low particle sizes of the mist were being included in the monitor's readings. Through a DTSC-approved protocol for daily calibration of the incremental increase in RPM10 readings due to the effects of the misters, a daily adjustment to the action level for AMS #3 was applied. Near the end of October, as the misters were no longer in use, calibration and daily adjustment of the action level were discontinued. As the RPM10 chart indicates this adjusted action level had no relevance to the running average over the length of the project. The correspondence with DTSC regarding the daily calibration of the AMS#3 action level is provided in Attachment D2.

During the first six weeks of excavation, daily air samples were collected at several of the AMS locations for laboratory analysis of arsenic, lead and volatile organic compounds in conjunction with the real time monitoring of TVOC and RPM10 readings at seven AMS locations. These laboratory results verified that the derivations of the action levels for real-time monitoring were protective of the surrounding community. The daily collection of air samples was discontinued, with DTSC approval, after demonstrating that Site controls were keeping chemical concentrations in perimeter air below established performance standards. In addition, the real-time TVOC and RPM10 monitoring at the seven AMS location was determined to be acceptable for assessing air quality and protection of surrounding community. The DTSC approval letter is provided in Attachment D2.

On March 5, 2012, the perimeter air monitoring system was taken offline and replaced with local air monitoring using handheld units. This modification to the air monitoring program was previously approved by DTSC on March 1, 2012. The perimeter air monitoring system was subsequently decommissioned and demobilized from the Site in March 2012.

Local air monitoring was conducted within the Site during waste handling activities in March 2012, at breathing level heights outside and downwind of the exclusion zone. The local air monitoring during

this period and its results are discussed below; no action levels were exceeded during the activities. No waste handling activities requiring local air monitoring occurred in April 2012. Wastes materials transported offsite in April 2011 were in closed drums or boxes without potential for dust or vapor generation.

RPM10 readings during waste handling activities in March 2012 from handheld units ranged from 0.0 µg/m^3 to 490 µg/m^3 and averaged less than 45 µg/m^3 for any 4-hour period, which is less than the acute RPM10 action levels for activities: vadose zone soil removal and saturated soil removal. The readings maintain the running average for RPM10 since the start of the project to be less than the subchronic RPM10 action level.

TVOC readings during waste handling activities in March 2012 from handheld units ranged from 0.0 ppmv to 11.8 ppmv and averaged less than 0.40 ppmv for any one 24-hour period, which is less than the acute TVOC action level. The readings maintain the running average for TVOCs since the start of the project to be less than the subchronic TVOC action level.

1.5 Vadose Zone Soil Confirmation Sample Results

Vadose zone soil confirmation samples were collected and analyzed for arsenic, and compared to its cleanup goals for two areas of the Site:

- The main excavation area, and
- The four "hot spots" and former UST excavation areas.

The cleanup goal consists of the 95UCL of the arsenic results from the confirmation samples be less than 24 mg/kg, with no arsenic result exceeding 100 mg/kg. The results confirmed that the final excavation extents had removed vadose zone soils with arsenic above the cleanup goal. Confirmation samples collected from the vadose zone excavation sidewalls demonstrate conformance with the cleanup goal. A summary of these two sets of data is presented in Attachment D3.

Samples were collected from the excavation sidewalls in accordance with the RDIP. See Attachment B for Asbuilt Drawings showing the main excavation vadose soil confirmation sample locations. Attachment D3 presents the sidewall location information for each "hot spot" excavation vadose zone soil confirmation sample.

For the main excavation area, one sample was collected approximately every 50 feet along the sidewalls at random depths. Samples were collected during two separate events.

Around mid-September 2011, with DTSC approval, it was attempted to demonstrate attainment of the vadose zone cleanup goal prior to completing the western vadose zone excavation design extent presented in the RDIP; design excavation had been completed along Horton Street and the northern and southern extents. As such, 19 sample locations – spaced approximately every 50 feet – were identified around the perimeter of the excavation extents at this time, with location 1 in the southeast corner, along Horton Street, moving clockwise to location 19 in the northeast corner of the excavation, again along Horton Street. Results from samples 1 to 5 and 15 to 19 were below the cleanup goal, with arsenic results ranging from 3.8 mg/kg to 31 mg/kg. Results from samples 6 to 10 and 13 to 14 are no longer representative because further excavation was conducted in response to the high arsenic results from samples 8, 9, 10, 13, and 14, which ranged from 52 mg/kg to 1,100 mg/kg. Given

these high results, samples from locations 11 and 12 were not collected and additional excavation was conducted at these areas.

After the additional excavation, vadose zone confirmation samples were collected along this new western extent in late November 2011, at locations 20 to 29. Results from samples 21 to 29 were below the cleanup goal, with arsenic results ranging from 4.1 mg/kg to 54 mg/kg. Result from sample 20 is no longer representative because further excavation was conducted in response to its high arsenic result of 115 mg/kg.

Four "hot spots" were located and sampled based on previous soil boring sample results exceeding 100 mg/kg arsenic in the vadose zone outside the main excavation, as presented in the RDIP. "Hot spots" were named based on these previously associated soil borings: SA-BH-04, SA-AH-01, CDM-SB50, and SB-7AB. The locations of these four "hot spot" excavations are presented in Attachment B.

The results for the north, east, and west wall sidewall samples from "hot spot" SA-BH-04 were below the cleanup goal. The arsenic results ranged from 5.4 mg/kg to 29 mg/kg. The south wall sample result of this "hot spot" exaction is no longer representative due to subsequent additional excavation conducted for an underground pipe removal. No additional sample was collected along the south wall as the excavation progressed to the Sherwin-Williams property line with the City of Emeryville Parcel D site, where soils had been removed previously by the City of Emeryville and replaced with imported backfill.

Results for sidewall samples from "hot spot" SA-AH-01 were below the cleanup goal. Arsenic results ranged from 7.7 mg/kg to 9.4 mg/kg.

Initial north, east, and west sidewall samples from "hot spot" CDM-SB50 were above the cleanup goal, with arsenic ranging from 50 to 370 mg/kg. The south sidewall sample was below the cleanup goal, at 21 mg/kg. Additional excavation was conducted towards the north, east, and west, and this "hot spot" was incorporated into the main excavation toward excavation to the east. After the additional excavation, vadose zone confirmation samples were collected along these new extents to the north and west. These results were below the cleanup goal, with arsenic of 21 mg/kg and 9.9 mg/kg, respectively. The eastern extent of the "hot spot" was connected to the main excavation, and there no longer was an eastern sidewall to sample.

Initial results for south sidewall samples from "hot spot" SB-7AB did not meet cleanup goal, with arsenic ranging from 55 to 77 mg/kg. After further excavation of the south sidewall, an arsenic result of 24 mg/kg was obtained. With the north, east, and west sidewall arsenic results of 9.6 mg/kg to 29 mg/kg, the final sidewall sample results were below the cleanup goal.

Due to changes in the extent of the main excavation (discussed further in Section 2), one of the "hot spot" excavation areas was incorporated into the main excavation ("hot spot" excavation for boring CDM-SB50) for comparison to its cleanup goal.

At DTSC's direction, sidewall samples from the former UST excavation for arsenic were incorporated with those from the "hot spot" excavation areas for comparison to its cleanup goal.

1.6 Groundwater Monitoring and Sample Results

In accordance with the RDIP, monthly depth to groundwater measurements and quarterly groundwater samples were collected from specified wells. A summary of these results are presented in Attachment D4.

The monthly water levels demonstrated the affects from the excavation dewatering activities as lowered groundwater elevations were observed in wells away from the excavation extents. These results were part of the rationale used to eliminate the need for the French drain and continue to meet the objectives of excavation and backfill (further discussed in Section 2).

Quarterly sampling consisted of analysis for arsenic and VOCs. The RAP established two triggers during remedy implementation for additional post-remedy action:

1. If arsenic exceeds 500 µg/L in any sample/well during remedy implementation, an additional well on former Rifkin well would need to be installed (as specified in RDIP Figure 13-1).

2. If arsenic exceeds its historical maximum detection during remedy implementation, quarterly sampling of that well would be maintained until stable or decreasing trend is determined.

The first trigger did not occur; therefore, an additional well was not installed on the former Rifkin property.

The second trigger occurred at wells RP-1, RP-4, and MW-3 during the remedy implementation, as presented in Attachment D4. These three wells are identified for quarterly sampling in the project OM&M plan.

1.7 Underground Storage Tank Abandonment

Working with DTSC and Alameda County Department of Environmental Health (ACDEH), a tank closure plan was developed for the former UST. The closure plan was developed during an onsite meeting on February 22, 2012. At that time, it was understood that the former UST had been abandoned in place during the slurry wall installation in 1993, as previously reported. Excavation was conducted around the former UST to determine if it would be feasible to remove the abandoned UST, presumed to have been previously filled with grout. However, it was discovered that the former UST had not been abandoned in place. In addition, it was observed that a portion of the former UST was underneath the Site transformer and therefore could not be removed without providing structural support to the transformer. The top of former tank was measured at El. 13.3 ft North American Vertical Datum of 1988 (NAVD88).

As agreed upon by DTSC and ACDEH, the former UST closure consisted of abandoning it in place. As instructed by ACDEH, the tank interior was rinsed to remove sludge and to clean the interior walls. The former UST was filled with neat cement on February 24, 2012. An ACDEH representative observed the tank cleaning, documented that the tank interior was sufficiently cleaned, and observed the filling with neat cement. Approximately 12 cubic yards of neat cement were poured into the former tank, which is consistent with the dimensions of the former UST. During filling of the former tank, lighter material coming to the surface from the former tank interior was not observed, confirming the former UST had been cleaned sufficiently.

At the direction of DTSC, potential impacted vadose zone soils were excavated around the former UST to approximately El. 10 ft NAVD88: north along the transformer pad, east toward the Site building until underground water lines were encountered, south into the arsenic "hot spot" excavation, and west into the existing excavation for railroad and storm sewer demolition. Excavation surrounding the former UST was conducted to the extent possible with the engineering constraints of the transformer pad, existing waterlines and Site building. See Attachment B for Asbuilt Drawings showing the footprint of the excavation around the former UST.

Vadose zone soil samples were collected along the north, east, northwest and northeast sidewalls of the excavation. Soil samples on the southern portion of the excavation were collected as part of the arsenic "hot spot" excavation. One groundwater sample was collected on western, downgradient side of the former UST by creating a two-foot sump in this area of the excavation bottom (i.e., below the vadose zone soil). Groundwater elevation was approximately El. 9.7 ft NAVD88 at the time of sample collection.

As directed by DTSC, sidewall vadose zone soil and groundwater grab samples were collected for analysis of arsenic, lead, total petroleum as gasoline (TPH-g), diesel (TPH-d), and motor oil (TPH-mo), volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). With DTSC approval, TPH-d and TPH-mo analyses were conducted with silica gel cleanup.

The arsenic results from the sidewall vadose zone soil samples are discussed in Section 1.6 along with the other vadose zone soil confirmation results. These results conform to the Site cleanup goal. Attachment D5 presents a summary of the other results from the sidewall soil samples and the groundwater sample, and provides a comparison to the Site cleanup goals. Of these other results, TPH-d in soil and TPH-g, TPH-d, TPH-mo, and arsenic in groundwater were found above their Site cleanup goals.

After sample collection, the former UST excavation was backfilled consistent with other vadose zone excavation areas at the Site.

1.8 CEQA Mitigation Measures

Two CEQA mitigation measures were identified for the project and were monitored during the remedy implementation as described below.

1.8.1 Cultural Resources Monitoring Results

Archaeological monitoring was undertaken during soil-disturbing activities, when excavating from El. 18 ft NAVD88 to El. 6 ft NAVD88, including removal of asphalt caps and buried concrete and debris and removal of existing slurry walls and groundwater monitoring wells at the Site from July 1-August 8, 2011. Archaeological monitoring during soil-disturbing activities did not identify prehistoric or historic archaeological materials with a potential for significance under CEQA. The Archaeological Monitoring Report, prepared for S-W by the archaeological monitors at URS, is included with this Completion Report as Attachment E.

1.8.2 Park Avenue Street Beautification Project

Due to project-related truck-traffic, the City of Emeryville Park Avenue Street Beautification Project was impacted by the legally loaded truck traffic travelling along the City of Emeryville truck route over the recently finished Park Avenue and Halleck Street intersection. A set of bricks inlaid in the pavement at this intersection were prematurely damaged (chips and cracks) due to the increased

truck-traffic. This assessment was based on comparing the conditions of these bricks after remedy implementation to pre-remedy photographic documentation. The damaged bricks were replaced with new bricks during the week of June 11, 2012. The City of Emeryville provided the new bricks and specifications for installation.

1.9 Permits and Clearances Obtained

1.9.1 RDIP Section 2.2, Permitting

Envirocon or CDM Smith obtained the following permits, which are included in Attachment F, associated with the remedy implementation work:

Permit	*Permit Number*
Alameda County Department of Environmental Health-Underground Tank Closure Permit	SR0020135
Alameda County Public Works Agency-Water Resources Well Permit	W2011-0213 to W2011-0264, W2011-0398, W2011-0399, W2012-0105 to W2012-0107, W2012-0126 to W2012-0139, W2012-0159
BAAQMD Permit to Operate for Soil Vapor Extraction and Abatement System	Application: 23044 Condition: 24917 Plant: 20614
BAAQMD Permit to Operate for Facility-Wide Soil Excavation Project	Application: 23244 Condition: 24986 Plant: 20716
BAAQMD Notification for Water Treatment Plant Demolition and Acknowledgement	Regulation 11, Rule 2
City of Emeryville Grading Permit	G2011-0001
City of Emeryville Shoring Permit	B2011-0031
City of Emeryville Water Treatment Plant Demolition Permit	B2011-0257
City of Emeryville Encroachment Permits	21105121, 21105122, and 21107136
East Bay Municipal Utility District Wastewater Discharge Permit	50372992
OSHA Excavation Notification Permit	2011-904305
Water Quality Control Board, San Francisco Bay Region, Notice of Intent for Coverage under the General Construction Storm Water permit	Application: 415037 WDID: 2 01c361055

Work was conducted in compliance with the requirements and/or conditions established in these permits. City of Emeryville permits were closed with and signed by the City of Emeryville. Other permits were terminated with the respective agency or not renewed at the end of the project.

1.9.2 RDIP Section 2.3.2, Community Safety Plan

The Community Safety Plan, approved as part of the RDIP and included as Appendix B of the RDIP, was successfully implemented during the phases of the remediation activities.

A toll-free, 24-hour community complaint telephone answering service was activated as part of the Community Safety Plan. During the course of the remediation activities, the service logged over 50 calls from 10 individuals within the neighborhood. The project team personally responded to each call by calling the individual the same day. In several cases phone messages were left in lieu of

reaching the caller. In such cases follow up calls with the individual were done within the next day. The responses to the community calls were done in coordination with DTSC as appropriate. The calls were responded to and no open issues are remaining.

The calls and responses were documented in the monthly status reports.

1.9.3 RDIP Section 3.4, Clearance and Relocation of Utilities

Underground Service Alert (USA) was contacted according to the RDIP procedures. The following USA ticket numbers were obtained for the clearances performed:

USA Clearance Area	*Ticket Number*
For asphalt removal and replacement on Halleck Street	080637
For Parcel D excavation	342110
For excavation along Horton Street	047933
For monitoring well installation	0041212, 0073275, 0073316
For BAAQMD construction and operation of SVE system	0111814

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Section 2
Variances from RDIP

The RDIP presented engineering and monitoring details regarding the planned remedy implementation activities as anticipated with the information available at the time. Based on field conditions encountered at the time of implementation, some of the engineering and monitoring details were modified in order to maintain the effectiveness of the remedy. The information presented in this section identifies only those details that varied in some way from RDIP. Section references presented here identify the specific sections of the RDIP, and in some cases refer to additional information in attachments to this Completion Report.

For reference, the RDIP Table of Contents is included with this Completion Report as Attachment A. Only RDIP Sections with variances are presented below.

2.1 RDIP Section 3 – Pre-Excavation Activities

2.1.1 RDIP Section 3.2, Groundwater Monitoring Well Abandonment

Table 3-1 of the RDIP listed the groundwater wells planned for abandonment. These wells were abandoned under permit and reports for the abandonments were submitted to ACPWA, except well LF-6. LF-6 was determined to have been previously abandoned and its status was confirmed with ACPWA. Copies of these reports are included in Attachment G1. Site permits are included in Attachment F. One deviation from the RDIP was that in addition to abandonment of wells by (1) drill out with tremie grout backfill or (2) in-place abandonment via tremie grout and removal of well vault, some wells were removed completely during excavation. This was approved by ACPWA. .

2.1.2 RDIP Section 3.6, Subsurface Vapor Extraction and Treatment

The SVE system was installed and operated in accordance with the RDIP. The original schedule for operation of the SVE system was estimated for no more than 4 weeks. However, the system operated for 6.5 weeks in order to remove additional mass of subsurface organic vapors.

2.2 RDIP Section 4 – Raised Cap Removal and Shoring

2.2.1 RDIP Section 4.1, Removal of Raised Cap

The actual sequencing of Raised Cap removal differed from the RDIP text (see last paragraph of this particular RDIP section) to accommodate scheduling changes for the shoring installation subcontractor and overall excavation logistics on the Site.

2.2.2 RDIP Section 4.3, Shoring along Horton Street and Building 31

Two of the installed soldier beams (beams numbered 2 and 3) for the shoring wall met refusal while being vibrated into place. These two beam installations were reviewed by the project structural engineer and approved as installed.

Timber lagging for the shoring wall was not necessary in the bottom five feet of the deepest excavation areas due to a change in the excavation sequence. Excavations along these areas were originally to be conducted in the middle of the main excavation activities. It was actually conducted at the end and removed in small sections and backfilled immediately, allowing for sufficient support of

the shoring wall at these depths. Sumps at both ends of the deep excavation area were installed and continuous pumping was conducted to lower the hydraulic gradient along the shoring wall.

The RDIP allowed for the installation of tie-backs. It was initially planned, during the RDIP preparation, that tie-backs would not be allowed by the City of Emeryville to be left in place once the excavation was completed. Therefore, the RDIP indicated that "No shoring elements will remain". However, during finalization of the RDIP, the City of Emeryville approved and permitted the use of tie-backs, and for them to be left in place. These tie-backs were cut, during removal of the shoring wall, and the portions under Horton Street were left in place. Locations of the remaining portions are presented in Attachment B. Site permits are included in Attachment F.

2.3 RDIP Section 5 – Excavation and Dewatering

2.3.1 RDIP Section 5.1, Excavation Dewatering

The RDIP text in this section included an estimate that excavation water would be pumped at an average steady state rate up to 10 gallons per minute (gpm) following the initial higher flow rate at the start of excavation. In using a series of sumps with interconnecting ditches, the actual dewatering rate averaged 30 to 35 gpm, with periods of peak flow around 60 gpm. The higher actual dewatering rates encountered during remedy implementation, compared to the RDIP steady-state estimate, are due to the following factors:

- Dewatering operations conducted on an episodic basis with shutdowns during night shift and over other down times. [1]
- RDIP steady-state estimate included only groundwater flow from the A-aquifer and did not estimate process wastewater, water from daily dust control and misting operations, storm water, or surface water component. Significant flow rates of storm water were experienced during the remedy implementation, particularly in October and November 2011.
- RDIP steady-state estimate did not include any vertical groundwater leakage induced from the B-aquifer into the excavation. The dewatering operations maintained significant drawdown of the water levels in the A-aquifer within the excavation and in the surrounding cone of depression, and increased vertical movement from the B-aquifer into A-aquifer.

With inherent uncertainty in all modeled geologic settings, the higher than estimated dewatering rate could indicate hydrogeologic characteristics may need to be reevaluated to understand post-remedy implementation groundwater flow pathways.

The post-remedy implementation groundwater monitoring program (discussed in Section 2.10 of this report) is structured to provide the data necessary for evaluating flow direction and hydraulic gradient. As the A-aquifer reaches equilibrium re-saturation, the groundwater flow conditions will be compared to the projected design groundwater model conditions for the remedy. If the assessment determines that groundwater movement patterns differ significantly from projected design

[1] A total of 4,892,618 gallons were pre-treated and discharged to the sewer between the start of continuous dewatering operations (22 July 2011) and when the maximum depth of the excavation was reached (30 November 2011). Over this 132 day period, an average discharge rate of 25.7 gpm was observed.

conditions, S-W will provide written recommendation to DTSC for either implementation of additional monitoring/investigation steps or a contingency action.

During the remedy implementation, over five million gallons of water in total were pre-treated and discharged to East Bay Municipal Utility District (EBMUD) under permit. Quarterly reports were submitted to EBMUD to document the results from dewatering and pre-treatment system and adherence to their permit, and are included in Attachment H. Site permits are included in Attachment F.

2.3.2 RDIP Section 5.3, Soil Excavation and Handling

Actual soil removal sequencing varied from the plan presented in the RDIP text to accommodate improved Site logistics for rail car transport; high-pressure natural gas transmission line relocation; excavation dewatering; and soil stockpile handling. Due to the spatial variability of the waste categories it became crucial to excavate areas of similar categories to meet rail car transport requirements. Also, the mass excavation of similar waste categories lowered the potential for cross contamination of soils with differing preliminary categories. These objectives required modifying the RDIP method of "strip" excavation spanning the entire length of the excavation across multiple waste categories.

The RDIP described installation of a temporary "French drain" at the bottom of the excavation along the northern S-W property line with the Novartis parking lot (the former Rifkin property). The intent of this drain line was a safety measure to control groundwater seepage in the open excavation and prevent it from migrating northward across the property line into newly placed clean backfill. Subsequent calculations, modified excavation and backfilling methods, and discussions with Novartis and DTSC determined that this temporary drain line was not required to control groundwater migration during the short amount of time the excavation depth was exposed. The groundwater gradient was maintained in a positive direction away from the Novartis property and verified by increased monitoring of the potentiometric water surface in wells, sumps and at the seepage face elevations. Groundwater monitoring data are provided in Attachment D4.

The final soil excavation areal footprint is illustrated on the Asbuilt Drawings provided in Attachment B. The final bottom excavation contours are also provided in the Attachment B Asbuilt Drawings.

2.3.3 RDIP Section 5.3.1, Vadose Zone

As described in this RDIP section, additional vadose zone soil removal was anticipated if data from soil sample analyses indicated continued high arsenic or other constituent concentrations. Actual excavation included extending soil removal beyond RDIP preliminary projected extents to areas containing arsenic concentrations above the cleanup goal. The additional vadose zone soil removal included the areas northwest and west area of the RDIP identified area. The removal of vadose material in these areas was also to facilitate the removal of additional saturated soil as discussed below. Conversely, several "cells" of in-place soil were not excavated according to the RDIP plan because soil sample results confirmed that in-place constituent concentrations already met the cleanup goals.

Vadose zone soils within the four "hot spot" excavations were removed per the RDIP. The lateral extend of a number of the sidewalls in these locations coincided with other soil removal for utility demolition, rail spur demolition and slurry wall extension. In these cases the remaining sidewalls were confirmed below the cleanup goals. As such, the "hot spot" excavation for boring CDM-SB50 was

merged with the main excavation, and included in that soil sample results set. The three other "hot spot" excavations continued to be evaluated independently.

Confirmation soil sample results demonstrating conformance with the cleanup goals are presented in Attachment D3.

2.3.4 RDIP Section 5.3.2, Saturated Zone

The RDIP presented a concern regarding heaving of the excavation floor at the top of the A/B aquitard (El. -11 ft NAVD88), which resulted in the preparation and inclusion of a Heave Management Plan (RDIP Appendix I-2). As discussed above in RDIP Section 5.3.1, mass excavation of similar category waste was utilized for saturated soil excavation rather than the "strip excavation" presented in the RDIP. However, this did not affect the excavation conformance to the RDIP objective of minimizing the exposed areal floor of the excavation above the aquitard to no more than 5,000 square feet at any moment. The bottom five feet of saturated soil above the aquitard was excavated and backfilled concurrently, never leaving more than 5,000 square feet of the top of aquitard exposed.

The exposed lithology during saturated soil excavation was observed to confirm final source area removal extents for permeable materials along the sidewalls of the excavation. Portions of the western extent of the design excavation boundary had greater than 4 feet of sand/gravel (permeable materials) in areas identified with having arsenic concentrations in groundwater above 1 mg/L prior to the remedy implementation. As such, additional saturated soils were removed in these areas until total permeable material amounts were less than 4 feet. At the other extents of the excavation, less than 4 feet of sand/gravel were observed. The final extents of the saturated soil excavation are presented in Attachment B.

2.3.5 Section 5.5, Waste Stockpiles Management

The project simultaneously tracked and managed in excess of over 160 waste stockpiles. The RDIP estimated that approximately 5,000 cubic yards of stockpiled waste material may be on Site at any one time, as inventory staged between placement, characterization, and load out. Due to the segregation of eight different potential waste streams from the excavation and to avoid unwanted delays for rail car transport, the stockpiled volumes maintained onsite increased up to approximatly12,700 cubic yards for short periods of time. On average, stockpiled waste amounts were much smaller, close to the RDIP estimate of 5,000 cubic yards.

Due to the limitations of space and to avoid extending the project schedule any further than necessary, every effort was made to minimize the amount of stockpiled waste present onsite at any given time. Waste characterization turnaround times were accelerated from planned RDIP schedules in an effort to minimize the onsite stockpiling of material. Much of the stockpiled volume was due to the separate stockpiling of multiple categories of waste, while limited to the loading of a single waste category in multiple train cars (unit trains) intended for a single location.

2.3.6 RDIP Section 5.6, Vadose Zone Soil Confirmation Sampling

The only variance to the RDIP sampling procedures described in this section was that some samples were also collected using 8 oz. jars, instead of sample tubes. Sampling materials were sample specific so no equipment blanks were necessary. Confirmation soil sample results demonstrating conformance with the cleanup goals are presented in Attachment D3.

2.4 RDIP Section 6 – Excavation Backfilling

2.4.1 RDIP Section 6.4, Backfill Placement, Compaction and Interceptor Trench

The variance to the RDIP is that the width of the curtain wall for the inceptor trench was reduced from 36 inches to 30 inches. A sensitivity analysis on this modification did not show any significant change to the modeled groundwater flow paths.

2.4.2 RDIP Section 6.5, Membrane Barrier and Trench Installation, RDIP Section 6.5.1, Selection of Material

Busan 1058 was used instead of Busan 1059WS Biostat (Dazomet) for extension of the biopolymer slurry used during installation of the membrane barrier.

As part of the HDPE Membrane Barrier installation, Envirocon also installed a geonet HDPE drain fabric on the HDPE panels to help protect the panels against punctures from the placed drain gravel. The drain gravel selected for the trench had both the required natural filtering requirements for the hydraulic design of the trench and a consistent particle size. This minimized "layering" of the gravel during placement in the bio-polymer slurry. The selected gravel had a slight angular shape; it was anticipated to be well rounded in the RDIP. The geonet was installed to protect the membrane liner from potential damage from the drain gravel. The geonet is expected to have a higher transmissivity than the drain rock and therefore reduce the hydraulic pressure on the membrane, further protecting the membrane.

SDR 17, 6-inch diameter rigid HDPE, pipe was installed at the base of the interceptor trench, instead of the proposed flexible pipe stated in the RDIP. This rigid pipe was required as it had sufficient pipe strength to work with the installation method and selected gravel.

2.4.3 RDIP Section 6.7, Panel Placement

The Curtain Wall panels (fabricated by GSE Lining Technology) that comprise the membrane barrier system were installed as intended, to depths below the top of the aquitard in order to prevent movement of A-zone groundwater from the S-W property toward the Novartis property at this shared property line. The bottom of the panel elevations ranged between El. -12 ft NAVD88 to El. -14.5 ft NAVD88. The top of the aquitard is at approximately El. -11 ft NAVD88 in the project area.

The RDIP Section 6.5 indicates that "[t]he bottom of the membrane barrier will be placed adjacent to the north wall of the excavation as to achieve direct contact with the undisturbed soil or compacted backfill." During field installation activities, the steel frames holding the panels during placement were lowered adjacent to the north wall of the excavation trench and were lowered to depths equal to or greater than the top of the aquitard. Each panel placement, subsequent to the first one, was joined to adjacent panels, in accordance with the specifications. Due to the method of placement and the required use of the biopolymer slurry, however, actual "direct contact" of the panels with the trench bottom could not be confirmed by direct observation.

In lieu of direct observation, the bottom elevations of the placed panels were compared to the target trench bottom elevation using the following measurements: GPS surveys of the tops of installed panels and surrounding ground surface, previously measured panel heights, and depths to the trench bottom (conducted prior to panel placement using a weighted rope). Measurements for 5 of the 11 panels that comprise the membrane barrier system indicated that the panels were lowered to the target trench bottom elevation when released from their frames. For 6 of the 11 panels, measurements

could not confirm that the bottom of the panel frames reached the actual trench bottom. Fine-grained deposits, from the compacted backfill trench sidewalls, settling out from the slurry and accumulating at the trench bottom during panel installation is believed to have affected the assessment for reaching the target trench bottom elevation at these six panels. For all panel placements, however, the panel frame bottoms were determined to reach depths below the top of the aquitard at El. -11 ft NAVD88.

2.4.4 RDIP Section 6.8, Drain Pipe and Gravel Backfill Placement

A pea gravel (3/8 inch minus) material was used for the bedding material beneath the interceptor trench drain pipe. This was a modification from the RDIP specified "drain gravel" gradation specification. Due to the placement of pipe bedding being dropped from the top of the trench in the presence of the bio-polymer slurry, a pea gravel material was used. The pea gravel has a more uniform particle size and can achieve the desired compaction values compared to the more "well graded" drain gravel as specified in the RDIP for permeability and self-filtering design, as installed.

2.5 RDIP Section 7 – Slurry Wall Breach

2.5.1 RDIP Section 7.3, Slurry Wall Breach

The final design of the three slurry wall breaches varied from the design presented in the RDIP, to accommodate improved constructability and to avoid installing the northwestern breach across the western property boundary with Union Pacific Railroad. The breach design revisions maintained the required transmissivity necessary per the groundwater flow modeling. The location of Breach 3 was moved to the east in order for it to be in adjacent with saturated soil excavation. The asbuilt design and locations of the slurry wall breaches are included in Attachment B. This change was reviewed and approved by DTSC.

2.5.2 RDIP Section 7.5, Trench Excavation

Actual trench excavation procedures differed from the RDIP text due to the redesign of the slurry wall breaches, therefore reference to biopolymer slurry in the cross trenches and the up- and down-gradient trenches are no longer applicable. See Attachment B for the asbuilt design and locations of the installed breaches.

2.5.3 RDIP Section 7.6, Backfill Placement

References in the RDIP text to the up and down gradient and cross trench backfilling are no longer applicable due to the breach redesign.

2.6 RDIP Section 8 – Slurry Wall Extension

2.6.1 RDIP Section 8.4, Slurry Wall Extension

The actual slurry wall extension was 675 feet long; the RDIP estimated a length of 494 feet. The extension was brought into the existing slurry wall further north than originally designed to accommodate installation closer to the property line (further west). This change was reviewed and approved by DTSC.

The actual slurry wall thickness, in accordance with approved design modifications, was 30 inches; the RDIP text indicated a minimum wall thickness of 36 inches. A sensitivity analysis on this modification did not show any significant change to the modeled groundwater flow paths.

The slurry wall extension also included design and installation of a slurry wall cap, to protect the bentonite-based slurry wall from damage due to future active surface loads. The slurry wall cap was also of similar low permeable clay soil to allow for a higher impermeable wall height. See Attachment B for the slurry wall extension asbuilt location and installation details.

2.7 RDIP Section 9 – Waste Profiling, Transport and Disposal

Aside from the sample tubes presented in the RDIP for stockpile sample collection, 8 oz. glass jars were also used. In discussions with the lab, En Core® and Terra Core® samplers from the Site could not be composited without losing significant VOCs that may be present. The laboratory recommended that samples for VOCs be taken from the tubes or jars and composited the same day in EnCore® samplers by the laboratory. The sampling materials were designated to each sample and no sampling equipment was re-used, so no QC samples were taken or necessary.

The amount of truck loads/tons and rail car loads/tons exceeded the original estimate. A variance to the RDIP is that truck beds were not lined with plastic or straw when trailers were being loaded with non-hazardous material. Material was placed onto truck beds directly and covered for exporting. The non-hazardous material being placed in the truck trailers passed the wet paint filter test and passed through the decontamination pad where the loads were inspected prior to leaving the Site.

Another variance to the RDIP is that dry decontamination methods were used when trucks exited the Site. Stiff brushes were used to clean tires while stopped on the decontamination pad. The trucks being loaded for export of waste material were limited to hard surface travel and daily removal of spilled soil from the truck route was performed. MEC sprayers were used to spray tires while on the decontamination pad on rainy days or days with an excess of mud on the truck path.

At the final stages of the project it became necessary to begin removal of the Site rail line and spur track at the north end of the property to begin final backfill and grading in these areas. Without the access to the adjacent Union Pacific rail yard, final loads of non-RCRA hazardous waste (California regulated) were loaded on trucks for transport to the San Francisco Bay Railroad (SFBR) for loading onto rail cars for final transport. This transportation variance was approved by DTSC and the community was informed of this activity.

During loading of non-hazardous waste to the local Class 2 non-hazardous waste landfill, approximately 20 loads of non-RCRA hazardous waste were mistakenly transported by truck to the Class 2 landfill. The transport of this material was identified within hours of leaving the Site, and arrangements with the landfill were made to isolate and contain the waste for removal and transport to the SFBR for transport by train to the appropriate landfill facility. A total of 334.26 tons of waste were initially delivered to the Class 2 landfill. In order to assure complete removal of this waste, approximately 12 tons of additional material around and beneath it were excavated; totaling 342.41 tons. This waste was taken to the SFBR for transport by train to the appropriate landfill.

Final waste amounts removed from the Site were based on stockpile sample results and are presented by their waste characterization results below, based on reported weights received by the disposal facilities.

Waste Characterization	*Project Waste Category*	*Amount (Tons)*
Class 2 Non-Hazardous	1	69,671
Class 1 Non-RCRA Hazardous	2	60,650
Class 1 RCRA Hazardous (US Ecology)	3, 4, 5, 7	19,387
Class 1 RCRA Hazardous (Arlington)	6 & 8	0

Attachment D6 provides a summary of the stockpile sample results and their determined waste characterizations. Section 1 provides a chart presenting excavated materials transported offsite (in accumulated tons by month).

2.8 RDIP Section 10 – Non-Remedial Activities

In addition to the spur track removal and storm sewer removal activities anticipated and presented in the RDIP, Envirocon also encountered and removed other inactive subsurface utility pipes and buried concrete foundations associated with former railroad activities, former S-W operations, or other historic operations. See Attachment B for Asbuilt Drawings showing areas where piping was encountered and removed.

2.9 RDIP Section 11 – Soil Gas Evaluation

The RDIP text indicates the anticipated schedules for post-remediation activity installation and sampling of soil gas occurring in February/March, and August/September 2012, assuming a completion of remediation activities in November 2011. These dates for soil gas evaluation are now anticipated to occur in June 2012 and November 2012. Soil gas evaluation strategy is further discussed in the project OM&M plan. The soil gas evaluation strategy is consistent with Section 11 of the RDIP, with the following modifications:

- Additional investigation location near the former UST area.
- Additional investigation location downgradient of the former UST area and within the former water treatment plant area.
- Re-location of one sampling location from near slurry wall Breach 3 to upgradient of the breach.

2.10 RDIP Section 13 – Groundwater Monitoring Program

2.10.1 RDIP Section 13.1, Groundwater Monitoring Well Locations

The project OM&M plan includes the groundwater monitoring program for the project after remedy implementation. This groundwater monitoring program is consistent with Section 13 of the RDIP, with the following modifications:

- Slight movement of actual new well installations based on field conditions.

- Installation of additional well, CDM-113, upgradient of current location of slurry wall breach #3 (breach moved east to connect with saturated soil excavation).
- Installation of additional well CDM-114 at RDIP-identified piezometer location, downgradient of the former UST area and upgradient to the existing slurry wall.
- Re-numbering of piezometers based on above change.
- Contingent well not needed on former Rifkin property.
- Modification to sampling frequency of wells RP-1, RP-4, and MW-3 based on groundwater monitoring results during the remedy implementation.
- Addition of existing monitoring well MD-5 at downgradient offsite property for periodic depth to groundwater measurements.
- Change frequency of depth to groundwater measurements to annually for downgradient wells LF-24 and LF-25 on Union Pacific Railroad property.

Wells installed during remedy implementation were installed under permit and reports for the completions were submitted to ACPWA. Copies of these reports are included in Attachment G2. A summary of their construction and surveyed coordinates are also included in Attachment G2. The locations for these newly installed wells and other remaining wells are presented in Attachment B. Site permits are included in Attachment F.

The first post-remedy implementation groundwater monitoring report will be submitted by July 31, 2012 to DTSC and Novartis. It will include data from March 2012, April 2012, May 2012, and June 2012, monthly water levels and sample results from April 2012. April 2012 sampling/analysis conforms to the annual sampling requirements for the project.

2.10.2 RDIP Section 13.2.1, Groundwater Quality Sampling and Analysis during Remedy Implementation

Groundwater sampling and analysis were conducted in accordance with the RDIP. The results were used to assess potential impacts to the former Rifkin property from the potential spreading of upgradient, offsite plumes and, to evaluate any arsenic concentration changes during remedy implementation. The results from the activities are presented in Attachment D4.

2.10.3 RDIP Section 13.2.2, Depth to Groundwater Measurements during Remedy Implementation

Depth to groundwater measurements were conducted in accordance with the RDIP. The results were used to assess potential impacts to the former Rifkin property from the potential spreading of upgradient, offsite plumes and, to evaluate any arsenic concentration changes during remedy implementation. The results from the activities are presented in Attachment D4.

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Section 3

Photographs of Site Conditions

Representative photographs of the Site before, during, and after remediation activities are presented in Attachment I.

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Section 4
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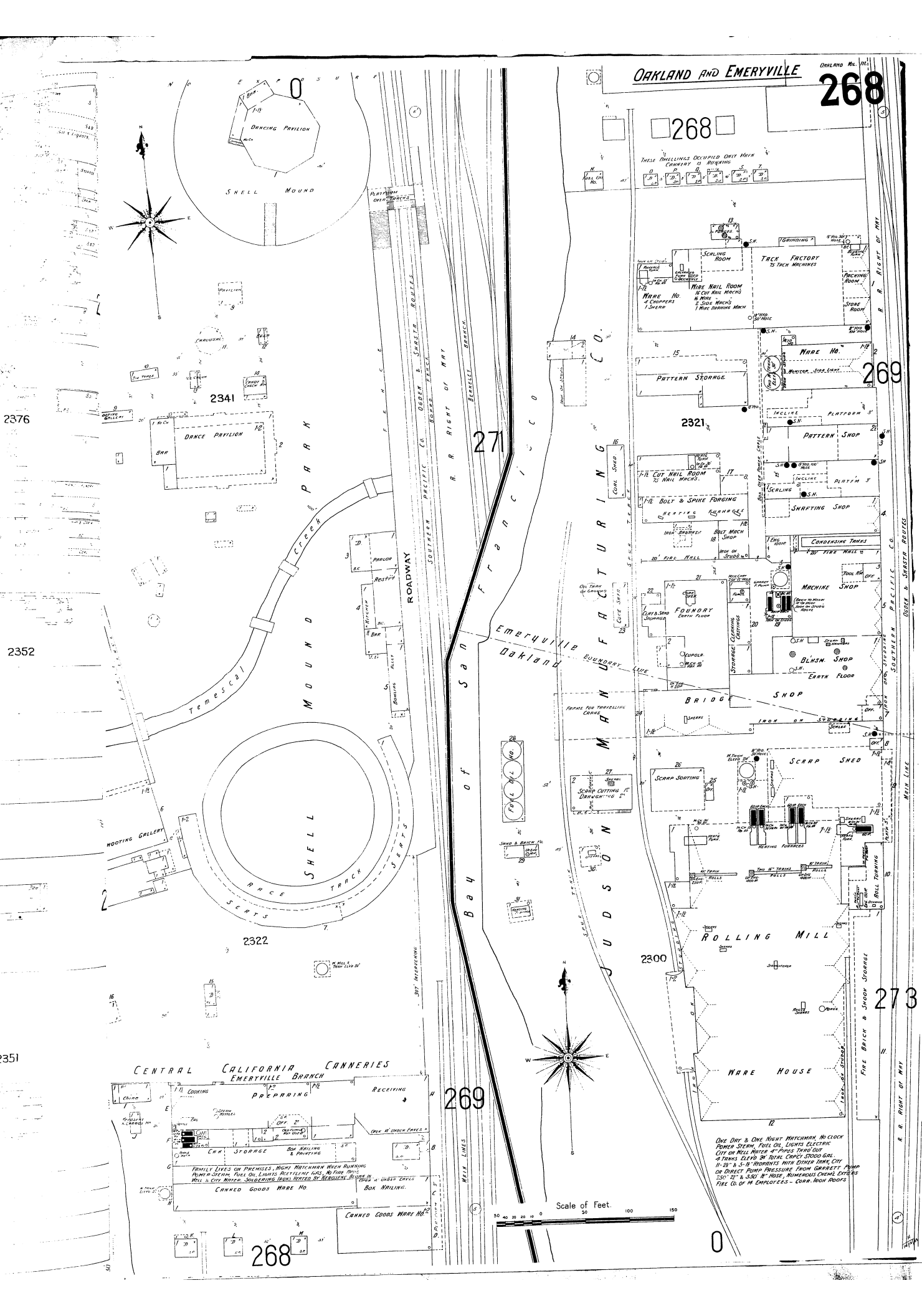
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Scale of Feet.
50 40 30 20 10 0 50 100 150
0

THE EMERYVILLE SHELLMOUND

FINAL REPORT

BY

W. EGBERT SCHENCK

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN AMERICAN ARCHAEOLOGY AND ETHNOLOGY

Volume 23, No. 3, pp. 147–282, plates 35–54, 8 figures in text, 1 map

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UNIVERSITY OF CALIFORNIA PUBLICATIONS IN AMERICAN ARCHAEOLOGY AND ETHNOLOGY
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Issued November 24, 1926

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA

CAMBRIDGE UNIVERSITY PRESS
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PREFACE

For perhaps seventy-five years a number of artificial shellmounds scattered along the shore line of San Francisco bay have excited the curiosity of the incoming white settlers. As long as fifty years ago collections were being made of the aboriginal relics found on their surfaces or turned out by the plow.[1] In the spring of 1902 Professor John C. Merriam and Dr. Max Uhle of the University of California first directed scientific attention to these mounds, making careful excavations at the Emeryville site and publishing methodical considerations of the evidence obtained.[2] During the years 1906–08 N. C. Nelson made a detailed study and report on the Ellis landing mound;[3] and in 1908 he completed a survey of the entire San Francisco bay region, located, numbered, and mapped the mounds, analyzed them in detail and published a summary of his observations and conclusions.[4] This work disclosed nearly 400 of these shell-heaps and established the fact that they were of the same general nature as the "kitchen-middens" of other countries. In 1913 E. W. Gifford made a series of laboratory analyses to determine the constituents of the mounds.[5] In 1915 L. L. Loud reported on the mound at Stege.[6] Other field work was done which has not yet been reported.[7] In 1924 one of the most conspicuous of the mounds, situated in Emeryville (No. 309), was leveled in order to convert the area into a factory site. This destruction presented an opportunity for the collection of fresh data which the University was enabled to embrace. The main purpose of the present paper is to present these data.

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[1] Thompson and West, Historical atlas of Alameda County, 15, 1878.

[2] The Emeryville shellmound, present series, VII, 1907.

[3] The Ellis landing shellmound, present series, VII, no. 5, 1910.

[4] Shellmounds of the San Francisco bay region, present series, VII, no. 4, 1909.

[5] Composition of California shellmounds, present series, XII, no. 1, 1916.

[6] The Stege mounds at Richmond, California, present series, XVII, no. 6, 1924.

[7] 1902. E. L. Furlong acquired specimens for the University from the West Berkeley mound.

1906. N. C. Nelson, S. A. Barrett, P. E. Goddard, and A. V. Wepfer under the direction of Professor John C. Merriam dug a pit and obtained specimens from the Emeryville mound.

1908–1912. N. C. Nelson made excavations in divers mounds about the bay. A number of specimens were obtained but his report has never been written.

1911. L. L. Loud excavated and studied a mound (No. 356) near the southern end of San Francisco bay but has not yet published the result of his labors.

1913. L. L. Loud did the same for a mound at Glen Cove near Benicia on Carquinez strait at the northeastern end of the San Francisco bay region.

The new studies fall into two divisions. First, the removal by steam shovel of the upper portion of the mound was utilized for observations and the gathering of skeletal and artifact material exposed. Second, after the conclusion of the leveling operations, controlled excavations were made by hand in the undisturbed lower levels. These excavations were rendered possible by the generosity of Mr. P. E. Bowles.

The steam shovel work at Emeryville offered one great advantage. The large volume of material handled and the disclosure of cross-sections of the entire mound enabled us to secure a comprehensive view denied by the narrow horizons incident to limited excavations. We were struck by the check which this broad view gave on conclusions suggested by our own hand work, and which led us to regard with great caution comparisons with work done at different places by different methods. Hence in giving our conclusions frequent reference is made to the work of Uhle, Nelson, Gifford, and Loud so that the reader may conveniently weigh the evidence and check our assertions. In some cases where such citations differ from our own conclusions considerable discussion has been indulged in. It is hoped that this will not appear unduly contentious or obscure the feeling of obligation and respect which the author feels for previous workers.

Several considerations have governed us in comparing the findings at Emeryville with those of other areas. It seemed best to make no attempt to go beyond the borders of California. Within these limits the material available for such comparisons is limited mostly to San Francisco bay itself and to the Santa Barbara region. Other material exists but in order to be used it would have to be worked up somewhat along the present lines and it seemed unreasonable to delay the present paper until such work could be done. Hence while a consistent attempt has been made to compare Emeryville with other San Francisco bay mounds which have been worked, our comparisons with other areas are limited to the facts which happened to be familiar to us as we wrote.

It is in an endeavor to make such regional comparisons easier in the future that we have developed and described so fully as many types as possible, that we have sometimes used material inadequate in quantity, and have indulged in conjectures based thereon. A *casual* survey would establish the shellmound culture as ranking very low in the cultural scale. Hence the value of its study seems to lie in the possibility of tracing relationships through regional comparisons. Uhle's work reflects the awakening of the anthropologists of his time to the

remoteness of man's beginnings. Nelson is influenced by the dawning importance of the stratification of human deposits.

Some justification for our liberal indulgence in speculation seems necessary. Partly this is to offset previous speculations, but most largely it is due to our belief that speculative hypotheses furnish one of the most stimulating guides for the acquiring and testing of evidence and the arranging of it into its true position in the scheme of things.

The Department of Anthropology is under particular obligation to Mr. P. E. Bowles, of Oakland. His generous financial patronage rendered our intensive work possible. Mr. John Hubert Mee, president of the Mee Estate, thoughtfully made known to the University his intentions concerning the property on which the mound is located, permitted us to use the land as we desired, and furnished interesting information. Mr. Charles Claudius, in charge of the leveling work for the Pacific States Construction Co., did everything in his power to help us secure the maximum of scientific data, furnished us with maps and surveying data, and lent much equipment for our work. Mr. Sayler, of the adjacent Sherwin-Williams sulphur plant, supplied us with steam and tools. Many persons whose names are unknown secured and turned over to us specimens that would otherwise have been lost.

The author especially appreciates the guidance and assistance given him by Dr. A. L. Kroeber and Mr. E. W. Gifford of the Department of Anthropology. Mr. L. L. Loud, of the Museum of Anthropology of the University, was his untiring and able assistant in the field. Members of the Department of Geological Sciences of the University, especially Dr. George D. Louderback, kindly assisted with the geological points involved, as did Dr. Warren D. Smith, of the Department of Geology, of the University of Oregon, and Mr. Hubert G. Schenck, Associate in Paleontology, in Leland Stanford Jr. University. To Miss Edna Fisher, Assistant Curator of Osteology of the Museum of Vertebrate Zoology of the University of California, we owe our identification of the animal remains recovered.

GEOGRAPHY OF THE MOUND

LOCATION

The Emeryville shellmound was situated a little north of latitude 37° 50′ N and somewhat east of longitude 122° 18′ W on the eastern shore of San Francisco bay, almost due east of the Golden Gate (fig. 1). It lay in Emeryville, a civic incorporation between the cities of Oakland and Berkeley, Alameda County, California; on ground officially described as the western portion of Plot No. 7 of the Kellersberger Survey of the Peralta Grant;[8] and between the bay and the Southern Pacific Company's railway tracks and between the Shellmound Park and Shellmound Tower stations of that line. Nearer the last-named station and westerly across the tracks from it the southerly property line of the sulphur plant of the Sherwin-Williams Paint Co. intersects the westerly property line of the Southern Pacific Company's right of way (A, pl. 35). Thence southerly along the Southern Pacific right of way line (AC) 125 feet and then westerly at right angles 100 feet lies the point which hereinafter will be called the center of the mound (M, pl. 35).[9]

ENVIRONS

In discussing the situation of this spot our desire is to note those features of a permanent nature and as far as possible to reconstruct the aboriginal environment (fig. 1).

The situation is on an alluvial plain which stretches from north to south along the entire eastern shore of San Francisco bay with an average width of some three or four miles. After this distance it passes sharply into the steep slopes of the Berkeley and San Leandro hills of the Coast Range mountains. The maximum elevation attained by these hills is about 1800 feet. On the south this plain merges imperceptibly into an extensive area now known as the Santa Clara valley.

[8] Being part of a Spanish grant the area has never been laid out in townships, ranges, and sections.

[9] It will of course be understood that there was nothing on the ground to mark this point. Further, no idea of mass is implied, i.e., it has nothing to do with the center of gravity. In any horizontal plane it is the point perpendicularly under the supposed apex of the mound.

The center according to Uhle's map (*loc. cit.*, pl. 37) does not coincide with ours. Our map is based on the survey made by the Pacific States Construction Co. Both probably approximate the truth and the discrepancy would not invalidate any conclusion drawn herein.

On the north after meandering the shores of San Pablo bay it is obstructed by the hills. However, at no place do these hills offer any real obstacle to travel and after a two or three days' march a good walker will debouch upon the vast interior plain of California, the San Joaquin valley.

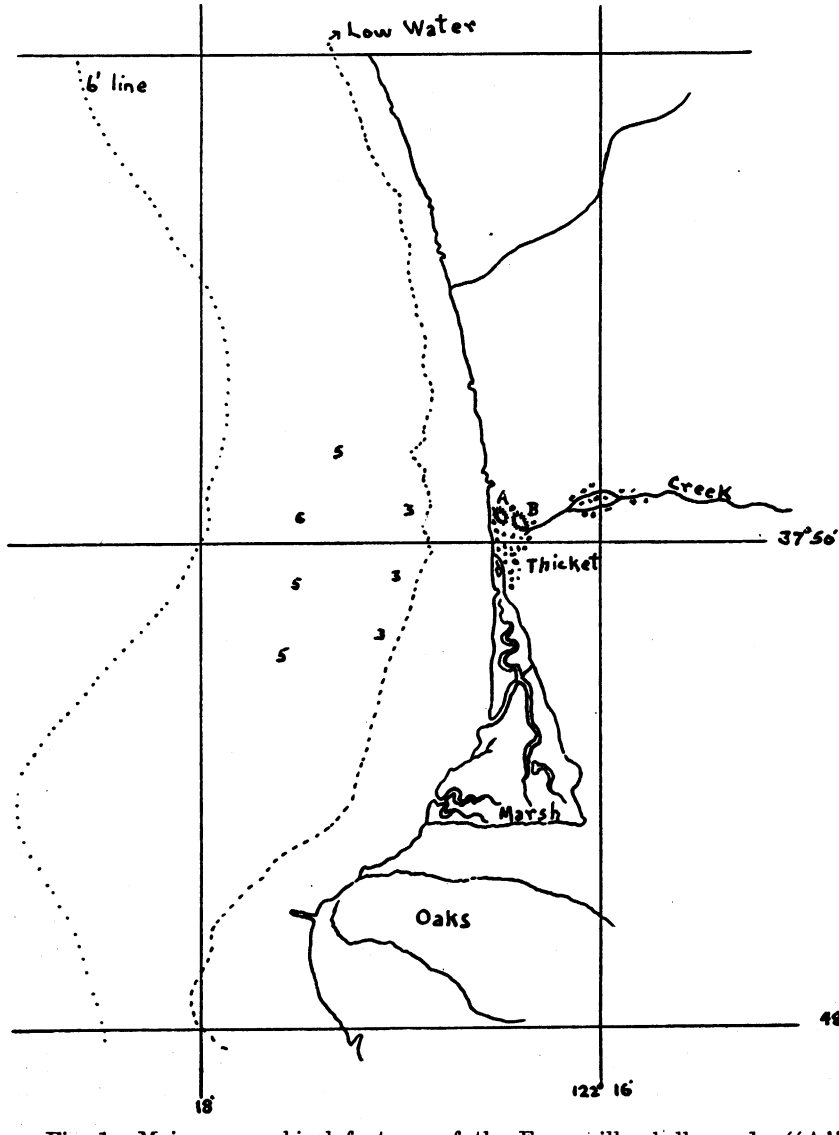


Fig. 1. Main geographical features of the Emeryville shellmound. "A" is the western cone dealt with as "the mound." (Based on U. S. Coast and Geodetic Survey of 1859.)

Returning to our particular locality we find that under fair weather conditions the details of the bay and the Berkeley hills are strikingly visible. And in an hour's walk one can attain an elevation on those hills whence the entire bay regions appears as a map. In other words, anyone living in such a situation must certainly have had a fair knowledge of the surrounding country—its groves, streams, settlements, etc.

On the east, in 1924, the mound was bounded by the railway tracks above mentioned. When these tracks were laid a portion of the mound was cut away and twenty or so burials were unearthed. Just across the tracks, farther east, were formerly other "mounds" which were leveled to make a race track, revealing burials and artifacts when the work was done. Beyond this the plain, treeless except for the stream courses where there were buckeyes, willows, etc., extended to the hills.

The information on these other "mounds" is conflicting. "Old timers" told the writer that there were two large mounds just east of the tracks. Others said that there was only one but that it was larger than the present mound. The Coast Survey map of 1859[10] and that of 1915[11] both show two connected mounds. An old history of Alameda county[12] prints a picture of the residence of Mr. J. S. Emery (at the present corner of San Pablo avenue and Forty-fifth street) which, in the background, shows the race track (for which at least one mound had probably been leveled), the present mound with shrubbery, windmills, and a tank or pavilion thereon, and also two other mounds (southwest toward the bay) connected with it. This makes four in all. Nelson[13] numbers this site 309 on his map and plots one large and two small mounds "still present," and two large mounds "disappeared." From all this it seems certain that several cones were formerly visible on this site.

But from the evidence on the ground as well as from the stories and maps it is also clear that at least two of the larger cones were connected. These data point to the existence on the site not of a number of isolated "mounds" but of a single, widespread, perhaps rather thin mass of mound material from which there arose a number of cones of the same material. In figure 2 the elements of this conception are presented. No data exist which enable us to divide this mass accurately into definitely separate entities, either horizontally as by cones or vertically as strata. To avoid confusion we will follow precedent and use the terms "mound," "Emeryville shellmound," etc.; but whereas in previous discussions those were meant to designate a distinct and separate unit our conception is that only a portion of the whole is being dealt with and in our use of the terms we cover only the western cone (cone A, fig. 2). This distinction is of importance when we come to consider the origin and growth of the mound.

[10] U. S. Coast and Geodetic Survey map, Entrance to San Francisco Bay, 1859.

[11] U. S. Coast and Geodetic Survey map, San Francisco Entrance, No. 5532, 1915.

[12] Thompson and West, Historical Atlas of Alameda County, 9, 1878.

[13] Shellmounds of the San Francisco bay region, present series, VII, no. 4, 1909, map 1.

Flowing in from the east and passing south of the mound was a small creek, called on present maps Temescal creek. Its nearest point was about 450 feet southeast of the center of the mound (M) and it discharged into the bay some 800 feet southwest of the center. This creek seems to be the determining physiographical feature of the location. In the first place, it would have tended to focus population by furnishing a supply of fresh water. At the present time its flow is not natural since it was dammed in the hills in 1866 to form Temescal lake. It has a drainage area of six square miles and in 1866 it was the principal water supply for the several thousand inhabitants of Oakland.[14] In the second place, it must have been of importance as a source of food. Within the memory of men living nearby it has had salmon runs. And Mr. P. E. Bowles informs me that in the early 1880's it was a favorite resort for amateur fishermen. Farther on, the creek overflowed producing marshy ground in which was a more luxuriant plant growth and which must have furnished coverts for game. Just east of the mound was a considerable area of this kind (fig. 1). Finally, forming a bar at its mouth in the bay, it directed the cut and fill of the current of the Sacramento river which flows very definitely through the bay hugging this shore. Within the past fifty years much of this bar has been removed and the wash from the hills has been decreased because of human settlements. In the same period the river current has cut in, bringing the shore line farther east as is discussed below.

South of the creek was a "willow thicket" some 20 acres in extent which probably furnished a convenient and ample supply of firewood. Farther south (fig. 1) the thicket merged into a marsh extending about one and a half miles along the shore and gradually increasing in width until at its southern end it was three-quarters of a mile wide. Beyond this was a mile of rolling highland supporting a beautiful growth of oaks which reached eastward to the hills and which gave Oakland its name. These furnished an important source of food and no aboriginal settlement seems to have existed nearer to them than the Emeryville mound.

West of the mound is San Francisco bay. In 1924 the shore line was 220 feet from the center of the mound (fig. 2). In 1902, Uhle's map[15] shows it was 260 feet. Uhle further states[16] that in 1877 it was about 300 feet. In other words, the shore line is working eastward at

[14] M. W. Wood, History of Alameda county, 650 *et seq.*, 1883.

[15] *Op. cit.*, pl. 3.

[16] *Op. cit.*, 3.

the rate of about 150 feet a century. Such cutting may not have been going on for a century but only since modern conditions have prevented the wash from the hills balancing the cutting. However, the 1859 Coast Survey map shows the 6-foot depth line (fig. 1) farther west—not only opposite the mound but north of it—than in 1915. This would indicate that the cutting was largely independent of the creek.

Low tide left a quarter of a mile of beach exposed. This was true even at the creek mouth. Hence boats or rafts could have been beached or brought into the safe port of the creek only at high water. Beyond the low tide line it was another mile before a man was over his head at low tide. Within the memory of nearby residents this was a fine clean beach of white sand containing shellfish.

North of the mound the plain was not marshy, supported few trees, and had few streams. A small creek falls into the sea about 3300 feet north of Temescal, and in another 3300 feet is a second small creek. The mouth of Strawberry creek in West Berkeley, where there was another mound, is 5600 feet north. Thence northward the shore was more marshy with a creek parallel to the shore. About four miles beyond Strawberry creek, Stege with its mound was reached, and in another mile the Ellis Landing mound; from which it will be seen that aboriginal settlements were reasonably close together in this direction.

HISTORICAL DATA

The first recorded traveler to pass along the eastern shore of San Francisco bay was the Spaniard Pedro Fages in 1772.[17] He reports much game—deer and bear, but no Indians. Since he does mention them at the southern end of the bay and again at the northern end, as do also the two succeeding explorers, Anza and Moraga, and since the weather was such that he plainly saw the Golden Gate it seems incredible to the author that any people could have been residing at the time in the present vicinity of Oakland-Berkeley. However, when Commander Ayala explored the bay by water in 1775 he mentions meeting a number of Indians on balsas.[18] Following these brief mentions we have little historical data pertaining to our site until we reach the modern history of Oakland. The land on which Oakland stood was granted by the King of Spain to Luiz Maria Peralta in 1820. He

[17] H. H. Bancroft, The native races of the Pacific states, II, 595, 1886.
[18] H. H. Bancroft, History of California, I, 246–247, 1884.

divided his grant among his five sons and Vincente Peralta obtained the portion in which we are at present interested. Vincente established his residence near Temescal creek about one and a half miles east of the mound (near the point where the present Telegraph avenue crosses the creek, i.e., at Vernon street). This region became known as the Mexican village of Temescal.[19] Now Uhle deduces from the name Temescal the existence of an aboriginal settlement.[20] But it seems to the author just as likely that the name arose from the Vincente Peralta establishment. Among his retainers would be Indians or others using the sweat bath and it is likely that they would establish a sweat house (temescal) near their houses on the creek, whence the creek would receive its name. The supposed name first appears on the 1857 Kellesberger Survey map as "Temescouta" which may or may not be Temescal.

In 1857 Kellesberger made his survey of the Peralta grant and in 1859 Edward Wiard[21] bought the plot on which the shellmound stands. Maps of that date show buildings on both mounds. In 1871 he leveled at least a portion of the easterly mound and established a mile race track known as the Oakland Trotting Park. In 1876 he opened a holiday resort and picnic grounds known as Shellmound Park. "It derives its name from one of the ancient Indian shellmounds which . . . . rises to a height of 60′. Its summit being crowned with a dancing pavilion."[22] It was doubtless due to its inclusion in this park that the mound was so long preserved practically intact. It is doubtful that the mound was ever 60 feet high though an indeterminate amount of its top was cut off to provide the level plateau for the pavilion. In 1879 the park was leased to Captain Ludwig Seibe, who held the lease until the destruction of the mound in 1924. In the meantime James Mee acquired the property from Wiard in 1886 and passed it to the Mee Estate in 1906.[23] Its subsequent history we have indicated in the introduction.

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[19] M. W. Wood, History of Alameda county, 652, 807–808, 1883.

[20] *Op. cit.*, 5.

[21] M. W. Wood, History of Alameda county, 996, 1883.

[22] M. W. Wood, History of Alameda county, 807, 1883.

[23] Letter from John Hubert Mee dated November 22, 1924.

TOPOGRAPHY OF THE MOUND

When Uhle abandoned the mound in 1902 it was surmounted by a pavilion surrounded by a cypress hedge.[24] By 1924 both of these had been destroyed. The cut by the Northern Railroad (now Southern Pacific Company) had destroyed the natural contours on the east. On

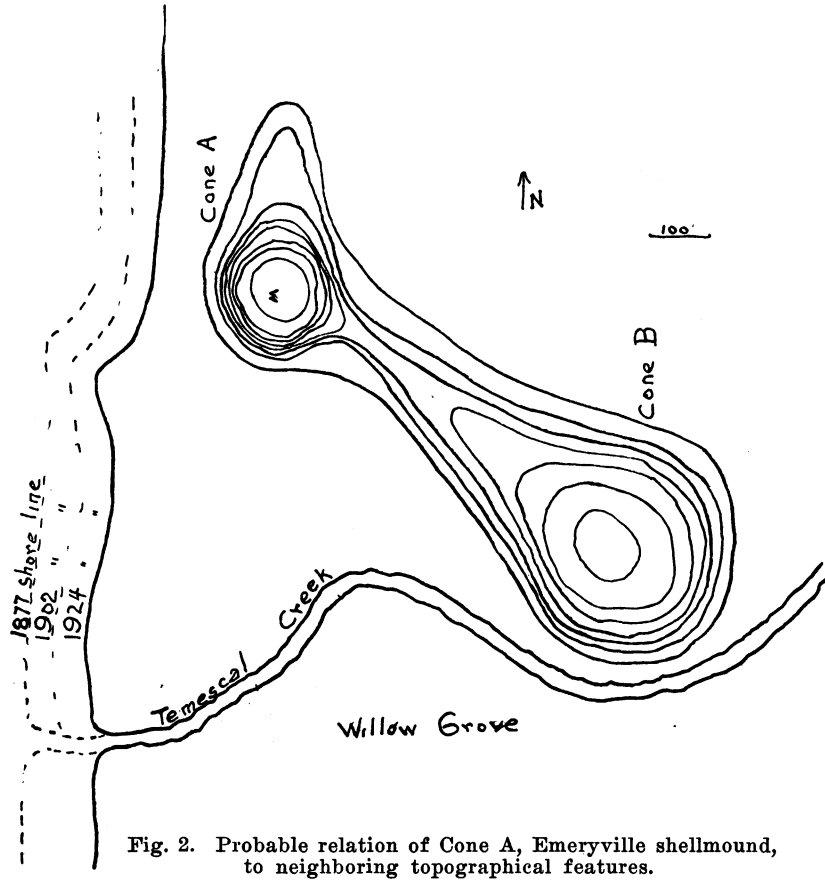


Fig. 2. Probable relation of Cone A, Emeryville shellmound, to neighboring topographical features.

the north a factory and a tank had been erected. This work had disclosed burials but had obliterated the northern projection of the mound (fig. 2). On the west between the mound and the bay a concrete road had been built. A portion of the mound had been used for the purpose and this further confused the contours. Even with these disfigurements the mound presented itself as a fairly symmetrical truncated cone with steeply sloping sides (pl. 36).

DATUM POINTS

With reference to datum points it would be simplest to follow Uhle except that he nowhere definitely states his bases but uses such terms as the "level of the plain." Moreover his maps[25] and his text employ as synonomous such radically different terms (see below) as "shore line," "sea level," "level of high tide," "level of the bay," "general tide level of the bay," etc. Therefore for heights we have adopted the Southern Pacific Company's system wherein zero, known as "C. P. datum" is apparently an arbitrary point. Combining the railway data with those obtainable from the Coast Survey Chart 5532, 1915, the elevation of the following points can be set down, all relating to San Francisco bay.

—1.733 feet	Lowest tide
0.	C. P. datum
+0.767 feet	Coast and Geodetic Survey datum (mean lower low tide)
1.867 feet	Mean low tide
3.667 feet	Mean level of the bay at North Point
5.567 feet	Mean high tide
7.367 feet	Mean higher high tide (Oakland)
9.+ feet	Highest tide = shore line

Since both Uhle and Nelson have drawn important conclusions based on "sea level," it seems desirable to explain this schedule in detail. In San Francisco bay, one high tide is radically different from the other high tide of the same twenty-four hours. The low tides likewise differ. In other words, there is a higher high tide, a high tide, a low tide, and a lower low tide. All these tides vary with the seasons. The very lowest water observed fell 1.733 feet below datum. But the average of the lower low tides (used as datum by the coast survey) rose .767 feet above our datum. "Mean low tide," 1.867 feet, is the average of all low and lower low tides for a year, 3.667 feet being the average of *all* tides at a point near the open sea (North point), would come nearest to our ordinary conception of "sea level" or to Uhle's "general tide level of the bay." "Mean high tide," 5.567 feet is the average height of the lower of the two daily high tides, while the higher high tide averages 7.367 feet. But the highest seasonal tides would rise beyond this and mark the shore line which according to the Pacific States Construction Company's figures was somewhat over 9 feet opposite the shellmound.

In this paper heights will be referred to in terms of elevation above C. P. datum, *not* above any tide mark. For example: the concrete road west of the mound is 11 feet elevation, and the top of the rails of the Southern Pacific tracks 14.2 feet elevation, meaning that they are

[24] *Op. cit.*, pl. 2. [25] *Op. cit.*, pl. 4.

11 feet and 14.2 feet respectively above C. P. datum, or 2 feet and 5.2 feet above the very highest water.

For horizontal locations our datum will be the "center of the mound" previously 'tied in' with the Southern Pacific railway right of way.

HEIGHT

The highest point of the mound in 1924 had an elevation of 38.8 feet; the lowest point an elevation of 4 feet. This high point, however, is unfortunately not the original highest point, the top having been more or less leveled for the dance pavilion. If the cone had continued its slope to a definite point it might have attained an elevation of some 66 feet, which is not far from the height of 60 feet given by the county historian. This seems improbable. It is doubtful if Wiard would have undertaken the moving of a symmetrical cone containing some 7000 tons. There is not sufficient trace of such a bulk of material having been placed elsewhere. It would seem, therefore, that the maximum elevation attained by the mound was about 40 feet. The "level" top of the mound is uneven, ranging in elevation from 36 feet to 38.8 feet; hereafter we consider this plateau to be level with an elevation of 37 feet, which becomes a datum point in considering burials.

SHAPE AND SIZE

While the mound when first seen conveys the impression of a truncated cone (pl. 36) and while the 24-foot elevation to 37-foot elevation contour lines are remarkably uniform (pl. 35), a cone-shape for the entire mound with a determinable basal diameter does not seem so easily established. Viewing the top portion we see a truncated cone (pl. 35). Reconstructing the middle portion (elevations 12 to 24 feet) from data available we can at least disclose a very irregular figure (fig. 2). To support these we must hypothecate an even more irregular base.

The roughly circular plateau enclosed by the hedge (37 feet elevation) may be said to have an average diameter of 145 feet.

When we come to the next dimension we are confronted by the question: where is the base? Uhle[26] says the mound has "a diameter of 270 feet at its base" which we determine from his map (pl. 3) to be about 8 feet above "shore line." But a little farther on[27] he speaks

[26] *Op. cit.*, 3. [27] *Op. cit.*, 11.

of "the base of the mound two feet below the water level" and from his plate 4 we determine the diameter to be some 354 feet at that point. The base might be taken as the plane where the slope of the mound at present definitely rises from the slope of the plain which Uhle judged to be about 8 feet (probably our 17-foot elevation) above the shore line and which seemed to us to range from that figure down to 12 feet elevation. These facts, together with the fact that when the mound was leveled it was cut down to the 15-foot elevation line, leads us to denominate that contour as the base of the *cone,* but not the base of the mound. At this point the cone might be said to have a diameter of about 250 feet. The diameter cannot be stated exactly since grading work on adjacent property utterly destroyed the original contours which break abruptly at the fences marking the property lines (A B and A C, pl. 35). Our data do seem to point to the 15-foot elevation lines extending 100 feet farther north and possibly 800 feet farther east. When we drop to Uhle's "two feet below the water level" (possibly our (7-foot elevation) the mass constituting the base of the mound must at least attain that extent. At 16 feet elevation we unearthed burials 135 feet northwest of the center of the mound, and at 11 feet elevation we found a body 310 feet southeast of the center. Burials were disclosed in digging tank foundations at about 15 feet elevation, about 175 feet north of center. All of this confirms the older maps and reports, which extend the shell mass some 700 feet east of our center. In short, it seems to the writer that all idea of a circular basal perimeter to finish out the truncated cone must be dropped. What the exact shape was must remain uncertain but that shown in figure 2 seems as fair a guess as any. The area of the base is again a guess but it would appear likely that it might have been as much as 300,000 square feet and the cubic contents as much as 150,000 cubic yards.

To summarize: The mound when we began work on it (pl. 35) had been considerably distorted; we deal largely with an approximately conical section with diameters of 150 feet and 250 feet and a height of 22 feet containing, according to truck measurement as it was hauled away, 26,500 cubic yards; this section may not properly be projected into a larger cone with a circular base but is simply a portion of a very large and irregular mass.

RELATION TO SEA LEVEL

A series of twenty-two 9-inch holes sunk by us in the central portion of the mound established an average elevation of 6 feet for the lowest portion of the mound. The lowest was 4 feet elevation and the highest 7 feet elevation. These results seem to check reasonably close with Uhle's determination, which was apparently 7 feet elevation.

This places the base about 2 feet below the point attained by the highest tides at present, which is construed by Uhle[28] as a fact of major importance. He postulates therefrom a general subsidence of the area and a remote age for the mound.

As we see it, however, no such inference follows: The mound rests upon a stratum of yellow clay stained rather dark above probably by seepage from the mound and gradually becoming lighter in color and more sandy until at about 3 feet (under the central portion) it passes into a stratum of gravel. A well 150 feet or so to the north of the center indicates that these strata of clay and sand alternate to a depth of 300 feet, the first gravel stratum being 17 feet thick. Holes dug to the west of the mound below high tide line, by the contractor in canalizing Temescal creek, reveal the same clay. The surface of this clay would not have been absolutely even but must have presented slight rises or depressions which would account for the variation in our elevations of the bottom. Larger knolls may have occurred which were missed in our random digging. Farther on this clay plain slopes from the sea upward toward the east. Both Uhle's work and our work was confined to the western portion of the mass of shellmound material. Extending as this does 700 or 800 feet farther east it seems probable that the slope of the plain might carry its base a couple of feet higher in that distance. Now even our average base (6 feet elevation) is not below "sea level" but is just about at the level of the average high tide (fig. 3). It is 4 feet at least above average low tide. Granting that it would have been unlikely[29] for the aborigines to start a shell heap on the wide, hard[30] tide-flat exposed, it would still require but the slightest knoll or a very small gain from the general slope to afford a dry spot at all tides. Since the base is not below sea level, but only

[28] *Op. cit.*, 11–14.

[29] H. G. Schenck, Associate in Paleontology, Leland Stanford, Jr. University, informs me that he has seen "Indians in Chehalis county, Washington, that had shell heaps on tidal flats."

[30] At present, even with the sea cutting in, one can walk dry-shod a hundred feet or more west of the present shore line near the mouth of Temescal creek when the tide is out.

below high tide level, it may be recalled that the tides do not depend entirely on sea level but on bottom and shore configuration as well. For example, from the same sea level tides rise 3.5 feet higher at Alviso on the southern shore of San Francisco bay than they do at North Point. A change in the contours off shore from the mound might well cause enough change in the local tide to inundate the base of the mound or leave the place entirely dry. The entire present base of the mound need not have been dry land. All that was required was a foundation, whether a heap of shells formed at low tide or a small dry knoll. A settlement started here could spread the shell heap across tide-flats at

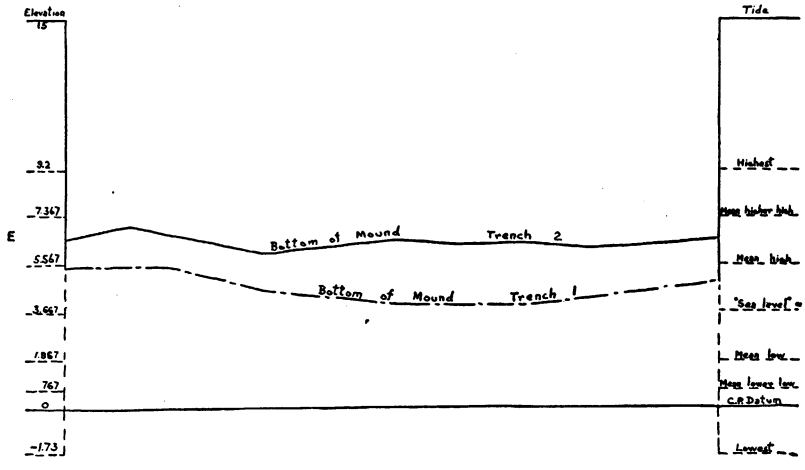


Fig. 3. Longitudinal cross-sections of trenches 1 and 2 showing bottom of mound material. Horizontal scale is twice the vertical scale.

low water, or into a marsh or the bay at high water. The need of pile dwellings in order that the foot of a mound might start below a high tide level seems utterly unnecessary. A shell heap once formed by thus "creeping" out into the water or a marsh from a higher nucleus may acquire deceptive characteristics. We dug at Emeryville during one of the wettest Februarys on record—and this month comes in the wet season and the season of highest tides. The flow of water into our pits was from the east and was fresh, indicating that it was due to the run-off from the rains. High or low tides made no perceptible difference and after a few dry days one could work, without being unduly troubled by water, at an elevation of six to seven feet. During the dry season of more than half of the year this condition must have been greatly emphasized. In other words, once a shell heap has been formed—in or out of water—the aborigines could just as well dig

pits in it for burial or residence below the water level as we could make dry-footed excavations to recover them.

Finally, while it seems that the facts of the base and foundation of the Emeryville mound may be reasonably explained without postulating subsidence, even if we postulate it we have little clue to age. General subsidence in this region is very obviously proved by San Francisco bay itself. But this subsidence was so remote as to have no bearing on the present discussion. As evidence of recent subsidence the shellmounds were always first cited to the author by geologists. Of these, the mounds at Emeryville and Stege seem at least open to argument. The only other mound intensively studied from this angle is that at Ellis landing where the base appears to be several feet below the spring shore line. The data then are not exhaustive. To take the mounds as evidence of subsidence and then subsidence as an indicator of the age of the mounds seems a roundabout manner of assumption. As far as the Emeryville mound is concerned it seems that the fact of geological subsidence since the mound's base was laid down is far from proved and that, if granted, the conclusion to be drawn is uncertain since the area is specified by geologists to be one of buckling, while this subsidence and elevation of contiguous limited areas is believed by them to have taken place in quite recent times.

Some consideration must also be given to the settling of an accumulated mass, such as the shellmound, in the silts of the bay. Where railway tracks were laid in the Sacramento delta region this settling was enormous. The substratum at Emeryville would not lead one to expect such settling, and Uhle decided against such a possibility.

METHOD AND EXTENT OF WORK

From October 17 to November 30, 1924, we watched the leveling of the mound by steam shovels. From January 19 to March 11, 1925, trenches were sunk by hand with the sole object of obtaining archaeological data.

In the prosecution of the leveling work scientific ends were secondary, and our methods had to be adapted as far as possible to the situation. The material was placed in trucks by steam shovels, hauled a short distance where it was dumped and spread by means of a Fresno scraper. About 750 cubic yards were handled by a shovel each eight-hour working day. On account of the nature of the mound no blasting was necessary. The shovel dug into it leaving a vertical wall about 22 feet high somewhat obscured at its foot by a talus accumulation.

Traversing this wall the shovel would undercut it, caving in the top ten feet or so. This was done with the bottom of the dipper open so that the loosened material would pour through. A single cave-in usually extended back 12 to 24 inches and in one traverse the shovel would make a cut 10 to 15 feet wide.

This method of the contractors offered advantages as well as disadvantages. The material was turned over pretty thoroughly and more or less exposed to view four times—in cutting from the wall, in dumping from shovel to truck, in dumping from truck to ground, in being spread by the scraper. We paid most attention to the mound itself but specimens were obtained in all the processes. All large objects were likely to be disclosed by this work and it is believed that the percentage of existing articles of this kind which were noted or recovered is high. Burials also were likely to be disclosed because the bones were different from the material in color and readily seen; and because a burial occupies so much space that it would be a rare exception for the shovel working with dipper closed to hit it so exactly that no trace would be observed. On the other hand, the lower levels were obscured partly because of the talus and partly because the shovel worked here for a greater portion of the time with the dipper closed. Infant burials were likely to be missed because of their small size. Since most of the burials were turned up in the direct work and path of the shovel, they could not be consistently examined for articles which might have been interred with them, although the larger part of all the small articles found, except bone awls, were found associated with burials. No doubt, then, we missed by far the greater number of small artifacts.[31]

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[31] Uhle found on the average 1 burial per 28 cubic yards. Our average in the shovel work was 1 in 40 cubic yards and in the trench work 1 in 7 cubic yards. Uhle's work and our trench work was done in areas where burials were thought to be most numerous. Our own work in particular excludes the unproductive perimeter of the mound, the volume of which is included in the steam shovel figures.

In the matter of artifacts comparisons are worthless since they are not based on the same standards. Uhle got one artifact in each 0.47 cubic yards of material handled. We counted, however, many bits of stone and bone similar to scores of pieces rejected by us. The next trouble arises from the uncertainty of the count. How many artifacts is a mortar with some olivella disc beads stuck thereon? On certain skulls such beads appeared to be inlaid. If one hundred are taken from a skull should one count one hundred artifacts? With one burial we secured over a thousand such beads. To count one thousand artifacts, making each bead equivalent to a mortar or charmstone, would be misleading. Yet if found one by one, here and there, how else could they be counted? From the cone we catalogued 675 entries, from the trenches 317 entries. Counting each bead the total is over 6300 artifacts. In the trenches we have one artifact in each 0.74 cubic yards; in the cone, one in 39 yards. For the whole work we show one artifact in 4.2 cubic yards. We emphasize that in our opinion such average figures are misleading rather than helpful.

It was frequently impossible to minutely examine structural features such as pockets of ash, etc. On the other hand, the scale of the work, exposing as it did a series of cross-sections 22 feet high of the entire mound, enabled a more comprehensive view to be had of layers, strata, etc., than could possibly be got from a small pit or trench. These features appeared more fully and in a more complete relation to other features. Since the shovel left each wall undisturbed for several days there was ample opportunity to study these grander features of structure. Depths were noted and recorded whenever possible. Unless a specimen was seen *in situ* no depth was taken. No original surface finds were made. Hence everything had some depth, but where it was not found in place it was recorded as "surface." Most depths had to be estimated by eye, but this was done with reference to check points. All depths were taken from the actual surface of the ground. In the central portion of the mound this introduces an error since it is known that that portion was originally higher. This difference might have been three feet; but to introduce a supposition as a correction seems aside from the point. True comparative vertical positions could be indicated by reducing depths to elevations, i.e., by subtracting the depth from the surface contour over the position. In the central portion this would be simple since the surface contour for all is 37 feet.

Horizontal position has been roughly indicated by the use of areas. The successive cuts made by the shovel were subdivided with reference to the hedge around the plateau and the axis of the mound. The resultant areas were numbered as shown on plate 35. Each burial and artifact was, where possible, assigned to the area in which it was found. Area 1 is abnormally large partly because much of the work was done here before we arrived on the scene and partly because this portion of the mound had been previously demolished to a considerable extent.

For the intensive work three trenches were dug near the center of the mound (pl. 35). The center line of trench 1 was 22 feet south of the center of the mound; of trench 2, 22 feet north; of trench 3, 13 feet west. Trenches 1 and 2 extended both 25 feet north and 25 feet south of the center of the mound and trench 3 connected them. These trenches were six feet wide. They were sunk with shovels only and the material was removed in one foot stages until the bottom of the mound mass was reached. This gave a depth of from 7 feet 6 inches to 9 feet (fig. 3). The adhesiveness of the material due to dampness and the presence of such a large proportion of shell fragments of

various sizes precluded sifting without the spending of more time and money than Uhle's experience and our knowledge from the steam shovel work seemed to justify. The workmen were intelligent and interested, the work was done slowly, and much of the material was handled and examined a second time on the surface. Hence it is felt that a very fair percentage of existing artifacts and all burials were discovered.[32] All burials were disinterred with the utmost care by the author and Mr. Loud. All finds were located by measurement of their distance east or west and north or south of the center of the mound.

Depths were taken by actual measurement from the then surface (15 feet elevation). Hence all trench depths have been corrected by the addition of 22 feet and may be directly compared with the depths of the steam-shovel work.

INTERNAL STRUCTURE OF THE MOUND

The lowest stratum beneath the mound of which we have knowledge is a layer of gravel. Where the well is, north of the mound, this is 17 feet thick. Above this is a stratum of yellow sandy clay which loses its sand and yellowness towards the top where it is blackish in color either from a previous vegetal growth or more likely because of stain from water which has seeped through the mound. This layer where tested by us averages about 3 feet in thickness. This thickness was obtained by sinking 9-inch holes with a post hole digger about 5 feet from one another in all three trenches.

Above the clay comes the mass of the mound proper.[33] Uhle divides this mound mass into ten strata which he depicts.[34] He apparently uses the term "stratum" with its usual geological connotations, and we understand that he meant a layer distinguished by definite character-

[32] In note 31 the average number of cubic yards of material per burial was given. This was obtained by dividing the total cubic yards from the trenches by the total number of burials discovered. However this method is open to serious reservations. A burial on the average occupied a space 2 feet by 3 feet. When an indication of a burial was noted (perhaps a bare corner of the 2 by 3 space), it was exhumed and counted. In other words, if only burials lying squarely in the trenches had been counted the total number would be greatly reduced. It seems, therefore, that, as far as burials are concerned, allowing for the law of chance, an area wider than six feet was explored and that in figuring yardage per burial we would have to add one and a half feet to the trench dimensions, i.e., instead of having a trench 6 feet by 50 feet we would have in effect one 9 feet by 53 feet.

[33] Uhle's excavations indicated that at the one spot where he crossed the perimeter of the mound there had been a silting in of clay so that the clay stratum is not only under the mound but forms a wedge-like tongue extending into its slope near the base.

[34] *Op. cit.* pl. 4.

istics which extended over the entire area under consideration. Taken in this sense our study did not indicate that the mound contained any strata at all.[35] While Uhle's vertical vision was complete his horizontal horizon was very limited and we believe that had he run a second trench in a different portion of the mound he would have distinguished a second series of "strata" which would not have coincided with his first series either in character or number. This is due to the fact that the construction of the mound is lenticular. The lenses vary greatly in size, ranging from pockets a few feet long and a few inches thick to layers thirty or forty feet long and several feet thick. They do not lie in the same plane and some of the larger layers lie contrary to the general contours of the mound. Certain of these lenses of homogeneous material may dominate a considerable portion of a wall but entirely disappear a few feet to either side and pinch out in front or behind. Hence a drawing of any given cross-section would in our opinion differ from any other cross-section. However, within limited areas certain lenses were very dominant and one of the most notable of these was the calcined layer which extended over most of the northwest slope of the mound to a depth of 6 or 8 feet (pl. 36*a*). This is in the area explored by Uhle and helps to explain his strata. Another notable lens was in Areas 21, 22, 29, 30 (pl. 37*a*). Still another layer running parallel with the surface of the plateau and about 3 feet below it extended along the eastern part of the southerly wall of Area 8 and of Area 9 and the western part of Area 10. This was from 2 feet 6 inches to 5 feet thick and of a lighter color (pl. 36*b*). Heavy wavy layers of clamshell marked the southerly wall of Areas 19 and 20 (pl. 37*b*). Again, in Area 19 was a heavy curved lens of clamshells with the concave side up so that it formed a pocket perhaps 25 feet across. This pocket seemed to contain an unusual proportion of soil. This is in no way intended as a recital of the main structural features. They are simply examples cited to show the kind of features that existed. It is quite possible that could we have noted all the main features a study of their relationship might lead to something. We are unable to set down such features, however, and must rest with the negative conclusion that strata were not present.

The presence of moisture in the mass gave a false appearance of stratification. Supposed planes of bedding detected by trained observers disappeared with the drying out of the wall. If two or three cubic yards of material were

[35] At Ellis landing Nelson, also with full views in cross-sections, found an absence of strata. (N. C. Nelson, The Ellis landing shellmound, present series, VII, 374, 1910.) But when he dug a hole six feet square in the Emeryville mound he found "strata." (Manuscript notes.)

allowed to pour through the dipper from a height of several feet and a clean cut made in the pile the wall thus obtained presented an appearance of stratification analogous to that obtained from a cut into the undisturbed mass of the mound.

Both Uhle and Nelson proceed on the assumption that a lower level is older than a higher level no matter what its horizontal position. With lenticular construction only an area more or less directly under another area can be considered relatively older. For example, the top layers of Area 21 might well be older than the lower levels of Area 13.

This lack of strata extending over the entire mound and the presence of local lenses and pockets is what we should expect, since they would seem to be the more natural results of human life. Human activity should not be expected to produce a series of essentially homogeneous strata extending over the entire mound. Some of these pockets undoubtedly indicate fireplaces. Others seem to run contrary to the general contour of the mound as would be expected from depressions caused by house-pits. Still other pockets may have represented seasonal activities. A detailed and intensive study, which we were denied, might have made it possible to classify the pockets under such headings. The impression left on us was the strong conviction that if they were used as cultural indices it was just as necessary to consider them with reference to different horizontal areas as to different vertical "strata."

CONSTITUENTS OF THE MOUND

METHODS OF DETERMINATION

The main constituents of the mound are readily ascertained by field observation. To secure an accurate idea of their relative abundance would require a long series of physical and chemical analyses. Such have never been made and could not be made by us on account of the prohibitive financial cost. E. W. Gifford in his study of the composition of this and other California shellmounds[36] made some exhaustive analyses of the samples submitted to him and the interested reader is referred to that work for very comprehensive details. The present author must state, however, that several weeks' observation of the internal structure of the mound has impressed him with the need for great caution in drawing conclusions from such analyses.

[36] Composition of California Shellmounds, present series, XII, no. 1, 1916.

Where large masses of homogeneous material are dealt with, typical sampling is easy. In the peculiarly constructed shellmounds one taking samples is confronted with the practical necessity of making a choice. For example, Gifford states that in the samples he worked with "pockets and their contents have been purposely avoided as not being typical." Yet the mound at Emeryville is essentially a mass of pockets, now of ash, sometimes of clam, or again of mussel, etc. There are certainly hundreds of square feet of cross-section where the pocket is more truly representative of the content than is the balance of the area. Many of Gifford's Emeryville samples were selected by Nelson as being "characteristic of the stratum." Further selection is obviously necessary when dealing with such samples as Gifford had to work with. A sample almost all ash he includes; one almost entirely stone he rejects. His average sample was about 4 ounces, hence the sample taker had to pass over a stone or a bone as exceptional, or have a sample all bone or stone. In short the samples, first in the field and again in the laboratory, were selected local material. Error is therefore likely when in analysis or in the laboratory such samples become the type for wide areas and the basis for broad conclusions. To illustrate: Gifford's analyses are of necessity semi-physical, semi-chemical. Considering bone content, for example, the percentage he gets is what can be picked out by hand *after* the larger pieces have been left out in the field and not counting the smaller pieces that cannot be hand-separated. How can two mounds be accurately compared on the basis of such bone content? His percentage of ash is based on the chemical analysis of 5 grams. Samples taken at set distances will still be selective and misleading unless they are of considerable volume. The 20-foot mark may come in the center of a 3-inch lens of clam and a small sample will show a very high clam percentage. A shift of the point 6 inches in any direction would as likely as not show a large preponderance of mussel. Such small samples in large numbers might average up for the mound as a whole but would remain deceptive in comparisons of its different depths or horizontal areas. As intimated our next criticism is of the size of the samples. Nineteen samples (totaling some 6 pounds) are utterly inadequate for a miscellaneous mass of more than 26,500 cubic yards. If samples of, say, one cubic yard each, were taken on a fixed linear basis and all material therein carefully analyzed, first by physical selection and then by chemical means, a reasonably accurate estimation of main elements would be had. This would be tremendously expensive. Unless this is done, proportions of contents expressed in figures

are too largely a statement of percentages of selection and chance; and a probable source of error is avoided by sticking to what at other times is undesirable—the use of general descriptive phrases to express relative quantity. Hence in this connection our statements are of a general nature. In suitable places Gifford's percentages for certain of the constituents of the Emeryville mound are inserted for convenience.

Through the kindness of Mr. Ernest C. Bolté, Inspector of the Division of Chemistry of the California State Department of Agriculture, that department made three chemical analyses for us. The material for test 373 came from several points along the talus slope of the southerly wall of Areas 8, 9, and 10 and represented various horizontal areas as well as depths down to about 18 feet. Material for test 372 was taken at a depth of 25 feet in Area 9. Test 371 was of calcined material from the large deposit in Area 7. All samples were small in quantity. They were taken by thrusting a tubular tester into the mound, thus excluding all large pieces. The results obtained follow. Dashes in tests 372 and 371 indicate that the analyses were not carried out.

TABLE 1

CHEMICAL ANALYSIS OF SHELLMOUND MATERIAL

Test No.	371	372	373
Moisture, per cent	1.00	13.70	8.04
Calcium carbonate ($CaCO_3$), per cent	82.77	61.67	56.33
Calcium phosphate ($Ca_3P_2O_8$), per cent	3.07*	5.27*	7.43*
Magnesium carbonate ($MgCO_3$), per cent	1.55	2.27	1.49
Silica (SiO_2), per cent	.....	.....	18.45
Oxides of iron and alumina (Fe_2O_3, Al_2O_5), per cent	.....	.....	.75
Water of constitution and organic matter, per cent	.....	.....	5.50
*Phosphoric acid, per cent	1.41	2.43	3.41

In addition to the above test Mr. Bolté carried out three secondary tests for the purpose of obtaining a comparative idea of the amount of phosphoric acid (a characteristic index) in animal and in human bones. All bones were from the mound and air dried. Test 374 was of animal bones; 375, of small human bones; 376, of large human bones. All were collected in approximately the same place—Area 8. The results show:

Test No.	374	375	376
Phosphoric acid, per cent in bones	32.8	32.3	33.5

In other words, the tests in the first series while indicating the presence or absence of bone would not enable us to state whether it was animal or human.

SHELL

The mound was composed principally of shell. Gifford's figures are 59.86 per cent and the Department of Agriculture tests indicate well over half. The shells were mostly those of clams (*Macoma edulis* and *M. nasuta*), mussels (*Mytilus edulis* and *M. californianus*), and oysters (*Ostrea lurida*). Cockleshells (*Cardium corbis*) were plentiful enough to be readily noticeable. Other shells found in much smaller quantities included: *Purpura crispata* and *P. canaliculata, Cerithidea californica, Helix, Standella.*[37] Still other shells were found in rare quantities and had apparently been treated by the former inhabitants in the manner of possessions. These are discussed under material culture.

The most casual observation indicated that clams or mussels or oysters predominated in given areas with reference to either horizontal or vertical divisions. Our data, however, do not permit us to determine the relative abundance of these species in the mound as a whole.

The clamshells are the strongest and were the least broken up. Indeed a very considerable percentage of entire valves appeared. Consequently these shells were very conspicuous, appearing in layers or lenses which were rendered more noticeable by their whitish color. Plate 38*b* shows portions of typical lenses. Such deposits were seen throughout the mound down to a depth of 22 feet. Below in the trenches we did not detect any notable layer of this kind. Clamshell was present but it was not conspicuous in specialized deposits.

Oyster shell layers were the next most conspicuous. Here again were many valves entire and perfect. These also were throughout the mound both above and below clam layers. There was a very definite deposit several inches thick at the very bottom of the western end of trench 2. This deposit was so free from débris attributal to human agency that it suggested a natural bed of oysters the existence of which might have been a contributing factor to original settlement near the site. It may be added that these shells showed no more disintegration than layers higher in the mound. These deposits of clam and oyster shell where other shell was practically absent and there was only a very small percentage of soil, though bones and artifacts were found therein, seem to imply periods during which a given species was almost exclusively gathered for food. Seasonal conditions or activities

[37] All these species have been reported by previous workers. Nelson reports for San Francisco bay shellmounds the following additional species: *Modiola* sp., *Myra arenaria, Tapes staminea, Tapes tenerrima, Acinea patuna* (*op. cit.*, 338).

might account for such a specialization in diet. The apparent frequency of alternation makes such a theory more plausible to the author than one hypothecating an exhaustion and later replenishing of one or the other species.[38]

Mussel shells are also very abundant, but being fragile they were seldom found entire. Hence they seldom form such conspicuous deposits though they constitute a very considerable part of the mound.

SOIL

Soil is the second largest constituent of the mound. This is noticeable in three forms.

In places layers several inches thick of pure clay such as forms the substratum were found. There was nothing about such layers to suggest house floors, fireplaces, or the like. Had they been of larger extent one might be tempted to adduce water deposition. As it is, no explanation of their presence can be advanced. Sand also existed in localized pockets though in much smaller quantities.

The bulk of the material distinguished as soil was the fine, black "filling" of the mound not specifically identified. It has been stated that the clam and oyster layers were comparatively free of soil and in other layers such as ash and calcined shell soil was a minor component. Otherwise it filled in the interstices between the other components and at places formed definite layers. Near the surface the slopes showed the most soil as was to be expected since the plateau was not the original top of the mound. Considering the four directions, the east slope seemed to show the greatest proportion. It is presumed that soil was present through vegetal decay, through having been brought in with shellfish, through the agency of the wind, and possibly from decayed acorn and buckeye shells, etc.

ROCK OR STONE

This material was present to a considerable extent. (Gifford's figure is 8 per cent.) Possibly the greater part consisted of a fine gravel such as is found in Temescal creek-bed or in the gravel stratum beneath the clay substratum. In many cases such gravel is covered with barnacles or sea growths which would indicate that it had been

[38] Uhle concluded that oysters predominated below and clams above. We have spoken of the oyster shell deposit we encountered toward the west just above the clay substratum. Also, we noted a large lens of clamshell near the top of the area where he worked. It seems, however, that his deduction is too broad for the mound as a whole.

brought in from the tidal flats with shellfish. A quantity of this gravel was collected from twenty-nine feet to thirty feet deep in trench 3. See sample A, table 2. Other rocks occurred in bits generally smaller than one's fist and these more often than not showed signs of having been used as fire-stones. A number of such fragments from the upper portions of the trenches compose sample B, table 2. For the comparison of these samples indicated in table 2 we are indebted to Dr. George D. Louderback.

TABLE 2

TYPES OF ROCK IN EMERYVILLE SHELLMOUND

Rock types	Number of pebbles Sample A	Sample B
Franciscan sandstones (distinctive facies)	8	8
Chert	17	25
Metamorphic rocks:		
Quartzite	7	4
Mica schist	1	2
Hornblende schist	0	8
Glaucophane schist	0	1
Meta-sandstone	1	0
Meta-shale	1	0
Greenstone (meta-diabase and basalt)	5	2
Black hornblendite	0	4
Vein quartz	11	1
Leona rhyolite	7	0
Tertiary basalt, or basaltic andesite	16	51
More definite andesite type	3	1
Sandstone, brown, Cretaceous or Tertiary	11	11
Red micaceous sandstone	2	7
Monterey chert	55	4
Fresh water chert	0	3
Burned sandstone	?	13
Obsidian (small chip)	0	1
Quartz porphyry	1	1
Gabbro	1	0
Monterey limestone	2	0
Amygdule	1	0
Red chert chips	0	2
	150	149

Sample A refers to bag sample marked "Shellmound débris, 7–8 feet deep, Trench 3." Sample B refers to heap of pebbles separated from mound débris and examined in field. Determinations made by aid of lens only.

Louderback points out that Sample A pebbles represent all the types of rock that occur in the Berkeley hills in the area drained by Temescal and Claremont creeks and that are likely to be recognized in creek pebbles. He sees no evidence of selection or sorting other than would be done by the creeks. Sample B pebbles are about the same

TABLE 3

DISTRIBUTION OF ROCK IN LOWER PORTIONS OF MOUND

Depth in feet	Trench 1 Quantity in pounds			Trench 2 Quantity in pounds			Trench 3 Quantity in pounds		
	Burned	Unburned	Chert	Burned	Unburned	Chert	Burned	Unburned	Chert
23 to 24							62	19	2
24 to 25							22	8.75	.25
25 to 26				20	3.5	5.5	40	6.5	3.5
26 to 27				35	7	4.5	13	7	2.5
27 to 28				60	11.5	2	26	9	6.5
28 to 29				72	7	6	27	7	4
29 to 30	45	10.5	.5	23	4	5	48	13.5	8.5
30 to 30.5							13	1.75	.25
30 to 31	18	7	3						
31	15	3.5	1.5						

although they differ somewhat in relative proportion. This may in part be due to a different method of selection from the mound material. Sample A was carefully picked out after the material reached the surface. Sample B was made up of larger bits of rock which the shovelers found in the course of their work.[39]

In the trench-digging an attempt was made to save out the coarser rock of which sample B is typical and while the results do not permit total content determinations they may be used in relative comparisons. The data are given in table 3. No collections were made from the upper levels of trenches 1 and 2. Chert is listed separately and was all apparently unburned.

The collecting was uneven and the determination of the burned rock could not be exact. Withal it would seem that the results might be fairly interpreted as showing that a very large percentage of the larger stones was brought in by man and used in connection with his fires or cooking. There is no correlation between depth and amount. Chert has been kept separate owing to the greater probability of its selection by man and to Uhle's belief that it occurred in greater quantities in the lower portion of the mound. The data do not seem to confirm this belief. That such stone was at times selected is undoubted. A cache, for example, was uncovered in trench 3, 29.5 feet deep, and a number of pieces had been used as hammerstones. The chert was generally of a coarse greenish or reddish variety. It is further discussed under "Material Culture—Eoliths."

VERTEBRATE REMAINS

Besides human burials, skeletal remains of many quadrupeds, birds, sea mammals, and fish were found in the mound. Gifford's percentages are: fish remains 0.186 per cent, other vertebrate remains 0.031 per cent. In other words, fish remains are six times as heavy as those of other animals. This implies a contingent train of possibilities which would characterize the inhabitants. Two of the small samples, however, were very much out of line with the others. Omitting these, the average for fish becomes 0.038 per cent, or about the same as for other vertebrate remains. This tremendous change indicates the danger in dealing with this material with limited statistics.

Aside from the question of their total proportion of the mound, it may be said that such remains appear in sufficient quantities to readily strike the eye in practically any part of the mound.

[39] Letter from George D. Louderback dated September 28, 1925.

Most of these bones were in comparatively small pieces, since practically all large bones had been broken or split, presumably for their marrow. Many bits of charred or burned bone were found in various parts. In the calcined layers all bone present had been burned and frequently had turned a greenish color. This color is so characteristic of the bones in these layers that it must be the result of a natural process, possibly the effect of sea water in contact with the bones as they were being burned. No bones were noted which gave evidence of having been gnawed, as might be expected were there dogs about camp. Nelson adds in this connection that dogs would not have been likely to leave so many practically entire bird bones.[40] Bones of wild animals were generally much better preserved than human bones from the same location.

While bones were scattered throughout the mound there was concentration in some spots. In some cases such spots were near evidences of hearths. This is particularly true of fish bones and fish scales. The latter were seen at times in compact masses (1–26031) several inches thick and covering perhaps a couple of square feet. It might be expected that the killing of even one large animal would result in a concentration of its bones at a given spot. It is noteworthy, however, that, while the bones of a given species do seem to characterize a concentration, the species may be a small animal. Spots were noted where gopher bones were present in relatively large quantities and the same was true of bird bones.

A great number of these bone remains were collected and turned over to the Museum of Vertebrate Zoology of the University where Miss Edna Fisher is classifying them and preparing a paper on the evidence which they present. Accordingly, we present herein only the provisional identifications and a brief statement of the points they suggest.

The species represented were about the same as those reported by Uhle with a few exceptions. They may be listed as follows according to Miss Fisher's preliminary determination.

Sea-otter, *Enhydra lutris*.—These bones were the most abundant in the mound with the possible exception of deer bones. They occurred at all depths down to the bottom and in various parts. Obviously this animal was of prime importance in the economy of the inhabitants. As it yields one of the finest furs known it seems probable that the fur was used as well as the flesh. Early explorers on the Californian coast

[40] *Op. cit.*, 339.

report otter skins as an article of dress.[41] This animal is very rare now on the Pacific coast but was plentiful off San Francisco in early Spanish times.[42] Its remains are too common to be accounted for by trade and it must have been consistently and successfully hunted during a great part of the mound's history. Such hunting suggests a considerable cultural advance. The Indians at the mouth of the Columbia river approached the sea-otter by boat when it was lying asleep on the rocks and used a crescent-shaped paddle blade because it helped render the approach noiseless.[43] The Eskimos hunted the sea-otter with boats and harpoons which were specialized for the purpose.[44] When the first Spaniards arrived in San Francisco bay they found the natives using tule balsas, or cigar-shaped rafts, with great dexterity. It is possible that such balsas were used in hunting otter. No evidence of harpoons was discovered by us.

Deer, *Cervus*.—Deer remains were more numerous than those of any other animal except the sea-otter. Their distribution was practically universal including the lowest levels. As a source of food the deer apparently shared honors with the sea-otter, and was used concurrently with that animal. There may have been seasonal differences which cannot now be detected, but the aborigines all during the mound's life seem to have been able to procure land and sea-food with equal facility.

Elk, *Cervus canadensis*.—Bones of this animal constitute the third most numerous class. Tule elk were exceedingly numerous in the San Joaquin valley and in the northern part of the bay district until recent times and it is likely that in early historic times they were abundant around the marshy shores of San Francisco bay.

There is a big difference between the quantity of bones of the above three species and that of any other. No doubt this is due in part to the more perishable nature of the bones of smaller quadrupeds, birds, and fish. Hence caution is required in basing conclusions on relative frequency. The species are listed in the order of the abundance of their remains as observed by us.

Fish.—Several species of fish were noted, none of which have been identified except the sting ray. This fish must have been a principal

[41] La Perouse and Fages as quoted by H. H. Bancroft, Native races of the Pacific states, I, 369, 1886.

[42] Bancroft says 8000 otter were killed in San Francisco bay in 1809–11. *Ibid.*, 383.

[43] Gabriel Franchère, Narrative of a voyage to the N. W. coast of America in the years 1811–14, 247, 1854.

[44] O. T. Mason, Rep. U. S. Nat. Museum, 1900, pls. 12, 16, 17.

food supply as its remains are very common. The bones indicate that many small fish were taken, which suggests fishing by means of a net. However, only one recognized net sinker was found—whereas in West Berkeley and Stege these articles were plentiful. Enough probable fishhooks were recovered to indicate that fishing by that method was employed.[45]

Water-fowl.—Apparently a great variety of water-fowl were used as food including ducks, geese, cormorants, pelicans, waders, etc. The complete list, we are told, will include a great many species. This is very natural for the location must have been an ideal haunt for such fowl. During our work thousands of ducks were observed close inshore just off the mound. No evidence as to how they were caught was procured. But their remains in the mound imply, as Nelson states,[46] that the aborigines must have lived on the mound at least during the season the birds frequented the bay, i.e., the winter. Bones of these birds were in two cases found associated with burials in unusual quantities. One case was in the northwest perimeter, the other (12–3796) was in trench 2, twenty-five feet deep. Near the vertebrae of this body was about a pint of wing bones. In the first instance no particular bone seemed to predominate.

Whale.—Whalebone was found in the trenches and at a number of places in the cone. A single one of these animals would account for a much larger deposit than any seen by us. Still it would seem that every now and again the inhabitants utilized one of these mammals. Fages reported "whales" (possibly black fish) in San Francisco bay in 1772.

Seal (*Phoca*), sea-lion (*Zalophus*), and porpoise (*Phocaena communis*) were reasonably frequent.

The following small animals were possibly plentiful though their remains were fragmentary and tended to escape attention—rabbit (*Lepus*), gopher (*Thomomys*), raccoon (*Procyon lotor*), badger (*Taxidea*), skunk (*Mephitis occidentalis*), wild cat (*Lynx*).

Uhle and Nelson also identify the ground-squirrel (*Spermophilus*), the bear (*Ursus*), and the wolf (*Canis*). Up to the time of this writing our material had disclosed none of these. It seems likely that the squirrel will be forthcoming. Uhle's bear was based on one tooth which might have been obtained through trade, particularly since it had been worked into a pendant. At any rate bear remains are exceed-

[45] Nelson thought that fishing was an art unknown to the early Emeryville residents. (Manuscript notes.) Our evidence does not support this supposition.

[46] *Op. cit.*, 339.

ingly rare and since, according to Fages, bear were present in the vicinity, their absence in the mound is significant. While no wolf bones are present the genus is represented in our collection by the coyote.

Both Uhle and Nelson doubtfully identify the common dog. We can only join in their doubt. Skeletal remains were recovered which might have belonged to the dog or coyote. The evidence is so unconvincing that the author feels that doubts would be much stronger were the dog not *a priori* expected in connection with man.

Certain new species have been provisionally identified, notably the mountain lion (*Felis oregonensis californica*), the antelope (*Antilocapra*), the southern bald eagle (*Haliaeetus leucocephalus leucocephalus*), and the condor. To find the mountain lion where the bear is absent is unexpected. The antelope might be anticipated. The southern bald eagle has been noted in the San Joaquin valley and was formerly common on the islands of the Santa Barbara channel. This suggests the possibility that the bones present may have been imported. One of the bones identified had been cut off, apparently in the process of forming a tube of the missing portion.

ASHES

Ash[47] was found in many places in small crescentic pockets. It was light gray in color, fine, and densely packed, and what would be expected from a series of wood fires. These pockets are supposed to have been fireplaces, and are remarkably free from all substances save ash.

In addition to the pockets, ash was noted in layers. At 26 feet, 6 inches in trench 1, under burial 12–3778, was a layer of ash a couple of inches thick. Under the head of 12–3782 at 27 feet, 1 inch in the same trench, was a layer two and one-half inches thick. At about 25 feet, 6 inches in trench 2 was a layer extending over the entire western ten feet of the trench and a part of trench 3. This layer varied in thickness. Skeletons 12–3799, 12–3800 rested on it and a few inches above was a reddish line of paint, sand, and ash. Also in trench 2, near the eastern end covering an area wider than the trench and six feet or more long, at 29 feet, 1 inch, was a layer of reddish ash. Such layers suggest house floors, though our data are insufficient to push the suggestion further.

[47] Gifford's percentage of ash was 13.47.

In the northeastern areas of the cone, particularly on the slopes, were heavy layers of ash which were yellowish in color (pl. 37*b*). As has been indicated these layers were a foot and over in thickness and thirty or forty feet long. The ash mass seemed to be divided by the interposition of mound material so that three or four layers were indicated. In total mass these layers would be measured in cubic yards and to account for them is very difficult. The possibility of their being due to cremation is discussed on page 183. Seasonal ceremonials with intervening periods is the only other speculation we can advance.

The ash deposits cited above are only typical examples. Their relation to one another and to other features besides the burials in the trenches cannot be stated. The fact that such layers were so frequently just below the burials suggests that the bodies were covered over and not placed in a dug pit.

CALCINED MATERIAL

Isolated instances of calcined artifacts or material were noted in various parts of the mound. But in the western areas was a great layer of calcined material that was unique (pl. 37*a*). This did not extend over the entire mound as a stratum, and in character it offered such a contrast to the ash layers on the east that it would seem impossible to connect the two even if a mass of mound material did not separate them. This calcined layer is mostly shell but the shell has been thoroughly calcined. In the shell are bone fragments which are also calcined and frequently have a greenish tinge. This probably is the basis for Uhle's stratum of cremation. However, the analysis made by the State Department of Agriculture (page 172) indicates that there is less bone content in this calcined layer than elsewhere, and the chemists inform us that cremation would not destroy the value of the phosphoric acid index. In other words, even though a body had been cremated its presence would be indicated by this test. Hence if this was indeed an area of cremation we should expect a greater phosphoric acid content, whereas we have less. One test is far from conclusive but it is suggestive. We found no direct evidence of cremation in this layer and even if cremation occurred it is hard to understand why so many calcined shells should be present. One would rather expect ash layers such as those on the eastern slopes. The presence of so many shells suggests that their burning was connected with the preparation of their contents for food.

HUMAN REMAINS

CREMATION

The evidence which the mound yields with reference to the practice of cremation is rather remarkable. With the exception of two infants the lowest bodies found by us were 28 feet 7 inches deep. Here was a mass of burned bones in a layer of heavy charcoal two inches thick and more. This mass formed a concave lens about seven feet in diameter. Portions of the skeletons had been burned entirely away while other bones nearer the circumference had not been touched. By these it was possible to distinguish with reasonable certainty seven bodies (12–3807–13), of which four were infants or children. About six inches under the mass was the thin layer of reddish ash previously described and possibly a house floor. Within a few inches of this was the clay substratum of the mound.

This seems unquestionable evidence of cremation. It is as near the bottom (or beginning) of that part of the mound as it is possible to get. Evidently then, in the early history of the mound, cremation was practiced by at least one group that visited the site.

On the other hand, in all the balance of the trench work where thirty-four bodies were disclosed, there was not the slightest evidence of cremation. Skeleton 12–3801 lay upon a very light layer of charcoal but no bones were burned with the exception of the right knee and shoulder bones which were scorched. The suggestion here seems to be that the body fell or was buried on the family hearth, because one inch below the face is a layer of fine whitish ash one and three-fourths inches thick. Similar layers were associated with other bodies. Sufficient fire to account for their accumulation would certainly have done more than scorch a few bones of a single skeleton if the purpose had been cremation. This case (12–3801) is unique in other respects as will be seen from table 6. The individual had been wounded at least four times and died a death of violence while defending himself, as the blade in the hand suggests. For such a one to have been thrown on his own fire with the framework of his house about him, would not seem unreasonable. Opposed to such a hypothesis was our observation that the body was flexed. It seemed to lie on its face with the knees under it at the chest. The posture might have been accidental, however.

In the cone 651 bodies were noted. There was one possible case of cremation. In Area 32 at the 12-foot depth were found some bits of well-charred human bones (12–3745). In a few other cases, e.g., 12–3598, 3715, 3721, the skull appeared slightly calcined. Even if this discoloration be not due to age it might very reasonably be attributed to accidental scorching after burial considering that burials were apparently shallow and of necessity near subsequent fires, or to incidental burning through the use of fire in burial rites.

Uhle was convinced that "during the period represented by strata VI to VIII the dead were buried in the ground" but that during the period of the accumulation of strata II, III, and IV they were cremated.[48] Bearing this in mind, and leaving aside our inability to identify his strata, we searched diligently for evidence of such cremation, but with no results. Uhle's own evidence is indirect. First is the great mass of calcined material which we have described and which was probably his stratum II. It would also appear that cremation would result in heavy ash layers rather than in layers of calcined shell. This layer is primarily shell, and "shellfish thrown into the fire as food for the departed" seems an inadequate reason for such an accumulation. Another reason which Uhle cites for believing in cremation is the large percentage of calcined awls in stratum II. Here it seems to us that Uhle confuses awls with unworked bits of refuse bone which one might naturally expect to see burned. Our search did not result in many calcined bone artifacts nor in a concentration of them in a particular area. An amount of cremation sufficient to account for the mass of this particular calcined layer would imply the burning of many bodies. It seems impossible that all these should have left so few traces that in searching for them we should find none.

The case in Area 32 presents a few bones and considering the fires about the mound the writer would prefer to regard this as a case of accidental burning of bones sometime after burial. The evidence from the bottom of the mound is both direct and unmistakable. It may be questioned then, if the practice of cremation was known thus early in the mound's history why can it not reasonably be supposed that it was practiced thereafter? In the first place, no direct evidence supports the inference. In the second place, the hypothesis that in this early group that practiced cremation were the ancestors of the group that accumulated the upper levels finds no more support than the hypothesis that the cremation represents a visit by a group from across the bay where cremation was practiced.

[48] *Op. cit.*, 22.

BURIALS

From what has been said of cremation it will be seen that burial was at least the characteristic and ordinary way of disposing of the dead. The circumstances surrounding these burials offer the most suggestive evidence in the history of the mound.

Observation and Record

From October 21 (work began October 17) until December 1, when the mound was leveled, a record was kept of the burials seen. Always one and sometimes two observers made it a point to watch the digging for this purpose. Considering the general possibilities of observation, the efforts made to observe, and the results subsequently obtained in the trenches, it is believed that the record is a fairly accurate statement of the number of adult skeletons which were present in this cone of the mound at the time of its destruction. Of the upper eighteen feet of the mound particular certainty is felt, since here the chances to see everything were excellent. In the lower portions where a certain amount of talus material was always present it is probable that more burials existed than were counted.

One important reservation must be made. In the trenches, where the probabilities are that all skeletal remains were noted, thirty-four burials were distinguished. Of these, thirteen (38 per cent) were babies. The implied infant mortality while high would probably not be unreasonable for such a group. Uhle in ten burials found three infants (30 per cent). Now in the cone we saw very few infant remains and the probabilities are that we missed them on account of their small size.

Burials in the cone were recorded with reference to their horizontal position by placing them in one of the forty areas into which the mound was divided. When a skeleton was seen in position in the wall the depth was recorded. If it came down with a cave-in, or was first noted in a truck or elsewhere, it was recorded as of uncertain depth. These depths were eye estimates with check points to go by. In most cases the mere fact of the presence of a burial and its location was all the observer could note. Still there were many cases where it was possible to examine the burial with care and to complete the disinterment by hand. Hence evidence was secured concerning details. But since the majority of the burials were not thoroughly examined, the resultant data do not permit satisfactory comparisons between the cone and the trenches.

These data pertaining to horizontal and vertical distribution in the cone are presented in table 4. In this table the areas have been divided into three groups. Group I includes the slopes and perimeter, group II the outer part of the plateau section, group III the more central section.

In table 5 are presented all data obtained from the cone with relation to burial associations.

In the trench work exact locations were recorded which together with burial associations and all skeletal evidence from the trenches is summarized in table 6.

The work in the trenches, where we could be more thorough, is made the basis for the discussion of several phases that follow. At times the results seem to differ from those from the cone, and where these differences are not readily reconciled it must be emphasized that they may as well indicate the difference in our work as any cultural change.

Horizontal Distribution

The figures (table 4, last two columns at right) principally show that there is an increasing concentration of burials as the center of the cone is approached.

To the south between the cone and Temescal creek, two burials were found when digging out tree stumps. (One at 160 feet from the edge of the cone, the other at 75 feet; both about eighteen inches deep, and both twenty-five feet west of the plotted east limit of the cone.) Three burials were turned up by a plow in the northwest perimeter. Some ten feet north of Area 12 foundations for a tank were dug and several burials were disclosed. East of the cone in the continuation of the mound the railway cut brought to light a score or more of skeletons. All these burials were in shell. There appears to be a fringe of burials on the outskirts of the present cone.

In what is more definitely recognized as the cone, group I composes the periphery. This group is readily divisible into two divisions which are again subdivided into four directional regions.

	Region	Areas	Number of burials
Outer periphery	Southern	13, 14, 15	2
	Eastern	18, 25, 49, 39, 38	15
	Northern	37, 12, 1	16
	Western	2, 7	0
			33 or 5.07%
Inner periphery	Southern	16, 17	20
	Eastern	34, 36, 30, 22	15
	Northern	11, 6	44
	Western	0	0
			79 or 12.13%

The percentage is of the total burials in the cone. Thus the outer periphery contains less than half as many burials as the inner periphery. Nearly half of the burials in the outer periphery are in Area 12, in which direction the mound extended some distance. Practically all the others were toward the continuation of the mound to the east.

Group II, much smaller in extent, has 261 burials or 40.09 per cent of the total in the cone. Lastly group III has 278 burials or 42.71 per cent of the total. All this shows a constantly increasing intensification of burials as the central region of the cone is approached. In other words, there seems to be manifest a disinclination to bury near the outer edges of the mound. Is this connected with the existence of the great layers of calcined material which were most conspicuous on the slope of the mound on the west, south, and northeast? Possibly the calcined material postulates an activity which precluded burial in the same region.

From the directional regions indicated it will be seen that in each division of group I about 50 per cent of the burials were on the northern side of the mound. Group II may be similarly divided.

Region	Area	Number of burials
Southern	19, 23, 24	91
Eastern	31, 33, 35, 29	56
Northern	21, 10, 5	58
Western	3, 8	56
		261 or 40.09%

Here the greatest number of burials is on the southwest. Group III does not admit of directional division. This distribution may indicate that no particular side of the mound was constantly favored as a residential site, or that practices changed as to whether the non-residential territory was used as a graveyard, or whether bodies were buried near the living quarters.

The trenches cover such a limited area that distributional data from them are not very convincing. Trench 1 (south) produced thirteen bodies; trench 2 (north), twenty-three; trench 3 (west), five. Data for an east-west distribution are more suggestive. Omitting trench 3 which covers no eastern territory we find that trenches 1 and 2 yield twenty-three bodies from the western portion and only thirteen from the eastern. Of the thirteen, seven belonged to the cremated group. Infant burials appear to have been exceptional as will be seen later. Leaving them out, we have seventeen adult burials of which only one was east of the center of the mound. Our conclusion from this is that at a given time there was a tendency to concentrate burials and we discuss the matter further under "location of graves."

TABLE 4

SKELETAL DISTRIBUTION IN THE CONE

	Area	Depth in feet																						Total bodies	Per cent of total in cone
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	22	23	24	25	?	
Group I	1																							12	12	1.84
	2																							0	0	
	7																							0	0	
	13																							0	0	
	14									1															1	.15
	15														1										1	.15
	16																							6	6	.92
	17							3		4		3	1	1	2										14	2.16
	18		1			1		1	1	1		2	2	1	1										11	1.68
	6																							19	19	2.92
	11									4	1	5		1	9			1	3	1					25	3.86
	12			2				1				1													4	.62
	22										1	1													2	.30
	25																								0	
	30							1		2					1	1						1			6	.92
	34																								0	
	36				2			1		1		1			2										7	1.08
	37																								0	
	38			2																					2	.30
	39									1															1	.15
	40									1															1	.15
Total Group I			1	4	2	1		7	1	15	2	13	3	3	16	1		1	3	1		1		37	112	17.20
Per cent total in cone			.2	.6	.3	.2		1.1	.2	2.3	.3	2.0	.5	.5	2.5	.2		.2	.5	.2		.2		5.7		17.20

Group II	3																					20	20	3.08
	8			1			3		3		2			2	1		1	2	2			4	15	36	5.53
	19			1			3	1	2	2	2	1	1	2				3						18	2.76
	23		1	1			2	1	5	4	10		1	1				2				1		29	4.45
	24					1	5	6	14	1	5	1	2	4			1	4						44	6.76
	31							2	1	3			1	4	1		1							13	2.00
	33					1		1					1	2	1		2							8	1.23
	35		1	1	1		5		3	1	3		2	1										18	2.76
	29							1	3		3			1	1		4		1		2			17	2.62
	21	1				1	2		4	1	4		1	5			1	1						21	3.22
	10			1			1				3		1	2	1	1	2	6	1		3			22	3.37
	5																						15	15	2.31
Total Group II		1		2	5	1	3	21	10	36	10	35	2	10	24	5	1	12	18	4		1	10	50	261	40.09
Per cent total in cone.		.2		.3	.8	.2	.5	3.2	1.5	5.5	1.5	5.4	.3	1.5	3.7	.8	.2	1.8	2.8	.6		.2	1.5	7.7		40.09
Group III	4																						15	15	2.31
	9					1		1		1		4		1	3	2		2	6		1		3		25	3.86
	20							7	3	10	6	15	5	2	10			2	5					65	9.96
	26	1		1				2	6	19	1	1			7			5	4	4			1	52	7.98
	27					3				3	3	5	1	3	3				4					25	3.86
	28							1		18	3	11			10			4	3	1		1	1	53	8.13
	32					1		2		5	1	12	2	1	8	3	3	3			1		1	43	6.61
Total Group III		1		1		5		13	9	56	14	48	8	7	41	5	3	16	22	5	2	1	6	15	278	42.71
Per cent total in cone.		.15		.15		.77		2.0	1.38	8.60	2.16	7.37	1.23	1.08	6.31	.77	.46	2.45	3.38	.77	.30	.15	.92	2.31		42.71
Grand totals..		2	1	7	7	7	3	41	20	107	26	96	13	20	81	11	4	29	43	10	2	3	16	102	651	100.00
Per cent total in cone.		.3	.2	1.1	1.1	1.1	.5	6.3	3.1	16.4	4.0	14.7	2.0	3.1	12.4	1.7	.6	4.4	6.6	1.5	.3	.5	2.4	15.7		100.00

TABLE 5

Burial Associations in the Cone

Museum No. 12–	Depth	Circ. Area	Olivella beads			Abalone	Bone	Paint	Obsidian	Plummet-like stone	Miscellaneous	Remarks
			Circ.	Rect.	Whole shell							
3769	1′	NW Per.	Rings				"Scratcher"				Sea-otter tooth	Antler wedge
3769B	1′	NW Per.	Rings					Yellow			Many bird bones	
3662	3′	18				Pendant						
3611	6′	6	×									
3613	6′	6				Entire valve						
3691	7′	24	×									
—	8′	6						Red		Steatite		
3637	8′	9				Pendants (9)						
—	8′	35						Red	Pebble		Mortar	
3612	9′	6				Disc						
—	9′	26		×		Pendants (2)						
3587	10′	3	×		×		Awl	Red				
3646	10′	10	×			Disc						
3671	10′	19				Pendant					Quartz crystal	Bones in mortar
3698	10′	24	×		×	Pendant						Bones in mortar
—	10′	25	×									
3703	10′	26		×								
3704–5	10′	26	×		×	Pendant						
3702	10′	26		×	×							
3724	10′	28		×	×		Awls (3)				Small mortar	
3615	11′	6	×									
3616	11′	6	×		×	Discs (2)						
3617	11′	6	×									
3708	11′	26		×	×	Discs, pendants (3)			Points (2)		Steatite pipe	
3618	12′	6	×			Disc						
3619	12′	6	×		×	Pendant, discs (3)					Beaver teeth	
—	12′	6					Whistles (8)				Asphaltum whistle plugs	Whistles inlaid with olivella discs
—	12′	6	×		×	Pendant, disc						
—	12′	19		×							Marine clam valves (5)	
3678	12′	20	×		×	Pendant	Tube					
3719	12′	28		×								
—	13′	6	×			Disc, entire valve			Point		Plug	Olivella discs in shell
—	13′	17							Point			
3688	13′	23						Red				
3692(?)	13′	24	×									Under inverted mortar
3738	13′	31		×	×	Ornaments (6)					Quartz crystal	Beads shingled over skull
3610	14′	6	×			Pendants (4)						
3620	15′	6	×									

—	15′	8	×			Disc, beads						
—	15′	10				Pendant	Awls (5)					
							Whistles (9)	Red			40+ sting rays	Many fish vertebrae and scales
3680	15′	20	×			Bead		Red				Beads stuck to inside and outside jaw
3684	15′	21	×			Pendant		Red				Beads stick to bones
—	15′	27						Red			Drilled horn tip, steatite pipe	
—	15′	27	×									
3729	15′	28	×									
3753	15′	32		×							Mica discs	
—	15′	35		×								
3757B	15′	36		×	×	Pendant	Tube					
3735	16′	29			×							
—	16′	31		×		Pendants (3), disc	Whistles (5)	Red			3 steatite pipes and contents	
3747	16′	32		×		Pendants (3)						
—	16′	33							Point, chip	Two	With mortar	
3748	17′	32		×	×	Pendants					Steatite pipe	
3730	18′	28						Red			Mica disc	
3740	18′	31						Red				
—	20′	10	×			Pendant	Awls (4)			Two		
—	20′	20	×			Pendant		Red and yellow			Quartz crystal, mica pendant	Traces of wood, greenish mineralized wood
—	?	5	×									
—	?	6									Mica discs	
—	?	20				Pendant	Whistles (2)					
—	?	20					Bird bone tubes (3), mammal bone tubes (3)					Tubes may be human bones
—	?	20									Open sea clam shell	
—	?	27									Mica discs	In mortar
—	?	28		×	×							Rectangular beads in regular order on back of skull
3736	?	29	×					Red on bones				
3734	?	29									Open sea clam shells	
—	?	35				Pendants (2)						
—	?	?					Incised deer metatarsus, burnt bird bone tubes	Red		9 "killed"	Nest of roundish pebbles	

TABLE6 6

Burials and Associations in the Trenches

Museum No. 12–	Location	Depth	Orientation Skull	Orientation Side	Artifacts	Position of artifacts	Remarks
3778	24′ S; 5′ 10″ W	26′ 3″	NE	L	Flesher, needle	2′ above left knee—abdominal area	Layer of undisturbed shell 4″ above
3779	19′ S; 5′ 6″ W	26′ 6″	NW	L			Layer of gravel below
3780	25′ S; 17′ W	26′ 1″	W	R	Spatula-awl, Diamond shaped bone	6″ deeper and W of skull Abdominal area	Red paint below. Undistrubed shell layer 2′ 5″ above
3781	23′ S; 17′ 4″ W	26′ 8″	W	L			
3782	21′ 5″ S; 19′ 6″ W	27′ 1″	W	R			Partly under 3781. Head on ash 2½″ thick
3783	18′ 1″ S; 19′ 9″ W	26′ 10″	NW	Face	Olivella disc bead		
3784	22′ 6″ S; 24′ 6″ W	26′ 8″	W	L	Abalone pendants	On chest; near ankle	Red paint near neck
					Abalone disc	Near lumbar vertebrae	Charred timber under head
					Abalone rings	Near head	
					Abalone whole shellbeads	Near head	
					Mortar	On chest	
*3785	24′ 6″ S; 2′ W	27′ 5″	SE	R	Awl	Near pelvis	
*3786	20′ S; 19′ E	28′ 10″					
3787	24′ S; 25′ W	26′ 6″	W	L			Same charred timber that was under 3784 under feet
3789	18′ 6″ S; 24′ W	25′ 11″	W	R	Abalone disc	In crotch	
					Abalone disc	Near right knee	More or less involved with 3791
					Olivella beads	Around neck	
					Abalone pendant	Stomach	
					Abalone pendant	Near wrist	
					Abalone pendant	Under pelvic bone	
					Abalone pendant	Near ribs	
					Abalone pendant	Near left knee	
*3790	23′ 6″ S; 5′ E	31′					
3791	17′ S; 25′ W	26′ 9″	NW	L	Obsidian point	At left scapula	Right foot under pelvis of 3789
					Calcined awl	Vicinity	
*3792	25′ N; 2′ E	23′ 7″			Abalone discs		
					Olivella disc beads		
*3793	26′ N; 2′ E	24′			Red paint	⅛ to ¼″ thick under body	
					Abalone rings	Upper body	
					Abalone pendant	Upper body	
					Olivella whole shell beads	Upper body	
*3794	24′ N; 6″ E	24′		R	Red paint	Under body	
					Olivella whole shell beads	Like cape	
					Abalone discs (3)	Shoulder and chest	
					Stone bead		

Museum No. 12–	Location	Depth	Orientation Skull	Orientation Side	Artifacts	Position of artifacts	Remarks
3795	24′ 6″ N; 5′ 9″ W	23′ 5″	SW	Face	Pestle	In ash under head	Extended (?) 3″ under head, layer of ash 3″ thick.
3796	23′ N; 18′ E	25′	W	R	Many bird wings	Abdominal area	
*3797	21′ N; 13′ W	24′ 3″					
†3798	20′ N; 23′ W	25′			Olivella—bead	Vicinity	Scattered. Charcoal and reddish ash below
	17′ N; 24′ W	24′ 10″					Charred elk antler near
——	17′ 6″ N; 25′ W	24′ 7″					
†3799	20′ N; 15′ 4″ W	25′ 3″	SW	L			Thin red line of paint, etc., strikes center of skull. Layers of white ash under body.
3800	19′ 4″ N; 14′ 4″ W	24′ 9″	W	Back	Obsidian point	Embedded in centrum 13th vertebrae: pierced from behind	Contiguous to and touching 3799. Layers of ash under body
3801	22′ 6″ N; 23′ 6″ W	25′ 10″	W	Face	Obsidian point	Left side, above tibia	
					Obsidian point	¼″ in pelvic bone	1″ below face layer of ash 1¾″ thick
					Tip of obsidian point	In 3rd lumbar vertebrae	
					Obsidian point	In R hand at base of skull	Light layer of charcoal at right side. Knee and shoulder bones slightly scorched.
					Obsidian point	Embedded in L cheek and upper jaw	
					Flint point	1′ W	
					Deer bone awl	1′ W	
					Bone pin	1′ W	
3802	24′ 9″ N; 15′ 6″ W		W	R			
*3803	24′ N; 4′ W	27′					On layer of mussel shell
*3804	21′ N; 11′ W	26′ 9″					
*3805	25′ 3″ N; 13′ 6″ W	26′ 6″					In layer brownish paint
*3806	19′ N; 19′ W	26′ 7″					In layer red paint and charcoal
3807–13	25′ N; 4′ E	28′ 7″					Mass of burned bones in heavy layer of charcoal
*3814	18′ 6″ N; 11′ W	24′			Olivella cir. beads	Shingled on garment (?)	Brown paint near body
					Abalone pendants (3)		Layer red paint below
3815	13′ S; 18′ 5″ W	22′ 6″	W	Face	Obsidian chip	Right scapula	Red paint on leg bones
					Round bone artifact	4″ N. prox. end R femur	
3816	6′ 6″ S; 9′ 9″ W	23′					Disturbed by visitors
3817	3″ S; 16′ 10″ W	25′ 5″	NW	R	Mortar	Inverted over pelvis	
					Mortar	Inverted over skull	Red paint on bones
3818	12′ 3″ N; 18′ W	25′	SW	Face			In layer reddish ash. No red paint on bones.

*, Infant; †, Juvenile.—Location and depth taken from center of skull, and is given with reference to center of mound. All flexed and in poor condition unless otherwise noted.

Vertical Distribution

Table 4 also gives the depths at which burials were found in each area of the cone.

The three groups seem to be relatively similar as regards vertical distribution, hence, for the only inferences which the author has been able to draw, it is simpler to use summarized totals.

Depth of burial	Number of burials	Per cent of total in cone
0 to 5 feet inclusive	17	2.61
6 to 10 feet inclusive	178	27.37
11 to 15 feet inclusive	236	36.26
16 to 20 feet inclusive	87	13.36
21 to 25 feet inclusive	31	4.75
Uncertain	102	15.65
	651	100.00

Even leaving all uncertain burials aside, considerably more than half of all the bodies (52.7 per cent) in the mound were located between six and fifteen feet, inclusive.

These figures should perhaps be adjusted somewhat. Round numbers should be more frequently used in estimates. Also the steam shovel did not consistently dig as low as twenty-five feet. At times it probably got no lower than twenty feet and it might be safer to leave out the twenty-one to twenty-five-foot level. Allowance also should be made for burials missed in the talus at about the seventeen to twenty-two-foot levels. The data still appear, however, to show a definite preponderance of burials around about the ten to fifteen-foot level and a marked scarcity in the upper levels. At Ellis landing Nelson found a very unequal vertical distribution and a scarcity of burials in the upper eight feet.[49]

Turning to the trenches we find that of twenty-one adult burials sixteen were between twenty-five to twenty-seven feet. Since measurements were made to the skulls only, the fact that these sixteen burials belong to one level is plain.

With the exception of two infants the lowest bodies were at 28 feet 6 inches—the cremated ones. Otherwise as far as the trench data go a layer of mound material at least three feet thick appears to have accumulated before burials were made in that portion of the mound. If pits were dug for graves this accumulation must have been about five feet thick even with very shallow graves. This might be connected

[49] *Op. cit.*, 381.

with the hypothesis that the mound, growing by creeping out over marsh or tide-flat, was not usable until a height of three feet or so above the clay base had been attained. Above this the figures seem too confused for interpretation although there is possibly a hint at concentrations at given levels, e.g., twenty-five to twenty-seven feet in the trenches, then eighteen to twenty feet, then fifteen, then twelve feet, then ten feet. Finally, there seem to have been more bodies about the ten to fifteen-foot level than elsewhere; this possibility is discussed in connection with the problem of varying accumulation.

Graves

Location.—In our survey of the cone we were not able to establish a fixed relationship between the position of graves and such features as fireplaces, ash-layers, etc.

In the trenches the association with layers of whitish ash seemed too definite to be accounted for by chance. This was the type of ash which one would expect to accumulate on a hearth or fireplace. In the vicinity of the cremated group (seven bodies), of the group (eight bodies) in the west end of trench 1, and of five of the burials in the west end of trench 2, appeared the thin layer of red paint, sand, ash, and charcoal, which might have been a house floor. If these speculations are correct, burials seem to have been made in the house and very close to the hearth. There is at least one apparent objection to this hypothesis. The bodies were more or less contiguous as would be expected in a graveyard or regular burial place. Of course the house might have caused such a concentration yet it seems extraordinary that so many bodies could have been so intimately associated with an inhabited house. On the other hand, the nature of the group—adults and children—would suggest the home as the explanation for their association in burial.

Preparation.—It has usually been assumed that the dead were buried in graves which consisted of dug pits. From present-day views this is rational, but the evidence of the mound seems to point just as much the other way, that is, to the practice of placing the body on the surface of the ground and covering it over. Holes which had been dug for posts were indicated by the disturbed earth, and the purpose confirmed by the charred remains of the tops of the posts. But no such disturbed earth could be found above a single burial. On the contrary, burials were found a few inches below undisturbed pockets of clamshell which extended considerably beyond the bodies in all directions. Such

pockets could not have been dug through to place a body below them without leaving marked evidence of the fact, e.g., 12–3778, 12–3780. How could many corpses rest on the ash layers if placed in dug pits? A pit might be dug, ashes accumulated in it, and later a body placed therein. In such a case the ash deposit would not be flat but would indicate the pit, which was never noted. In the upper San Joaquin valley, Gifford and the author found that burials in low earth mounds were usually at the highest portion of the mound. Elmer J. Dawson has reported the same from the Sacramento-San Joaquin delta region. A reasonable explanation is that the portion of the mound containing the burials is slightly higher because of the covered-over burials made there. The many cases of non-pit burials on the Pacific coast of America, for example, in the Aleutian islands, the laid-out burials of the Cascades region of the Columbia river, the covered-over burials of the upper Columbia river, are too well known to require detailed citation as instances of the reasonableness of a recurrence of an analogous practice on the shores of San Francisco bay.

Nelson mentions disturbed burials in the Ellis Landing mound as evidence of dug burials.[50] Disturbed burials are so frequently reported in California as to be the rule rather than the exception (e.g., Heye—San Miguel; U. S. Geographical Survey—Santa Barbara; Gifford—Tulares; numerous private "diggers" with stories of massacres and the consequent dismemberment indicated by the disturbed skeletons). A great deal of this disturbance must be laid to burrowing animals. The settling of the earth must also be a factor. A large number of the skulls in the Emeryville mound were cracked and flattened in, presumably from the pressure of the material above them. However, a covered-over burial would spread and indicate more disturbance upon the settling of the surrounding material, than would a pit burial.

If bodies were generally buried by being covered over the attention would be given to the corpses rather than to the graves. At any rate what evidence there is suggests that scant attention was given to the preparation of the graves. Nelson reached the same general conclusion with reference to the Ellis landing mound.[51] Uhle in his study of the Emeryville mound gives some rather elaborate details[52] which were noted by the present author but given a much more limited significance than Uhle implies. For example, Uhle says a "layer of charcoal from one-half to an inch thick is found at the very bottom" of graves. An association of charcoal and burials was noted in the cone. In the

[50] *Op. cit.*, 383. [51] *Op. cit.*, 383. [52] *Op. cit.*, 24.

trenches it also appears. For example, charred pieces of what appeared to have been a large timber were under the head of 12–3784, under the feet of 12–3787, and in the general vicinity. Again a thin charcoal layer was under part of 12–3801. But it seems more reasonable to account for this charcoal in some other way than as a layer spread in a grave. It should also be remembered that similar layers could be observed, particularly in the mussel shell deposits, where there were no burials nearby. Above the layer of charcoal Uhle found "another layer of like thickness of iron oxide." In a number of cases we observed layers of iron oxide though not necessarily superimposed on a charcoal deposit. In other cases red or yellow "paint" in chunks was associated with a skeleton. In many others the bones had a reddish tinge. Our conclusion is that while red "paint" was frequently used in the preparation of a body for burial, and a supply sometimes buried with a person, there is no evidence that it was used in the preparation of graves.

Here and there, immediately under a skeleton, there seemed to exist an unusually large proportion of small stream gravel such as may be found in the neighboring Temescal creek. In possibly six cases evidences of decayed wood or mats that might have lined a grave or covered a body were seen.

Bodies

Position.—Practically all bodies had been flexed before burial, i.e., placed in the general position of knees to chest and heels to buttocks. A very few may have been extended. These few are so doubtful that it is probably safe to say that flexed burials were the universal rule throughout all levels and areas in the mound.

For the bodies in the cone no statistical data were obtained as to position of the body. Bodies were noted lying on the back and on either side and apparently with the heads in various directions. This agrees with what Nelson found at Ellis landing. In the trenches our evidence is more suggestive. Of the forty bodies disclosed the seven cremated bodies and the thirteen infant bodies are omitted. About an equal number of bodies (see table 6) were placed on each side, i.e.,

Right side, 6; left side, 7; face, 5; back, 1; (?) 1.

It is more than likely that settling and movements consequent upon decomposition make determination of the original position uncertain and that at least some of our "face" and "back" burials were origin-

ally on the side. Presumably the even favoring of the two sides is only chance, although if data were available it would be interesting to correlate it with sex.[53]

These trench burials with reference to the direction of the skull may be summarized thus:

West, 11; northwest, 4; southwest, 2; northeast, 1; (?) 2.

In other words, over 94 per cent of the identifiable cases lay in a westerly direction. This seems too uniform a practice to be explained except by intention, and it is possible that the ordinary practice was to place the corpse with its head toward the sea, i.e., westerly. Heye found this true at San Miguel.

Preparation.—As far as evidence exists the preparation of the body for burial seems to have consisted of adorning it with red paint and with finery, although, this was not done for all. Many bodies in the cone, in the trenches more than half, showed no signs of red paint. In some cases the paint must have been spread on very profusely for the bones are heavily covered. At other times there is a mere trace. The variation may indicate a difference in social status.

The same remarks seem to apply to adornment. Body 12–3781 was entirely unaccompanied, whereas 12–3784 had abalone pendants on chest and head, and other ornaments. Body 12–3789 was adorned with necklace, bracelet, leg bands, etc. Other examples (see table 6) suggest garments or head coverings ornamented with shell. Such cases seem to indicate that the corpse was dressed as it might have been on ceremonial occasions in life. Presumably such ornaments were not especially prepared for burial purposes but were those ordinarily used for adornment in life. Hence their profusion or lack thereof would represent the relative wealth of the possessor. There is another inference from this preparation. In the upper levels the eyes and (or) face were frequently covered with abalone ornaments. And the finding of olivella beads inside the jaw, apparently in the ears, and abalone discs over the eyes, mouth, and in the crotch suggests the practice of covering the openings of the body with such shell ornaments.

[53] Uhle states (*op. cit.*, 24) that "the corpse is usually laid upon the right side, generally facing northeast." This would appear to orient the skull southwest. However, the details which Uhle gives for his six adult burials do not seem to bear out his general statement.

Burial Methods

Associations.—Closely connected with the preparation of the body must have been the association with the corpse in burial of various artifacts. The principal associations noted in the cone are listed in table 5, while table 6 gives the associations in the trenches. It must be emphasized that table 5 is by no means a list of all the burials in the cone that had associated artifacts, and, on the other hand, that a great many burials, perhaps the large majority, were utterly without associations. The implication is strong that different associations represent a difference in social status.

Three questions present themselves. What kind of objects were associated with burials? Does the complexity of association and the type of object change in the upper levels? The last question is dealt with under material culture. In considering the others it seems that olivella beads, abalone pieces, and paint should be omitted since they represent personal adornment as distinguished from other possessions.

In the trenches some of the cases listed in table 6 are doubtful associations, e.g., the flesher with 12–3778 was two feet away. Of the remaining cases, 12–3800–01 and probably 12–3791 do not represent burial associations but rather weapons which could not be removed. It should be noted that in all these cases ornaments were also missing. There are then four burials (12–3778–79, 3785, 3815) each with one bone artifact in association. In addition 12–3815 had a small obsidian unworked chip near it. The pestle in the ash under the head of 12–3795 is doubtful of association; the flint point more likely. Body 12–3784 had an inverted mortar in the chest region while 12–3817 had one mortar inverted over the head and another over the pelvic bones. Finally, 12–3796 was accompanied by many bird-wing bones.

As will be seen under material culture the number, variety, and quality of objects recovered from the trenches makes the above first five cases of association seem peculiar. Why bury such insignificant objects with the dead when more valuable ones were possessed? Moreover, in none of these cases was an ornament present. Considering these things in connection with the hypothesis that these bodies were buried in or near the house it seems reasonable to expect from the laws of chance some artifacts near bodies as well as elsewhere. These associations then would be accidental not intentional.

The association of the mortars with bodies is discussed later. In both cases the body showed other evidences of care in its burial.

The case of the bird bones appeared to be an undoubted case of burial association. Yet those are not artifacts nor do they appear valuable. Neither ornaments nor other artifacts were with this burial. In the northwest perimeter with 12–3769B were also found many bird bones. This last burial was at the fourteen-foot elevation and as 12–3796 was at the twelve-foot elevation it is possible that they are of the same era, though the latter was under the cone. Whether the bones were put into the grave as bones or as wings, whether they were raw material, or intended for food, or were proofs of skill as a hunter, cannot be stated. It does seem probable that they are related to the instances where a number of similar articles were associated with a body. For example:

8 whistles at 12 feet in Area 6; 5 open-sea clam shells at 12 feet in Area 19; 9 whistles at 15 feet in Area 10; 40 sting ray barbs at 15 feet in Area 10; 5 whistles, 3 pipes at 16 feet in Area 31; 2 plummet-like stones at 16 feet in Area 33; 2 plummet-like stones at 20 feet in Area 10; 6 bone tubes at ? feet in Area 20; 9 plummet-like stones at ? feet in Area (?).

A group of obsidian points was also secured by other diggers. These instances seem to indicate some form of specialization but whether of manufacture, use, or ownership seems indeterminable. The bone tubes suggest manufacture; the whistles, use; the pipes, ownership.

Turning to the cone, table 5, we find the lowest recorded burial associations (20 feet) comparatively elaborate. The one in Area 20 was particularly so. Paint was abundant. The wrappings had been heavy. Some wooden material had been present, a quartz crystal, a mica pendant, and an unusual piece of mineral or mineralized wood were found in addition to ornaments. At this depth were plummet-like stones. At seventeen feet we meet the first pipes; at sixteen feet the first whistles. (Whistles were found in the trenches, but not in burials.) Thus far it might appear that a case of increasing complexity of culture was being made out as we approached the upper levels. The doubtful nature of such a conclusion will be more apparent by considering the various articles of material culture. The question of increasing complexity of burial associations is even more doubtful. Especially do the upper ten to eleven feet of the mound appear to be as simple as the lower ten feet.

Olivella beads and abalone ornaments were associated with burials throughout, and very few were found that were not thus associated. Bone articles were more definitely associated in the middle levels. Throughout more bone articles were found not in association than in association. Obsidian found throughout seems more definitely a burial

association above sixteen feet. Other articles are of such sporadic occurrence that comparisons seem useless. On the whole, however, it might be said that burial association seems somewhat more elaborate in the middle portions of the mound. But any conclusions which might be drawn seem vitiated by the fact that equivalent or greater differences might be found by comparing horizontal areas. This is not done because what was found was dependent not only on what was present but also on whether or not the steam shovel gave us an opportunity to recover it.

A few special association traits may be noted. In the trenches were two instances and in the cone a considerable number where a mortar had been inverted over a portion of the body, or where a portion of the body had been placed in a mortar. These were usually type IV mortars. Such burials seem to have been particularly numerous in Areas 8 and 19. In other Areas, notably 5 and 10, were a great number of "killed" mortars of porous basalt. These were also associated with burials but never contained bones. As far as the evidence goes this is a case of horizontal rather than vertical distribution.

The "killing" or breaking of objects associated with burials was noted with other articles than mortars. The nine beautifully shaped plummet-like stones found with a burial had all been broken, though so many of the pieces were present that rather complete restoration could be made from the fragments recovered. Several of the whistle groups suggested deliberate breaking, but it is here difficult to be certain. No evidence of the "killing" of objects appeared in the lower levels, and no "killed" ornaments were found.

Infant burials.—Infants or young children seem to have been treated differently from adults. In the cone very few infants were found and most of these were closely associated with adults. Very likely the others were missed. In the trenches no infants were found associated with adults. In fact, it looks as though they had been deliberately buried in quite distinct locations. In trench 1 were three infants, all well to the east of other burials. Two of these were the deepest burials found (28 feet 10 inches and 31 feet). None showed ornamentation, but an awl was near one. In trench 2 were nine infants (the cremation group excepted). Three of these were well to the east of the adult group. These three were close to one another and all bore signs of comparatively elaborate preparation, much more than many adults. The other six were interspersed with the adults but none of them was accompanied by an artifact. No infants were in trench 3. Our conclusion is that infants were treated with less consideration

than adults both with reference to preparation for burial and to choice of burial place. Uhle's four infant burials were not grouped. Two were without an artifact; but the other two were his most elaborate burials.

The three infants in trench 2 placed close together and all elaborately prepared (12–3792–93–94) may be presumed to have belonged to the same household, one that was of more than usual importance. The artifacts with them could not have been self-acquired and were apparently definitely adapted to the infants in the form of garments. Such a case may simply represent unusual parental care but there seems also a hint of importance of family.

Group burials.—From seventeen feet to twenty-five feet west of center in trench 1 were seven bodies (12–3781–82–83–84–87–89–91 at about the same depth, touching one another in some cases, closely associated with the same object, e.g., charred timber, in others. It has been postulated from the ash layers and possible red floor lines that these burials are those of a single group made in or about the group's dwelling place. One of the bodies was elaborately adorned, another well adorned and associated with it a mortar, a third had an obsidian point, a fourth an olivella bead, and the other three nothing at all (see table 6). Such differences might represent those of a family. On the other hand, the even depths of the burials, the fact that one has not broken into another, the charred timber, and the variety of the burials suggest an identical or nearly contemporaneous interment.

The group in trench 2 was somewhat more scattered (12–3798 to 12–3802). They extended from 15 feet 4 inches to 23 feet 6 inches west of center. Here we had a juvenile skeleton very much disturbed and scattered, and an infant, both near a charred elk antler; another juvenile; a probable male of about forty with an obsidian point in his back; an adult male with a number of obsidian points embedded in him; an adult of forty-five with no artifacts. Ash layers were under these bodies and charcoal was evident. The absence of ornaments from all bodies but the presence of artifacts in the vicinity suggests a hasty burial. This may represent a contemporaneous burial by a group living on the mound in which event the inclusion of two men slain in fighting would not be remarkable. The most persistent reconstruction, however, is of a family group surprised and slain in its own house, one of the men at least making a desperate resistance and being wounded five or more times before being overcome, when he fell upon his own hearth and was partly burned. In such an event we must presume that before the bodies could be disturbed by animals friends returned, flexed at least some of the bodies, and covered them over.

This indication of violent death on a scale which suggests an outside group is interesting since it implies visits of groups from other places bringing with them different customs and objects of material culture.

The seven bodies in the cremated group (12–3807–13) suggest an intrusive custom on the one hand, and on the other, seasonal or group disposition of the dead as mentioned for the group in trench 1. These seven bodies burned at the same time would represent the deaths in a group of, say, 100 over a period of some months. Can this mean that groups visited the mound and disposed at one time all those who died during such a visit?

SKELETAL EVIDENCE

Preservation

The condition of the bones varied greatly. Some were firm and sound; others in such condition that they crumbled on being handled. Condition was apparently independent of location and age. Bones found near the bottom of the mound were at times in better shape than those from near the top. Similar differences existed with reference to horizontal distribution. Perhaps on the whole the bones from the trenches were in worse shape than those above. At any rate in the trenches every skull was cracked and many of them had been pressed quite flat. Bird and animal bones were much better preserved than human bones from the same location. In general, the poor condition of the bones makes it impossible to secure desired skeletal data.

Age and Sex

From the skeletal material collected from the cone Gifford and Loud have been able to make sixty-seven sex and age determinations using the skull and teeth as indicators. The results are given in table 7.

TABLE 7

AGE AND SEX OF DETERMINABLE SKELETAL REMAINS

	Male		Female		Total	
Age	Number	Per cent of males	Number	Per cent of females	Number	Per cent of all
40 years or less.....	3	6.4	2	10	5	7.4
45 years.....	4	8.5	7	35	11	16.4
50 years.....	13	27.7	6	30	19	28.4
55 years.....	11	23.4	2	10	13	19.4
60 years.....	16	34.0	3	15	19	28.4
	47	100	20	100	67	100.

No skulls were obtained from the trenches, but thirteen out of thirty-four burials were infants (38 per cent).

It would seem that we missed many infants in the cone. Yet even allowing for such oversight, the proportion of infants is unreasonably small. Moreover, in the trenches only two bodies were noted between the very young infants and the age when wisdom teeth are cut. This age is even more scantily represented in the cone. At Ellis landing Nelson noted the same disproportion and suggests, to account for the fact, a low death rate among adolescents or the possibility that only the old and infirm lived permanently on the mound.[54] Reverting to our table we find that 92 per cent were forty-five years old or older. There are serious objections to placing too much weight on the conclusion suggested by this large percentage. Six hundred and eighty-five burials were noted but only sixty-seven (9.8 per cent) are included in the table. An inclusion of all burials might—probably would—change the proportions since the skulls examined were those which were firm enough to withstand the rough treatment of the steam shovel. The skulls of young people would be more likely to have collapsed. In using the teeth as a criterion without a known standard one is more likely to place the age too high than too low. If Nelson is right we have an indication of non-continuous residence on the mound; but we feel that such a segregation was unlikely and that a full determination of ages would reveal a more nearly normal proportion of middle-age deaths. It will be noted later in this paper that we follow Nelson in assuming an average life to be 33 years. If this figure should be changed to accord with the present data our results based thereon would be rendered all the more reasonable.

Some 70 per cent of the determined bodies were males. The low percentage of females may be accounted for by the greater fragility of their bones as mentioned above. In fact, this disparity between the sexes leads one to doubt the data rather than to speculate on an explanation. A tendency toward earlier death is noted among the females. But on Nelson's hypothesis physical disability, not number of years, would be the basis for a division of the population on or off the mound, and we are left without a cause for the disparity in sexes.

Crania

Such cranial measurements as could be procured have been presented by E. W. Gifford.[55] Mr. Gifford informs me that the cranial type is the typical California type and that there is nothing about them

[54] *Op. cit.*, 382.

[55] Californian Anthropometry, present series, XXII, 370–373, 1926.

to indicate a change between the higher and lower portions of the mound. It seems possible that a prolonged study might indicate physical similarities with inhabitants of adjacent territories. The present author cannot conceive a "shellmound people" and physical affiliations might help to explain the seeming variations in material culture.

Pathological Data

Very few unusual or diseased bones were noted. Body 12–3801 had the left tibia and fibula pathologically united at the ankle, probably the result of a break. A body in the northwest perimeter had a pathological elbow. Number 12–3604 had an unusually large jaw apparently due to the teeth not having been properly cut. Number 12–3640 had indentations in the forehead suggestive of fractured bones' healing and leaving pits. A skull with a rare, diamond-shaped suture formation was also seen.

STATISTICAL SUGGESTIONS

Varying Rate of Accumulation

Whether or not specialists produce illuminating data from the examination of these human remains, their mere number and location is one of the most definite forms of evidence the shellmound yields. It has been assumed that the shellmounds are accumulations of human refuse and that the population responsible for the accumulating is buried therein. To be exact the current population would have to be added. The data on vertical distribution have shown that half of the population of the cone was concentrated in some six feet of the cone. How then could the other half of the population pile up the fifteen feet or so of the balance of the cone?

A similar varying rate of accumulation per burial is seen when different mounds are considered. Data secured by three investigators may be tabulated as follows:

TABLE 8

MATERIAL PER BURIAL IN VARIOUS MOUNDS

	Quantity of mound material	Total burials noted	Cubic feet per burial
Uhle, Emeryville	7,000	10	700
Nelson, Ellis landing, graded portion	67,500	140	482
Nelson, Ellis landing, trench	5,500	16	343
Nelson, Ellis landing, shaft	560	4	140
Schenck, Emeryville, cone	715,500	651	1,100
Schenck, Emeryville, trenches	7,038	41	174

For the closer work the figures require correction. It has been seen that entire areas in the cone yielded no burials but must have been accumulated by those buried nearer the center. Hence comparisons can be made only with data which include perimeter areas as well as central areas of the mound, in other words, Nelson's scraper work and our steam-shovel work. In both these cases infant burials are practically eliminated. It seems fair to conclude that the same errors of observation would have existed in both cases. With these reservations, a comparison shows that Ellis landing accumulated at the rate of 482 cubic feet per burial and Emeryville at the rate of 1100 cubic feet per burial. Three explanations suggest themselves for this varying rate of accumulation: cremation, change of food habits, and non-continuous residence.

Cremation

If some of those who accumulated, lived, and died on the mounds were cremated the present problem would break down. But neither Nelson nor the author found sufficient evidences of cremation to justify the conclusion that cremation existed to any appreciable extent.

Change of Food Habits

Shellmound constituents have been used by investigators as indices of the diet of shellmound residents. Because of the difficulty of accurately determining these constituents such evidence cannot be leaned upon too heavily, but its general indications seem strong enough to support the limited conclusions arrived at under this heading.

Suppose one group of shellmound dwellers were to subsist upon a diet of 90 per cent acorns and 10 per cent shellfish and an equal group on 30 per cent acorns and 70 per cent shellfish. Suppose, further, that the non-shellfish diet leaves little or no trace. It has been suggested that in such a case two similar mounds might result, but this does not seem possible. If shells are being cast aside in one place, say, seven times as fast as in another, heaps of different types must be formed. The layers or lenses of shell produced should differ since the same amount of natural and human wear and tear would each day impress itself upon vastly different masses. More important, the proportions of the constituents of the mounds would differ. In other words, the ash from daily fires, wind-blown dust, mud tracked in, and all other natural or human non-dietary accumulations would be roughly the same in both mounds each day although in one case they would be

associated with seven times as much shell as in the other. Finally, human skeletons are an essential feature of these mounds. If a man lived upon a 90 per cent acorn–10 per cent shellfish diet he would leave behind him when he died a smaller accumulation than if his diet had been 30 per cent acorns and 70 per cent shellfish. These considerations lead us to the following generalizations: The greater the proportion of shell the more rapidly was the mound accumulated, and the larger should be the mass of material accumulated for each body buried therein.

Turning to two cases for which data are in hand we note from Gifford's analyses that the average shell content at Ellis landing was 69.43 per cent, while at Emeryville it was 59.86 per cent. Since, then, shellfish made up a larger part of the diet at Ellis landing than at Emeryville, the former mound should show a greater volume of mound accumulation per capita, whereas the contrary is true. The mere existence of the mounds predicates that we are dealing with a diet largely of shellfish and the shell-content figures show that at Ellis landing a greater proportion of shellfish was eaten than at Emeryville. It would require then the assumption of an impossible reduction in the daily shellfish consumption at Emeryville in order to harmonize the per capita accumulation.

Non-continuous Residence

In the above discussion we have followed our predecessors who have assumed that a given mound was a place of continuous residence. If we drop this assumption it is easier to explain the varying rates of accumulation for, if a group lived on a mound only part of the year, it might live on that mound a longer time each year than some other group upon another mound, and varying ideas as to burial in the shell-mound site or the residential site for the balance of the year would make it unreasonable to assume that all those responsible for the accumulation of a mound were buried therein. This would explain not only why different mounds showed different rates of accumulation per burial but also the variations noted in the different levels of the same mound.

If residence on the mounds is established as non-continuous or seasonal, as seems probable, not only are we assisted in considering the habits of the aborigines, but we also have an important factor in determining the age of the mounds themselves. The skeletal evidence is as concrete as anything we have bearing on the subject and so the question is pursued farther.

Thus far no notice has been taken of three unknown factors which must be assumed, i.e., the current population of a given mound, the average human life, and the daily rate of accumulation of mound material.

Current Population

From house pits discernible, Nelson supposes the current population at Ellis landing was 100.[56] Gifford assumed that the same population inhabited Emeryville.[57] This figure seems as reasonable as any which it is possible to obtain.

Average Life

Nelson estimates the average life at 33 years.[58] Since we are leaving infants out of consideration and few children are found among the burials it is possible that this is too low. It is howecer essentially correct. If the figures given by us on page 203 are more nearly correct, the reasonableness of the views advanced below is enhanced.

Rate of Accumulation

Nelson decides that a person will accumulate 0.01 cubic feet of mound material per day,[59] in which Gifford acquiesces. The skeletal data and accepted assumptions may be applied to this figure.

If one person accumulates at the rate of 3.65 cubic feet per year and lives continuously on the mound to be 33 years old, then the 140 lives represented at Ellis landing would accumulate 16,863 cubic feet; and the 651 lives represented at Emeryville would accumulate 78,412 cubic feet. But at Ellis landing the portion of the mound actually containing the bodies amounted to 67,500 cubic feet, and at Emeryville to 715,000 cubic feet. This leaves some three-quarters of the Ellis landing mound and nine-tenths of the Emeryville mound to be accounted for.

From another angle, if a person accumulates 3.65 cubic feet per year, then the average life of the 140 accumulating the 67,500 cubic feet at Ellis landing would have to be 151 years; and of the 651 accumulating the 715,500 cubic feet at Emeryville it would have to be 309 years.

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[56] *Op. cit.*, 346.
[57] *Op. cit.*, 13.
[58] *Op. cit.*, 381.
[59] *Op. cit.*, 346.

The rate of accumulation seems much too low. Further, it is obvious that an adjustment which would fit one case would not fit the other so long as continuous residence is assumed. With an adult population, an annual death rate of 3 per cent would appear to be a maximum. The Emeryville cone with 1100 cubic feet of material to each body is again a maximum. Now, with continuous residence and a 3 per cent death rate, the 651 Emeryville bodies would indicate an ultimate population of 21,700 persons. Since the bulk of the cone is 715,500 cubic feet, each man each year must have accumulated 32.9 cubic feet.

Or, if residence on the mound was continuous then the bodies in the mound plus the current population must account for its accumulation. The current population on account of its smallness and the probable term of years involved may be ignored without essential error. Then at Emeryville, since one body represents a mass of 1100 cubic feet and its average life is 33 years, the rate of accumulation would be 33.3 cubic feet; which checks closely enough with the estimate from different factors (32.9). The corresponding figures for Ellis landing are 14.4 and 14.6 cubic feet, about four times Nelson's estimate.

Is a rate of 33.3 cubic feet per year possible? Gifford established the specific gravity of shellmound material as 1.3, or 81 pounds per cubic foot.[60] His percentage of shell content varied from 69.43 per cent at Ellis landing to 59.86 per cent at Emeryville with 55.59 per cent as an average for San Francisco bay mounds. Again, to be on the maximum side, let us allow 65 per cent. Then each cubic foot of mound material contains 52.65 pounds of shell; and the 33.3 cubic feet accumulated per year means that one adult would accumulate 1753 pounds of shell per year or 4.8 pounds per diem. According to the present weight of the shells of similar oysters and clams this would mean a daily ration of 75 clams or 250 oysters. These oysters are tiny and a modern man would think nothing of consuming 30 or so of them a day as cocktails in addition to his regular meals. The clams also are small. To the author there seems nothing improbable in an aborigine's eating the requisite number. From the point of view of food values 75 of these clams or 250 of the oysters (uncooked) would have a food value of from 600–1000 calories[61] whereas a reasonably active man requires from 3000 to 4000 calories daily.[62] Nelson treats clams and oysters as equivalent, but this does not seem to be the case. No matter how

[60] *Op. cit.*, 12.
[61] M. S. Rose, Feeding the Family, 343, 1918.
[62] *Ibid.*, 54.

under-nourished the shellmound population may have been, 50 tiny oysters daily per man would not have been nearly enough to support life.

In judging how many shellfish might be eaten, it is well to consider how they were prepared. Abbott in writing of the shellmounds of the Atlantic coast says that oysters and mussels were prepared in large quantities for winter use, "probably being dried and ground in mortars."[63] Strong, an educated observer long resident on the lower Columbia river, states "the Indians near the Coast made trips to the ocean for clams. These later were dried and smoked and so cured."[64] Such citations seem to indicate a widespread custom of drying shellfish, and, when considered with well-known similar aboriginal practices with other food-stuffs, suggest the reasonable possibility that shellfish were so treated on San Francisco bay. When dried and pulverized the inadequacy of 50 tiny oysters as a daily ration becomes more striking.

Summarizing, our conclusion is that a daily ration may be assumed which will check with the burials seen in the mound material handled, and with the maximum rate of accumulation necessitated by them.

The point may be advanced that if residence on the mounds was non-continuous, a greater daily rate of accumulation would be required. This does not seem necessary, for if residence was non-continuous a population would be engaged in eating which would not be reflected entirely by the burials in the mound. Further, if shellfish gathering was of a seasonal nature, it may be presumed that during the visits to the mound this work was intensive and that the shells resulting from a visit represented not only consumption but food prepared and carried away to be eaten later.

Time of Accumulation

Having assumed a current population of 100 and a possible maximum accumulation at the rate of 33.3 cubic feet per year per person, a simple calculation determines that it would have taken but 215 years for the mass of the cone (715,500 cubic feet) to be accumulated.

But under this cone was an additional volume of perhaps 400,000 cubic feet, and there was shell to the north and on the perimeter, say 315,500 cubic feet. Thus the volume is doubled to 1,431,000 cubic feet, and, other conditions remaining unchanged, the time of accumulation would be increased to 430 years.

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[63] C. C. Abbott, Primitive Industry, 149, 1881.

[64] Thomas Nelson Strong, Cathlamet on the Columbia (1906).

Now in the earlier part of this paper the opinion was expressed that this cone was simply part of a mound covering a much larger area and containing perhaps 150,000 cubic yards in its base. On this base were at least two cones, so that as a maximum highly speculative figure it might be said that the total shellmound mass at Emeryville was as much as 6,000,000 cubic feet. It would take about 1800 years for a population of 100 to accumulate this. However, since the size of such a site is more than double that considered as the cone and since at least two cones are present, a larger population, say at least 200, seems more than probable. In short, 1000 years would appear to be the greatest possible period allowable for the time of accumulation of all shellmound material on the Emeryville site.

From 245,000 cubic feet in sight, Nelson estimates the entire Ellis Landing mound at 1,260,000 cubic feet. Proportioning the 160 observed burials in the 72,000 cubic feet of material handled, he decided that there should be 3000 bodies in the mound. Then dividing this estimated mass (1,260,000) by the assumed current population (100) multiplied by the estimate rate of accumulation (3.65 per person for year) he determines the time of accumulation of the mound as 3500 years.[65] However, other of his factors may be applied. With a current population of 100, an annual death rate of 3 per cent, and 3000 bodies in the mound, it would have taken but 1000 years for these bodies and the mass enclosing them to be accumulated. Or, since each life represented accounts for 482 cubic feet, and the average life was 33 years, the annual rate of accumulation would have been 14.6 cubic feet per person. This increase of the rate by four would cut the time of accumulation down to 875 years.

Gifford estimated the time for accumulation at Emeryville as 3300 years. But he assumes the same current population and rate of accumulation as at Ellis landing. Then, since he uses Uhle's estimate of the mass of Emeryville (39,000 cubic meters), he is bound to arrive at a result nearly the same as Nelson's for Ellis landing where nearly the same mass was used (35,650 cubic meters). In other words, this estimate introduces no new evidence and is simply a mathematical corroboration of previous ones.

Gifford estimates the time of accumulation in another way. By analyzing nineteen samples he determines an arithmetical average of 13.47 per cent which he takes as the ash content of the Emeryville mound. Then, on the basis of Uhle's estimate of 39,000 cubic meters as the mass of the mound, he finds that 7528 tons of ash would be present in the mound. Averaging the percentage of ash present in trees likely to be accessible to the mound-dwellers, he decides that the ash would represent 0.9 per cent of the wood burned. It was assumed that the current population was about fifteen families of seven persons each, and it followed that each family would have to consume about 88 pounds of firewood daily if it took 3700 years for the mound to accumulate. He judges this daily consumption of 88 pounds to be reasonable and hence 3700 years is also taken as reasonable.

Several objections to this method appear. In the field the samples were selected, and in the laboratory those that showed no ash were not used. Five grams each of those used were tested chemically. It is very difficult to deter-

[65] *Op. cit.*, 381.

mine accurately the ash in a shellmound because of the identity of elements involved. Also, one sample of no ash included instead of being selectively eliminated would make a difference of 0.71 per cent in the result. The ash content once determined is not necessarily equivalent to the residue of wood fires. Hence the 13.47 per cent cannot be taken too exactly. (The samples ranged from 0 to 28.11 per cent; the tests from 3.37 per cent to 28.11 per cent.) Yet a change of 1 per cent in this figure, with other factors remaining unchanged, results in a change of about 285 years in the time of accumulation.

Since the wood burned is not known the 0.9 per cent ash yield from fires must be regarded as approximate, especially since chemical analysis and current practice differ. Yet here again a small variation produces a great difference in the "age." One-tenth of 1 per cent variation might change the time of accumulation 410 years.

Finally, the estimate assumes continued residence on the site. If residence were for part-time only, the "age of the mound" would be increased proportionally.

In illustration: Suppose two of the samples analyzed are replaced by two samples taken from the same strata in the mound. The average percentage of ash would then become about 10 per cent and the "age" would be decreased 855 years. Or if instead of a mixed lot of wood, only willow and cottonwood, such as grew nearby, were burned the ash residue percentage would be reduced to 0.6 per cent. Bone and other burnt material not the residue of wood fires may also be eliminated, reducing this figure, say, another 0.1 per cent to 0.5 per cent, and increasing the "age" 1640 years. Finally, if residence on the mound was for only six months each year, the "age" would be doubled.

MATERIAL CULTURE

ARTICLES OF ASPHALTUM

We use the term "asphaltum" to designate an adhesive material used as a binder or glue, such as asphalt, bitumen, and other viscous tar-like matter. All specimens of adhesive material were not tested. In one case pine pitch was used (1–25550). Fish glue might also have been employed, but generally it would seem that asphaltum would be favored because other materials would be more difficult to procure than asphaltum, which occurred on the eastern side of San Francisco bay and in many other places in California.[66]

This asphaltum was used for sticking beads to various articles, for covering wrapping (e.g., the cords on charmstones), possibly for producing decorative designs (e.g., whistles). One may infer a number of other uses. But as far as actual evidence goes the usage was more for aesthetic than practical purposes. It was used throughout the mound's history and the knowledge of it manifested in the earlier stages suggests a comparatively developed people.

[66] Andrew C. Lawson, San Francisco Folio, Geological Atlas of the U. S., 23, 1914. California State Mining Bureau, Minerals of California, 285, 1923.

ARTICLES OF BONE

Articles of bone constitute the largest and most remarkable class in the material culture of the shellmound, but as a class are not so frequently associated with burials. They offer a variety of suggestive utilitarian forms and afford probably the most pronounced evidences of aesthetic traits.

The bones most often used were those of deer and elk and the wing and leg bones of birds. Traces of probable whale bone artifacts were recovered and it seems likely that fish bones may have been used but not preserved. Exceptional bones are noted as the different artifacts are discussed.

Practically all bones of size were broken. So many of these show absolutely no traces of use that it has been presumed that the bones were split for their marrow. In this study we leaned to the conservative side and unless a fragment showed indisputable signs of having been worked or used, it was not counted as an artifact. Uhle considered a number of such fragments as the "most primitive ethnological implements of which we have knowledge."[67] This seems aside from the point for evidence is available which shows that these primitive forms, if such they are, existed alongside much more developed forms which in the author's view must characterize the cultural horizon. In other words, Uhle believed that these primitive forms fitted in with the conception of a more primitive culture in the lower levels whereas our evidence shows that primitiveness and lower levels cannot be correlated.

Bone artifacts were found in all parts of the mound, but so frequently not in association with burials that most of our specimens from the cone were not found *in situ*. The careful work in the trenches produced proportionally more specimens. Does this indicate that in the lower portion of the mound we have the manifestation of a difference of culture? Probably not. From the cone, 175 bone artifacts were listed, of which only 55 (31 per cent) were found with burials. In the trenches 138 were recovered, of which 7 (5 per cent) were with burials. The inference is that without the conspicuous markers furnished by burials we missed a great many bone artifacts in the cone and that this accounts for the difference in relative abundance seen in our collection.

The bone artifacts generally suggest utilitarian uses, which may help to account for their exclusion from burials. Some of the forms

[67] *Op. cit.*, 71.

are readily identified but others, particularly those which we have brought together under Type IV of awls, cannot be determined.

A few pieces show incised decorative attempts, others show traces of bead work or string adornment. The whistles may be considered musical instruments. No other class shows so much attempt at aesthetic expression.

Astragali

From the cone there were recovered two astragali or knuckle-bones from the ankles of deer each of which had had a hole drilled through it (pl. 43, *mb*, 1–26457). It seems probable that a number of other astragali were not distinguished by us as artifacts. The use of astragali as dice or as part of a game has a remote antiquity and a wide distribution not only in the old world but apparently also in the new, although it is not entirely clear that its presence in the new world is not due to Spanish influence.[68] It is by no means certain that the drilled astragali from the Emeryville mound were implements for games. They might have been used as catches on the ends of cords or for other practical purposes. The depth of one of the pieces, 23 feet, seems to preclude Spanish influence. Astragalus bones are known to have been used by the Pomo Indians some fifty miles north of the bay and also by the Piman tribes in Arizona and Sonora.

Awls

The most common type of bone artifact is a pointed implement. Pins, needles, bodkins, punches, weapons, flakers, shell-openers, etc., might all be included. These articles merge into one another and into true awls so gradually, and actual indication of their use is so generally lacking, that our awl class is quite arbitrary. It is subdivided into eight types on the basis of the bone used. To some extent the bone employed and the use to which the awl was put were probably related. Compare, for example, the typical deer ulnae awls (pl. 38 *a–e*) with the cannon bone awls (pl. 38 *h–l*), or with an awl such as shown in plate 38*q* (1–25749). Many awls recovered are too fragmentary to be classified. For distributional consideration these have been thrown into a miscellaneous group. Type IV invites particular attention. Many articles quite different from the ordinary awls are found here, e.g., possible knives, scrapers, marrow spoons.

[68] Stewart Culin, Chess and Playing-cards, Rept. U. S. Nat. Museum 1896, 826–30, 1898.

A vertical cross-section of the trenches shows that all the different types had practically the same distribution, that this distribution was quite even, and that artifacts of this awl type extended from top to bottom of the mound.

Type I. Of ulnae.—Thirteen pieces in the trenches. These are blunt, strong awls usually made of the ulnae bones of deer (pl. 38*c*, 1–25737), although elk is also used (pl. 38*a* 1–25735), and one specimen of probably coyote ulna (pl. 38*d* 1–25739) was found. The elk specimen illustrated was one of the largest found (200 mm. long) and the deer specimen illustrated, one of the smallest (120 mm. long). Other specimens are shown in plates 38*e* and 38 *b* (1–26079, 1–26081). These tools have an excellent natural handle and are so sturdy that they must have been used for the heaviest work.[69] They might even have served as daggers.

Type II. Of cannon bones (metacarpals and metatarsals).—This formed the most numerous type of awls. They were generally long (*ca.* 115 to 185 mm.), well jointed, and highly polished. Four subtypes were recognized determined by the way in which the bone was used.

(*a*) Sometimes the bone was split so as to divide the knuckle. These where the knuckle end was the handle make up this subtype. Plate 38*h* (1–25756) shows a finished awl and plate 38*g* (1–25780) a bone used for this purpose. Five pieces classified. (*b*) Sometimes the non-knuckle end of the cannon bone was preserved as a handle, the bone being split as in (*a*). Plate 38*k* (1–25760), and plate 38*m* (1–25781) show a bone in process. Fifteen pieces classified. (*c*) In one case, from Area 10 at 10 feet, the entire knuckle was left for a handle; see plate 38*f* (1–25764). (*d*) Lastly, small fragments of the bone would be used with little or no preparation; see plate 38*l* (1–25762); two pieces classified.

In addition to the classified pieces 13 specimens were indeterminate, making a total of 36 for this type. These were horizontally distributed as follows:

Subtype *a*	5	Areas 2, 3, 8, 10, 14
Subtype *b*	15	Areas 3, 3, 5, 14, 17, 18, 19, 32, 36; trench 1, 2; trench 2, 4
Subtype *c*	1	Area 10
Subtype *d*	2	Area 8, 9
Indeterminate	13	

All the trench specimens that could be identified were of subtype *b*. A very sturdy awl was found 28 feet 9 inches deep (pl. 38*j* 1–26092).

Type III. Of tibiae.—Identification of these bones is more doubtful. Practically all awls in this class are made of deer tibiae. Specimens range in length from 95 to 195 mm. There is considerable variation of

[69] Compare Heye, fig. 12, *op. cit.*, 87.

form. Plate 38*p* (1–25748) shows what might perhaps be called a typical piece. Plate 38*n* (1–25745) is curved, very sturdy, and very highly polished. Plate 38*q* (1–25749) is interesting because of the very short point on such a large fragment of bone. In plate 38*o* (1–25752) we have shown one of the abundant fragments out of which awls of this type might have been made.

Type IV. Of deer rib.—Artifacts of this type are usually made of deer rib though this is not always the case. These articles are proportionally plentiful and are hard to classify. It seems certain that the extremes which we have included must have been used for very different purposes. Yet the interchange of characteristic features is so uncertain that no line can well be drawn. Knives, skin-scrapers, and smoothers are probably included. Some may have been hair ornaments.[70] Some features are common to all. There is a definite polished point although this point may vary from straight to curved or flat to round. All are relatively thin. This thinness has been obtained in a number of cases by grinding down the inner surface of a deer or elk rib (1–25788). They generally have a definitely finished base (pl. 39*j*, 1–25789).

Plate 39 *i–r* shows a number of these artifacts which were probably actual awls; *o* (1–25785) has a round point and a rather gouge-like cross-section. It also has the curve of the rib; *j* (1–25789) has been mentioned as illustrating the finished base, in this case rounded. It is quite flat and thin and it was associated with a burial and a number of other artifacts in Area 10 at 15 feet; *i* (1–25790) suggests the same type as 1–25789 with which it was associated. However it is much larger, having a width of 30 mm. It is sturdy enough to have been an effective weapon; *r* (1–25799) shows some of the abundant raw material. Whether such pieces had or had not been worked or used it seems impossible to state; *k* (1–26101) displays how the rib has been cut to a taper. This piece has a high polish on the outside and the inside has been ground down; *l* (1–26105) is part of an awl from 30 feet 6 inches deep; *m* (1–26106) illustrates a curving point; *n* (1–26112) has a squared somewhat concave-convex base; *p* (1–26113) has a rounded base and certain scratches on one side which seem entirely meaningless. The other side is ground down. Sixteen pieces like these came from the cone and 15 from the trenches.

Twenty-one articles intimately connected with the above and obtained from the trenches are illustrated in part in plate 39*a–g*; *g* (1–26116) shows a shaped base rather faintly suggesting a spoon. Note the reduction in the width of the specimen toward the middle; *f* (1–26123) also shows the reduction in width near the middle as though from wear; *d* (1–26122) is only the base of an interesting piece. The corners are shaped, the end square, and the whole piece only about 1 mm. thick. This is probably not rib bone. There is a hole in it about 5 mm. diameter, 60 mm. from the base. One of the truck-drivers recovered a piece which this may have resembled. It possessed the hole, was thin, curved, very

[70] Heye, *op. cit.*, pl. 61.

long, and pointed. Nelson secured a similar piece at Ellis landing (1–11214); *e* (1–26129) is unusual both on account of its base and the indication of decoration. At the base the piece has been beveled off for some 50 mm. and made somewhat concave. These bases may have been used for extracting marrow. Four incised lines appear at the broken end (reverse of plate). This specimen was 25 feet 6 inches deep; *c* (1–26131) suggests a scraper. The base is quite sharp and somewhat concave-convex. The bone is 2 mm. thick and has been ground down on the convex side at the base apparently to give the base an edge; *a* (1–26134) suggests a knife; *b* (1–26135) suggests a spoon.

Type V. Of sea-otter penis bones.—These bones were frequent and two from the trenches had unquestionably been used as awls (pl. 38*s*, 38*r*, 1–26137–38). The last piece is much worn down as though it had been sharpened many times. These may have been used as flakers, as was done in the Aleutian islands.

Type VI. Of bird bones.—Bird bones presented many doubtful cases. In very few cases did a detailed examination of the bone result in a conviction that it had been intentionally sharpened or polished by use as an awl. The fragile character of the bone itself makes it difficult to imagine what type of work they could have been used in. Plate 39*h* (1–25820) made from a radius bone and 190 mm. long seems almost certainly to be an awl. It is possible that such an artifact was used in extracting marrow. From Area 19. No awls of this type were found in the trenches.

Type VII. Of fish bones.—Awls of this class were scarce. One reasonably certain specimen is shown in plate 43*d* (1–25819). This may have been a needle. It came from Area 33 at 15 feet. Fragments of polished sting-ray bone suggest the same use.

Type VIII. Of uncertain bones.—Most of these bones were mammal and probably 95 per cent were deer. In the cone we secured 15 specimens. Plate 43, *a* and *b* (1–25806 and 1–25814), show rough splinters which have had a point polished by use; 43*c* (1–25807) shows a very thick, blunt specimen that suggests a special use. Another heavy specimen is plate 42*a* (1–25818) from Area 5. This was probably made of deer humerus. It is 105 mm. long. From the trenches 21 specimens of this type were secured. Plate 42*c* (1–26141) is a calcined basal fragment which shows considerable trimming of the bone.

Beads

A number of the bird bone pieces described later as tubes may have been used as beads. We have taken length as the distinguishing characteristic. All tubes are beads if less than 25 mm. long. In the trenches were five such pieces; in the cone, two. All these are shown in plate 43, *j–n*.

	Trench	Depth
43*j*, (1–26182)	1	24′ 3″
43*k*, (1–26183)	2	25′
43*l*, (1–26184)	3	26′ 9″
43*m*, (1–26185)	3	29′ 10″
43*n*, (1–26186)	3	30′ 9″

Specimen 1–26184 is 20 by 8 mm. and there is a second shorter bead thrust into it. Specimen 1–26185 has two olivella disc beads still stuck to it with asphaltum. These are apparently the remains of more elaborate decoration. The presence of these beads, particularly the comparatively complex ones just described, in the lower depths of the mound should be emphasized as they are important in determining its cultural level.

Plate 43, *a* and *p*, show the two pieces from the cone, while *q* and *r* are so long as to rank as tubes but are shown here to illustrate the arbitrary line between these and beads.

A portion of what was apparently a large bone bead was seen. It consisted of half a ring, 30 mm. diameter with a wide groove in its edge. This piece seemed to have been cut out of deer bone and is evidence of considerable skill.

Club or Sword

Plate 42*g* (1–26194) presents a very remarkable fragment. It seems to be the handle end of a club or sword fashioned from bone. The grip is well made for the purpose and the edge is much battered from use. This interesting piece came from the bottom of the mound—29 feet 10 inches deep in trench 3.

Fishhooks

See this caption under "articles of Horn," page 226.

Fleshers or Saw-like Implements

A common implement of which 27 identifiable specimens were found was made by notching the scapulae of deer and elk (pl. 40 *a–m*). The blade is too thin and too brittle to have served as a saw for wood or hard materials; also the teeth are spaced too far apart, are too irregularly placed, and frequently extend over too limited an area. The teeth are not worn on the ridges but on one side. At times when teeth were broken out or worn away the pieces were renotched and the resulting edge was much too wavy to permit sawing; see plate 40*g* (1–25727). In some cases more than one edge was notched; *i* (1–25730) shows two edges notched; *a* (1–26069) shows a piece where the other two ridged edges have been trimmed down to give the piece a better finish (see also *b* and *c*). The variation in the size of the notches is indicated by *h* (1–25731) and *f* (1–25723). A single article similar to the above is here included. It is also notched bone and the teeth are very fine (pl. 6*e* 1–25734), the piece is made of deer rib instead of a scapula.

These pieces were scattered throughout the mound and were never associated with burials. The 11 pieces found in the trenches make us believe that the 16 from the cone are only a small part of those present. These articles are very fragile and must have been easily broken. Many scapulae were seen which were too fragmentary to indicate whether or not they had ever been notched. It must have been an implement in common use throughout the history of the mound since a piece (1–26066) was found as deep as 29 feet in trench 1. If anything, the lower specimens (pl. 40*a–c*) indicate more care in preparation as shown by the trimming of the ridges above mentioned. Twenty-three of the pieces were of deer scapulae (pl. 40 *j–m*), the balance of elk (pl. 40 *d* and *g*).

Mr. Henry Schumacher (brother of Dr. Paul Schumacher) has stated to the author that some years ago at Pleasant valley, Nevada county, California, he saw an Indian who had notched the edge of a steel knife blade and was using it for fleshing hides. This Indian informed him that formerly such implements had been made of bone. For heavy skins the notched shoulder blades of deer were used; rabbit shoulder blades were used for mole and other light skins. Such implements are used on the inside of the skins. Mr. Schumacher identifies our specimens as similar fleshers. This use seems probable as the teeth adapt it for catching the particles of meat and fat. The wear on the sides of the teeth suggests the rubbing which would result from the fleshing operation. This seems to the writer a more probable use than the use in connection with weaving, which Uhle suggests.

Pieces of this type have a high antiquity. The Palaeolithic pieces shown by Wilson[71] appear to be very similar. So also do pieces found by Mr. A. C. Parker at the Ripley Erie site in New York.[72] Similar specimens were secured by previous San Francisco bay shellmound investigators and Uhle[73] notes them as being reported from Bavaria, Alaska, and Massachusetts. Our point in citing these distributional references is simply to show that both temporal and spatial distribution point to a fundamental use, such as preparing hides, rather than to a specialized or localized development.

Knives, Scrapers, Marrow Extractors, Hair Ornaments

See Awls, Type IV, page 216.

Miscellaneous

From the cone we obtained four artifacts, and from the trenches one, made from entire cannon bones of deer. These pieces were highly polished and had lightly incised upon them, without apparent arrangement, a number of lines or marks (pl. 42*b*, 1–25886). Similar pieces are used by the Yurok Indians of northwestern California in sifting acorn meal. The meal is placed upon a flat tray which is tapped with these bones, effecting a separation of the fine and coarse material.

An elk's cannon bone (1–25890) split in half suggests an implement for dressing skins, or perhaps an awl in course of manufacture (pl. 42*d*).

Plate 42*f* (1–26195) presents another unique object recovered from the dump. This is 165 by 52 mm., has a very high polish, and looks much like a modern shoe-horn. A spoon or ladle is suggested. This piece is made from a broad piece of unidentifiable bone.

Needles

Bone needles were found though in very limited quantities which might be due to their size. Plate 43*g* (1–25826) shows a bone fragment 5 mm. long with a notch around the base. This was from Area 28. A highly polished basal fragment of an apparently similar piece was recovered from the dump. A few additional specimens were gathered by others.

In trench 1 at 26 feet 4 inches the knobbed-end specimen shown in plate 43*e* (1–26165) was found. In trench 2, at 23 feet 8 inches, was a

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[71] Thomas Wilson, Prehistoric Art, Rept. U. S. Nat. Mus. 1896, 376, pls. 13, 14, 1898.

[72] The Archaeological History of New York, N. Y. State Illus. Bull, nos. 235, 236 (1920), fig. 43, pl. 97, figs. 10, 11.

[73] *Op. cit.*, 76–78.

specimen 66 mm. long by 2.5 mm. thick, with a drilled eye (pl. 43*f*, 1–26166). A very similar one came from 26 feet in trench 3, and from 27 feet came a similar piece with the eye started on both sides but not yet drilled through.

Pins

In trench 2 at 23 feet 9 inches to 25 feet 10 inches were four small bone pieces which we denote as pins. Plate 43*h* shows the base of one of these (1–26162) and plate 43*i* the point of another (1–26163). A number of the small awls discussed under that head were probably used as pins in preparing hides, etc.

Saw-like Implements

See Fleshers.

Sting-ray Bone Objects

Awls of sting-ray bone have been mentioned. These fish were apparently very plentiful in the bay near the shellmound probably because of the food available in the shellfish beds in the vicinity. They were represented in the mound principally by their dental plates, of which, relatively, there was a great quantity. It was suggested at San Miguel[74] that they were used as artifacts. They look so well fitted naturally for some use that one is tempted to think they might have been used; but not a vestige of direct evidence was seen. Many of the pieces certainly were not used since in a number of instances several plates were still in place together when found. The sting-ray barbs may have been used. Here again direct evidence of shaping or wear is lacking. But a burial at fifteen feet in Area 10 furnished suggestive evidence in the form of a cache of forty or more of these barbs gathered together.

Teeth

With burial 12–3619 at twelve feet in Area 6 were two beaver teeth plate 43*bt* (1–25895). These had not been drilled but were associated with bead and abalone work near the skull. This seems to indicate that they were held in esteem. Uhle also found beaver teeth and he thought their presence was an indication of antiquity for he believed the animal to be long since extinct in the neighboring territory. One

[74] Heye, *op. cit.*, 110–111 (Heye identifies the species as *Myliobatis californianus*).

of the men working for us had caught beaver in a skunk trap within about fifty miles of the mound on the lower Sacramento–San Joaquin river as late as 1918. And they exist at present in the Mokelumne river near its junction with the Sacramento. Hence their presence indicates no particular age.

Many sea-otter teeth were obtained. The large canines were frequently found isolated but with nothing about them to indicate use. However, one specimen was seen, but not recovered by us, which had been notched at the end as though for a cord for suspension as a pendant. Uhle illustrates in his figure 36 (1–8736) a bear's tooth used in the same way.

Deer jaws with the teeth still present were common. We saw nothing about any of these to suggest artifacts. A. C. Parker thinks similar ones were used as scrapers at the Ripley Erie site in New York.[75]

Tubes

A large number of bird bones, principally ulnae, occurred in all parts of the mound. While they might have been intended as raw material for tubes, whistles, etc., we have adopted the view that they were normal refuse unless definitely worked. The work which converted such pieces into our "tubes" was the cutting off and grinding square of one or both ends. In addition "tubes" often showed a definite polish. Plate 41*d* (1–25865) shows a typical piece. The diameter of the tubes depended on the bone used. Since in cases (pl. 41*f*, 1–25881) this was as great as 20 mm., the inference is that some large birds such as pelicans, condors, and eagles must have been available at times. There was a great variation in length, 1–25865 is 60 mm. long; 1–25881, 85 mm. long. Plate 41*m* (1–25871) shows a piece 15 mm. diameter by 35 mm. long; plate 41*c* (1–25872), one 125 mm. long. The longest was 195 mm. The most delicate specimen, plate 41*e* (1–25880), was 100 by 5 mm. It was the only worked radius bone tube noted and there is a reasonable doubt as to its having been worked.

These tubes had a wide horizontal and vertical distribution in the cone, and six were found in the trenches, the deepest at 26 feet. One of these, plate 41*a* (1–26188), is 195 mm. long. The piece shown in plate 41*b* (1–26189) from 23 feet 6 inches has beveled ends and is probably not bird bone.

[75] *Op. cit.*, 293.

In the nature of the case it seems doubtful if these tubes were a finished product. They were probably articles in the process of manufacture. The short tubes suggest beads or game bones, the longer ones pipe stems, whistles, or the like.

Plate 41*i* (1–25884) presents an interesting specimen. It is the distal end of the femur of a large bird which has been provisionally identified[76] as a bald eagle. The end has been cut off probably for the purpose of making a tube of the missing portion. Other distal ends are shown in plate 41,*g* and *h*.

Only three tubes were noted which were not of bird bone. These are shown in plate 41, *j–l* (1–25885). They are well matched in size (115 by 13 mm.), workmanship, and material, and were found together and with the fragments of some exceptionally large bird bone tubes (pl. 41*n*, 1–25873). The material of the three tubes is uncertain; it is probably deer.

Whalebone Artifacts

A number of fragments of whalebone were recovered which had been ground down on one side. It was possible in one case to reconstruct a slab *ca.* 150 by 200 mm. The smooth, uneven surface indicates an artifact that had seen much use. Other pieces had been polished on both sides but are too small to permit speculation. This material was badly decomposed and it is quite probable that whalebone was utilized to a greater extent than these fragments indicate.

Whistles

By whistles we mean bone tubes as above described but with a notch in one side (pl. 41 *o–w*). They might also be termed calls or flutes. In some cases plugs of asphaltum were found in the vent and there are indications that one end was plugged or wrapped around with asphaltum, but we have no whistles with such actually in place. The vent was comparatively small and in no case was there more than one. It was apparently made by abrading rather than by drilling. In most cases it is rubbed so smooth that no tool marks can be distinguished. About thirty-seven of these whistles were found in the cone. The number cannot be stated exactly on account of the fragmentary condition of some specimens. In the trenches only four pieces were discovered. A remarkable thing about their distribution is the fact that they seemed to run in groups. Of the total thirty-seven pieces no less

[76] By Miss Edna Fisher, of the Museum of Vertebrate Zoology, University of California.

than twenty-two complete pieces and some fragments were found in three lots, all with burials, i.e.: Area 6 at 12 feet, 8 pieces; Area 10 at 15 feet, 9 pieces; Area 31 at 16 feet, 5 pieces. On this basis a single whistle-burial found in the trenches would have brought them quite into line with the cone. The distribution in the trenches ranged from 23 feet to 26 feet 10 inches deep. The grouping of these whistles together is curious. Does it indicate specialization in making or in use or neither? In two cases the burials were accompanied by other artifacts. Many of the whistles are fragmentary in these groups, and as some if not all the pieces were near at hand it is possible that they were "killed" at the time their owner was buried.

Another interesting feature about the whistles is that many of them show attempts at decoration. This was apparently done with asphaltum, red paint, wrappings, and beads. Plate 41*v* (1–25835) shows one of the group from Area 6. This piece is 195 by 11 mm. Seventy millimeters at one end have been blackened. Plate 41*s* (1–25836), found in the same group and 155 by 11 mm., shows blackened areas alternating with lighter ones as might have resulted from thongs or cords wrapped about it. Still another from this group (pl. 41*t*, 1–25837) shows a diagonal design in black lines. Two others though not colored still bear the imprint of olivella disc beads (*ca.* 5 mm. in diameter) which had been stuck to them. Plugs recovered from these whistles are apparently asphaltum (1–25842). The occurrence of so many of these whistles together and the marks of lashings suggest the possibility that two or more were bound together in use, somewhat in the manner of those found by Schumacher on Santa Catalina island,[77] or perhaps more neatly with cords to form double whistles like those used by the Hupa Indians of northern California and illustrated by Wilson.[78]

The group from Area 10 also showed traces of asphaltum markings and red paint. Plate 41*r* shows 1–25845 (195 by 15 mm.) and 41*q*, 1–25846 (150 by 8 mm.) from this group. Some of the pieces in this group were curved with the notch on the concave side (e. g., pl. 41 *o–p*, 1–25848–49). These pieces seem so well matched as to again suggest the possibility of their having been bound together to form one instrument. The group from Area 31 contains one fine large specimen 210 by 11 mm. (pl. 41*w*, 1–25855). The others are fragmentary. The pipes and pendants associated with this burial make it unusual. Plate 41*u* (1–25861) shows a piece 185 by 11 mm. with well indicated black markings.

[77] Report of U. S. Geological Survey west of the 100th Meridian, VII, 237, 1879.
[78] *Op. cit.*, pl. 73.

A very problematical piece is presented in plate 42*j* (1–25891). This is a piece of a large bone (deer or elk, or perhaps human) with a hole in it looking like an unfinished whistle vent. Whether this hole was gnawed by animals or represents man's work is doubtful. If gnawed it seems strange that the gnawing would concentrate on so small an area and that no marks of teeth would show on other parts of the bone. It also seems strange that evidences of gnawing should be limited to this single specimen. On the other hand, scratches are observable farther from the vent than seems likely in human workmanship. Whistles made of large bones identified by Nelson as human femur[79] were found in a shellmound at San Rafael, across the bay in Marin county (1–14944–50). These seven pieces were marked with wrappings and asphaltum and two still have parts of olivella inlays (1–14947).

ARTICLES OF CLAY

No evidence of pottery was secured. (One very doubtful exception is noted below.) As this checks with previous investigations, it seems safe to say that pottery was unknown to the users of the mound.

In Area 1, a baked clay ball about 50 mm. in diameter (pl. 54*d*, 1–25543) was found. In trench 3, 26 feet 6 inches deep was a biscuit-shaped fragment of baked clay with an impression on the bottom such as might have been made by a pointed stick (pl. 54*f*, 1–25960). In the same trench at 28 feet deep was a small fragment of fire-baked clay 1–25961). Finally in trench 2 at 27 feet deep was a sun-baked or fire baked piece of mud or sandy clay so shaped that it somewhat resembles a portion of the rim of a vessel (1–25959, pl. 54*e*). Clay balls were made and used in the neighboring delta region where stone was scarce and the two specimens first mentioned may represent contacts with that region. Considering the uncertain shape of the other pieces and their great scarcity the author regards them as incidental by-products of some activity (e.g., cooking) and not intentional artifacts.

A clay mold of a textile is treated under "Textiles."

Articles of European Make

Articles picked up on the surface which were obviously of European make and which were likely to have accumulated through the use of the mound as a park were discarded. Beneath the surface no European artifacts were found.

[79] According to our re-identification these are not human but are elk bones.

ARTICLES OF HORN

Articles of antler or horn were comparatively numerous and were found in the trenches and in the central portion, edges, and perimeter of the mound. The material of the specimens has not been determined in detail but judging from skeletal remains the antlers most frequently used were those of deer.

Cups

The base of an antler cut off, hollowed out, and the edges beveled was found in two instances. The result was a cup-like object about 30 mm. in diameter and 55 mm. long. Specimen 1–26219 from a depth of 23 feet 9 inches is shown in plate 44*i*. Such an article is too small for practical every-day use. It may have been a container though no appearance of paint or other contents was found.

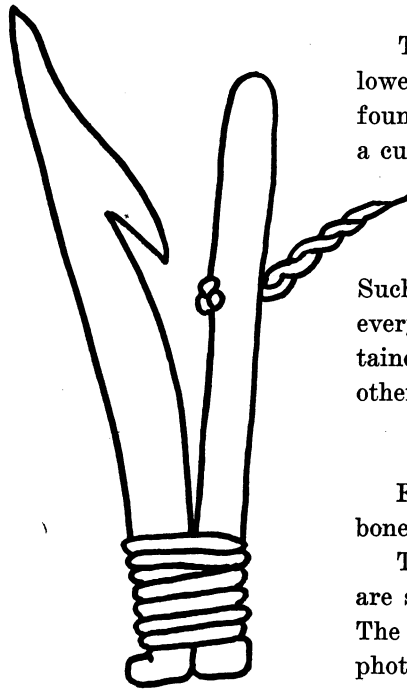


Fig. 4. Restoration of composite fishhook. Natural size of actual barbed elements (1–25907, pl. 9*z*).

Fishhooks or Fish-spears

Fishhooks or spears are made of both bone and horn and are of two types.

The characteristics of the first type are shown in figure 4 and in plate 43z. The point and barb are broken in the photographed specimen (1–25907). The flattened edge where the hook was bound to the second member or to the shaft of a spear, and the notch for holding the binding in place are evident. Their resemblance to equivalent pieces in halibut hooks used by the Tlinkit Indians is so marked that their use as hooks seems reasonable. Only two specimens were found, 1–25907 at a depth of 12 feet in Area 8 and (pl. 43 *hp*, 1–25908) at 15 feet in Area 32. The latter is a fragment which gives evidence of a double barb. These objects do not seem to have been plentiful, although apparently they were not limited to one section of the mound. Plate 43 *fh* (1–26527) suggests a transition from this to the next type, having features of both.

The second type[80] of barb or hook is simpler. This barb is usually a plain, short, double-pointed piece (pl. 43 *s–v* 1–26170–73. See also Uhle, pl. 9, figs. 11–16). The pieces range from 45 to 90 mm. in length and are about 12 mm. in diameter. They are slightly convex in shape. In several cases the point at one end seems to have been worn smooth (fig. 5*a*). At the other end on one side for a distance of *ca.* 15 mm. is a somewhat roughened area (fig. 5*c*); next a smooth area (*b*), then a second roughened area (*c*) and finally the smooth point. Heye (pl. 53) illustrates similar objects except that in his

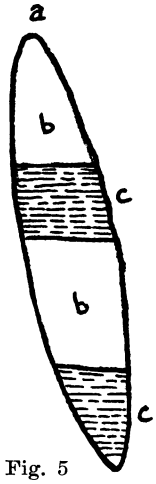


Fig. 5

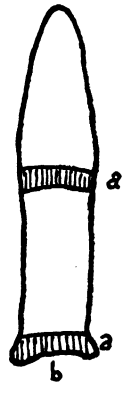


Fig. 6

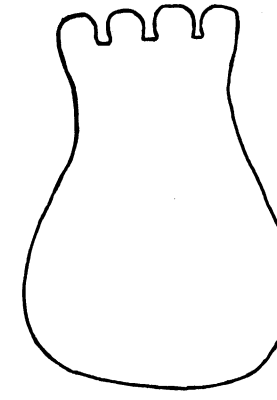

Fig. 7

Fig. 5. Double-pointed horn gorge or barb for composite fishhook (1–26170, pl. 9*s*). Natural size.

Fig. 6. Single-pointed horn gorge or barb for composite fishhook (1–26175, pl. 9*w*). Natural size.

Fig. 7. Outline of abalone ornament (not recovered). One-half natural size.

pictured specimens there are apparently only two areas, a lower blackened or rougher one and an upper smooth area. It seems probable that these blackened areas represent spaces covered by thongs and thus protected from wear. A covering of asphaltum might have further aided the blackening. A probable manner of use is illustrated and described by Heye.[81] Our binding areas, however, make it seem impossible for the specimens to have been used exactly as illustrated by Heye; perhaps rather as the barb in the Eskimo composite hook.

[80] These articles are sometimes called gorges. For example, by W. J. Sollas, Ancient Hunters, 329, fig. 197*b* and *e*, where he shows Magdalenian artifacts of this type. It should be added that Uhle is more inclined to consider them arrowpoints, *op. cit.*, 74–76.

[81] *Op. cit.*, fig. 10, p. 83–86.

In some cases these plain fishhook parts seem to have been modified without approaching the barbed type. Specimen 1–26175 (pl. 43*w*) has slight ridges (fig. 6*a*) where the blackened areas would be expected and there is a shallow notch (*b*) in the base. Specimen 1–26177 (pl. 43*x*) has the blackened areas but a tapered haft. The width (2 mm.) of this last specimen is so thin in proportion to the other dimensions (70 by 10 mm.) that it seems hardly strong enough for a fishhook. Also the upper blackened area seems too near the end.

All eight specimens of the plain type came from trenches 1 and 3. Number 1–26170 was at about the 30-foot depth in trench 1. The most shallow was at 23 feet 10 inches in trench 3. It is possible that this indicates that such hooks were characteristic of the lower portion of the mound although small pieces like these would likely be missed in the steam shovel work.

Plate 43*y* (1–25909) illustrates a doubtful specimen which is discussed under "Fork-like implements."

Flaking Tool

A long (165 mm.) tip of an antler (pl. 42*e*, 1–26220) with the portion near the point very much notched and scarred and the other end smooth as though from handling was found at 29 feet 10 inches in trench 3. This piece is longer and perhaps more pointed than the ordinary flaking tool but it suggests that implement.

Fork-like Implement

A portion of a fork- or hand- or trident-like object (pl. 43*y*, 1–25909) was found associated with skeleton 12–3769. In size and shape it greatly resembles the Chinese "back-scratchers," the shaft being missing in the specimen recovered. Sollas[82] suggests that very similar Magdalenian pieces are gorges or fishhooks. We were inclined to agree with this classification until we examined a similar piece (1–11172) though with 4 "fingers," pictured by Nelson[83] from Ellis landing. The shaft of this specimen is also broken but it is too long to fit the gorge conception. Nelson suggests that the piece is a scratcher, such for instance as might be used during the period when, on her initiation into womanhood, the Indian woman is forbidden to touch her head with her hand. The great antiquity of similar pieces militates against such a localized, ceremonial interpretation. Further, the ends

[82] *Op. cit.*, fig. 195, p. 328. [83] *Op. cit.*, pl. 46, fig. 1.

of the piece show no wear such as would be expected were it used as a scratcher, but on one side there is a definite bevel apparently from such wear as might result from pushing the piece back and forth as a skin-smoother.

Miscellaneous

A number of fragments of antler were found in the trenches which gave definite evidence of having been worked on but were either unfinished or the waste ends. In some cases these were the cut-off tips, in others the base, and again medial fragments, cut off at both ends. The cutting was done by notching about as a boy would cut a stick with a dull knife. One piece (1–26221) was rectangular, having been cut on all four edges, and suggested a gorge in process of manufacture. The tips might have been unfinished pendants such as described below, and the basal fragments intended for "cups." One medial fragment (1–26223) is particularly interesting inasmuch as it came from 31 feet deep in trench 1.

Pendants

Plate 43 *pd* shows a flat, oval, horn pendant (1–26196) found 27 feet 7 inches deep in trench 3. This is the only specimen of its kind that we found.

Pieces of antler (1–26528 and 1–25905) which might have been pendants are shown in plate 43 *k, l*. These are natural tips (43*l* is *ca.* 60 mm long by 12 mm. diameter at base) somewhat hollowed out at the base and with a transverse hole drilled through the base. Arthur C. Parker pictures a similar piece, except for the transverse hole, from Ripley, New York, and thinks that it may have been an arrow head.[84] Number 1–25905 was found with a skeleton not recovered 15 feet deep in Area 27. Number 1–25906 (plate 44*j*) is possibly such a pendant in course of manufacture, or perhaps simply a discarded tip.

Wedges

The most common artifact made of horn was the wedge (pl 44 *a–g*). In the steam shovel work 8 were found distributed pretty well through the central portion of the mound. In the trenches 18 pieces were discovered. These articles were not with burials, with the exception of one (1–25904) in Area 32, 12 feet deep; and more should have been found in the cone unless they were used to a greater extent in the era

[84] *Op. cit.*, pl. 99, fig. 8, 296.

represented by the trenches. A few of the pieces, e.g., 1–26208 (pl. 42*i*) are comparatively long, show marks or scratches on their beveled points, and have ends so little battered that they suggest other uses than wedges. They might have been used to open shellfish or as flakers. One specimen (1–26210, pl. 44*h*) 120 mm. long, being flat and more or less pointed at both ends, may have been a large gorge.

These wedges may be divided about equally into two types.

Type I of which 1–25897, plate 42*h*, is a typical example is a comparatively long natural spike of horn with the tip more or less beveled. The length varies from about 100 mm. to 165 mm. and the diameter from 25 to 50 mm.

Type II is a short length of horn cut off at one or both ends. One end shows a decided bevel and the other end is usually battered from hammering. The lengths range from 75 to 90 mm. and the diameter from 25 to 60 mm. The usual size is about 30 mm. diameter. The piece 60 mm. diameter (1–26013) is an unusually sturdy one, the length being 90 mm. Plate 44 *a*, *b* shows typical specimens (1–25898 and 1–26200).

The distribution between the three trenches was quite even as was the vertical distribution. The deepest wedge found was at 29 feet 8 inches in trench 3. This was a flat piece 120 mm. long by 45 mm. by 22 mm. Regular wedges, however, were at 28 feet 3 inches in trench 1 and at 27 feet 9 inches in trench 2.

It may be observed that most of the battered wedges are too short to be gripped in the whole hand and struck. Also no mauls were found for pounding the wedges.

ARTICLES OF SHELL

In actual number of separate artifacts articles of shell exceeded all other materials. It seems obvious, however, that one should count one string of beads rather than several score of individual beads, or one necklace rather than half a dozen pendants, etc. Even so, the quantity of shell artifacts in the Emeryville mound was still relatively plentiful; but when the location of the site is recalled and the region compared with other regions the scarcity of shell articles is impressive.

Here were a people located on a bay of the ocean procuring much of their sustenance from the sea and handling hundreds of pounds of shell annually. Yet of the forty-one bodies found in the lower part of the mound only eight were associated with shell artifacts. (See table 6.) A similar comparison for the upper part cannot be made

for data do not exist for all the burials there. From table 5 it may be noted that out of sixty-eight cases of observed association between bodies and some form of artifact, fifteen instances were entirely without shell. In other words, while table 5 shows that shell was the most commonly associated artifact, it gives no suggestion of the percentage of total burials without shell. Otherwise, one might conclude that the use of shell was much more general in the latter part of the mound's history. The allowable conclusion seems to be that although shell was the most common non-decomposable material used for ornamentation, apparently not more than 25 per cent of the population possessed shell articles. Further, in most cases the amount possessed was small in quantity. Compare, for example, the few beads found with the Emeryville bodies, with the yards of beads which frequently accompany the bodies in the Sacramento-San Joaquin delta region thirty to fifty miles away.

The poverty of form is almost as striking as the lack of quantity. In the region just referred to the abundance and elaborateness of abalone ornaments is striking. In the Santa Barbara Channel region shell was worked up into a surprising variety of forms, as Heye has indicated. Here at Emeryville one would not be far wrong in grouping all shell objects under two heads: beads and pendant-like objects. The exceptions would be rare and unimportant. Moreover, most of the beads are of the two simplest forms known, the olivella whole-shell and the olivella circular disc bead, although another form did exist in appreciable quantities, i.e., the olivella rectangular disc bead. All the pendants are of abalone shell. Practically all are very simple in form and are rather poorly made. In a limited number of cases attempts at decoration were made. Such attempts consisted either of incising the edge of one side, or of parallel, circular, incised lines.

It seems necessary to account for this paucity of shell artifacts. The first suggestion is that raw material was not in fact as available as at first seems evident. Local shells were apparently not suitable. The olivella and abalone shells used were open-sea shells. To reach the open sea from Emeryville would have required a tedious march of three or four days around the southern end of the bay. An even more difficult march and the crossing of Carquinez strait would be involved in a northern trip. The direct way would be ten miles across the bay to the Golden Gate. Accordingly, the conclusion is that the aborigines did not possess the means or the ability to make such a trip frequently. Yet, if such an explanation is valid, how did it happen that the delta region, more or less behind these people and much farther from the

sea, possessed so many more shell artifacts? Again, the abundance of shell-work reflects the economic status of the people. The Emeryville people had few shell articles because they did not have the means of acquiring such articles through trade.

Shell articles were practically always with burials; and, as has been stated, were the most common burial association. Although so associated they were never "killed." This non-killing of ornaments which could be more easily stolen than other forms of wealth implies that the practice of breaking up certain of the deceased's possessions had already become a definite ritual, and that one is far from the beginnings of such practices.

From the viewpoint of horizontal distribution, shellwork emphasizes the localization of certain types of artifacts. For example: practically all the haliotis shell beads were with one burial; the ring-type olivella bead (pl. 45 *j, k*) was found only in the northwest perimeter;[85] rectangular discs (pl. 45*s*) came only from Area 6; abalone ornaments (pl. 45 *p, q*) were only with burial 12–3738. The distribution of pendants is noted in detail later. Such a distribution may indicate the differences of different makers, or, having a wider basis, which the presence of exceptional pieces (e.g., fig. 7) supports, may lead back to the conception of various groups from different localities visiting the mound.

Vertical distribution does not suggest an evolutionary development during the history of the mound. The practice of inlaying was apparently known from its very beginning. Changes in types of artifacts are noted but these seem equivalent to the horizontal localizations just commented on. For example: the pendants most elaborate in form (type V) do not appear below twenty-two feet deep. But the most elaborately decorated pendants are all from below that level. The occurrence of rectangular olivella beads is suggestive. These beads appear to be a more advanced product than the circular type. They were found only above seventeen feet deep (from 9 to 17 feet to be exact). Apparently the rectangular type is later and did not reach the mound until it had attained half its growth. That it was an intrusion rather than a local development is suggested by the two styles of rectangular beads. These two styles were used as complementary parts of a whole and it seems unlikely that, so related, they would have sprung simultaneously from the circular bead.

[85] A number of similar beads were recently obtained from a site on the Orinda Country Club golf course. This site is over the first range of Berkeley hills and about ten miles from Emeryville.

Beads

Shell beads were found throughout the mound from 6 feet to 29 feet 6 inches deep. In practically all cases they were associated with burials. As there is every reason to think that they were present in many of the burials not carefully examined, suitable data for comments on distribution do not exist. For convenience in discussion we consider only articles less than 17 mm. in diameter as beads; if larger they are discs or pendants. Beads are first classified according to the material of which they are made, and then according to form.

Beads of abalone (Haliotis) shell.—With a burial at 15 feet in Area 8 were a number of centrally perforated abalone pieces varying from circular to rectangular in outline (1–25616, pl. 45 *a, b*) and about 15 mm. in diameter. These were associated with larger abalone discs and with olivella beads. In Area 20 with skeleton 12–3680 at 15 feet was a similar bead (1–25617).

Beads of mussel shell.—Three disc beads *ca.* 7 mm. diameter (1–26053, pl. 45*c*), found at 26 feet 10 inches with skeleton 12–3783 in trench 1, seemed to be of mussel shell. With them were sixty-five or more olivella beads of the same type. It is possible that other beads made of mussel shell were not distinguished by us, but we are more inclined to think that this was an exceptional material.

Beads of olivella shell.—Beads of this material are of three types.

Type I.—These are whole olivella shells with the spires ground off. Plate 45 *d, e* shows a typical specimen (1–25628). Twenty-six lots were recovered. The average bead is from 10 to 13 mm. long; but pieces as small as 6 mm. and as large as 25 mm. were seen. In one lot (1–26057) the range was from 7 to 25 mm. and it seems probable that they were strung or arranged in some kind of a design. Another lot (1–26058) of more than one hundred pieces was well covered with red paint. The beads were all about 22 mm. long. This large number of large beads seemed to have been sewed on a cape or garment of some sort which covered the shoulders and upper portion of an infant (12–3793). Another infant (12–3794) which lay at the same level (24 feet deep) and about four feet away was also accompanied by a large number of these beads (1–26059). The lowest shell bead found was of this type—a single bead at 29 feet 6 inches (1–29061).

Type II. Olivella disc beads.—These are the common circular bits of olivella shell, ranging in diameter from 2.5 to 15 mm., and centrally drilled with a biconical hole. Plate 45 *f, g* shows a typical specimen

(1–25654). Thirty-eight lots were recovered from the cone and only three from the trenches, which appears to indicate a relative scarcity of the type in the lower portion of the mound. All beads of this type found were with burials. Moreover, it was the most common association and was frequently the only artifact that appeared in a burial. But in many cases it was associated not only with other artifacts but also with other types of beads. In some cases they were present in lots of 500 to 1000 pieces and were probably not all recovered even then.

The position of the beads was usually near the head, sometimes apparently haphazard as though strung and wrapped around the skull, and in still other cases "shingled" or set in position as though they had been sewed on something. In most cases a head covering or ornament of some kind was suggested though in a few cases a necklace or shoulder covering might be implied. Beads were also found in the mouth and ears.

Some of these beads were in such poor condition that it was impossible to handle them; on others the luster was still bright. Some were covered with red paint, some showed traces of asphaltum or other material forming a yellowish film; some were perfectly clean. Condition and depth had no discernible relationship.

Three styles or subtypes of these beads may be readily identified. There is first what may be termed the regular style wherein the diameter ranges from 6 to 15 mm. In the larger ones there is a marked curvature (natural in the shell) and the outline is somewhat irregular. The smaller beads are much flatter and the outline is more even although it may range from circular to almost rectangular. The second style consists of the "inlays or bushings." Diameters here are from 2.5 to 6 mm. The beads are quite flat and the whole is proportionally large. Plate 45 *h, i,* show a typical specimen (1–25659). Beads of this style were scarce (4 lots recovered). Also they are far from being the only beads used in inlay work. For example see Uhle's plate 2. Style three is almost a ring. The bead is well made and the hole is very large proportionally and does not disclose biconical drilling. The specimens (78) are too definitely true to style to permit the assumption that they are accidental forms. This style was found only in the northwest perimeter of the mound where three lots were recovered. Plate 45 *j, k,* show a typical specimen (1–25682).

Type III. Rectangular olivella beads.—These beads, also made of the walls of the olivella shell, offer interesting contrasts to the circular

bead. Generally speaking, they show a great deal more skill, having good straight edges and square corners. The hole is placed with more care and as nearly as can be determined it is drilled from one side only. Plate 45 *l, m,* show a typical specimen (1–25688). Twenty lots were recovered at depths ranging from 9 feet to 17 feet. One lot (1–25693) contained over 700 pieces. None, it will be noted, came from the trenches where the circular beads were also scarce. These rectangular beads were frequently used in overlay or shingling, their position in the work being often visible. In at least three cases this inlay was on the skull, suggesting a head covering (e.g., 12–3702).

There is some variation in sizes of these beads. The largest was 8 by 10 mm. and the smallest 3 by 6 mm. The most striking difference in form, however, consists of the relation of width to length. In one group of beads, by far the most numerous, the width is more than half the length, in others it is not and the beads appear slender. A comparison of plate 45 *l, m* (1–25688) and *n, o* (1–25699) will make the difference clear. Such difference was doubtless intentional for the two styles were utilized in producing designs.

Discs

The distinction made here between a pendant and a disc is simply that the disc is not perforated. The only shell discs recovered were made of abalone (*Haliotis*) shell. Their distribution was limited and all were associated with burials. Two types may be considered.

The first type (pl. 45*s*, 1–25598), which is of a generally rectangular shape, was the most numerous (12 lots recovered). Sizes range from about 47 by 48 mm. to 55 by 75 mm. The two shorter edges are often decorated with light notches. All pieces of this type came from Area 6 at depths of from 9 to 13 feet. In one case (1–25600) the pieces were over the face of a skeleton (12–3618), and in the other cases the association with the head was intimate.

The second type is made up of circular pieces (pl. 45*t*, 1–25610). The distribution is more uneven as we obtained one lot from each of the following areas, 8, 10, 26, 31. The depths were from 10 to 16 feet. In all cases the edge appears to have been decorated by notching.

No. 1–25618 (pl. 45*r*) gives an indication of what may have been a common practice—the ornamenting of a disc by setting olivella disc beads thereon by means of asphaltum.

Miscellaneous

Six rectangular ornaments of abalone shell (1–25619, pl. 45*p, q*) found with burial 12–3738 at 13 feet are out of the ordinary since they are drilled at both ends and one piece has six holes.

With three different burials large open-sea clam (*Schizothaerus nuttallii*) shells were found. No other such shells were seen in the mound. In one lot (1–25707) were five pieces. This appearance only with burials would appear to indicate that these shells were indeed rare. This conclusion is made reasonable by the fact that this species is not found in the bay waters and must have been obtained from the seashore outside the Golden Gate. On the hinge of one of the valves barnacles have grown, which would seem to indicate that the shell, not the shellfish, had been collected by its former possessor. In all, these shells suggest visits to the open sea but at the same time imply the rarity of such visits.

A similar suggestion is offered by a salt-water mussel shell of a species not common in the bay which was obtained in trench 2 at about 25 feet. Of course abalone shells also had to be obtained on the seacoast.

Pendants

The only shell pendants found were made of abalone (*Haliotis*) shell. They were found only with burials and generally over the eyes or face. In almost every instance the pieces were exceedingly fragile and consequently a number seen could not be recovered and many of those obtained are in fragmentary form. The holes are usually biconically drilled. All abalone pieces seem to have a stain (or patina?) of a brownish hue. This will wash off.

In considering distribution the concentration in a few burials should be noted. For example, twenty-two pieces of abalone (all pendants) were identified in the trenches. In the same trenches were forty-one bodies. Of these six had abalone associated with them as follows:

Skeleton 12–3784, 6 pieces of abalone; 12–3789, 8; 12–3792, 2; 12–3793, 2; 12–3794, 1; 12–3814, 3. It will be seen from this how treacherous quantitative or distributional generalizations are likely to be.

Pendants may be divided on the basis of form.

Type I. Rim type.—This type of pendant is made from the heavy rim of the haliotis shell, and preserves some of the crescentic shape of that rim. One specimen (pl. 46*a*, 1–25557) of this type was found with skeleton 12–3662 in Area 18 at 3 feet. It is 13 by 110 mm. and is drilled at one end. Other pendants of this type are shown in Heye, plate 78.

Type II. Dagger type.—These pendants are long, slender, somewhat dagger-shaped, and drilled at the non-pointed end. A typical specimen (pl. 46*c*, 1–25568) has a notched design around its inside (nacrous) edge. Sixteen pieces were found of which five were from the trenches, the deepest pieces (1–26032–33) being with skeleton 12–3784 at 26 feet 8 inches deep. Three were with skeleton 12–3814, one of which was very slender and the other quite broad. In the cone, specimens ranged from a depth of 3 feet to 15 feet and came from the following areas: one each, Areas 20, 21, 24, 36; two each, Areas 10 and 26; three, Area 6. In two cases (1–25567–26036) there were two holes in the specimens instead of one.

Type III. Rectangular type. — This type (pl. 46 *e, f, g, h, i,* 1–25570–71, 1–25576) generally has straight sides and square corners. It is variable in size. The end is not pointed. The hole is in different places. No specimens of this type were found in the trenches. Those in the cone were distributed as follows: depths 8 feet to 15 feet—one each in Areas 9, 35, 36; two in Areas 6, 21, 36; four in Area 20. Some specimens are decorated with the light notches around the edge. Specimen 1–25574 has the drilled hole in the center, 1–25575 has two holes at one end, and 1–25576 has three holes at one end.

Type IV. Rough outline.—This type is represented by the specimen (1–25577) shown in plate 46*j*, from Area 26 at 4 feet. The distinguishing feature is that the outline is not only irregular but it is not shaped.

Type V. Irregular outline.—In this type the outline is irregular but it is shaped and is inclined to be symmetrical. The base is broad, the top more slender with two projections somewhat like horns. Plate 46 *k, l* show a typical specimen (1–25579). The edge is usually decorated with notches, the hole is in the base, i.e., the broad end. In some specimens there is more than one hole (1–25580, pl. 47*k*, 3 holes in base; 1–25584, pl. 47*o*, 5 holes at top and one at base; 1–25585, pl. 47 *m, n* 4 holes in top). No pieces of this type were found in the trenches. The distribution in the cone was: depths 8 feet to 17 feet—one each in Areas 19, 25, 31, 32, and four in Area 9. The most

elaborate specimen of this type noted by us was recovered by others. It is shown in outline in figure 7. Pendants somewhat of this type are common in the San Joaquin–Sacramento delta region.

Type VI. Circular type.—This type is distinguished by being circular or oval in outline. The diameter ranges from 17 mm. to 60 mm. The inside edge is nearly always notched (pl. 46 *p, r, s*). The hole is usually near one margin. One specimen (1–25596) was noted with three holes. Plate 46 *m–o* show characteristic specimens (1–25587). Plate 46*p* had some adhesive material (asphaltum?) around the rim (1–25592) suggesting an inlay with olivella beads like that more definitely shown in plate 46*q* (1–26044). Plate 46 *r, s* (1–25595) show a large size. Distribution in the cone was: depths 8 feet to 16 feet—one each in Areas 20, 35; two in Areas 9, 26, 31; three in Area 10; six in Area 32; ten in Area 36. The distribution in the trenches has been touched upon in the introductory remarks to pendants. Skeleton 12–3789 was not only supplied with a number of abalone pieces but they showed variety. Plate 46*t* shows specimen 1–26038. This specimen is about 60 mm. diameter with a 7 mm. hole. It is incised with two pairs of roughly parallel lines about 3 mm. apart on the lustrous side. This design is interesting because it is the only one used for decorating the abalone pieces except the slight notches above mentioned. Another specimen (1–26039) with skeleton 12–3789; two (1–26044–45) with the infant 12–3792; one (1–26049) with the infant 12–3793; and a very similar design (1–26051, pl. 46*u*) with 12–3793 represent the most definite attempt at design that we saw. It is interesting that such an attempt appears in the lower levels (24 feet to 25 feet 11 inches) and the similarity supports the supposed relationship between articles of this general level in the trenches. The location of the pendants about skeleton 12–3789 was as follows:

1–26038, incised line design, central hole, 60 mm. diameter	In crotch.
1–26039, incised line design, central hole, 42 mm. diameter	In abdominal cavity.
1–26040, two small marginal holes, 40 mm. diameter	Near right knee.
1–26041, central hole, 35 mm. diameter	Under pelvic bones.
1–26042, central hole, oval, 20 x 15 (2) mm. diameter	Under ribs.
1–26043, central hole, 30 (2) mm. diameter	Near left knee.

See burial 12–3789 for further comments.

A variation of the circular type wherein the central hole is so enlarged as to make the piece a ring was noted. Four specimens were

near the head of skeleton 12–3784. The diameters and holes were 35 x 15 mm.; 25 x 15 mm.; 35 x 20 mm. A similar piece, 30 x 15 mm., was found with the infant 12–3793.

Vessels

Five more or less entire abalone shells (*Haliotis californiensis*) were recovered, two in association with burials. These may have been raw material, or they could have been used as vessels, containers, scoops, etc. (See Heye pls. 73, 74, fig. 22, fig. 23.) One specimen (1–25621) apparently had olivella disc beads stuck to its inside; 1–25622 showed some evidence, in the form of light notches, of having been worked; 1–25624 was soiled as though by previous contents.

ARTICLES OF STONE (CHIPPED)

Arrowpoints, Spearheads, and Knives

Form.—The artifacts of this class found at Emeryville may be grouped on the basis of form as follows:

Type	Characteristic form	Plate 48	Quantity
NAa	Not stemmed, leaf-shaped, pointed at both ends	*h*	2
NAa(?)	Probably same as above but specimens incomplete		5
NAb1	Not stemmed, leaf-shaped, pointed at one end, convex base	*f*	4
NAb2	Not stemmed, leaf-shaped, pointed at one end, straight base	*g*	2
NA—	Not stemmed, leaf-shaped. Further determination impossible		2
SAa	Stemmed, contracting stem, shouldered only	*a*	2
Unidentifiable fragments			9
			26

This tabulation is based on the scheme followed by Gifford and the author in working up material from the upper San Joaquin valley.[86] There it was necessary to develop eighteen regular types and several special ones for classification. This is in marked contrast to the situation at Emeryville where consideration will show that there are even fewer types than would seem apparent from the table. As many of the specimens were poorly made or damaged by use, detailed classification is difficult so that it is probable that all the NA group specimens listed should be taken as having been intended for the same type of point. It will be noted that these differ only with

[86] Archaeology of the southern San Joaquin valley, present series, XXIII, 1–122, pls. 1–34, 1 map, 1926.

reference to one end, which may be sharply pointed, convex, or straight—a neat distinction to make in many cases. A number of the unidentifiable fragments are parts of large, rather than small, blades and hence also probably of the NA group. In short, it would appear that we would commit no essential error if we decided that the Emeryville inhabitants used but two types of chipped stone arrowpoints or spear points; (1) a small, stemmed type (SAa) which occurred very infrequently; and (2) a larger, leaf-shaped, non-stemmed type generally pointed at both ends (NAa).

Type SAa.—The two specimens found are both comparatively small (1–25505, pl. 48*a* and 1–26006, pl. 48*b*). This smallness coupled with the fact that they are stemmed and shouldered leads one to regard them as arrowpoints. The collections of Uhle, Nelson, and Loud bear out the fact that the stemmed type was much less frequent in the bay district. In the Alpaugh region of the upper San Joaquin valley the non-stemmed type predominated. In the lake region of the same area type NBb (non-stemmed, triangular, concave base) constituted 45 per cent of all points. In the Dalles region of the Columbia river, type SB (stemmed with parallel-sided stems) constituted almost all the points. Attention is called to the heavily serrate edges of 1–25505.

Type NAa.—Plate 48 illustrates a number of these point s(1–25452, 1–25455, 1–25456, *d–f*, type NAb1; 1–25457, *g*, type NAb2; 1–25451, 1–25460, 1–26000, *h–j*, type NAa). These are large, sturdy points as a rule; so large, indeed, that it seems impossible to regard them as arrowpoints.

Material.—Of the twenty-six points, twenty-three were made of obsidian and three of a deep chocolate-colored, white mottled flint. This flint is quite different from the chert which was common in the mound in the form of raw material. No points were found made of that chert. These flint blades were fragmentary but appeared to be of the same type, i.e., NAa (1–25997, pl. 48*k*). All were from the trenches, two from trench 2—one at 23 feet 8 inches deep and the other at 23 feet 5 inches deep with skeleton 12–3795; the third from trench 1 at 26 feet 9 inches deep with skeleton 12–3791. They appear to represent an early intrusion which was not subsequently repeated. Obsidian, the usual material for these artifacts, does not occur locally. The nearest supply was probably some distance north of the bay. A few pieces of raw material were found in the mound in the shape of water-worn obsidian pebbles (1–2546, pl. 54*i*). As these were found associated with burials, more than ordinary value was evidently placed

upon it. Obsidian chips were noted here and there, one from as deep as 29 feet 6 inches. The chips from their smallness and scarcity suggest breakage in use rather than an indication of the manufacture of points. All in all, one is inclined to think that these points were brought in or traded in from the north where they were made.

Workmanship.—The workmanship exhibited by the points is fair at best.

Distribution.—The distribution of the flint points has been noted. We now take up the twenty-three of obsidian which may be tabulated.

Area	Depth	Quantity	Association
General surface		3	———
Area 6	13′	1	With skeleton
Area 6	13′	1	With skeleton 12–3616
Area 6	?	1	———
Area 8	?	1	———
Area 17	13′	1	With skeleton
Area 26	11′	2	With skeleton 12–3708
Area 33	16′	2	With skeleton
Area 40	?	1	———
Trench 1	26′ 4″	1	
Trench 2	24′ 9″	1	With skeleton 12–3800
Trench 2	25′ 10″	6	With skeleton 12–3801
Trench 2	29′ 7″	1	———
Trench 3	27′ 7″	1	———
		23	

Fourteen of the twenty-three were found with skeletons. Since the others were not all found in place it is probable that nearly all, if not all, these points were originally buried with bodies. This concentration is very remarkable and is emphasized by the six pieces (nearly 30 per cent of the total found) with a single burial (12–3801). In other words, the entire collection from the mound points to less than a score of users of such points. Even allowing for what was overlooked and taking a minimum age of 1000 years for the mound this paucity of hunters or fighters equipped with such simple weapons is indeed extraordinary. This scarcity of points is an outstanding feature of the bay mounds. The results of the investigations of Uhle, Nelson, and Loud are more or less analogous to our own. These are artifacts usually collected by "relic hunters," yet even by the early settlers in this district the scarcity of points was noted.[87] Such artifacts are usually comparatively plentiful in aboriginal sites in California which have been dealt with archaeologically. The abundance

[87] Thompson and West, Historical atlas of Alameda county, 15, 1878. "The arrowheads found here are usually of obsidian." There is a "scarcity of weapons of warfare."

of similar points in the counties north of the bay again leads us (as did the material) to attribute the origin of the Emeryville points to that region.

The fact that a goodly portion of these points were actually left in the wounds (pl. 48*o*) of the individuals with whom we found them shows that they were not the property of the person buried. This lends weight to the hypothesis of their foreign origin, suggesting that they were brought in by enemies and left as the result of fights. In this way, it is likely that other points as well came into possession of the mound-dwellers.

The horizontal distribution indicates a rather widely distributed use.

The vertical distribution is more interesting. Number 1–26006 (pl. 48*b*), as well worked a piece as any found in the mound, was from a depth of 29 feet 7 inches, another from a depth of 11 feet. Apparently then, knowledge of obsidian points was possessed from the earliest days of the mound to well toward its end. When such a piece as 1–26006 occurs practically on the bottom of the mound the question as to whether or not chert chips were eoliths seems aside from the point.

Usage.—As has been suggested only two or three of the points found seem suitable for arrowheads. Since points were made but arrowheads were not, we conclude that the bow and arrow was not popular. The other points could have been used as knives or spears. The fact that 1–26004 (pl. 48*l*) was apparently held in the hand of skeleton 12–3801 during a fight suggests its use as a knife or dagger. On the other hand, the nature of the wounds inflicted makes the use of these points as spears seem more probable. Number 12–3801 might have grasped the head of his enemy's spear in the course of the fight. Spears were apparently more popular than the bow and arrow. Our evidence would further suggest that they were used in war rather than for hunting. Indications of slain game are plentiful and if chipped stone had been used for this purpose it should be more abundant. The lack of such weapons in hunting might help explain the practical absence of any skeletal material of bears and other carnivores which were numerous in the vicinity.

Scrapers and (or) Knives

Only two articles of this class were found (1–25450, pl. 48*p*, and 1–25998, pl. 48*q*). Both are of the type that have a shaft or handle, i.e., more or less gouge or chisel-like.

Specimen 1–25450 was made of gray chalcedony, 1–25998 of greenish chert. This last piece is of particular importance since it is the only specimen made of the chert material plentiful in the mound in its raw state. This may have been because the material was hard to work or it may indicate that chipped implements were usually made in some other spot where a more suitable material (notably, obsidian) was available. The amount of chert of this nature in the mound has been mentioned and the possibility of the chips being eoliths or the refuse of a workshop has also been discussed. Hence it may simply be repeated here that if this chert was as widely worked into artifacts as the chips would suggest if made by man in manufacturing points, knives, etc., it seems remarkable that only a single specimen representing such manufacture should be discovered.[88] It is possible that on account of its brittle nature the aborigines in making scrapers tried to substitute tougher materials for obsidian which was generally used for their points.

The workmanship exhibited by these specimens is fair.

Specimen 1–25450 was found in Area 25 at eleven feet deep not in association with anything. Number 1–25998 was 25 feet 10 inches deep in trench 2, with skeleton 12–3801, with which were also associated six obsidian points. This gives the contemporaneous use of obsidian and chert. The chalcedony was found at a depth of eleven feet. Apparently from the beginning both chert and obsidian were known to be suitable for chipped implements. Obsidian was preferred and other material used only infrequently or for special objects. The material from Stege and Ellis landing indicates the same practice there.

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[88] A possible exception to this statement is 1–8815 found by Uhle. This is a portion of a point made of red chert. Uhle's specimen 1–8929, possibly an awl, was made from a chip of quartz. Uhle's other specimens we would call chips, not artifacts. See his pl. 6.

Loud found only one flint artifact at Stege as against 11 obsidian ones. At Ellis landing the proportion of non-obsidian artifacts was low, although Nelson does not give exact quantities.

TABLE 9

EMERYVILLE MORTARS

Type	I	II	III	IV	V
Diameters	Upper and lower about equal	Unequal: lower smaller	?	Greatest diameter at neither top nor bottom	Uncertain
Height	Much less than diameter	Much less than diameter	?	Less than diameter	Less than diameter
Sides	Concave	Straight	?	Convex	Irregular
Lip	Flat: square corners, outward slope	Flat: square corners; *no* outward slope	?	Rounded and thin	None
Rim	*ca.* 40 mm. thick	25–40 mm. thick	?	*ca.* 25 mm. thick	Small hole in large pebble
Base	75–150 mm. thick	40–100 mm. thick	40–100 mm. thick		
Bottom	Flat	Flat	Flat	Rounded	Irregular
Usual size	Over 400 mm. diameter	150–510 mm. upper diameter	Lower diameter 300–400 mm.	Medium	Extremes
Finished	All over	All over	All over	Exterior indifferently	Inside only
Workmanship	Excellent	Good	Good	Fair	Poor
Illustrated	Plate 49*b*	Plate 50*a*	Plate 50*b*	Plate 50*c*	Plate 49*a*
Typical specimen	1–25323	1–25531	1–25337	1–25343	1–25349
Quantity recovered	3	23	7	10	8

ARTICLES OF STONE (GROUND)

Mortars

Forty-seven mortars were recovered in the steam shovel work, and four from the trenches. A number of other mortars were noted but were acquired by others. It seems probable that practically all the mortars in the cone were observed and that the number was not far from 80, or one mortar to about seven bodies.

With the exception of three pieces in Area I and one in Area 30, the thirty located pieces were from the areas within the hedge. Nine were from Area 10; otherwise the distribution was rather even. Data for vertical distribution are insufficient. The highest was 7 feet, the lowest 28 feet 6 inches deep.

Most of the mortars were made of basalt or fine sandstone. Mortars of unidentified stone were also noted but none of granite were seen. This material suggests either the neighboring Berkeley hills or the mountains north of San Francisco bay as sources of supply.

In size the mortars varied greatly. The smallest was 90 mm. diameter; the largest 500 mm. diameter by 290 mm. high. The great majority were about 300 to 400 mm. diameter. The smallest piece (1–25914, pl. 54*m*) was also from the lowest depth (28 feet 6 inches) and was associated with a pestle.

On the basis of form we have divided the mortars into five types. Characteristic features of these are given in table 9 and typical forms displayed in plates 49 and 50. Since these types converge it is difficult to classify some specimens. Type III should perhaps be more properly included in the other types.

Type I.—Specimens of this type seen are of porous, gray basalt. The superiority of workmanship should be emphasized. The symmetry of form and the excellent finish, taken in conjunction with the large size, implies a most thorough mastery of technique and a very high degree of mechanical skill. Six mortars of this type were noted and three recovered, one each from Areas 10, 30, 35.

This type is also reported from Sonoma county just north of San Francisco bay.

Type II.—Mortars of this type were generally made of the Franciscan basalts or sandstones. The workmanship was in many cases excellent but more variable than in type I. The lower diameter is

frequently very much smaller than the upper. The size varies greatly. The next to the smallest specimen found (150 mm. diameter by 120 mm. high) was of this type. Also the largest diameter noted, 510 mm., was of this type. This was the most popular type, twenty-three out of fifty-one classified specimens belonging to it. These were quite evenly distributed.

Type III.—These are "killed" mortars, i.e., mortars deliberately broken, presumably at the time of burial of their owners. That the breaks are deliberate is adduced from these facts. The pieces broken off the sides resemble one another in size and shape so as to suggest their having been broken off by similar strokes from the same implement, e.g., pestle. They vary from three to eight to a mortar. In several cases pieces were discovered near the broken mortar which fitted it, indicating that it had been moved little if any after the breaks were made. The number of similarly broken mortars seems to preclude accidental breaking. This breaking has been used as the criterion for classification. All these specimens, however, belonged to types II or IV before being "killed" and it seems probable that most of them were type II. Specimens found were scattered in the central portion of the mound.

Type IV.—This type is meant to include the bowl-like specimens. The sides are usually definitely convex though sometimes they are straight. The base is also variable for while it is usually more or less rounded or pointed, specimens with a flat base were found. The quality of workmanship is also variable. As a rule the exterior is not symmetrical and is not well finished. Ten specimens were found, one each from Areas 1 and 10, two from Area 9; three from the trenches; and three uncertain. This seems to indicate a limited distribution in the mound.

The type is particularly interesting because of its frequent close association with human bones. In several cases part of the skull or skeleton was actually in the mortar (1–25354); or it was on the chest (1–25911 on 12–3784); again it was inverted over the skull (1–25912 on 12–3817). In this last instance a second, similar mortar (1–25913) was inverted over the pelvis. These are only typical instances as other cases where specimens were not recovered were noted.

Excepting a small "paint"(?) mortar the only mortars found in our trenches were three of type IV (the three last mentioned above) and these approached type II in having a flattish base and a fairly

well-shaped and finished exterior. Mortars of this type showed variation in material.

Type V.—These are mortars made from large pebbles, small boulders, or irregular masses of material. The hole is small compared to the mass of the mortar. The shape is irregular and the exterior is very slightly finished or more frequently not at all. The range in size is from large specimens to the smallest one (1–25914) recovered. The small so-called paint mortars are likely to be of this type. Number 1–25918 from 28 feet 6 inches in trench 2 is apparently a pebble in which a mortar was being started. Marks of red paint were all around the edge. The seven pieces found show an even distribution. The material varies as in type IV. Mr. E. J. Dawson of Lodi, California, states that small mortars of this type are most common in the Lodi–Stockton area.

Several mortars were noted with flattened areas on their sides (e.g., 1–25350, 1–25911) as though this area had been used in some grinding or polishing process. Many specimens had the rims worn into grooves as might be expected from pestle action, and two were seen where holes had been worn clear through the bottom by ordinary use. The small specimen 1–25914 has sides and a base which suggest a muller.

Mortar 1–25333 (type II) is particularly notable. This fine mortar had a design on its lip formed of various sized rectangular olivella shell beads set in asphaltum. Both the mortar itself and this decorative attempt reveal a marked aesthetic sense.

In addition to complete mortars a number of mortar fragments were collected from the trenches. Many of these had been used as firestones. These were found to the lowest depths and suggest naturally that mortars were used very early in the mound's history, perhaps at its very beginning, but also that they were used by a people familiar with them before they settled when the mound now is.

Pestles

Pestles of various stones were found throughout the mound—fifty-two in the shovel work and ten in the trenches. These may be divided into four types as shown in table 10.

Type I.—The longest piece noted had a length of 200 mm. The greatest diameter was 100 mm. Only one piece was found outside the central portion of the mound. Two were in the trenches: one

TABLE 10

EMERYVILLE PESTLES

	Type I	Type II	Type III	Type IV
Length	Short and stout	Short and stout	Comparatively long	Comparatively long
Cross-section	Elliptical	Circular	More or less circular	Irregular
Ends	Same size: both used for pounding	Slight or no taper: both used for pounding	One end pointed: only one end used	Both ends used
Typical specimen	1–25376	1–25380	1–25412	1–25420
Illustrated	Plate 51*b*	Plate 51*c*	Plate 51*a*	Plate 51*d*
Quantity	10	15	29	8

(1–25923) near skeleton 12–3778 at a depth of 26 feet 7 inches; the other (1–25924) with mortar 1–25914 at a depth of 28 feet 6 inches. Both these are small (*ca.* 50 x 100 mm.) and 1–25923 shows red paint ingrained in the ends. Hence they were probably paint pestles.

Type II.—These ran in about the same sizes as type I. They were found on the edges as well as in the central areas. Six were in the trenches. One of these (1–26927) was imbedded in ash under the head of skeleton 12–3795. A fragment of another was one of the deepest artifacts found—30 feet 4 inches. It is possible that this type simply represents specimens of type III worn down by use. It is interesting to note that this type is most numerous in the trenches whereas such was not the case higher up.

Type III.—These were found throughout the mound and one rather flattish specimen (1–25932) was recovered from trench 2 at 28 feet 3 inches. Lengths averaged from 200 to 330 mm. and the average diameter was about 50 mm. Inasmuch as one end shows a tendency to specialization these might be regarded as the most elaborate pestles, but in excellence of workmanship they do not surpass many of the carefully fashioned specimens of types I and II. One specimen (1–25407) in its end specialization shows the so-called phallic end. It will be noted that this was by far the most frequent type.

Type IV.—These pestles are so irregular that it is often doubtful whether they were pestles or hammerstones. As both ends show use and the length is considerably greater than the diameter (maximum specimen 310 x 120 mm.) we have considered them pestles. They are natural pieces of rock and give no evidence of having been fashioned whereas types I, II, and III have all been shaped. Such specimens were found mostly in the western half of the mound. One specimen was recovered from trench 2 at 27 feet 6 inches.

In addition to complete pestles the number of pestle fragments (many of which had been used as fire-stones) in the trenches showed that this article was in common use in the early history of the mound.

Fragments of a pestle were noted which suggested that it had been "killed."

While the material of which the pestles was made is varied, there is nothing about it to suggest that it could not have been procured in the Berkeley hills.

Pipes

Form.—Six pipes, presumably for smoking tobacco, were secured. One is in fragmentary condition. The other five (1–25498–99, 25500–01–03) are shown in plate 52. All these pipes are of the tubular variety but no two are alike in detail and there is a tremendous range in size. Figure 8, giving the main outlines and comparative sizes, with plate 52, will best make these variations clear. Since practically all the pipes used in California, except in the northeastern part, are of the tubular type this feature is of little assistance. Pipes similar to 1–25498 (pl. 52*f*) are found in modern times in central California (e.g., 1–4083, Madera county). Numbers 1–25499 (pl. 52*e*) while differing considerably in proportions has about the same capacity and was apparently likewise adapted for the insertion of a bone stem or mouthpiece. Number 1–25500 (pl. 52*c*) resembles specimens from Santa Barbara. Nos. 1–25501 (pl. 52*b*) and 1–25503 (pl. 52*a*) resemble one another and are large, handsome pieces. On account of their size and material it is to be expected that they would resemble Santa Barbara channel types but they do not. Loud procured two specimens of similar form from the shores of northwest California. The five pipes secured by Uhle at Emeryville are also all of the tubular type and differ from one another and from ours. Hence they carry out the impression of entire lack of uniformity in these artifacts. Of the three specimens from Ellis landing one is cup-shaped somewhat resembling 1–25499 and the other two approach our specimens 1–25501–03 but are not the same.

Since three of these pipes (1–2500–01–03) were with one burial the three types represented were contemporaneous. Considering this fact together with the diversity of form, the questionable value of comparing our small series with those from other regions is emphasized. Pipe forms or ideas of them might have arrived through trade, but it seems clear that there was no predominant type and that individual taste and skill in manufacture were important factors. This indication is interesting when applied to such items as charmstones where the use is not definitely known and where the diversity in form has caused much speculation.

Mr. E. J. Dawson has kindly supplied me with data concerning the pipes in his collection from the Mokelumne-Sacramento river region and in the Barr collection from Stockton. Both collections exhibit the same variations as those commented on above. In both could be found specimens reasonably similar though not identical to those in our collection. While both collections are richer than ours, all our general comments concerning pipes would apply as well to this delta material.

Material.—Four of the entire specimens are of steatite as is also the fragmentary specimen. As four of Uhle's pipes and all three of Nelson's from Ellis landing were of similar material, it seems obvious that this was the favorite material for pipes in the bay region. Number 1–25500 is of fine grained sandstone; 1–25499 has been coated apparently with white paint or has acquired a heavy incrustation both

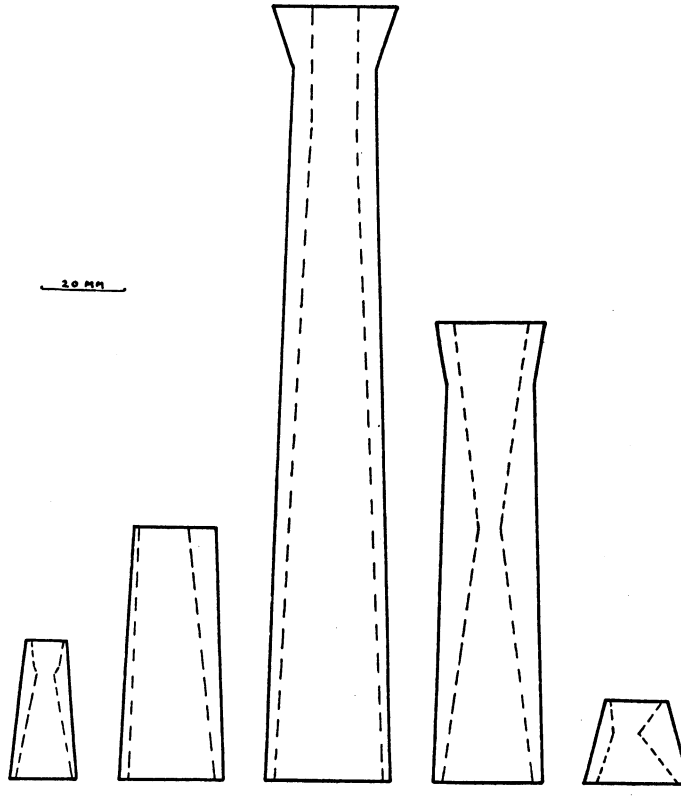


Fig. 8. Pipes. Diagrammatic drawing of outline and boring. See plate 18.

inside and out. The steatite of the other pieces does not resemble that found near Stege; this difference may be due to the fact that the pipes are highly polished.

Workmanship.—Considerable variation in skill is shown. In all cases except 1–25499 the exterior is well shaped. In 1–25499–500 the holes are eccentric (fig. 8); in others they are well done. The drilling was apparently from both ends except in 1–25500. Number 1–25498 pl 52*f*) is incised with two rather poorly executed lines around the stem end; 1–25501 (pl. 52*b*) is ornamented with a deep, regular groove

where the neck swells to the mouthpiece. Specimens 1–25501–03 because of the sureness of execution and perfection of form are much superior to the other specimens.

In addition to the aesthetic effect secured by the worked stone itself specimen 1–25501 still bears the impression in adhesive material of two rows of small, rectangular olivella beads set around the neck near the mouthpiece. Number 1–25499 also has two circular olivella beads still stuck to its side. Whether these are remains of ornamentation that existed during the use of the pieces, or whether they indicate the preparation of the pieces for burial is not clear. In support of the latter view it may be noted that 1–25503 has a considerable amount of red paint adhering to it.

Distribution.—It is to be regretted that the series of pipes is so small that the several interesting indications it offers cannot be more strongly emphasized. The data may be tabulated.

Museum No.	Area	Depth	Associations
1–25498	26	11′	Skeleton and other artifacts
1–25499	27	15′	Skeleton and other artifacts
1–25500	31	16′	Skeleton and other artifacts
1–25501	31	16′	Skeleton and other artifacts
1–25503	31	16′	Skeleton and other artifacts
1–25533	32	17′	Skeleton and other artifacts

In the first place it will be noted that not only were all pipes with burials but that all such burials had other artifacts. This suggests that owners of stone pipes were people of more than ordinary importance. This is emphasized by the fact that three out of the five pipes were with one body. Nelson's pipes at Ellis landing were similarly associated but Uhle makes no mention of his pipes having been associated with burials.

Next it will be observed that all the pipes are from one region of the mound. However, Uhle's finds were in quite a different region although they were also localized. This horizontal distribution suggests that the pipes were brought in by groups who visited the mound occasionally and that all groups who visited the mound did not have stone pipes. In other words, it points to a non-continuous residence on the mound and the probability that the groups which frequented it came from divers places.

The vertical distribution will bear the same interpretation. Our greatest variation is from 17 feet to 11 feet deep. The time interval represented might well cover only the period when a given group was frequenting the site. Uhle's finds were all in his stratum II, i.e., 5 to 6 feet deep. So we have the same suggestion. At Stege no pipes

were procured. At Ellis landing two pipes were together and they were within 25 feet of the third one, horizontally but about 13 feet vertically—possible accounted for by the slope of the then cone.

This localization of pipes might bear an even closer interpretation to the effect that only a limited number of persons could possess stone pipes.

As far as the data go another conclusion might be drawn from the Emeryville pipes. No pipes were found lower than seventeen feet deep. This roughly corresponds with the level where plummet-like stones first appeared and the two facts support one another as evidence of a change in the culture of the mound. The objection is that as far as our finds go there were no pipes above eleven feet either, whereas Uhle found several at five to six feet. This fact together with the localization which has been noted makes one wonder if another trench dug in the base of the mound might not disclose pipes.

Usage.—It has been assumed that these were tobacco pipes. Number 1–25501–03 actually contained a quantity of ashes and charred material (1–25502–04). For none of the others can tobacco smoking be proved and considering their difference in form it might well be that some were used for some other purpose, e.g., by a sucking shaman.

It should be emphasized that in the above discussion stone pipes only have been dealt with. Wooden pipes were much used in California including the region north of the bay and it is reasonable to think that they were known to people residing on the mound. However no archaeological evidence whatsoever bearing on this subject was found. Accordingly the matter of tobacco smoking must be passed by since stone pipes and the custom of smoking cannot be taken as identical.

Plugs

Such a designation for the short cylindrical stone objects here described is highly speculative, but no better suggests itself.

From 13 feet deep, Area 6, came a highly polished sandstone specimen, cylindrical in form, about 26 mm. in diameter by 22 mm. high (1–25496, pl. 52*g*). The sides of this object are slightly concave. Uhle found a somewhat similar article (1–8671, his pl. 12, fig. 12). Nelson also found similar specimens at Ellis landing (his pl. 43, figs. 9 and 10). At 25 feet deep, Area 20, we found an artifact closely resembling the above but with a deep groove in the side rather than a slight concavity, so that it somewhat resembles a spool (1–25497, pl. 52*d*).

The only possible usage which we can suggest is that offered by Uhle—ear-plugs or labrets.[90] Their occurrence is so infrequent that the practice of using them could not have been very common and it seems possible that they came from the Sacramento-San Joaquin delta region.

Plummet-like Stones and (or) Charmstones

Form.—No absolute line can be drawn between stone artifacts which obviously fall outside and those which can best be treated under this heading. Such stones have aroused much interest because of their promising implications but no scheme for treating them on the basis of usage has been developed because the actual use for which they were made is still a matter for discussion.[91] Accordingly, in a recent paper on the upper San Joaquin valley, E. W. Gifford and the author endeavored to develop a scheme for the classification of plummet-like stones which depended entirely upon their form. The major division depends upon whether or not pieces are perforated. Non-perforated pieces are then divided according to whether or not they have a pile at the end, i.e., a point formed by secondary curves rather than by a continuation of the primary curves. Subsequently subdivisions are based upon the character of the pile and the ratio of the breadth to the length of the piece.[92] This same plan will be followed here. Many of

[90] *Op. cit.*, 59, 60.

[91] For a succinct account of these articles and a bibliography the reader is referred to "Plummets," Handbook of American Indians, Bur. of Am. Ethn., Bull. 30, Part II, 1910.

[92] The form used for the upper San Joaquin valley, with the number of specimens of each type classified, is as follows:

	Per cent
D. Perforated	9.9
W. Not perforated	
A. No pile (i.e., no secondary curves at end)	
a. Spherical or egg-shaped (length not more than twice width)	
1. With grooving (longitudinal)	4.9
2. With notching (at ends)	1.2
3. Neither grooved nor notched	6.8
b. Spindle-shaped (length more than twice width)	
1. With horizontal groove	1.2
2. With notched ends	5.6
3. Neither grooved nor notched	6.8
B. With pile (i.e., end or ends show secondary curves)	
a. Pile at *one* end	
1. with horizontal groove	0.6
2. Plain	8.0
b. Pile at both ends. One end always plain and the other end:	
1. Plain	24.1
2. With shoulder	6.8
3. With button	8.0
4. With nipple	13.0
5. Notched	3.1
	100.00

the specimens obtained are too fragmentary to permit classification. Others though broken are so nearly complete as to render a given classification probable. Such specimens have been classified but the doubt indicated by a question mark (table 11).

TABLE 11

PLUMMET-LIKE STONES FROM EMERYVILLE (1924–25)

Type	Length Max.	Length Min.	Diameter Max.	Diameter Min.	Ratio Max.	Ratio Min.	Number	Per cent of total
D							5	12.5
WAb3	163	127	33	28	1:5.8	1:3.8	4	10.0
WAb3(?)							3	7.5
WBa2	220	100	40	25	1:7.9	1:2.5	5	12.5
WBa2(?)							8	20.0
WBa3	95		35		1:2.8		2	5.0
WBa3(?)							2	5.0
WBa4	143		30		1:4.8		1	2.5
WBb1	120	80	47	38	1:3	1:2	4	10.0
WC	35		18		1:1.9		1	2.5
Unidentifiable							5	12.5
							40	100.00

Type D. These are perforated pieces. No. 1–26015 (pl. 53*c*) is a typical piece. The hole is biconically drilled and is nearer one end. Three of the five specimens are notched at this end. (One is broken so that this feature cannot be judged.) Three pieces are irregular rather than cylindrical in form (pl. 53 *a–c*); one approaches the cylindrical (pl. 53*d*); and the fifth, a broken piece, suggests a slender flattened spindle. It will be seen that this class constitutes a small part (5 per cent) of the total and this relationship is borne out in other collections. None of the seventeen specimens discovered by Uhle were of the perforated type. At Ellis landing, at Stege, and in the San Joaquin valley the proportion of perforated pieces is about the same (5 per cent).

Type WAb3. These are specimens which are not perforated, which have no pile, and which are in general spindle-shaped; no. 1–25485 (pl. 53*k*) is a typical piece. A further characterization of this type is that the ends are plain, i.e., neither grooved nor notched. An interesting point is that the greatest diameter is nearer one end than the other whereas in the upper San Joaquin region the greatest diameter was near the center, thus producing a symmetrical piece. The relationship between this type and types WBa2 and WBa3 is close and it will be noted that the three constitute 60 per cent of all specimens. The same preponderance seems to hold good for the specimens found by Uhle, by Loud at Stege, and by Nelson at Ellis landing. Since the same is by no means true for the upper San Joaquin valley, where specimens

with a pile at both ends constituted more than half the whole, we seem to have not only a generic similarity for the specimens of a given region but a marked difference in detail when different regions are considered.

Type WBa2. This type (1–25463, pl. 53*p*) differs from the preceeding in having one of its ends brought more abruptly to a point, producing a pile. The other end is usually somewhat longer than in the WAb3 type, is tapering, and sometimes ends in a slight swelling which if enlarged a little would produce a second pile, or type WBb1. Its abundance has been commented upon.

Type WBa3. This type did not occur at all in the upper San Joaquin region. In type WBa2 the pile was at the pointed end. Here the pointed end is without pile (1–25476, pl. 53*e*) whereas the plain end of the type WBa2 is swelled by secondary curves.

Type WBa4. This is also a type not found in the upper San Joaquin collections. The variation consists of a notch in the end with the pile (1–25488, pl. 53*j*). Since only one piece was seen it may be taken as an unusual variant.

Type WBb1. This is the only type of the class with pile at both ends and is the simplest form of the class. It is relatively scarce—10 per cent of the total. Specimen 1–25473*b* (pl. 53*f*) is typical.

Type WC. A single piece of quartz was found (1–25471) which had the shape of a "charmstone" and which was associated with a group of "charmstones." Hence we are led to classify it as such although, never having been worked, it is not identifiable with any of the classified forms.

Material.—On the basis of the material of which they are made the plummet-like stones found by us at Emeryville may be grouped as follows. In this table the Franciscan sandstone and basalts, which are difficult to distinguish without extended analyses, are grouped together.

Material	Number
Franciscan sandstone or basalt	26
Granitic	3
Limestone	1
Schist	2
Steatite and (or) greenstone schist	7
Quartz	1

Of Uhle's seventeen pieces from Emeryville one was steatite, and the rest were of the Franciscan formations; none was of granite. At Ellis landing 20 per cent were steatite, the rest of Franciscan formation. At Stege 20 per cent were of Franciscan formations and over 50 per cent of steatite. In material then, as in form, the plummet-like

stones of the east bay region show a generic similarity. Further, these materials point to local manufacture. All materials noted are obtainable within a few miles and the most common, the Franciscan formation, is that most commonly used. In fact these formations and the glaucophone schist are so typical of the Coast Range that the inference of local manufacture seems sure. The connection between the material of which artifacts were made and its local occurrence is emphasized by the large proportion of steatite at Stege, the largest known local deposit of that material occurring nearest to Stege.

No absolute connection between material and form is established but in the perforated type steatite or greenstone schist is very definitely used more frequently than any other material. The relation may be tabulated. Fragmentary and doubtful pieces are omitted.

	Emeryville 1924–25	Emeryville 1902	Ellis Landing	Stege
Per cent of Type D made of steatite	80	No type D	100	70
Per cent of steatite pieces which are type D	60	0	80	70

Apparently, then, this material was preferred for the perforated pieces. This might be accounted for by the fact that it was easier to drill. But this does not seem to explain why, when steatite was used, it was usually made up into perforated pieces. The connection may be due to usage. Stege was nearest the largest local supply of steatite and more than half of its plummet-like stones were of that material. It seems more reasonable to suppose that the Stege residents utilized the local deposit and made articles to be traded, if they were permanent residents, or took advantage of the opportunity afforded by the visit to make themselves up a supply, if they were transients, rather than to think that the existence of the raw material would have modified the habits of the people in the use of such plummet-like stones.

Workmanship.—The quality of workmanship is very uneven. Photographs tend to eliminate differences in finish but the grace, symmetry, and skill required in the production of such pieces as 1–25463 or 1–25474 (pl. 53 *p* or *i*) may be contrasted with the lack thereof illustrated by 1–25482 or 1–25487 (pl. 53 *d* or *h*). The steatite pieces, being formed of softer material, might be expected to exhibit the nicest forms. The contrary is true: the best forms are found in the Franciscan formations. Nor were the lowest (the oldest?) specimens the crudest. Rather the workmanship seems to have varied with the maker; and considering, for example, part of the group (1–25463–66, pl. 53 *m–p*) found with one burial, their uniform character suggests that the individual maker could have been detected by his work in his

time. Remembering, however, the limited uniformity and the few pieces produced by a given area, horizontal or vertical, it would appear that no one person made any considerable number of these articles. This suggests that certain men made one or more for themselves. The group of nine pieces indicates that sometimes a considerable number were made; but since no other find even approximated this, the ordinary quantity must have been only one or two. Whether or not these were subsequently passed from man to man or remained the peculiar property of the maker is not clear.

Little suggestion is offered by the articles as to how they were made. Several steatite pieces apparently in process of formation have peck marks on them which suggest that the piece was first roughed out by pecking. The symmetry of the cylindrical pieces indicates that the finishing was done by revolving them in a vertical position in a hole and the fine polish of some pieces suggests that this revolving was done with some mechanical aid—such as a fire drill. The pile could be produced by changing the size of the hole. On the whole, considerable ingenuity was required to arrive at the process but once discovered it seems probable that a handsome specimen could be turned out in a comparatively short time.

Distribution.—In the cone there were found thirty-six whole or fragmentary specimens which can best be classified as plummet-like stones. A number of pieces were secured by other people so that perhaps fifty in all were noted by us. In the trenches were four pieces. Of the thirty-six pieces obtained from the cone seventeen were definitely associated with burials in five groups, namely 9, 3, 1, 2, 2. Some of those found by others were also with burials. Since many were not actually obtained *in situ* and since all were found in the central areas[93] where burials were most frequent, it is probable that

[93] The horizontal distribution noted was:

Area	Associated with burials	Others	Total
?	9	4	13
1	3	0	3
6	1	1	2
8	0	1	1
10	2	3	5
22	0	1	1
24	0	1	1
25	0	2	2
26	0	1	1
29	0	1	1
32	0	1	1
33	2	0	2
35	0	1	1
36	0	1	1
39	0	1	1
	17	19	36

the percentage of association would run high enough to indicate that the great majority of articles of this type were found in the cone because they were buried with the dead and not because they were lost in the course of daily life. None of the four pieces found in the trenches were associated with burials.

Our data for vertical distribution in the cone are too limited to permit detailed analysis. Specimens were recorded from 6 feet to 20 feet, in the area where burials were most numerous. In the trenches a specimen was found at the 29-foot depth. Plummet-like stones were evidently known from the time the mound was begun; those of its earlier stages (i.e., from the trenches), however, may be contrasted with later specimens (those from the cone). The four specimens from the trenches may be characterized as follows:

Museum No.	Type	Depth	Material	Associations
1–26012	Perforated	Trench 1, dump when 29 feet	Steatite (?)	Isolated
1–26013	Perforated	Trench 2, dump when 29 feet	Steatite	Isolated
1–26014	Not perforated	Trench 3, dump when 22–23 feet	Sandstone	Isolated
1–26015	Perforated	Trench 3, dump when 27 feet 7 inches	Steatite	Isolated

The 22–23-foot level in trench 3 had been more or less disturbed by the steam shovel so that it is quite possible that 1–26014 came from the higher levels of the cone. The three pieces of which we are sure show a definite similarity (pl. 53 *a–c*). All are perforated, all are notched, all are of steatite, none were found in association with burials.

Further, these similarities set the group off from those in the cone. Of the thirty-six specimens there only two were perforated. One of these (1–25482, pl. 53*d*) was 20 feet deep, was made of steatite, was not found with a burial. On the other hand, in form it more closely resembles those in the trenches. The second perforated specimen (1–25494) is entirely different from any other. It is made of glaucophane schist and is in fragmentary condition but it suggests a slender spindle flattened on the sides and drilled toward one end. The depth at which it was found is unknown. In this same mound seventeen identifiable plummet-like stones were discovered by Uhle all from above the 18-foot level and all of the non-perforated types. In the trenches steatite is the uniform material; in the cone it is the exception. None from the trenches were associated with burials; most of those in the cone were so associated. In short, the homogeneousness of the lower group, and its contrast to the upper group, suggest that

the perforated specimens are objects of a different nature from the non-perforated ones, or that they are earlier forms of the same object.

Since the purpose of all these stones is unknown no criteria for possible differences exist, but certain possible uses can be considered which would appear more applicable to the lower, perforated stones than to those of the upper group. Sinkers for fishing is the first thing suggested. An objection to such a purpose is their elaborateness. Simpler pieces of more common material would have served the purpose as well and were actually used as specimens recovered show. Still the same reasoning would eliminate much of the modern fisherman's equipment. While the hole would have enabled the piece to be securely fastened to a line, there seems no purpose for the groove. Neither holes nor grooves show the wear of a cord which would be expected after use in fishing. The pieces might have been used for pendants as steatite was widely used for this ornament. The drilling in the smaller end suggests a pendant. It is true that they seem rather large for ornaments (1–26015 is 77 by 35 mm.) but Heye shows steatite pendants nearly as large from San Miguel island.[94] Also the perforated pieces are smaller and lighter than the non-perforated ones. It is possible that these perforated pieces were effigies. Number 1–26013 (pl. 53*b*) strongly suggests an animal's head, the hole forming the eye, the groove the mouth; 1–26015 (pl. 53*c*) might represent an entire whale, the eye and mouth being again represented and the tail set off by a heavy incised line. Putnam believed that he found effigies of whales in the Santa Barbara region,[95] and Uhle thought that one of the specimens (1–8850) he recovered at Emeryville was the effigy of a bird. That many specimens do not resemble effigies can be accounted for; but it would appear that better representations could have been produced by the aborigines if effigies were really wanted. If the specimens of the lower group were effigies we would have an explanation for the development of "charmstones." Magical qualities would no doubt be assigned to effigies and though the form might change the supernatural association would endure.

The author does not lean to the opinion that an evolutionary development is revealed by these stones, but the data may be arranged to support such a view. Only the perforated type which might have evolved from a pendant to an effigy or fetich was found in the lower levels. In its simplest form it is a drilled and notched pebble (1–26012, pl. 53*a*). In the secondary form such realism as had been attained

[94] *Op. cit.*, pl. 24. [95] *Op. cit.*, 220.

is being supplanted by conventionalization and a more cylindrical shape is shown (1–26015, pl. 53*c*). In the third form all resemblance to the pebble is lost and the characteristic plumb-bob shape appears (1–25482, pl. 53*d*). (This specimen from 20 feet deep is the last of the perforated pieces as the higher levels are approached.) In the fourth step the hole is lost and a neck replaces it (1–25476, pl. 53*e*). From this point diverge the various more elaborate forms, usually through the development of longer pieces and an elaboration of an end. The objection to such a theory is that specimens may be arranged in such an ascending series in the laboratory but they were not found in the required temporal sequence (using depth as an indicator). For example, 1–25475 which is similar to 1–25476, our fourth step, came from the 6-foot level of the mound and was therefore above the types it should precede.[96]

Turning to the non-perforated types we find that all of Uhle's identifiable specimens (17) were non-perforated and from above the 18-foot level. Excepting a single doubtful piece we found no non-perforated pieces below 20 feet. Apparently then at the time when the mound was 10 or 12 feet high a definite change occurred. One type was replaced by another, or at least a new type arrived on the scene. This new type was not rudimentary but came as a fully developed product which showed little subsequent refinement. Our interpretation of this would be that the people using the mound were replaced by newcomers differing from any previous inhabitants.

Usage.—Although there are transitional forms as has been discussed above in some detail, nevertheless there is a similarity about the shape of these pieces that must have been dictated by the practical requirements of the use to which they were put or which depended upon custom and traditional association. What such a use might have been has been discussed in detail by the authorities mentioned above. It is the intention here to add only the suggestions that occur to us from a contemplation of the Emeryville specimens. The perforated type has been discussed and in the following discussion we consider only the non-perforated types.

The long delicate forms (1–25463, pl. 53*p*) in such easily broken material seem to preclude any very rigorous use such as fishing. On the other hand, 1–25487 (pl. 53*h*), which is of the same type but less than a third as long, would stand very hard treatment. Another

[96] The lack of vertical distribution data does not permit us to adduce specimens from Stege or Ellis landing in support of either view.

argument against rigorous usage is the shape of the pieces, which is such that it would be very difficult to fasten anything to them which would withstand much wear.

There is definite evidence in this connection. One end of these specimens (always placed toward the top in pl. 53 *q. v.*) is farthest from the center of gravity, is more gradually tapered and less pointed, giving somewhat the appearance of a shank. On account of the fragmentary condition of some specimens we have only fifteen complete examples of this end. In some cases the tip is not further specialized (1–25474, pl. 53*i*); in others it is slightly swelled at the very end (1–25463, pl. 53*p*); and in still others this swelling becomes very definite (1–25488, pl. 53*j*). On eight of the fifteen pieces there still remains on this end of the specimens more or less adhesive material such as asphaltum or pitch extending over a space of from 10 to 20 mm. (1–25473–*c*, pl. 53*g*; or, 1–25485, pl. 53*k*). In this are impressions of cord or twine. Obviously, then, this end was definitely specialized as the end used for attaching the stones to other articles. If the stones were suspended by a cord this end was always uppermost and for purposes of convenience it may accurately be called the top. It will be noted that the drilled end of the perforated pieces is likewise the top. A cord wrapped around 10 to 20 mm. of a tapering stone (or one with a slight button at best) and subjected to the weight of the stone would not withstand very hard usage. It is possible that the stones were placed in a sack or bag of skin the mouth of which was gathered around the top and fastened with a cord. So prepared the fastening would be very secure. The polish of the stones makes such mounting appear improbable. Instead of being suspended by a cord it is possible that the cord bound something to the stone. On one specimen (1–25479) there is an impression in the adhesive material such as might have been made by a feather and this suggests that the stones might have been handles for feather bunches used in dances. Breaks in the cord impression point to its use as a binder. In short, the evidence of fastening seems to eliminate such uses as pestles, sinkers, weaving, or spinning implements, etc., for these plummet-like stones.

The material used offers no conclusive indications of use. The use of a rare material might imply a mystical regard for the pieces. Loud found one piece of actinolite (1–23300) and Uhle one of hematite (1–8925). However Loud's specimen is not a typical specimen[97]

[97] *Op. cit.*, pl. 19, fig. 8.

and the re-identification which we had made of specimen 1–8925 determines it as one of the Franciscan formations and not hematite. Apparently then the most common raw material was that most ordinarily used and no valuation due to rarity can be attached. In the upper San Joaquin valley the specimens appeared to have been made of material selected for its beauty but of local origin. The material does suggest that whatever the use of the pieces it was well known before the people came to the shellmound.

In discussing workmanship the speculation was advanced that each individual made only one (or very few) such pieces. Such would not appear to be likely if they were intended for a practical purpose. But if a person arriving at a certain stage—physical, emotional, or material—had been allowed to acquire and keep, or use one of these stones in commemoration or celebration of the event, then such a person at such a time would make his piece, and their production would be diverse in quality and limited in quantity. On the other hand stylistic variations might be taken to refute the use of the pieces as charmstones. If made by many men, it may be claimed that what everybody does is not likely to possess a magical character.

The frequent association of this type of artifact with burials gives no indication of their use since all types of articles were so associated. However, the fact that in some cases, at least, the specimens were "killed" for burial is suggestive. No "killed" ornaments were found by us. This would eliminate the use of plummet-like stones as ornaments.

While the actual reconstruction of specimens from fragments (pl. 53 *m–p*) enabled us to prove "killing" in certain instances, it seems more than probable that a great many other fragments are really due to this custom of "killing." Bancroft as cited by Uhle[98] interpreted the fact that such stones were usually mutilated as indicating breakage in use and consequently practical uses. It would seem that the "killing" would explain the mutilation as well as the other suggestion.

To sum up: as far as the Emeryville evidence goes it would seem more likely that these pieces were used for ceremonial purposes than for practical ones.

No matter what their original use, a number of pieces offer suggestions of secondary usage. Quite a few are pecked and clipped as though they had been used as hammers, 1–25482, pl. 53*d*). The same piece is worn down at the end as though used as a pestle. Others have their sides flattened as though used as

[98] *Op. cit.*, 53.

a whetstone or for polishing. No. 1–25473*b* (pl. 53*f*), the granite piece, is a notable example. Modern Indians have shown great superstitious awe of these stones and it seems principally due to such opinions that the pieces came to be regarded as "charmstones."[99] Hence it may be noted that the very prosaic uses to which these pieces were put by some of the aborigines implies a definite lack of respect and an ignorance of the idea of their having magical qualities.

Rubbing Stones and Whetstones

In both the cone and the trenches fragments were noted which appeared to be parts of stones used for polishing or sharpening. One of these pieces showing a groove, probably from sharpening awls, is shown in plate 54*c* (1–25953). This was from the bottom of the mound in trench 2. Another from nearly as deep in trench 3 is shown in plate 54*b* (1–25955).

The specimen (1–26532) shown in plate 54*k* was probably used as a whetstone.

Sinkers

These articles are remarkable for their absence. Only one specimen, a standstone pebble grooved around the center, was recovered from the entire mound (1–25495, pl. 54*a*). Uhle got one such stone and three of a somewhat similar character. Sinkers were plentiful at West Berkeley, very abundant at Stege, and comparatively scarce at Ellis landing. Since all are made from material readily procurable from any site, this variation in frequency of occurrence must indicate a change of occupation. Considering the nearness of these sites to one another and the absolute absence of any physical bar to communication between them, it seems impossible to suppose that this evidence from the sites can properly be taken to characterize the culture of a people constantly located on the given site. The contemporaneous existence of two (e.g., Stege and Emeryville) markedly different cultures within sight of one another would be very remarkable. Hence we are inclined to take such evidence as characterizing the place rather than the people. Stege was a good place for fishing; Emeryville for shellfish gathering and sea-otter hunting. But the same groups of people may have occupied both sites and engaged in both occupations during the course of their existence.

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[99] However all ethnological data do not point in the same direction. Gifford took some charmstones to Central Miwok Indians in Tuolumne county. The names and uses given by his informants there were as follows:

	Name	Use
Long slender type	Kaiyānā	Fire drill with buckeye hearth
Round type	Hākūnā	To rub deer skins
Perforated type	Hikāani	In spinning

The generic name was lēpīpā. To both Gifford and the author this sounds like manufactured information.

ARTICLES OF STONE (UNWORKED)

Crystals

Associated with each of three burials in the cone were quartz crystals, 1–25449 and 1–25553 (pl. 47 *h–j*). All of these burials were more elaborate than ordinary and the crystals were more or less covered with paint. Uhle recovered a crystal (1–8791, his pl. 2, fig. 9) the base of which had been inlaid with olivella beads on asphaltum. This was also with a burial and 23 feet deep. Ellis landing yielded a considerable number of crystals but generally without data as to depths or associations. Evidently such articles were highly prized and were possibly part of a shaman's equipment. Whether or not they were known during the early history of Emeryville is uncertain, the data being insufficient to warrant a guess.

"Eoliths"

Uhle collected a number of very simple chert fragments (his pls. 6, 1–18) which he considered the handiwork of man. He believed that they were more abundant in the lower part of the mound. This relative abundance connected with the primitive character of the pieces seemed to Uhle evidence of the great antiquity of the mound.

Similar specimens were found by us and on page 175 we have set down the quantity of chert found at the different depths in the trenches. Such figures are not very complete but they seem to show that chert was as abundant in the top part of the trenches as at the bottom. All chert was not in the form of these fragments, but there is so little to distinguish one fragment from another that the total amount seems the best index.

To the writer these pieces show no signs whatsoever of having been retouched. Hammerstones of the same chert were used and it is possible that in such use fragments were knocked off these hammerstones. Beyond this possibility the fragments must be regarded as on a par with the "eoliths" of Europe the non-human occurrence of which is described by Boule.[100] Loud suggests that they are work-shop chips but there are two objections to this. In the first place they do not appear in concentrated form. One cache of several chert pebbles was found, but the fragments seem to be thinly and fairly evenly distri-

[100] M. Boule, Fossil Men (English ed., 1923), pp. 111–137.

buted. In the next place only one chipped stone artifact of this material was found (1–25998) whereas there were a number of obsidian pieces. After all, the possible eolithic nature of such pieces seems rather aside from the point for they would not determine the cultural horizon of any area. Where they were found, well-chipped obsidian, inlaid bone beads, mortars, etc., were also found.

Hammerstones

A number of pieces of chert were collected (1–25938–46) which gave evidence of having been used for pounding. Such usage of this chert probably accounts for the small chert chips found and which Uhle thought were eoliths. The chips would be knocked off during the hammering. The vertical distribution of such stones seemed rather uniform beginning at the bottom of the mound. They were particularly noticeable in the trenches although this is probably due to the manner in which we worked.

A lump of greenstone schist of about the right size and weight for a good hammer was recovered from an unknown depth. This is the only piece seen which suggests a groove for lashing on a handle and even here the groove is far from evident. See plate 54*n* (1–26534).

Mica Ornaments

Eight lots of mica ornaments were recovered from the cone. Five of these were actually with burials and it seems probable that all were originally so associated before being disturbed by the shovel. As the burials usually yielded other artifacts, our conclusion is that these articles were of unusual value. The ornaments are in the form of more or less circular discs both drilled and undrilled (1–25539–40, pl. 47 *a–e,* and 1–25538, pl. 47 *f–g*). The drilling is both biconical and from one side. Such pieces were probably pendants. Just how the undrilled discs were used is not clear. There was considerable variation in size—from 25 by 18 mm. to 73 by 45 mm. On account of the nature of the material these specimens have flaked off into a number of pieces. (There are about 100 pieces in the eight lots.) Hence it is difficult to tell the original number actually present. Still a concentration of a number of pieces with a single body is again evident. No such artifacts were recovered from the trenches or from deeper than 20 feet.

Miscellaneous

Here and there among the stone material turned over were noted pebbles or fragments that were possibly artifacts. Some of these were collected and are here commented on although the author is inclined to think that in many cases their inclusion as articles used by the aborigines is more due to selection on our part than on the part of the mound-dwellers.

Pebbles of several sorts were noted. Some were egg-shaped and might have been selected with the intention of using them for sinkers, sling stones (pl. 54*j*), etc., but nothing actually indicates such use. Several quartz pebbles—much water-worn—seemed rather flattened at one end somewhat as though they had been partly worked into pendants but no such pendants were seen. A large peculiarly shaped chalcedony concretion was noted which might have been of value because of its unusual shape and material (1–25447, pl. 54*g*). Associated with the burial with the nine charmstones were sixteen pebbles. This association may have been accidental or the pebbles may have had significance. Sometimes it seemed that there was an unusual number of small pebbles or gravel near skulls. This was ordinary water-worn gravel such as found in Temescal creek. Chert pebbles and fragments are dealt with elsewhere. We saw a couple of pebbles shaped like the "snakes' heads" (1–25439, pl. 47*p*) found in the upper San Joaquin valley collections. Uhle got a piece which he took to be the effigy of a bird. But since all these pieces are unworked and were not associated with burials their relation to man must remain questionable.

In addition to the fragments elsewhere described which could be recognized as parts of artifacts a few others may be noted. Number 25947 found 25 feet deep had one side stained with red paint when found and might have been an anvil. Flat slabs were noted in the cone which could have been used to cook on. From the bottom of the mound in trench 3 came fragments suggesting a shallow basin or dish.

Paint

Evidences of paint were frequent in the central portion of the mound and in the trenches. Thirty-eight lots were collected, of which three were yellow paint (ferric hydroxide). This was apparently the raw material from which red paint (ferric oxide) was made, for upon being heated and allowed to cool it becomes red. A number of red

pieces suggested this stage in the process of preparation. Other lumps consisted of material apparently ready for use (1–25506, pl. 54*h*). Paint was found on bones and artifacts, in thin layers under burials and elsewhere and in lumps without particular associations.

In the trenches red paint mixed with ash or sand was several times noted extending in a thin layer over a considerable area. One notable example at the depth of 25 feet 3 inches in trench 2 covered about 10 feet of the west end of the trench extending into the surrounding banks (1–26030 is a sample of this material). Under this was a layer of white ash particularly concentrated in spots and above it was charcoal. The skull of skeleton 12–3799 was well imbedded in this layer. A similar layer was observed in the east end of the same trench—at least 10 feet long and at a depth of 29 feet 3 inches. This layer (red paint and charcoal) varied from one-eighth of an inch to one inch in thickness. These layers suggest house floors.

This paint is the ordinary iron oxide used for similar purposes throughout the world. Its presence at a depth of 30 feet (at the clay substratum) and its common use at 29 feet 3 inches for a widespread layer indicate that it was well known in early mound times. Mr. Bennett, chemist of the Sherwin, Williams Paint Co., who kindly examined and tested some of the paint, stated that it occurs commonly throughout the mountains of California. It is usually found in the yellow state. It is to be expected that the raw material would exceed the finished product in quantity whereas the reverse is true. The probability is that it was prepared elsewhere than on the mound—either at the source of supply or at another place of residence.

ARTICLES OF WOOD

No actual artifacts of wood were found. Here and there when skeletons were unearthed the decomposed material suggested wood, but no form could be observed. In places the mound material still bore impressions of posts or poles (1–25546–47). One specimen of (probably) mineralized wood was obtained (1–25556). This was with a skeleton at 20 feet in Area 20 with which were other artifacts. It was not fashioned and was apparently prized because it was unusual.

TEXTILES AND CORDAGE

While, unfortunately, we have but a single piece of direct evidence of the presence of textiles, that piece is a most important one. It comes from the very bottom of the mound (30 feet deep in trench 1) and establishes at once that the people who first came to the site were already familiar with the art of basketry. This specimen (1–25958, pl. 47*s*) is a small piece of clay bearing the impression of several rows of basketry work, two of which are quite clear for some 20 mm. A positive in wax of this impression is shown in plate 47 *q, r*. Opinions as to technique differ. To the author the basketry appears to be of the coiled type, four and one-half stitches per 10 mm. The large number of awls may be adduced as strengthening this opinion as well as the probability, at least, that the coiled basketry type was made throughout the time the site was occupied.

In Area 28 were found some carbonized fragments indicating cordage and possibly basketry (1–25548). Two cords were detected, both 2-ply. One is about 2½ mm. in diameter, the other about 5 mm. These larger strands may have been worked up into twined basketry. Their relative association suggests this and that a vessel was burned is suggested by a charred material which has protected the cordage and which might have been the asphaltum lining of a basket.

From Area 30, at 10 feet deep, another fragment of carbonized material was recovered. This shows a 2-ply loosely twisted cord about 10 mm. in diameter.

As mentioned in connection with plummet-like stones, some of these stones carry impressions in asphaltum of cords. Not much can be detected from these impressions, but in one case (1–25485) quite a small (not over ¾ mm. in diameter) closely twisted cord is indicated.

Whistles also gave evidence of the use of cords.

Although the direct evidence is so slender, not much was to have been expected on account of the fragile and perishable nature of such articles. Suggestions of textiles are found in the arrangement of beads in the form of caps and possibly small capes, in the presence of sinkers for nets, in the many cooking stones, etc. In short, it seems reasonable to suppose that the Emeryville inhabitants always had a knowledge of cordage and basketry, that such things played an important part in their economy, but that no knowledge of higher textile forms was possessed.

SUMMARY

The variety of articles of material culture which the Emeryville mound yielded can best be seen by a glance at the table of contents. An attempt is made in table 12 to characterize some of the principal elements. This is offered as a convenience rather than as a scientific precis. It should not be used without reference to the detailed explanations and qualifications previously recorded.

One is first struck by the evenness of the culture displayed. The abundance of bone work, the quality of ground stone work, the rather limited use of shell, the great scarcity of chipped stone, and the entire absence of pottery characterize all sections of the mound. On a closer view the differences in detail are almost as striking. Not only are no two articles the same but the variation is so great that several types of almost any given article can be observed. These types do not occur in an evolutionary series with the crudest below and the higher forms above. Nor does there appear to be any evidence of stratification in which a given type characterizes all of a certain horizontal section. The differences are rather localized, and this localization or concentration is emphasized by the frequent grouping of several artifacts of a given type in one spot. Such localization suggests the residence of different groups upon the mound. A few types of artifacts do suggest that articles were unknown in the earlier stages of the mound that later came into use, e.g., non-perforated charmstones, stone pipes, mica ornaments, "killed" mortars. On the other hand, such essential elements as basketry, chipped stone implements, shell ornaments, whistles, fishhooks, etc., were known from the earliest times. In short, our data present very little if any evidence of an improvement in the culture of the people during the life of the mound.

An explanation of the conclusion just stated seems necessary. Reviewing the articles of material culture, a number could be found which were noted only above the 17–22-foot level of the mound; while a few types (notably, perforated charmstones) occurred only in the lower portions. In other words there seems considerable evidence that a general cultural change took place at about that level. Both Uhle and Nelson believed that somewhere in the vicinity of this level such a change could be observed. This change would be of primary interest. Why then is the possibility not dwelt on in detail?

The objection is that the evidence only superficially supports the hypothesis. The details of Uhle's material evidence and of his theory

TABLE 12

SUMMARY OF THE MAIN ELEMENTS OF THE MATERIAL CULTURE OF THE EMERYVILLE SHELLMOUND

Articles of	Type	Occurrence	Distribution	Uses	Associations with burials	Remarks
Asphaltum		Plentiful	Throughout	Adhesive	Generally with	More used on non-utilitarian objects
Bone		Most abundant	Throughout	Great variety—utilitarian	Generally not	
	Awls	Very abundant	Throughout		None	Many types
	Fleshers	Very abundant	Throughout		None	
	Whistles	Plentiful (grouped)	Throughout		Generally with	Notable aesthetically
Clay		Practically none	——			
European make		None	——			
Horn		Plentiful	Throughout	Utilitarian	Generally not	
	Fishhooks	Few	More in bottom	——	None	Composite type
	Wedges	Plentiful	Throughout	——	None	Imply wood working
Shell		Plentiful (concentrated)	Throughout	Ornamental	Practically always	
	Beads	Plentiful (concentrated)	Throughout	Ornamental	Practically always	Mostly olivella. Rectangular type not in lower portion.
	Discs	Few	Throughout	Ornamental	Practically always	Abalone only. Styles localized.
Stone (chipped)		Very scarce	Throughout	Weapons	Generally with	Mostly obsidian. Finds concentrated
Stone (ground)	Mortars	1 to 7 bodies	Throughout		Generally with	Several types: fine workmanship: one ornamented. Frequently "killed." Types localized
	Pipes	Very few	None below 17′	Tobacco smoking	Always with	Concentrated. Type—tubular, every pipe different
	Plummet-like (perforated)	Few	Below 20′	Uncertain	None	Steatite. Proto-type of non-perforated?
	Plummet-like (non-perforated)	Fairly plentiful	Mostly above 20′	Ceremonial	Generally with	Concentrated. Several "killed." Top indicated by asphaltum.
	Sinkers	1 only	?	Fishing	None	Remarkable for absence. Plentiful in nearby sites.
Stone (unworked)	Crystals	Very few	Throughout	Ceremonial	Always with	
	"Eoliths"	None				
	Mica	Very few	Above 20′	Ornamental	Always with	
	Paint	Plentiful	Throughout	Ornamental and	Generally with ceremonial	
Wood		None				
Textiles and cordage	Textiles	Twice	Throughout			Basketry only found
	Cordage	Plentiful	Throughout			2-ply twist

of change based on a change in the angle of mound material deposition have already been examined in the preceeding pages. It seemed to us that the theory depended more on the a priori assumption of its probability than on the evidence adduced. Nelson's views (still in manuscript form) are not so definite. He brings out the possibility of a general level having been established before the cone started to grow and then this general level acting as a catch for much later material which would roll down the sides of the growing cone. It does not seem, however, that the material he actually recovered supports this view or his more important hypothesis that the evidences of material culture if arranged as found from the bottom to the top of the mound will exhibit a series of increasing complexity. Our own evidence supported neither Uhle nor Nelson in detail. Hence its support of the theory of a general cultural change seemed open to question.

However, the main reason for doubting our own evidence pointing to a general cultural change at the 17–22-foot level is the extraordinary coincidence that the plane of such a change should coincide with the plane at which we changed from steam shovel work to hand work. Below 17–22 feet the material handled was examined with great care, but less than 250 cubic yards were turned over. Above, the emphasis must be placed on the great volume handled—some 26,500 cubic yards. Now if one were dealing with uniform material, increased care might compensate for decreased volume. But when it is recalled how localized the finds were it seems that the two methods are almost certain to give different results which may complement one another on the whole but which cannot be brought together in detail. For example: no pipes were found in the trenches, in the cone six were found. Is it safe to assume that no pipes existed in the lower cultural area until at least 4400 cubic yards of material were handled instead of 250 cubic yards? (4400 plus cubic yards was the average amount of material per pipe in the cone). From the opposite point of view, the intensive trench methods were more likely to disclose the exceptional find. According to evidence actually obtained, basketry was known only at the bottom of the mound. Had our single certain specimen been obtained from a depth of say 16 feet, the trend of speculation would be obvious. In short there appears to be more ground for considering the changes at about the 17–22-feet level as being due to methods of work than to differences of fact.

Finally, is there evidence of a general cultural change even in this plane where a number of differences seem to fall? Neither Uhle nor

Nelson dwell upon the differences discernible in different horizontal areas. A number of such localizations have been mentioned by us. These differences seem as definite and as profound as the changes in different vertical areas. For example: cremation was not noted above 28 feet 7 inches deep, but neither was cremation the only method of disposing of the dead at that level. Rectangular olivella beads were not found below 17 feet deep, but ring type olivella beads were found only in the northwest perimeter. Pipes were not found below 17 feet deep, but three out of five pipes were with one burial. Our conclusion is that to emphasize the vertical differences more than the horizontal ones seems unwarranted. If a theory of occasional visits will account for the horizontal changes, so it will for the similar vertical ones which were observed.

Comparing the material culture with that of other mounds on the east shore of San Francisco bay, one notes an essential similarity. A few differences exist such as the greater use of steatite at Stege and the practical absence of net-sinkers at Emeryville. On the whole, however, these do not seem to be more significant than those differences which can be observed in different parts of a given mound.

Broader comparisons are difficult. Little material for the adjacent regions is available. Yet it seems obvious that an enlargement of our field of comparisons would help to explain some of the differences. For example, the practice of cremation, the use of obsidian, and of porous basalt mortars is limited on our mound. All these traits are more common in the region north of the bay. The delta region yields a greater abundance of shell work and of pipes. The inference which the writer is inclined to draw from this is that groups from those nearby regions were represented from time to time upon the mound. Whether or not such an inference is justified, it is clear that no specific shellmound type of culture existed. The culture indicated is intimately related to that of the surrounding regions. Moreover it is of the low level generally characteristic of the central California Indian at the advent of the white man.

M—"Center of mound."
AB—Property line of Sherwin, Williams Paint Company.
AC—Property line of Southern Pacific Company.
S—Old stairs.
U—Approximate location Uhle cut, 1902.
Trenches—Excavations of 1925.
000—Hedge around plateau.
Contour intervals 2' (0 is ' C. P. datum).
Scale: 1 inch equals 13⅓ feet.
Numbers and light lines show reference areas.

PLAN OF THE CONE OF THE EMERYVILLE SHELLMOUND

GENERAL SUMMARY

Any connected account of the history of the Emeryville shellmound and its inhabitants must be largely hypothetical. Yet since such accounts have been offered of the shellmounds, an attempt is made to set down by way of summary a brief interpretation of the evidence examined.

ORIGIN AND GROWTH OF THE MOUND

From time to time groups of people from the surrounding country came to the seashore at the mouth of Temescal creek. Their primary purposes in coming were to gather shellfish from the beds existing there and to hunt sea-otter which abounded in the bay. It is probable that they came at that season when these things could be best obtained—not only taking care of their present needs, but drying and pounding up the shellfish for future food supplies and taking the otter skins for clothing.

The first people who came to the site camped just above the shore line, possibly on little hummocks at the edge of the marsh.[101] As shellfish were obtained, the shells were thrown aside, and these with the by-products of daily life increased the height of the camp ground and gradually crept out into the marsh where the first shell thrown aside might have been several inches below the water level. As the shell area increased, subsequent people utilized it because it was drier, placing their camps, perhaps, over what had previously been marsh. At the time of the arrival of the first comers the topography of the region was possibly much the same as now. No certain evidence of land subsidence or cataclysmic changes since the beginning of the mound exists. This shell area grew until it covered some hundreds of thousands of square feet marked by several cones, the highest of which was some 30 or 35 feet above the original camp.

CHARACTERISTICS OF THE INHABITANTS

The people who first settled on the Emeryville site were essentially the same as those who last used it. But all the groups who used it were not identical. Indications of the differences exist but the data

[101] M. S. Nicol reports that at the West Berkeley shellmound he obtained two skeletons and a number of artifacts at a depth of four and one-half feet under the lowest shell, in the clay substratum.

do not permit an attempt at reconstruction. Taking the mound's inhabitants as a whole, some of their characteristics may be stated.

Fires and basketry were known from the beginning and food was probably cooked in baskets into which hot stones were thrown. Water fowl and deer were plentiful and were freely obtained by means of snares, traps, and wooden weapons rather than by bows and stone-tipped arrows. At the same time the people were able to obtain sea food, hunting the sea-otter, perhaps with balsa rafts. Acorns, seeds, and other vegetable food were used as the plentiful presence of mortars attests. Fish were caught by hook and line but not in nets. Wood was worked with horn wedges and partly wooden shelters of some kind were constructed. Warfare was infrequent since few bodies show signs of having been killed. Obsidian weapons in the mounds suggest that the enemies came from across the bay.

From the time of the first settlers some idea of aesthetic expression existed. Shell was worked into ornaments. Pipes, whistles, mortars, and clothing were decorated with beads. In form, charmstones and pipes indicate an appreciation of line. Whistles were decorated with simple geometric designs as were also abalone discs. Beads were shingled on caps in designs.

That social distinctions existed is indicated by the differences in burial practices. Some bodies were accompanied by many articles; others by none. This was noted even in infant burials. Special groups of objects—pipes, or whistles, or charmstones—with given individuals point to definite social positions or specialization of occupation.

The existence of cults is suggested by objects of a ceremonial nature such as crystals and charmstones. Whistles and the implied music and possibly dancing point the same way. Considering the existence but scarcity of tobacco pipes it is possible that smoking also was of a ceremonial nature.

Burial was the common method of disposing of the dead but cremation was known. The care used in disposing of the dead varied, but most frequently sufficient attention was given burial to warrant our believing that it was attended with considerable ceremony. Ornaments, if possessed, were buried with the dead, other artifacts frequently. In many cases these were "killed" or broken. The corpse was flexed and possibly placed with the head always toward the sea. Paint was freely used in adorning the body. Shell discs were frequently placed over the eyes, ears, mouth, and other openings of the body. Bodies were not placed in a graveyard although they do seem to have been in groups near the dwelling places.

In short, although we are dealing with a very simple people our evidence all points to an equal level of development in the dwellers on the Emeryville site. A group at a given time differs from that of another time, but the general degree of sophistication attained by the first is equivalent to that of the last. The differences when worked out will permit us to trace cultural relations with adjacent territories rather than to disclose the evolutionary cultural development of one group.

AGE OF THE MOUND

In the above summary, the time element has purposely been left aside. More widespread interest has been shown in this phase of the problem than in any other phase. This warrants our embarking on a discussion that must be speculative.

The absolute age of the mound would be the time of accumulation plus some period equal to the time the mound was not in use. From the skeletal data we have arrived at a time of accumulation (see page 203). The other factor may now be considered.

Was residence on the mound continuous? It has been seen that the skeletal data obtained when considered with reference to the varying rate of mound accumulation seemed to point to non-continuous residence. It has also been noted from the evidences of material culture recovered that whereas no regular or suggestive differences could be discovered in different vertical strata such as might have indicated evolutionary changes due to time, yet localized differences do appear in different portions of the mound—horizontal and vertical. These differences we took to be due to the fact that different groups of people lived on the mound at different times, i.e., residence was non-contiuous. The sites of the different mounds themselves suggest non-continuous residence. Stege was a good fishing place; Emeryville a resort for shellfish. In the autumn rains furnished drinking water and wild fowl were plentiful at Ellis landing; but during the winter time it was very exposed and wood was not convenient, while during the summer time drinking water must have been problematical. During such adverse seasons the neighboring hills or river valleys would have offered more protection and food. Our knowledge of the habits of Indians suggests a non-continuous residence on one site. To quote instances of seasonal or periodic shiftings would be tedious, but a couple relating to shellfish may be recalled. Strong has already been quoted to show seasonal visits to places where shellfish could be obtained. Abbott states that "tribes came from long distances to make

autumnal visits to our (Atlantic) sea coast.''[102] The Tasmanians[103] accumulated large shell heaps, and the Australians ''immense mounds of shells.''[104] As in none of these cases has it been shown that the culture of the shellmounds differed from that of the nearby interior regions, we can only assume that the interior peoples are responsible for the mounds which they accumulated during periodic visits. At Rancho San Antonio del Mar in Baja California, the author has noted shell heaps left by Indians who within the last twenty-five years made seasonal (winter) visits to that spot.

Granted non-continuous residence on the mound sites, we are confronted with the question—how long were they dwelt on each year? Here it seems that one man's guess is as good as another's and guesses would differ for different mounds. Considering the very favorable location at Emeryville, residence there during six months out of each year would not appear unreasonable.

The next unknown factor is the time which may have elapsed due to abandonments of the site for several years. Again only a guess can be advanced, but it seems a speculative possibility that a site as favorable as Emeryville would be occupied, except for seasonal absences, continuously from its first occupation to its final abandonment. Finally there is the time which has elapsed from the mound's final abandonment to the present. There is no evidence as to when Emeryville was left. It was apparently not occupied when Fages passed in 1772, but Indians seem to have been along this shore of the bay, where this is a principal site, after the Spanish arrival. Hence the author would incline to the belief that the site was occupied as long as Indians frequented the east shore of the bay.

On this speculative basis then the author's opinion would lean to the following maximum age for the cone at Emeryville and its immediate base.

Time of accumulation of cone removed	215 years
Time of accumulation of estimted base	215 years
Addition because residence on the mound was for only 6 months each year	430 years
Addition for abandonments and reoccupations	0 years
Final abandonment to 1924	140 years
Total age	1000 years

[102] *Op. cit.*, 16.

[103] W. J. Sollas, Ancient Hunters, 76.

[104] *Ibid.*, 190.

That such an age is not unreasonable seems to be indicated by the archaeological material which shows a remarkable evenness. This has been cited to show the extraordinary stability of culture among the aborigines during a period of three or four thousand years. In view of the fact that such stability is taken as extraordinary, and considering the time of accumulation based on actual data, it seems more reasonable to the author to cite this evenness of culture rather as a proof of a short period of elapsed time for the history of the mound.

While the Emeryville mound may be no older than 500 to 1000 years, and the differences we are able to detect in its culture are not very helpful in determining characteristics of relatively older cultures, it must be remembered that Emeryville is not necessarily the oldest mound of the bay region. The absence of stratification does not eliminate the possibility of the discovery of characteristic differences in different mounds, and of the securing of evidence (e.g., subsidence) of the relative ages of the mound which would enable cultural distinctions due to time to be detected. Awaiting such studies we cannot place man's residence on San Francisco bay at too remote a period.

EXPLANATION OF PLATES

Plate 35. *a*. The Emeryville shellmound in October, 1924; *b*. Southerly wall of Areas 28, 29, and 30.

Plate 36. *a*. Calcined layer on northwest slope; *b*. Cross-section in Areas 8 and 9.

Plate 37. *a*. Heavy ash deposits in Areas 21, 22, 29, 30; *b*. Clamshell lenses in Area 20.

Plate 38. Bone awls; *a–e*, of ulnae—type I; *f–m*, of cannon-bone—type II; *n–q*, of tibiae—type III; *r–s*, of sea-otter penis bone—type V.

a. 1–25735
b. 1–26081
c. 1–25737
d. 1–25739
e. 1–26079
f. 1–25764
g. 1–25780
h. 1–25756
i. 1–25763
j. 1–26092
k. 1–25760
l. 1–25762
m. 1–25781
n. 1–25745
o. 1–25752
p. 1–25748
q. 1–25749
r. 1–26138
s. 1–26137

Plate 39. Bone awls; *h*, of bird bone—type VI; all others of rib bone—type IV.

a. 1–26134
b. 1–26135
c. 1–26131
d. 1–26122
e. 1–26129
f. 1–26123
g. 1–26116
h. 1–25820
i. 1–25790
j. 1–25789
k, 1–26101
l. 1–26105
m. 1–26106
n. 1–26112
o. 1–25785
p. 1–26113
q. 1–25788
r. 1–25799

Plate 40. Bone fleshers.

a. 1–26069
b. 1–26073
c. 1–26073
d. 1–25733
e. 1–25734
f. 1–25723
g. 1–25727
h. 1–25731
i. 1–25730
j. 1–25726
k. 1–25729
l. 1–25720
m. 1–25724

Plate 41. Bone tubes and whistles.

a. 1–26188
b. 1–26189
c. 1–25872
d. 1–25865
e. 1–25880
f. 1–25881
g. 1–26466
h. 1–26525
i. 1–25884
j. 1–25885
k. 1–25885
l. 1–25885
m. 1–25871
n. 1–25873
o. 1–25848
p. 1–25849
q. 1–25846
r. 1–25845
s. 1–25836
t. 1–25837
u. 1–25861
v. 1–25835
w. 1–25855

Plate 42. Bone and horn artifacts.

a. 1–25818
b. 1–25886
c. 1–26141
d. 1–25890
e. 1–26220
f. 1–26195
g. 1–26194
h. 1–25897
i. 1–26208
j. 1–25891

Plate 43. Bone and horn artifacts; *a–c*, awls of uncertain bone—type VIII; *d*, awl of fish bone—type VII; *e–g*, bone needles; *h–i*, bone pins; *j–p*, bone beads; *q–r*, bone tubes; *s–hp*, fishhook parts; *pd*, horn pendant; *bt*, beaver's tooth; *mb*, drilled astragalus bone.

a. 1-25806
b. 1-25814
c. 1-25807
d. 1-25819
e. 1-26165
f. 1-26166
g. 1-25826
h. 1-26162
i. 1-26163
j. 1-26182
k. 1-26183
l. 1-26184
m. 1-26185
n. 1-26186
o. 1-25874
p. 1-25878
q. 1-25877
r. 1-25879
s. 1-26170
t. 1-26171
u. 1-26172
v. 1-26173
w. 1-26175
x. 1-26177
y. 1-25909
z. 1-25907
fh. 1-26527
hp. 1-25908
pd. 1-26196
bt. 1-25895
mb. 1-26457

Plate 44. Horn artifacts; *a–g*, wedges; [*h*, doubtful; *i*, cup; *j–l*, antler tip pendants; *m*, doubtful.

a. 1-25898
b. 1-26200
c. 1-26201
d. 1-26207
e. 1-26206
f. 1-26213
g. 1-26216
h. 1-26210
i. 1-26219
j. 1-25906
k. 1-26528
l. 1-25905
m. 1-26470

Plate 45. Shell beads and discs; *a–b*, abalone shell beads; *c*, mussel shell bead; *d–e*, olivella whole shell bead; *f–g*, olivella disc bead; *h–i*, olivella inlay or bushing; *j–k*, olivella bead, ring type; *l–m*, olivella rectangular bead, broad type; *n–o*, olivella rectangular bead, barrow type; *p–q*, miscellaneous ornaments; *r–t*, abalone discs.

a. 1-25616
b. 1-25616
c. 1-26053
d. 1-25628
e. 1-25628
f. 1-25654
g. 1-25654
h. 1-25659
i. 1-25659
j. 1-25682
k. 1-25682
l. 1-25688
m. 1-25688
n. 1-25699
o. 1-25699
p. 1-25619
q. 1-25619
r. 1-25618
s. 1-25598
t. 1-25610

Plate 46. Abalone shell pendants.

a. 1-25557
b. 1-26036
c. 1-25568
d. 1-25563
e. 1-25570
f. 1-25570
g. 1-25571
h. 1-25571
i. 1-25576
j. 1-25577
k. 1-25579
l. 1-25579
m. 1-25587
n. 1-25587
o. 1-25587
p. 1-25592
q. 1-26044
r. 1-25595
s. 1-25595
t. 1-26038
u. 1-26051

Plate 47. Pendants, crystals, basketry; *a–g*, mica pendants; *h–j*, quartz crystals; *k–o*, abalone shell pendants; *p*, "snake's head"; *q–s*, basketry evidence.

a. 1-25539
b. 1-25539
c. 1-25539
d. 1-25540
e. 1-25540
f. 1-25538
g. 1-25538
h. 1-25449
i. 1-25553
j. 1-25553
k. 1-25580
l. 1-25596
m. 1-25585
n. 1-25585
o. 1-25584
p. 1-25439
q. 1-25958*
r. 1-25958*
s. 1-25958

* Wax impression of.

Plate 48. Chipped stone points. All are of obsidian except *k*, which is of mottled flint; *p*, which is gray chalcedony; and *q*, which is greenish chert.

a. 1–25505
b. 1–26006
c. 1–26010
d. 1–25452
e. 1–25455
f. 1–25456
g. 1–25457
h. 1–25451
i. 1–25460
j. 1–26000
k. 1–25997
l. 1–26004
m. 1–26001
n. 1–26007
o. 1–26011
p. 1–25450
q. 1–25998

Plate 49. Stone mortars; *a*, type V; *b*, type I.

a. 1–25349
b. 1–25323

Plate 50. Stone mortars; *a*, type II; *b*, type III; *c*, type IV.

a. 1–25531
b. 1–25337
c. 1–25343

Plate 51. Pestles.

a. 1–25412. Type III.
b. 1–25376. Type I.
c. 1–25380. Type II.
d. 1–25420. Type IV.

Plate 52. Pipes and plugs; *a–c*, pipes; *d*, *g*, plugs; *e*, *f*, pipes.

a. 1–25503
b. 1–25501
c. 1–25500
d. 1–25497
e. 1–25499
f. 1–25498
g. 1–25496

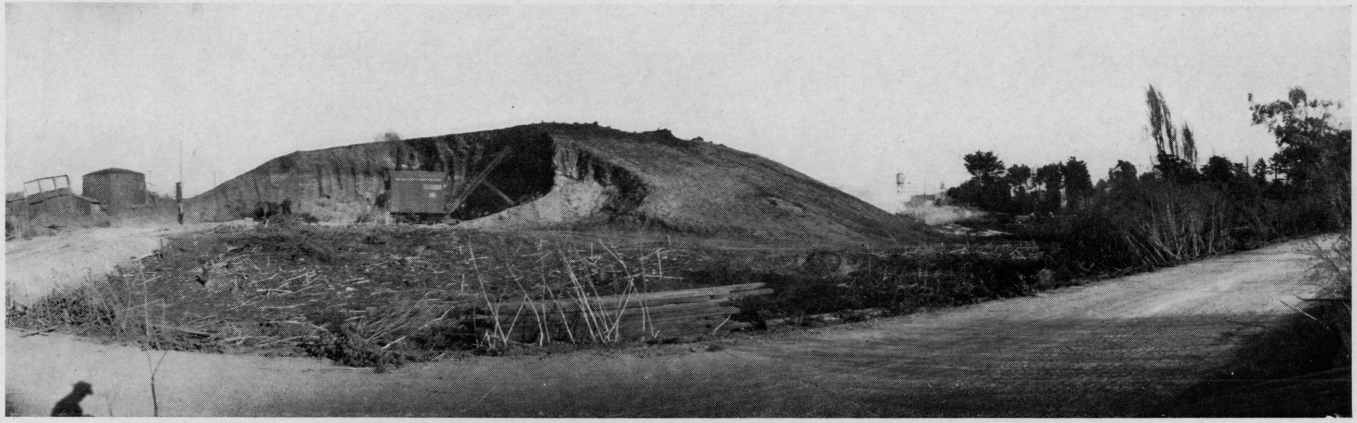
Plate 53. Plummet-like stones and (or) charmstones.

a. 1–26012
b. 1–26013
c. 1–26015
d. 1–25482
e. 1–25476
f. 1–25473b
g. 1–25473c
h. 1–25487
i. 1–25474
j. 1–25488
k. 1–25485
l. 1–25481
m. 1–25464
n. 1–25465
o. 1–25466
p. 1–25463

Plate 54. Miscellaneous mineral pieces. *a*, sinker; *b–c*, sharpening stones; *d–f*, baked clay; *g*, chalcedony concretion; *h*, "red paint"; *i*, obsidian pebble; *j*, round pebble; *k*, whetstone; *l*, doubtful; *m*, paint mortar; *n*, greenstone schist pestle.

a. 1–25495
b. 1–25955
c. 1–25953
d. 1–25543
e. 1–25959
f. 1–25960
g. 1–25447
h. 1–25506
i. 1–25461
j. 1–26541
k. 1–26532
l. 1–25436
m. 1–25914
n. 1–26534

PLATES 35-54



a. THE EMERYVILLE MOUND IN OCTOBER, 1924



b. SOUTHERLY WALL OF AREAS 28, 29, AND 30



a. CALCINED LAYERS ON NORTHWESTERN SLOPE



b. CROSS-SECTION IN AREAS 8 AND 9



a. HEAVY ASH DEPOSIT IN AREAS 21, 22, 29, AND 30



b. CLAMSHELL LENSES IN AREA 20



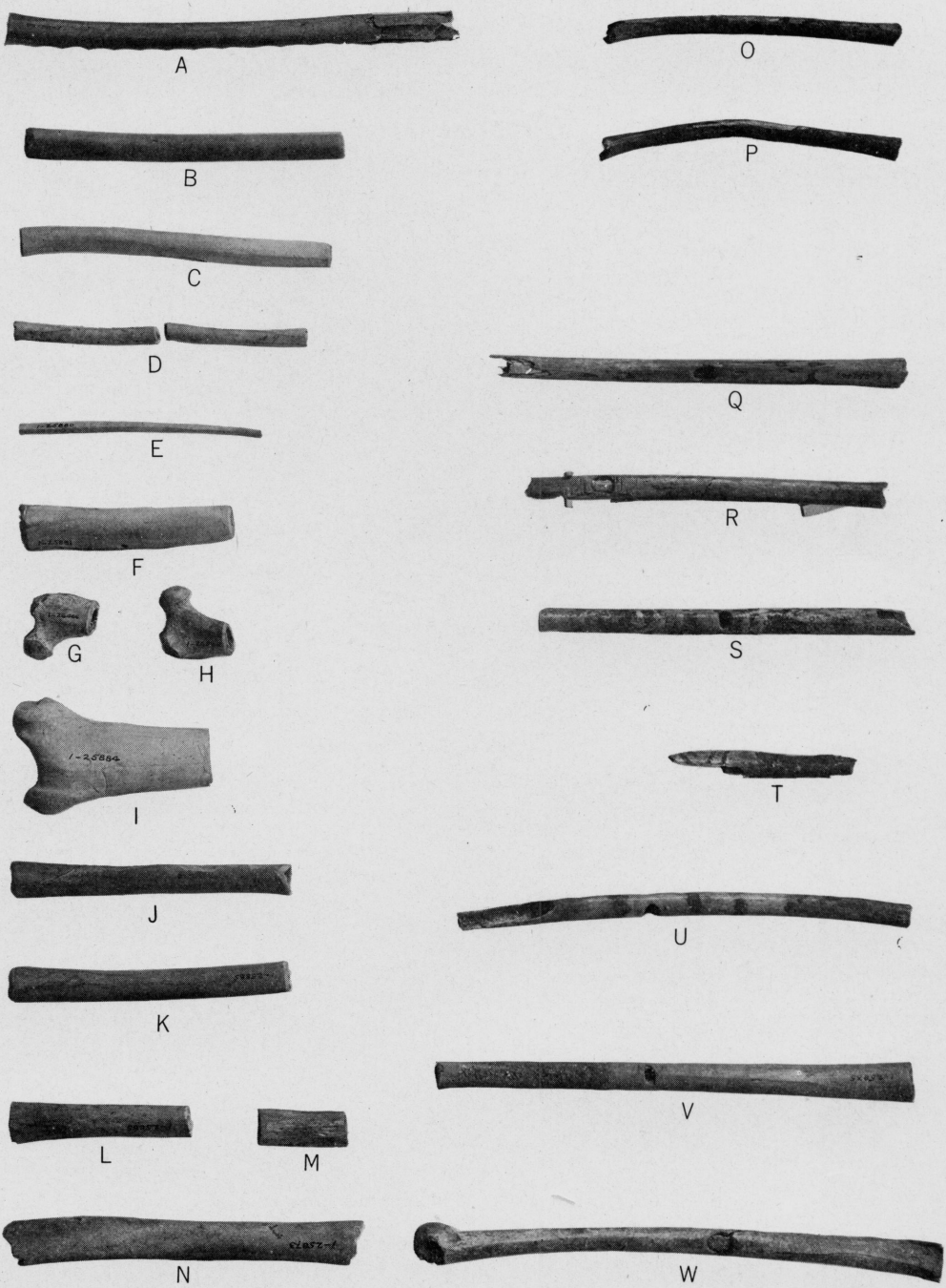
BONE AWLS



BONE AWLS

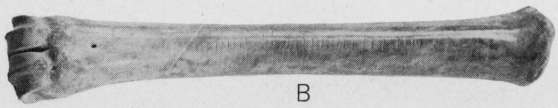


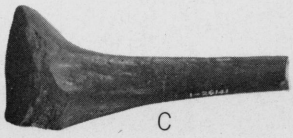
BONE FLESHERS



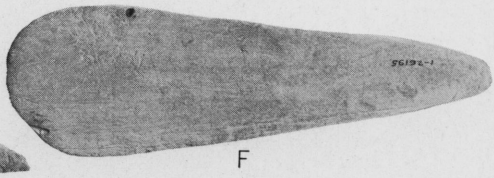
BONE TUBES AND WHISTLES













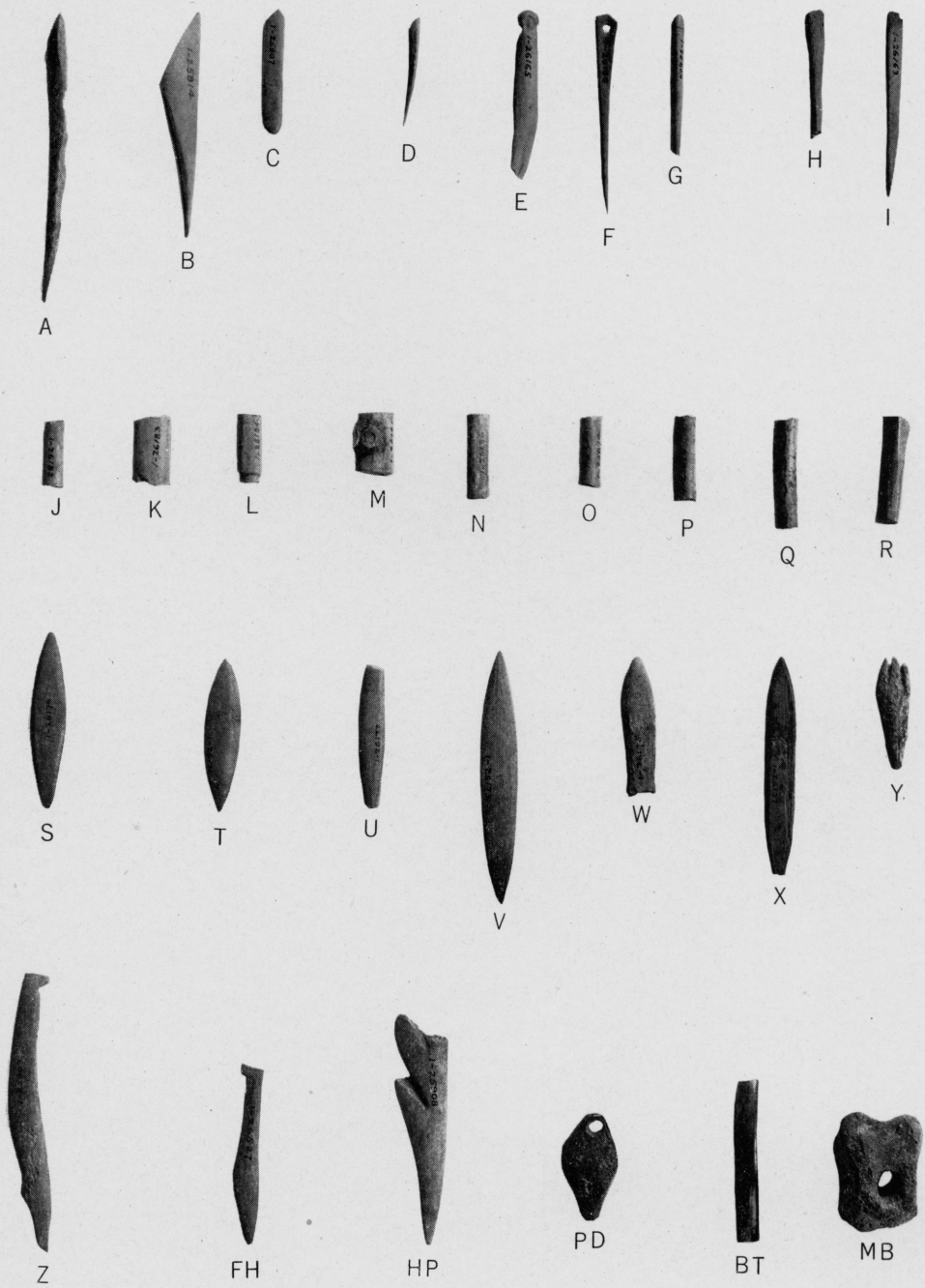






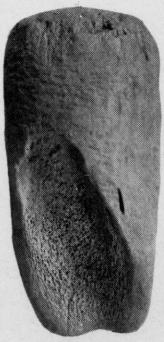


BONE AND HORN ARTIFACTS

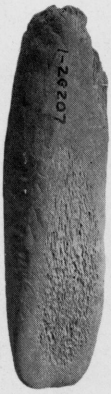


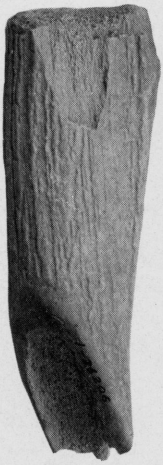
BONE AND HORN ARTIFACTS


A


B


C


D


E


F


G


H


I

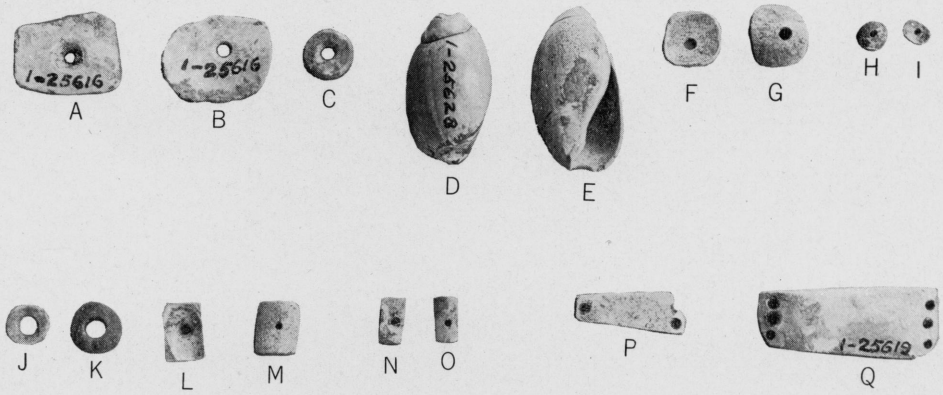

J

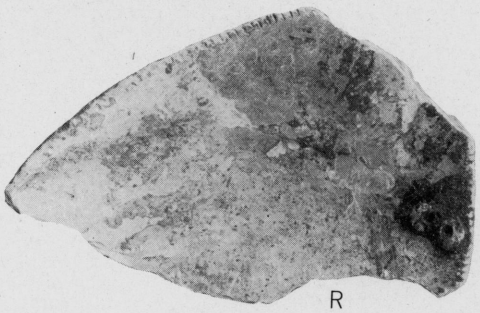

K


L


M

HORN ARTIFACTS

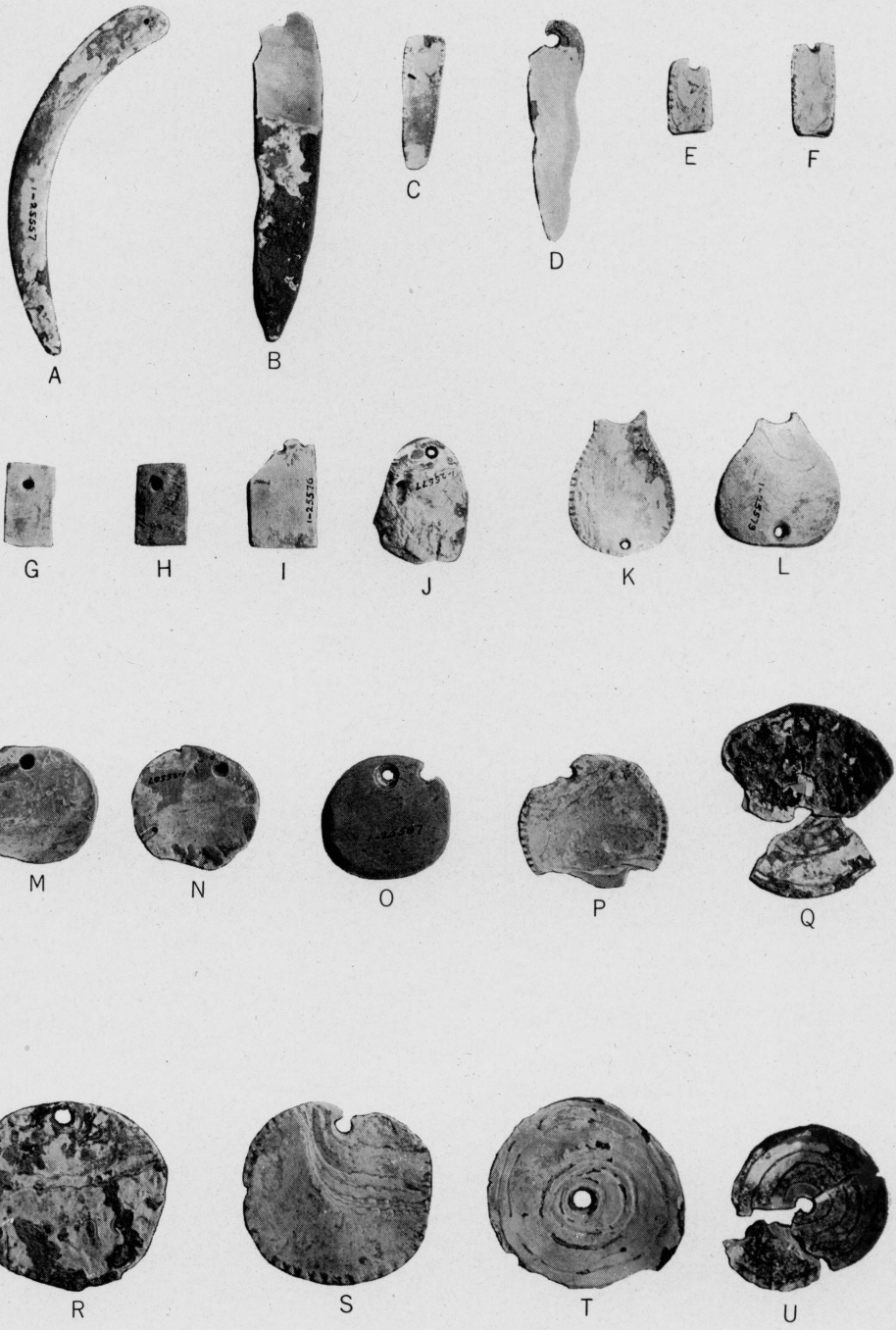




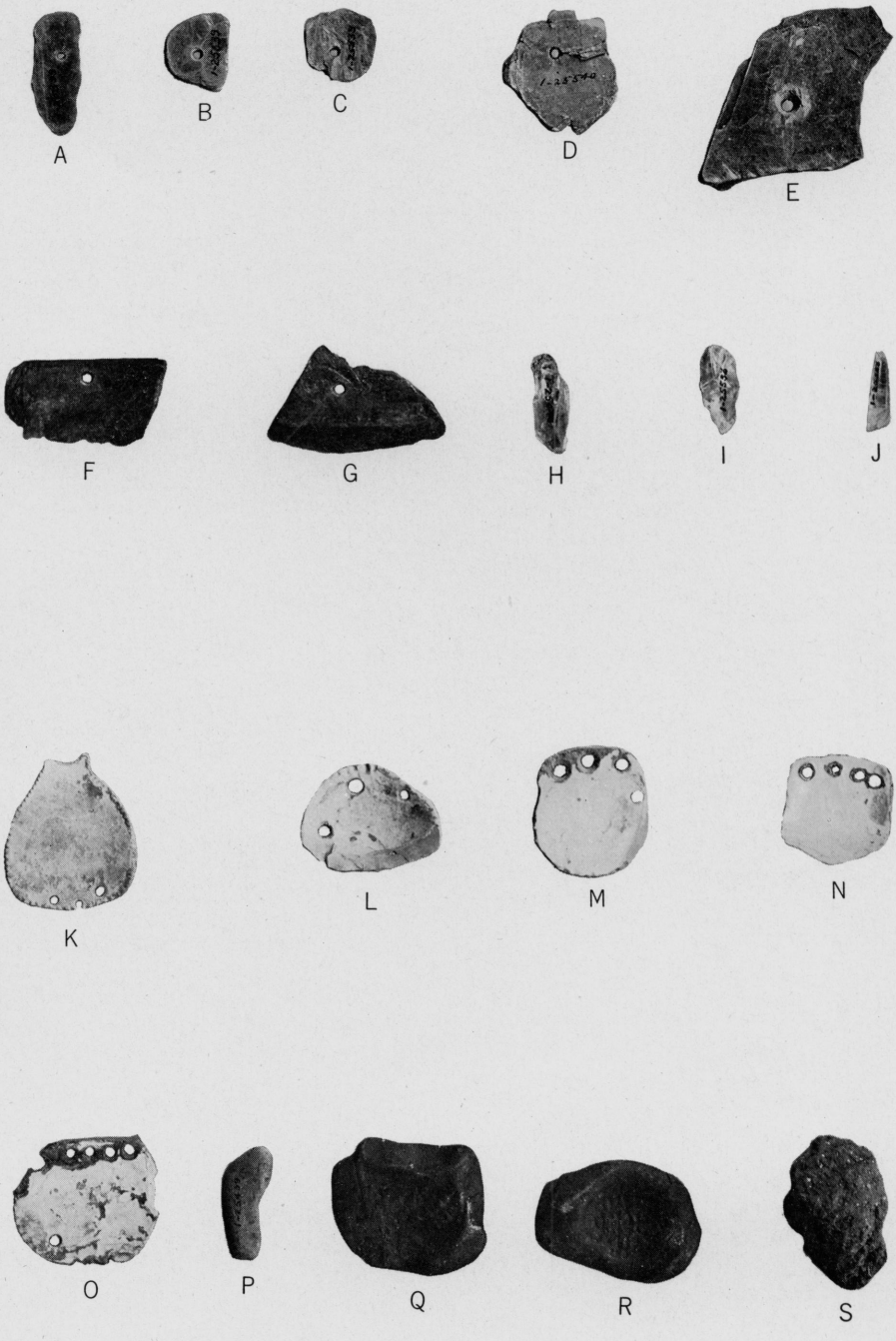




SHELL BEADS AND DISCS



ABALONE SHELL PENDANTS



PENDANTS, CRYSTALS, BASKERTY



CHIPPED STONE POINTS



A

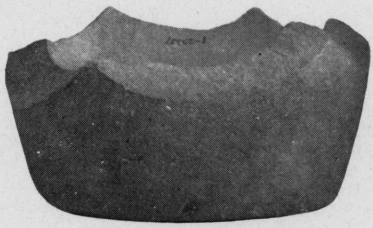


B

STONE MORTARS



A

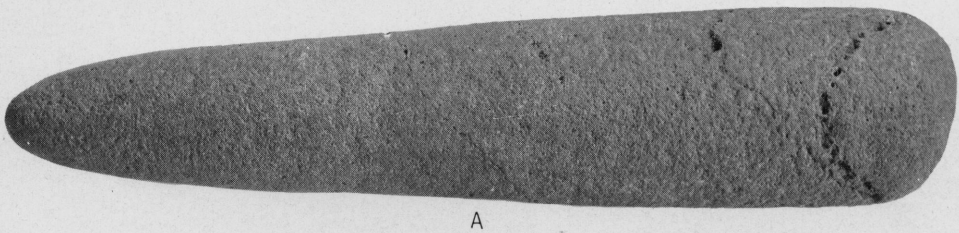


B



C

STONE MORTARS



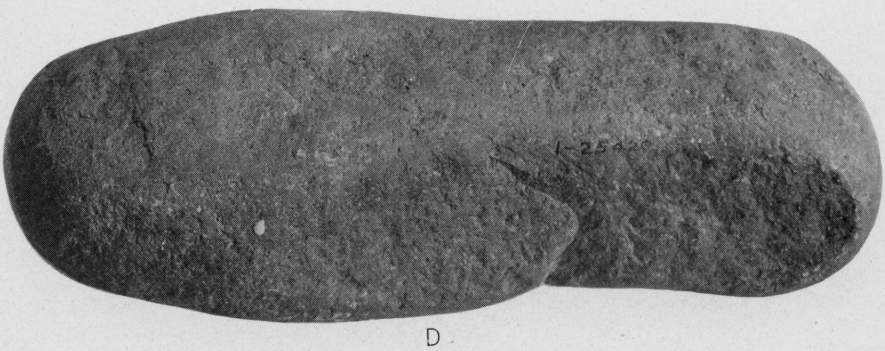
A



B

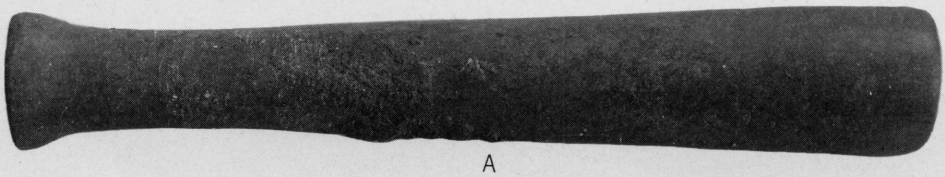


C

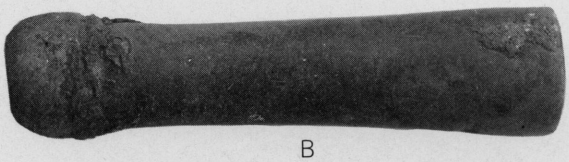


D

PESTLES



A



B



C



D



E

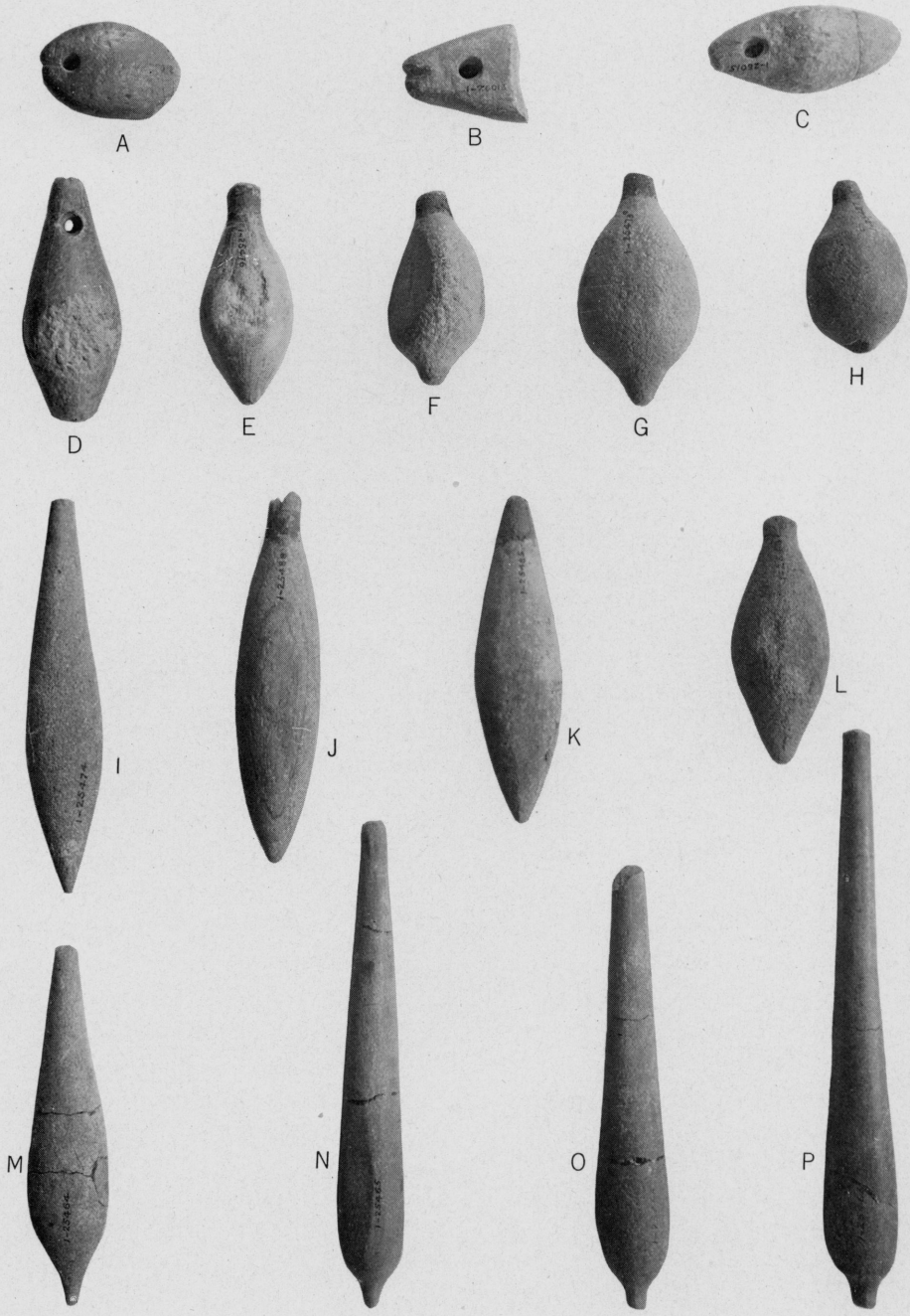


F



G

PIPES AND PLUGS



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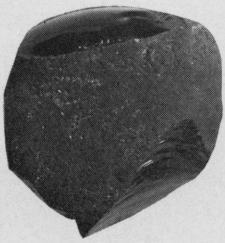

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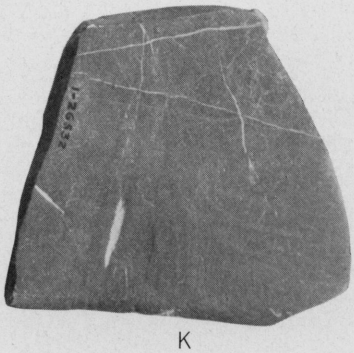

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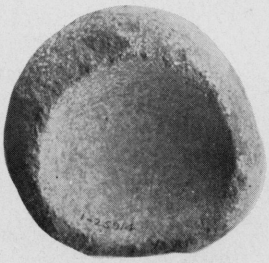

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CDM

The Sherwin-Williams Company

Remedial Action Plan
Emeryville, California

June 11, 2010

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Attention: Janet Naito

Subject: Transmittal of Remedial Action Plan, Sherwin-Williams Site, 1450 Sherwin Avenue, Emeryville, California, Imminent and Substantial Endangerment Determination and Order and Remedial Action Order, Docket No. IS/E 05/06-007

Dear Ms. Naito:

On behalf of The Sherwin-Williams Company, CDM is pleased to submit the enclosed Remedial Action Plan for the Sherwin-Williams Emeryville, California Site. The Site is the subject of the order issued on May 10, 2006 by the DTSC, entitled "Imminent and Substantial Endangerment Determination and Order and Remedial Action Order, Docket No. IS/E 05/06-007" ("the DTSC Order"). This report was prepared in accordance with Section 5.6 of the DTSC Order.

In accordance with the DTSC Order, this report is presented in both hard (paper) and electronic (as multiple pdf files on a CD) formats. If you have any questions, please call Pawan Sharma, Project Manager for CDM, (925) 296-8054, or Larry Mencin, Environmental Project Manager for the Sherwin-Williams Company, (216) 566-1768.

Very truly yours,

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Remedial Action Plan

June 11, 2010

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CERTIFICATION:
This document was prepared under the direction and supervision of qualified, registered professionals.







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Acronyms

ARARs	applicable or relevant and appropriate requirements
BAAQMD	Bay Area Air Quality Management District
bgs	below ground surface
CA	California
CAA	Clean Air Act
Cal/OSHA	California Occupational Safety and Health Act
CCR	California Code of Regulations
CCRS	Current Conditions Risk Screen
CDM	Camp Dresser & McKee Inc.
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CH&SH	California Health and Safety Code
CKD	cement kiln dust
COC	chain-of-custody
COC	chemical of concern
CWA	Clean Water Act
DCA	dichloroethane
DCE	dichloroethene
DTSC	Department of Toxic Substances Control
EBMUD	East Bay Municipal Utility District
EIR	Environmental Impact Report
FS	feasibility study
ft	feet
GC	gas chromatograph
GWET	groundwater extraction and treatment
HASP	health and safety plan
HHRA	human health risk assessment
HSWA	Hazardous and Solid Waste Amendments
HWCA	Hazardous Waste Control Act
IRM	interim remedial measure
IS/MND	initial study/mitigated negative declaration
LDR	land disposal restriction
LFR	Levine-Fricke-Recon
LUC	land use control
MCL	maximum contaminant level
µg/kg	microgram per kilogram
µg/m^3	microgram per cubic meter
µg/cm	microgram per centimeter
mg/kg	milligram per kilogram
mg/L	milligram per liter
MSE	MSE Technology Applications, Inc.

MSL	mean sea level
MT2	Metals Treatment Technologies, LLC
NAAQS	National Primary and Secondary Ambient Air Quality Standards
NCP	National Contingency Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutant
NOI	notice of intent
NPDES	National Pollutant Discharge Elimination System
OSHA	Occupational Safety and Health
PDP	preliminary development plan
PEL	permissible exposure limit
PM10	particle measuring 10 microns or less
POTW	publicly owned treatment works
PPE	personal protective equipment
ppb	parts per billion
ppm	parts per million
PRG	preliminary remedial goal
QA	quality assurance
QC	quality control
RA	risk assessment
RAL	remedial action level
RAO	remedial action objective
RBTL	risk-based target level
RCRA	Resource Conservation and Recovery Act
RG	remedial goal
RI	remedial investigation
RMP	risk management plan
S-W	Sherwin-Williams
SAAQS	State Ambient Air Quality Standards
SAP	sampling and analysis plan
SHSO	site health and safety officer
SPLP	synthetic precipitation leaching procedure
STLC	solubility threshold limit concentration
SVOC	semi-volatile organic compound
SWPPP	storm water pollution prevention plan
SWRCB	State Water Resource Control Board
TBC	to be considered
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TPH	total petroleum hydrocarbon
TSDF	treatment, storage, and disposal facility
TTLC	total threshold limit concentration
UHC	underlying hazardous constituent
UPRR	Union Pacific Railroad
USC	United States Code
USEPA	United States Environmental Protection Agency
UTS	Universal Treatment Standard

VOC	volatile organic compound
Water Board	California Regional Water Quality Control Board
WET	waste extraction method

Section 1
Introduction and Purpose

On behalf of the Sherwin-Williams Company (S-W), Camp Dresser & McKee Inc. (CDM) has prepared this Remedial Action Plan (RAP) to address remediation of the S-W property located at 1450 Sherwin Avenue in Emeryville, California and a portion of the adjacent former Rifkin property, located at 4525 – 4563 Horton Street, to which hazardous substances have migrated from the S-W property. Collectively the S-W property and this portion of the former Rifkin property are referred to as the "Site" within this document. The Site consists of approximately 10 acres and is identified by Assessor's Parcel numbers 049-1041-006-00, 049-1041-026-02, 049-1041-026-06, 049-1041-026-07, 049-1041-026-04, and 049-1041-005-00. Novartis Vaccines and Diagnostics, Inc. (Novartis) is the current owner of the former Rifkin property.

The RAP was prepared in accordance with the following:

- National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (USEPA, 1990);
- Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988);
- A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (USEPA, 2000);
- US Environmental Protection Agency (USEPA) Region IX Sampling and Analysis Plan Guidance (USEPA, 1997);
- California Health and Safety Code (CHSC) section 25356.1; and
- Department of Toxic Substances Control (DTSC) Imminent and Substantial Endangerment Determination and Order and Remedial Action Order No. 05/06-007 (the Order) (Cal/EPA, 2006b).

1.1 Background

S-W has owned and operated the coatings manufacturing plant at 1450 Sherwin Avenue since the early 1900s. Pesticides containing lead and arsenic were also manufactured at the plant from the 1920s until the late 1940s. The plant converted from oil-based to water-based paint production in 1987. The plant was used for latex paint manufacturing and packaging, storage of raw materials and paint products, and laboratory space until December 2006 when operation of the plant stopped and the plant was decommissioned. S-W initiated plant demolition activities in August 2007, which were completed in early November 2007.

Prior to the issuance of the current DTSC Imminent and Substantial Endangerment Determination and Order and Remedial Action Order No. 05/06-007 (the Order)

(Cal/EPA, 2006b) for the Site on May 10, 2006, the Site was regulated by the Regional Water Quality Control Board, San Francisco Bay Region, (Water Board) under Site Cleanup Requirements Order 98-009.

Several phases of soil and groundwater investigation have been conducted at the Site since 1988. The investigations have revealed that the chemicals of concern (COCs) in the soil and groundwater are metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPHs). The investigations concluded that COCs have migrated from the S-W property onto a portion of the adjacent former Rifkin property. Site soil and groundwater data through October 2000 are summarized in the remedial investigation (RI) report (ENTRIX, 2002). Since October 2000, results from periodic groundwater monitoring events have been summarized in a series of reports, the most recent for Second Half 2007 (LFR, 2008). In addition, several investigations have been conducted after October 2000 to complete characterization of the Site and to gather data in support of this FS report; these investigations are further discussed in Section 2.4.

Several interim remedial measures (IRMs) were implemented at the Site in the early 1990s to control the flow of COCs in groundwater off the Site and reduce the potential for human exposure to the COCs. The potential human health effects of the COCs in Site soil and groundwater for current and future scenarios are summarized in the Site risk assessment (RA) reports (EarthRisk, 2002 and Gradient, 2005). The IRMs are still in place at the Site and include a slurry wall, an asphalt cap, extraction and monitoring wells, and a groundwater treatment system.

In late 2006, a feasibility study (FS), including treatability studies, was initiated for selecting the final remedial action for the Site. The findings were presented in a FS report (CDM, 2009b). The FS report was approved by DTSC on May 7, 2009 (Cal/EPA, 2009).

1.2 Purpose

The purpose of the RAP is to summarize the selected final remedial action for the Site and its proposed implementation activities. In addition, the RAP summarizes previous investigations and studies, including evaluation of remedial action alternatives as presented in the FS.

Specific objectives of the RAP are to:

- Identify project administrative responsibilities;
- Present planning, pre-remediation, remediation, and reporting tasks of the selected remedial action; and
- Provide a tentative schedule for the remedial action.

1.3 Project Administration Responsibilities

Several entities and individuals will be responsible for the successful completion of the remedial action. Their specific responsibilities are described below.

Responsible Party: The Sherwin-Williams Company. Larry Mencin is the designated Project Manager for S-W. He is the corporate representative at all agency meetings; he is responsible for assuring that sufficient funding is available to complete the approved remedial activities; he is responsible for communication between senior corporate management and the rest of the remediation project team.

Lead Agency: Department of Toxic Substances Control (DTSC). Janet Naito is the designated Project Manager for the DTSC. She is responsible for assuring that S-W complies with all the requirements in the existing Order. As the lead agency representative, she is responsible for communicating all project activities to senior DTSC management as necessary. She is also responsible for all project communication with the general public, including the immediate residents around the Site. Representatives from the Water Board, City of Emeryville, Novartis, Shell Oil Company, S-W, and the local resident communities, serve advisory roles to the DTSC on this project.

Program Manager: Camp Dresser & McKee Inc. (CDM). CDM is the remediation program manager for the project. Randall Smith is the designated Program Manager for CDM. He and his representatives are responsible for all direct communication between CDM and S-W, and CDM and the DTSC. He is also responsible for the health and safety of all CDM workers and their subcontractors during all phases of site remediation. Working with Mr. Smith will be CDM Design Manager, Construction Manager, Field Environmental Manager, and a Health and Safety Manager.

Remediation Contractors: To Be Determined. S-W will select one or more contractors to perform the work described in this section and presented in more detail in the specifications yet to be prepared. CDM will oversee the remediation management. Selected remediation contractors will be responsible for preparation and implementation of required City permits, a worker Health and Safety Plan, and applicable noise, traffic, dust control, and/or other compliance plan submittals.

1.4 Report Organization

This RAP document is structured as follows:

- **Section 1, Introduction and Purpose**.
- **Section 2, Site Description**. Includes a summary of the Site location, description, and history; and, a summary of previous Site-specific remedial activities, including remedial investigations, risk assessments, current interim remedial measures, and treatability studies.

- **Section 3, Remedial Action Objectives**. Presents project-specific remedial action objectives (RAOs) and underlying applicable or relevant and appropriate requirements (ARARs) and preliminary remediation goals (PRGs).

- **Section 4, Remedial Action Alternatives**. Summarizes the findings of the FS, including identification, description, and evaluation of remedial action alternatives; and presents the basis for the selected action.

- **Section 5, Planning and Pre-Remediation**. Presents the preliminary implementation schedule for the action, planning activities prior to mobilization for the remedy, and pre-remediation Site activities to support the remedy.

- **Section 6, Remediation and Restoration**. Provides details on the implementation of the remediation activities, including excavation, backfill, off-hauling materials, and restoration.

- **Section 7, Post Remediation Monitoring**. Presents a summary of post remedy implementation monitoring.

- **Section 8, References**.

- **Appendix A, Selected Remedial Investigation Figures and Tables**. Presents figures and/or tables from the Site RI report and subsequent investigation reports showing sample locations, extent of impact for various COCs in soil and groundwater, and findings from these investigations.

- **Appendix B, Selected Feasibility Figures and Tables**. Presents figures and tables from the Site FS report showing remedial action alternatives and their evaluation process.

- **Appendix C, Determination of Chemicals of Potential Concern**. Summarizes the methods presented in the HHRA for selection of COCs for the Site, provides updated findings based on remedial investigations conducted subsequent to the HHRA being finalized.

- **Appendix D, Statement of Reasons**. Presents the reasons for selection of the preferred remedial action with respect to the six State of California evaluation criteria.

- **Appendix E, Non-Binding Allocation of Responsibility**. Presents DTSC's preliminary nonbonding allocation of responsibility for addressing contamination at the Site.

- **Appendix F, California Environmental Quality Act Documentation**. Presents DTSC's California Environmental Quality Act (CEQA) Mitigated Negative Declaration for this Site.

- **Appendix G, Selected Public Health Evaluation Figures and Tables**. Presents figures and tables from the Site PHERA report showing performance standards and action levels for COCs to be used during perimeter air monitoring.

- **Appendix H, Confirmation Vadose Zone Soil Sampling and Analysis Plan**. Presents the methods and scope for sampling and analysis of vadose zone soil during excavation.

- **Appendix I, Stockpile Soil Sampling and Analysis Plan**. Presents the methods and scope for sampling and analysis of stockpiles of excavated soils.

- **Appendix J, Criteria for Implementing Active Groundwater Extraction.** Presents the evaluation for determining the appropriate groundwater extraction contingency action criteria for arsenic at the slurry wall breaches along the Union Pacific Railroad property.

- **Appendix K, Contingency Groundwater Extraction Action Evaluation.** Presents the evaluation of groundwater extraction as a possible contingency action after implementation of the preferred remedy.

- **Appendix L, Responsiveness Summary.** Presents DTSC's response to comments submitted during the public comment period for the RAP and the CEQA Mitigated Negative Declaration.

Section 2
Site Description

This section describes the Site and surrounding area, and summarizes the Site history. In addition, summaries of the remedial investigations, risk assessments, interim remedial actions, and treatability studies performed to date at the Site are presented in this section.

2.1 Site Location and Description

The Site consists of the S-W property located at 1450 Sherwin Avenue in Emeryville, California, and a portion of the adjacent former Rifkin property, located at 4525 – 4563 Horton Street, to which hazardous substances have migrated from the S-W property. Figure 2-1 presents the location of the S-W property and the entire former Rifkin property. Figure 2-2 presents a plan view of the Site. This section provides a description of the S-W property, the former Rifkin property, and other adjacent properties.

2.1.1 Sherwin-Williams Property

The S-W property is located at 1450 Sherwin Avenue in Emeryville, Alameda County, California. The S-W property is located on the north side of Sherwin Avenue, between Horton Street and the Union Pacific Railroad (UPRR) lines. S-W has operated at the property since the early 1900's, most recently manufacturing water-based paints at the property. Subsequent to demolition activities that concluded in late November 2007, the property is now covered by asphalt/concrete paved areas, including the foundations for several demolished buildings, and two remaining buildings (Buildings 1 and 31). Past uses for the buildings have included: coating manufacturing; storage of raw materials and coating products; laboratories; and filling and packaging.

2.1.2 Former Rifkin Property

The former Rifkin property is located along the western side of Horton Street, adjacent to the north and east of portions of the S-W property. The former Rifkin property is owned by Novartis. The portion of the former Rifkin property included as part of the Site is currently covered by asphalt and serves as a parking lot.

2.1.3 Adjacent Properties

Properties located adjacent to or within close proximity to the Site include residential, commercial and industrial types. These other properties include: the former Shell Development property (currently South BGR property and 45th Street Artist Co-op); the former Southern Pacific Railroad (SPRR) (currently UPRR); the former Myers Container property and the former Elementis Pigment property (both currently Bay Street Partners LLC property); former Barbary Coast Steel property (currently IKEA Property Inc.); a former Sears Warehouse (currently Bayer-leased warehouse and East Bay Badminton Club); and multi-family residential buildings (i.e., Emeryville Lofts,

Horton Street Lofts, and Artists Co-op Annex). The nearest residences to the Site are opposite Sherwin Avenue and Horton Street, approximately 60 feet from the Site boundaries.

The South BGR/former Shell Development property, located east of Horton Street, consists of a few buildings that are currently leased to Novartis. The former Elementis Pigment property and the former Myers Container property, located northwest of the Site, have been remediated (through excavation with long-term groundwater monitoring) and developed for mixed-use purposes, including high-density residential, commercial, and retail use. The former Barbary Coast Steel property, located to the west of the Site, is currently occupied by an IKEA retail store.

2.2 Site History

This section provides a brief summary of the history of the S-W property and the former Rifkin property. The source of this information is the 2002 ENTRIX Site RI report (ENTRIX, 2002).

2.2.1 History of the Sherwin-Williams Property

From 1871 through 1915, the S-W property and much of the adjacent properties were initially part of a larger property first used as a horse track, known as the Oakland Trotting Park, and then as a gathering place for local aviators, known as the Oakland Aviation Field. By 1915, the field had fallen into disrepair, and the buildings were removed. The property was subdivided into smaller properties to sell to industries interested in moving to the Emeryville area.

The S-W property was part of the early wave of industrial development in the City of Emeryville. One of the earliest references to S-W presence in Emeryville was in the 1923 Oakland Tribune Yearbook. The Tribune indicated new businesses that had moved into their readership area with a location map. This map indicated that S-W built their plant in 1919 on three acres, and by 1923 had increased their property to six acres. A number of industries, warehouses, and railroad services developed over time on the adjacent properties. A general operational history of facilities at the S-W property and several nearby properties is provided below.

Since operations began, the S-W facility has been manufacturing various types of coating products. Lead-arsenate pesticides were also manufactured at the plant from the 1920s until the late 1940s. By 1987, S-W ceased manufacturing oil-based products and until late 2006 manufactured only water-based products.

In approximately 1920, buildings were constructed on the property for general warehouse, paint, and lead arsenate manufacturing and storage. Additional buildings were constructed in 1924 and 1926 for lead arsenate production and lacquer blending. Based on a 1933 aerial photo, areas adjacent to these buildings appear to have been unpaved. During this time, a railroad track spur was present in the middle of the S-W property, and seven sets of railroad tracks were present immediately off-site to the west. A production well to furnish water for the sprinkler system was

located in the north-central portion of the S-W property; the production well was taken offline in the 1980s and destroyed in the 1990s via pressure-grouting. The East Bay Chemical Company was located immediately north of the S-W property, and the east and south sides of the S-W property were bordered by Horton Street and Sherwin Avenue.

In the mid to late 1940s, lead-arsenate production and storage ceased, and only oil-based paints and varnishes were manufactured. By 1956, several of the older buildings at the S-W property had been demolished, and the railroad tracks immediately to the west of the S-W property were removed. New buildings were constructed over the footprint of demolished buildings, and storage tanks were installed to store alcohols and acetates. These chemicals were used in the production of lacquer.

In 1956, the solvents used in the manufacturing process were naphtha and kerosene. Through the 1970s, several types of solvents were used, such as naphtha, styrene, xylene, toluene, ketones, and acetone. Acetone was used as a low-boiling point thinner in some lacquers. Methyl isobutyl ketone was a medium boiling point thinner used in resins, enamels, and lacquers. Nitrocellulose was a binder being used in the early 1970s in the production of lacquers. Toluene and xylene were thinners commonly used in the late 1970s. The liquids were usually stored in aboveground storage tanks.

By 1964, Sherwin-Williams purchased the adjacent property to the west from the Southern Pacific Railroad creating the current 8.3-acre property. A large portion of this property was originally developed into a warehouse (Building 35) that was converted into manufacturing in 1987.

The 1987 switch from oil-based to water-based paint products was reflected by the following changes at the S-W property:

- Dismantling of the solvent tank farm and the removal of most of the solvents and oil.
- Removal of varnish production and storage facilities.
- Removal of the lacquer plant.
- Expansion of the latex and latex-product storage tanks.
- Expansion of water-based paint manufacturing into building 35.

Paint manufacturing operations ceased in December 2006 and the plant was decommissioned. S-W initiated plant demolition activities in August 2007, which were completed in November 2007.

2.2.2 History of Former Rifkin Property

The former Rifkin Property was also originally part of the larger area of the Oakland Trotting Park and later California Jockey Club Race Track until approximately 1915. It is uncertain what types of businesses operated on this property from 1915 to approximately 1928, although it is known that these early businesses included the East Bay Chemical Company.

Based on a chain-of-title search for the former Rifkin Property, during 1928 to 1937, one portion of the property was occupied by Rotary Oil and the other portion was occupied by Rheem Manufacturing and then owned by the Chubbucks. Both of these portions were combined and transferred to the California Container Corporation in 1937, which produced corrugated shipping containers and boxes. In 1958, the Container Corporation of America took control of California Container Corporation and the property. The Concora Corporation owned and operated the property between 1969 and 1978. Rifkin Investments purchased the property in 1978 and rented portions of building space to various small businesses including a small furniture refinisher, a silkscreen company, an automobile body and paint shop, and a foreign auto repair shop. The Chiron Corporation acquired the property in 1996. In 2006, Novartis acquired Chiron Corporation and became the property owner.

Several underground storage tanks (including heating oil, gasoline, coatings, and a diesel tank) existed on the Rifkin property as early as the 1940s.

2.3 Physical and Environmental Characteristics

This section provides a summary of the:

- regional geology;
- site geology;
- groundwater zones underlying the Site and their hydrogeology; and
- surface water system and groundwater-surface water interaction.

The source of this information is the 2002 ENTRIX Site RI report (ENTRIX, 2002).

2.3.1 Regional Geology

The Site is located on the eastern flank of the San Francisco Basin, which roughly corresponds to present day San Francisco Bay (herein referred to as the bay). The bay is formed by a major asymmetrical basement synform within the Coast Range Province. It is bounded on the east by the Hayward Fault and on the west by the San Andreas Fault. The trace of the Hayward Fault occurs in the Berkeley Hills, approximately 3.5 miles to the east of the Site. Basement rock underlying the bay consists of the Franciscan Complex. Bedrock features trend northwest-southeast through the area and have influenced the depositional history of the bay. The

Franciscan bedrock is unconformably overlain by the Early Pleistocene Santa Clara Formation, which consists of continental alluvial fan deposits.

As the Franciscan was uplifted in the eastern portion of the basin, these alluvial fan deposits were themselves eroded and re-deposited. The non-marine alluvial deposits on the eastern flank of the basin have been mapped as the Alameda, San Antonio, and Temescal Formations. The seas flooded the central portion of the basin and the Santa Clara Formation eroded into the Alameda Formation. The Alameda Formation is restricted to the marine units beneath the bay up to and including the Young Bay Mud. The alluvial fan units located between the bay and the hills are referred to as the San Antonio or Temescal Formations.

The basin sank during the time of deposition of the Alameda Formation, allowing marine incursion. The Site, however, continued to be an uplifted zone of continental deposition. The alluvial units of the Temescal Formation range in thickness from 10 to 300 feet and average 100 to 200 feet. The transition from the alluvial fan deposits to the marine bay muds west of the Site occurs approximately along the line of the existing railroad tracks.

The Young Bay Mud of the Alameda Formation currently being deposited in the bay is black, unconsolidated, saturated, organic rich clay containing some gravel and sand layers, shell fragment layers, peat, and organic debris. The mud generally ranges in thickness from 50 to 75 feet. The deeper Yerba Buena Mud (Old Bay Mud) of the Alameda Formation is widespread homogeneous estuarine mud. It consists of black organic-rich clay averaging 25 to 50 feet thick, and typically containing a gravel/shell layer in the middle of the unit. This formation occurs to the west of the Site.

2.3.2 Site Geology

The Site is located on the East Bay Plain, approximately 0.3 miles east of the current bay shoreline and 3.5 miles west of the Hayward Fault. Surface soil elevation ranges between 12 and 18 feet NAVD88 (1988 North American Vertical Datum). Several creeks drain the western Oakland hills, flowing west to the bay. The nearest creek to the S-W property is Temescal Creek, which originates in the Oakland hills at Lake Temescal and enters an engineered channel that runs under/through Oakland and passes along the northern edge of the Site. The Site lies entirely in the drainage basin of Temescal Creek.

The soils underlying the Site consist of Holocene through Early Pleistocene alluvial sediments of the Temescal Formation (ENTRIX, 2002). The Temescal Formation is primarily an alluvial fan deposit, comprised of interfingering lenses of clayey gravel, sandy silty clay, and sand-clay-silt mixtures. Total thickness of the sediments based on deep coring near the Site is approximately 200 to 300 feet. In addition, it is likely that north-south trending shoreline deposits (i.e., eolian sand deposits) have also been placed at the Site, given the shorelines historical vicinity to the Site location, concurrently with the alluvial fan deposits. The Temescal Formation has been penetrated to a depth of approximately 60 feet below ground surface (bgs) at the Site

in boring IS-BH-07 and can be broken down into four general units (fill material, Unit A, aquitard, and Unit B).

The shallowest unit beneath the Site is engineered fill that consists of sands, silts, and gravels with concrete fragments. This fill extends from ground surface and ranges from 0 to 4 feet in thickness. The fill material unconformably overlies Unit A (which includes the A-zone groundwater), which consists predominately of silt and clay with discontinuous lenses of sand from approximately 4 feet to 20 feet bgs. The lenses have been observed to range in thickness from approximately 1 to 10 feet at investigated boreholes and rapidly change in thickness between nearby boreholes. There is evidence of several discontinuous sand zones occurring in Unit A that vary in thickness from 1 to 5 feet between nearby boreholes.

Unit A is underlain by approximately 30 feet of silty clay that acts as a local aquitard separating Unit A from Unit B. The top of the aquitard begins at approximately 25 feet bgs (corresponding to an elevation of approximately -11.5 feet NAVD88). The top of the A/B aquitard appears to be laterally continuous across the Site. Investigations have not revealed evidence of erosional features on the surface of the aquitard.

Unit B (which includes the B-zone groundwater) consists of primarily silty clay and clayey silt beginning at approximately 50 feet bgs. The total depth of Unit B has not been characterized, but the top of Unit B ranges from approximately 45 to 55 feet bgs. Similar to Unit A, Unit B includes discontinuous lenses of silty sand ranging between 1 and 3 feet thick situated between 50 and 60 feet bgs. The A/B aquitard is distinguished from Unit B by the characteristics of the more permeable lenses within the Unit B formation. The lenses in the aquitard consist of clayey sand with some silt, while the Unit B lenses consist of silty sand.

Figure 2-3 presents the locations of three cross sections at the Site. Figures 2-4, 2-5, and 2-6 present these cross sections of Unit A, A/B aquitard, and an upper portion of Unit B for these three transects across the Site.

2.3.3 Hydrogeology

The two zones of groundwater (A-zone and B-zone) are part of a single hydrogeologic unit, containing multiple alluvial fan and eolian shoreline deposits. Accordingly, different groundwater zones beneath the Site are referred to as water-bearing zones rather than aquifers. The A-zone and B-zone groundwater underlying the Site is not currently being used for drinking water supply, and has not been used in the past. The Site is not located within a groundwater recharge area (Norfleet, 1998).

2.3.3.1 Groundwater Flow in the A-Zone

The A-zone is a predominantly shallow, unconfined to semi-confined water-bearing zone. A-zone groundwater is present in relatively thin (approximately 2- to 5-feet thick), discontinuous, lenses of sand that are interbedded within less permeable silty/clayey sediments. Depth to groundwater across the general area of the Site can vary seasonally from approximately 3 to 12 feet bgs. Prior to the installation of the slurry wall and the groundwater extraction system, the direction of groundwater flow

across the Site was predominately west to northwest toward San Francisco Bay and Temescal Creek. Groundwater flow in the northernmost portion of the Site appears to be locally influenced by Temescal Creek. Groundwater flow towards Temescal Creek partially discharges into the Temescal Creek's drainage channel, but not directly into the surface water. Tidal fluctuations occur in areas near the Temescal Creek and affect the amount of groundwater flow entering the drainage channel. The surface water associated with Temescal Creek is further discussed in Section 2.3.4.

The flow of groundwater in the A-zone beneath the Site has been altered by the installation of the slurry wall and the groundwater extraction system in the 1990s (ENTRIX, 2002). The flow inside the slurry wall is generally toward the extraction wells. The groundwater gradient is generally steeper in the southern portion of the area enclosed by the slurry wall and generally flows toward the west in this area. The groundwater flow outside of the slurry wall is toward the west-northwest, generally consistent with pre-slurry-wall groundwater flow regime on the northern portion of the Site, and is influenced by proximity to the slurry wall, groundwater extraction wells, and Temescal Creek.

Based on pumping tests summarized in the RI, the transmissivity has been estimated to range between 4.1 and 633 square feet per day (ft^2/day), and the hydraulic conductivity ranges between 0.28 and 28 feet per day (ft/day). The results of a tidal study also measured transmissivities, and found 18.7 ft^2/day for the northern portion of the Site adjacent to Temescal Creek (ENTRIX, 2002). This value is based upon a month of monitoring, and is considered a more reliable measure of sitewide transmissivity than the short-term pump tests. Pumping tests conducted in February 2007, in support of the soil treatability study and further discussed in Section 2.5, estimated a hydraulic conductivity of approximately 3 ft/day for the A-zone within the central portion of the raised cap part of the Site (CDM, 2007b); this value is within the range reported for the Site in the RI.

Based on an estimated effective porosity of 0.12 (Freeze and Cherry, 1979), the average linear velocity of groundwater beneath the Site is approximately 0.24 ft/day. Groundwater elevations vary seasonally between 4 and 10 feet NAVD88 within the A-zone. Groundwater levels can fluctuate up to 3 feet seasonally, with highest in the wet season between December and February.

2.3.3.2 Groundwater Flow in the B-Zone

The B-zone is a confined unit with several feet of piezometric pressure head above the top of the A/B aquitard. Groundwater elevation measurements have consistently measured a vertical upward hydraulic gradient from the Unit B to the Unit A groundwater zone (ENTRIX, 2002).

The groundwater flow conditions within the B-zone do not appear to have been significantly impacted by the installation of the slurry wall and the groundwater extraction system, indicating the limited permeability of the confining unit separating the A-zone and the B-zone. The groundwater flow direction both before and after the installation of the slurry wall and extraction system is from the southeast toward the

northwest. Pumping tests indicate the transmissivity ranges between 128 and 132 ft^2/day, and a hydraulic conductivity of approximately 28 ft/day (ENTRIX, 2002). Based on an estimated effective porosity of 0.12, the average groundwater linear velocity is approximately 1.07 feet/day. Groundwater elevations vary between 6 and 9 feet NAVD88 within the B-zone and can fluctuate up to 2 feet seasonally. The water levels are highest in the wet season between December and February.

2.3.3.3 Groundwater Use

The 2002 ENTRIX Site RI report concluded that groundwater at the Site cannot feasibly be used for long-term water supply. The conclusion was based on an interpretation of Site data and the exemption criteria set forth in State Water Resources Control Board (SWRCB) Resolution No. 88-63. According to Resolution No. 88-63, waters are considered suitable, or potentially suitable, for municipal or domestic water supply except where:

a. "Total Dissolved Solids (TDS) exceeds 3000 milligrams per liter (mg/L) (5000 microSeimen/centimeter (µS/cm) electrical conductivity);

b. Contamination exists, that cannot reasonably be treated for domestic use; and

c. The source is not sufficient to supply an average sustained yield of 200 gallons per day."

As reported in the 2002 ENTRIX Site RI report, the average TDS across the S-W Property is 1,200 mg/L, and the central portion of the property exceeds 3,000 mg/L on average. Development of the shallow groundwater for supply would likely lead to saltwater intrusion, as documented for several nearby areas in the Norfleet study (1998), and cause expansion of the area that currently exceeds 3,000 mg/L.

2.3.4 Temescal Creek

The Site resides within the Temescal Creek watershed. The northwest extent of the Site borders with Temescal Creek (see Figure 2-2).

2.3.4.1 Temescal Creek Watershed

The Temescal Creek watershed encompasses a 6.68 square mile (sq. mi.) area with headwaters in the Berkeley Hills on the north and south sides of Highway 24. The upper watershed has ridge elevations of approximately 1,200 to 1,300 feet and includes mixed open space and residential lands in the Berkeley Hills. The contributing area upstream of Lake Temescal is about 2.64 sq. mi. and includes the upper main stem of Temescal Creek (1.67 sq. mi.) and the Caldecott Tunnel branch (0.97 sq. mi.). Downstream of Lake Temescal, runoff from the other two upland subbasins, Vicente Branch (0.64 sq. mi.) and Claremont Creek (1.22 sq. mi.), combines with urban runoff within the densely developed lowlands of Berkeley and Emeryville. The mouth of Temescal Creek flows into San Francisco Bay about 0.4 mile north of the highway interchange leading to the Bay Bridge toll plaza, approximately 1,100 feet from the Site (ENTRIX, 2002).

A relatively small percentage of the main and tributary lengths of Temescal Creek still have earth-lined open channels with natural configuration. Those that remain are primarily within the Berkeley Hills. The lower 3.5 miles of the main stem and most of the tributary channel reaches are within engineered underground storm drain systems (ENTRIX, 2002).

2.3.4.2 "Old" Temescal Creek

In the vicinity of the Site, the surface channel of old Temescal Creek between Horton Street and the onsite railroad spur has been replaced by a relocated, underground culvert north of the Site and an open, engineered flood channel extending downstream (west) to Interstate 880. Old Temescal Creek (as part of the main flood channel) was abandoned following the 1968 construction of the flood control project.

The old channel persists as a topographic and drainage feature, although it no longer receives runoff from the upstream watershed. It crosses under Horton Street in two large concrete culverts and passes under the former Rifkin property in a concrete box culvert. Downstream of the former Rifkin property, a short section of the old constructed "U" shape channel exists (5 to 10 feet deep; 10 to 15 feet wide) with vertical banks supported by wood slats (ENTRIX, 2002). The location of the old channel is presented on Figure 2-2.

The old channel discharges through a 5-foot diameter culvert into the concrete-lined flood channel of the re-engineered Temescal Creek upstream of the railroad crossing. The old channel may receive surface flow from storm drains along Horton Street that appear connected, as well as local runoff from other nearby streets. Discharge of groundwater to the old channel was not observed during ENTRIX site visits (November 1998, November 2000, and December 2000) (ENTRIX, 2002). In addition, no flow was observed during CDM site visits in winter of 2006/2007.

2.3.4.3 Lower Temescal Flood Channel

Lower Temescal Creek from Horton Street to San Francisco Bay was constructed as an engineered flood control channel between 1964 and 1968 (ENTRIX, 2002). Within the Site vicinity, the only surface water contributions to the channel are the 5-foot diameter culvert from the old channel and a 21-inch diameter storm-water drain entering from the Sherwin-Williams property. No other storm drains have been observed within the Site vicinity.

Based on improvement plan design and as-built data, the flood control channel has a "U" shaped, concrete-lined cross section approximately 16 feet deep and 25 to 30 feet wide, with a long profile gradient of 0.00083 feet/feet (see Temescal Creek as presented on cross section K-K', Figure 5-3 of the ENTRIX RI, presented in Appendix A of this document) (ENTRIX, 2002).

The channel was excavated about five feet below the previously existing ground surface of old Temescal Creek, with side construction slopes of approximately 1 to 1. The area behind the vertical concrete walls and under the concrete bed was backfilled using filter material, crushed rock, gravel bedding, and reserved earthen materials.

The plans show a subdrain network was constructed under the channel, with pressure relief flap gates rising at intervals along the channel walls to minimize the risk of uplift, buckling, or shifting of the concrete liner. The subdrain network consists of 4-inch perforated pipe buried in the gravel bedding across the channel bed at relatively regular spacing (30 feet) that is connected by perforated pipes paralleling the channel left and right banks. Approximately every 90 to 120 feet along the channel length, vertical risers of 6-inch non-perforated pipe extend outside the channel walls to recessed openings in the concrete walls about two feet above the channel bed. Flap gates using 8-inch Waterman Drainage Gates (model F-10) were installed to allow one-way release of water from the subdrain system into the flood control channel when hydrostatic pressure is sufficient (hinges designed to require <1.0 foot of pressure head). The flap gates were not observed by ENTRIX in November 1998, November 2000, and December 2000) (ENTRIX, 2002).

The flap gates were observed by CDM during a visit in April 2005. The functionality of the flap gates has not been evaluated.

2.4 Previous Investigations, Risk Assessments, and Interim Remedial Actions

This section describes previous remedial investigations, nature and extent of COCs, fate and transport of COCs, groundwater modeling, risk assessments, and interim remedial actions.

2.4.1 Remedial Investigations

Soil, soil gas, and groundwater investigations have been conducted at the Site since 1988. The investigations have revealed that the COCs in the subsurface are metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and petroleum hydrocarbons. The investigations concluded that several COCs have migrated from the S-W property onto a portion of the former Rifkin property. Site soil and groundwater data through October 2000 is summarized in the 2002 ENTRIX Site RI report (ENTRIX, 2002). The RI report was approved by the Water Board on October 21, 2002 (Water Board, 2002).

Since October 2000, results from periodic groundwater monitoring events have been summarized in a series of reports. This document utilizes this groundwater data through the December 2007 event (LFR, 2008). In addition, several investigations have been conducted after October 2000 to complete characterization of the Site:

CDM, 2008b. Report of Findings, Soil Characterization Study Addendum, Sherwin-Williams Site, 1450 Sherwin Avenue, Emeryville, California. February 22, 2008.

CDM, 2007d. Report of Findings, Soil Characterization Study, The Sherwin-Williams Company, Emeryville, CA. Camp Dresser & McKee Inc., on behalf of The Sherwin-Williams Company. June 28, 2007.

CDM, 2007h. Data Summary Report for Soil Gas Investigation Activities, Sherwin-Williams Site, 1450 Sherwin Avenue, Emeryville, California. January 30, 2007.

CDM, 2007i. Data Summary Report for Installation and Sampling of Well CDM-1, Sherwin-Williams Site, 1450 Sherwin Avenue, Emeryville, California. January 30, 2007.

CDM, 2005. Report of Findings, December 2004 Subsurface Investigation, 1450 Sherwin Avenue, Emeryville, California. Camp Dresser & McKee Inc. March 2005.

CDM, 2002. Report of Findings, Subsurface Investigation, Former Rifkin Property, Emeryville, California. Camp Dresser & McKee Inc. December 2002.

The 2002 ENTRIX Site RI report concluded that the primary Site-related contaminants present in soil and groundwater beneath the Site include metals (primarily arsenic and lead), VOCs (primarily aromatic constituents and ketones), and petroleum hydrocarbons. Chlorinated constituents were also detected in groundwater samples collected throughout the Site, but in most instances appear to be related to past releases on adjacent properties and not attributable to S-W. Subsequent investigations have confirmed these conclusions.

Appendix A includes selected figures from the RI presenting the extent of impact from various COCs in shallow soil (0 – 3 feet bgs), deep soil (3 – 10 feet bgs), and groundwater (ENTRIX, 2002). In addition, Appendix A includes selected figures and tables from these subsequent subsurface investigations (CDM, 2002; CDM, 2005; CDM, 2007d; CDM, 2007h; CDM, 2007i; and, CDM, 2008b).

Appendix B includes selected figures and tables from the FS presenting summaries of arsenic, lead, total VOCs, and TPH concentrations in vadose zone and saturated zone soil samples across several depth intervals.

2.4.2 Nature and Extent of COCs

2.4.2.1 Metals

The extent of impacts from the release of metals (arsenic and lead) is limited to unsaturated, vadose zone soil, and the soil and groundwater within the Unit A aquifer. Aside from sporadic arsenic concentrations above its cleanup goal, metals have not been detected above cleanup goals in B-zone groundwater samples. Arsenic detected in A-zone groundwater at the Site does not appear to have significantly affected the B-zone groundwater (ENTRIX, 2002 and LFR, 2008). The highest concentration of arsenic detected in B-zone groundwater was 0.32 mg/L at well LF-B5 in April 1996; the latest arsenic concentration in this well was 0.0064 mg/L in October 2007. Arsenic concentrations in B-zone groundwater in 2007 ranged from less than 0.005 mg/L (at well LF-B3) to 0.054 mg/L (at well RP-BW-02).

The highest concentrations of the primary metal and COC at the Site, arsenic, in unsaturated soil were found in the central portion of the S-W property (within the

southern slurry wall area) and in the southern portion of the former Rifkin property (outside the slurry wall area). Arsenic was also detected at concentrations above its California Department of Public Health (CDPH) drinking water Maximum Contaminant Level (MCL) in A-zone groundwater extending from the central portion of the S-W property westward and also to the adjacent former Rifkin property. The extents of other metal COCs in the unsaturated soils and A-zone groundwater at the Site are within the extents of arsenic. In addition, a second area of arsenic in groundwater is present under the central portion of the former Rifkin property, originating from Horton Street (ENTRIX, 2002).

Groundwater monitoring events at the Site and a subsurface investigation on the former Rifkin property have been conducted since the completion of the 2002 ENTRIX Site RI report. The groundwater monitoring events have shown that the extraction wells EX-14, EX-15, and EX-16 on the former Rifkin property are capturing contaminants that have historically migrated from the S-W property (prior to installation of the slurry wall) and historically migrated from a release beneath Horton Street.

In September 2002, CDM conducted a subsurface investigation at the former Rifkin property to:

- characterize the presumed longitudinal axis of the arsenic A-zone groundwater plume on the former Rifkin property, originating from Horton Street;
- evaluate total arsenic in Unit A aquifer saturated soils under the portion of former Rifkin property to which arsenic may have migrated from the S-W property; and
- evaluate the soil-water partition coefficient (K_d) for arsenic.

During the September 2002 investigation (CDM, 2002), CDM collected saturated soil and grab groundwater samples from nine Unit A locations within the former Rifkin property (see figures presented in Appendix A). The results from the investigation yielded the following conclusions:

The Unit A aquifer arsenic plume in the central portion of the former Rifkin property, which originated from a release beneath Horton Street, has appeared to attenuate since the previous characterization of the plume in August 1998. During the August 1998 investigation, arsenic in Unit A aquifer groundwater was reported between 0.063 and 0.12 mg/L along the length of the plume. During the September 2002 investigation, arsenic concentrations ranged from 0.034 to 0.095 mg/L.

In December 2004, CDM conducted a subsurface investigation on the raised cap area and the area immediately west of the raised cap on the S-W property, and on an area of the former Rifkin property immediately adjacent to the S-W property, collectively defined as the study area (CDM, 2005). The objectives of the investigation were to:

- Characterize contaminants in the raised cap material to assess treatment and disposal options for the raised cap material, and

- Better define the horizontal and vertical extent of impacted unsaturated and Unit A aquifer saturated soils under and adjacent to the raised cap.

During the December 2004 investigation, CDM collected raised cap material, unsaturated soil, Unit A aquifer saturated soil, and Unit A aquifer grab groundwater samples from 38 locations within the study area (see figures presented in Appendix A). The results from the investigation yielded the following conclusions:

Unit A aquifer soil at the study area generally consists of clay with interbeds of well graded sand and gravel. The raised cap material consists of asphalt pavement over fill soil/bentonite from excavation of the slurry wall, concrete debris, and historic concrete foundations with rebar.

Arsenic is the predominant (highest concentrations and most widely distributed) metal COC in both unsaturated and Unit A aquifer saturated soils within the study area. The distribution of arsenic generally decreases with depth, with the highest at-depth concentrations detected in boring CDM-SB15, -SB16, and –SB18 (see figures presented in Appendix A). The investigation confirmed that the extent of other metals above cleanup goals in the unsaturated soils and Unit A aquifer saturated soils are within the extent of arsenic.

In the area west of the raised cap, arsenic concentrations in soil diminish to below 24 mg/kg above the A/B aquitard.

In November 2006, CDM installed a new Unit A aquifer well onsite (CDM-1) (see figures presented in Appendix A) in order to evaluate the extent of arsenic present in the areas outside of the southern portion of slurry wall (CDM, 2007i). Due to the presence of Building 35, the southern portion of the arsenic plume could not be contained within the slurry wall system. The groundwater samples from CDM-1 further delineate the lateral extent of the arsenic Unit A aquifer groundwater plume present outside and to the south of the slurry wall system, which are consistent with the results from Unit A aquifer wells LF-3 and LF-11.

2.4.2.2 Organic Compounds

VOCs were detected in Unit A soil and groundwater throughout the Site. In general, the highest concentrations of aromatic constituents (primarily ethylbenzene, toluene, and xylenes) and ketones (primarily acetone) were found in unsaturated soil: (1) along the former Rifkin property/S-W property boundary line (both inside and outside the slurry wall); and (2) in the north-central portion of the S-W property (inside the slurry wall).

In groundwater, the primary VOCs found in A-zone groundwater included: aromatic constituents (benzene, ethylbenzene, toluene, xylenes, and 1,2,4-trimethylbenzene); chlorinated constituents (1,2-dichloroethane (1,2-DCA), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-DCE, trichloroethene (TCE), and vinyl chloride); and ketones (acetone and 2-butanone). Of these VOCs, chlorinated constituents were not historically used at the S-W facility.

Aromatic VOCs (excluding benzene) were detected above their MCLs in A-zone groundwater in two primary areas of the Site: (1) both inside and outside the slurry wall, generally in the area west of Horton Street between former Building 29 and the southern portion of the former Rifkin property and (2) inside the slurry wall on the west-central portion of the S-W property, a former solvent tank farm location. Benzene was detected above its MCL in A-zone groundwater in three primary areas of the Site: (1) within the central area of the slurry wall under the current raised cap area, (2) adjacent to the slurry wall on the southern former Rifkin property and near former Building 35, and (3) along Horton Street at the central portion of the former Rifkin property. Ketones were primarily detected above their MCLs in A-zone groundwater on both sides of the slurry wall at the former Rifkin property and S-W property line.

The highest concentrations of chlorinated constituents were detected in A-zone groundwater in two primary areas of the Site: (1) in the south-central portion of the former Rifkin property and along Horton Street and (2) within the slurry wall near and north of Building 38. In B-zone groundwater, only 1,2-DCA was detected consistently above its MCL in groundwater samples from wells (and detected historically in groundwater samples from borings). The 1,2-DCA concentrations in B-zone groundwater are significantly higher than in A-zone groundwater beneath the S-W property, indicating an upgradient off-site release.

Petroleum hydrocarbons (quantified as both total petroleum hydrocarbon (TPH) in the diesel and gasoline ranges, but likely representing thinners and other raw materials) are present in soil and A-zone groundwater, located primarily (1) inside the boundary of the slurry wall, (2) in the southern part of the former Rifkin property at the boundary with the S-W property, and (3) along Horton Street near the northeastern portion of the former Rifkin property.

For TPH detected in groundwater at the S-W property and in the southern part of the former Rifkin property, TPH in the diesel range appears to represent mineral spirits and mixed oil compounds (rather than diesel fuel) and TPH in the gasoline range appears to represent the lighter fraction of oils (including mineral spirits) and individual VOCs (such as toluene and xylenes) that were detected in soil in these same areas.

The results from the December 2004 investigation (CDM, 2005) yielded the following conclusions concerning organic COCs in soil and groundwater:

- The highest VOC detections in soil at the study area were reported across the raised cap area, primarily from boreholes CDM-SB16, -SB17, -SB18, -SB23, -SB24, and -SB30. The highest detections were from toluene and xylenes.

- VOCs attenuate significantly between the raised cap area and the area to west of the raised cap.

- SVOCs, VOCs, and TPH detected on the former Rifkin property do not appear to be completely from releases on the S-W property.

The results from the November and December 2006 investigation (CDM, 2007h) yielded the following conclusions concerning organic COCs in soil gas:

- VOCs are present in soil gas at the Site, as previously inferred from vadose zone soil and shallow groundwater sample results. The southern portion of the former Rifkin property and the adjacent western portion of the raised cap area have the highest VOCs in soil gas concentrations.

- The presence of these VOCs in the subsurface may be attributed to historic releases of raw materials at the northwest corner of the raised cap area, historic operations by various businesses formerly present on the former Rifkin property, and historic releases on properties located upgradient of the Site and migration of impacted groundwater from these properties to the Site.

- The only VOC detected above its residential soil gas screening level on both the S-W and former Rifkin properties was benzene in 6 of the 9 samples considered representative of soil gas quality (see table and figure presented in Appendix A).

- In addition to benzene, 1,2-dichloroethane was detected above its residential soil gas screening level on the former Rifkin property.

- Methane in soil gas was detected in samples collected at both the S-W and former Rifkin properties. The methane at these areas is attributed to pervasive methanogenic conditions within the silt/clay zones, which is typical of the bay muds, and localized methanogenic conditions within underlying groundwater in sandy zones that have been impacted with organic compounds.

2.4.3 Conceptual Site Model

Pursuant to the NCP and associated California guidance documents, a conceptual site model (CSM) was prepared for the Site. The decision-making framework for Site investigations was developed based on the CSM. The CSM presents the primary and secondary sources of COCs and their release mechanisms to soil, soil gas and groundwater. The CSM was developed based on: known or suspected historical operations at the Site (see Section 2.2); investigation results (see Section 2.4.1 and Section 2.4.2); properties of the chemicals present; suspected chemical release mechanisms based on types of operations conducted and knowledge of where materials were handled; transport mechanisms; and potential exposure scenarios.

A narrative description of the CSM is presented below. The CSM description is based on a forensic evaluation of historical documents, chemical formulations and an understanding of the properties of the COCs and Site data. This CSM adequately describes the nature and distribution of COCs found at the Site. The development of the CSM and underlying arsenic in groundwater attenuation mechanisms at the Site, as discussed below, are consistent with recent publication from USEPA: Monitored

Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 1, Technical Basis for Assessment, dated October 2007 (USEPA, 2007). Figure 2-7 presents an illustration of the CSM for the release and transport of arsenic.

2.4.3.1 Release Mechanisms

The primary release mechanism of COCs to the subsurface is suspected to have been through historic releases of raw and finished materials at the Site. The Site produced lead-arsenate pesticides, coatings, and resins through its history.

The lead-arsenate pesticide manufacturing was centered at the current northern area of the Raised Cap area (see Figure 2-2). The primary raw materials used to generate the lead-arsenate pesticides (where arsenic is in the +5 oxidation state, arsenic [+5]) were litharge (a lead oxide) and arsenic acid (H_3AsO_4, where arsenic is also present as arsenic [+5]). Based on review of historic plant building plans from the 1920s and historical photographs depicting operations, the pesticides appear to have been prepared through the following process:

1. Raw materials included litharge, acid (unknown variety, but most likely multiple types of acids were used) and either arsenic acid and/or raw material for production of arsenic acid (arsenic trioxide and acid, mostly likely nitric acid) were delivered to the Site via railcars and transferred to storage areas and/or containers including wooden vats and/or tanks.

2. Litharge was combined with an acid (unknown, mostly likely acetic acid) to generate lead liquor. The lead liquor was generated in an historic facility building described as a lead tower in which acid was sprayed over a litharge at the top of a tower and allowed to percolate downward through a series of trays. The liquor was collected at the bottom of the tower and likely contained both dissolved lead and lead complex solids.

3. If arsenic acid was generated at the facility, arsenic trioxide would have been combined with an acid to generate arsenic acid. This arsenic acid may have been generated in a historic facility building described as the arsenic acid plant.

4. The arsenic acid and lead liquor were combined in a set of parallel settling chambers where the lead-arsenate precipitate was collected.

5. The precipitate was dewatered in a filter press and further dried in ovens. The dried material was crushed and packaged as a lead-arsenate solid.

Potential release mechanisms for the lead, arsenic, and associated acids include the following:

- Loss to surface and rail ballast of raw materials from storage areas and/or containers during transfer and within the process system;
- Loss to surface of finished materials during packaging and handling (product appeared to be shipped in both wooden barrels and paper sack packaging); and
- Loss to surface of wastewater from settling chambers and presses.

In the above, loss to surface may have involved one or all of the following potential points: building floors, floor drains, floor sumps, and/or bare ground. The daily operations over 25 years could have resulted in thousands of gallons of materials permeating the floor of the manufacturing buildings or pavement, resulting in the presence of COCs in both soil and groundwater.

The primary raw materials used to generate coatings and resins were organic solvents, water-based solvents, oils, polyhydric alcohols, dibasic acids, and pigments. Storage of much of these materials was in aboveground storage tanks located at the northwest corner of the Raised Cap area and near the central portion of the current railroad spur (Figure 2-2). The primary potential release mechanism for these materials appears to have been losses to the ground surface during tank filling or discharge.

As a result of releases, the COCs were present on the ground and floor surfaces and in catchment areas (e.g., cement storage areas, bare ground, sumps, drains, etc). Further releases of COCs, addition of water/liquids (e.g., wash water) or in some cases infiltration (in outside areas that were not covered) caused movement of the COCs into the soils below the surface. In this unsaturated vadose zone, the materials were adsorbed and/or retained in the soil until further liquid releases or mobilization by infiltrating water or other liquids. Eventually some of the COCs (e.g., arsenic, lead, and organic compounds) reached the groundwater and migrated with the groundwater to downgradient areas.

2.4.3.2 Natural Attenuation of Metals

Arsenate trioxide suspected to have been released at the Site would have contained arsenic in its more mobile (arsenic [+3]) state. Arsenic acid and lead-arsenate pesticides released at the Site contained arsenic in its less mobile (arsenic [+5]) state. However, arsenic (+5) in groundwater migrating from the release areas would have been reduced to arsenic (+3) as it encountered more reducing conditions. The relative distribution of oxidizing/reducing conditions is consistent with the CSM. Upgradient groundwater entering the arsenic release areas is less reducing and the arsenic is found primarily in its arsenic (+5) state. However, in the central portion of the Site, due to the reducing conditions in A-zone groundwater caused by releases of organic COCs and naturally occurring organic matter, groundwater in these zones is mildly reducing and both forms of arsenic are found.

Arsenic concentrations in groundwater attenuate by three to four orders of magnitude between the release areas and the downgradient property boundary. Studies were conducted (CDM, 2008b and CDM, 2007d) to further characterize the phases of arsenic present in the subsurface and the mechanisms for its attenuation in groundwater. The findings from these studies indicate a direct relationship between phases and extent of arsenic with the lithology, as discussed below. Although the primary focus of these investigations was the release areas, results from locations outside and downgradient of the release areas also confirm this relationship.

Lead is not mobile in Site soil, as a result, lead has not migrated beyond the current Raised Cap area (Figure 2-2).

2.4.3.3 Arsenic Distribution in High Permeability Sandy Zones

An acidic, arsenic-bearing solution containing organic ligands such as acetate was released into the ground via spills, leaking tanks and pipelines, etc. The acid with organic ligands appears to have dissolved much of the clays and feldspars and chemically attacked the quartz within the aquifer. As the arsenic plume migrated deeper within the aquifer and downgradient (within the High Permeability Sandy Zones under both the Sherwin-Williams and former Rifkin properties), the dissolution reactions appear to have eventually neutralized the water when the solubility of the amorphous silica phase was exceeded, at which point the phase precipitated, forming a coating on the existing grains or cementing grains together. The organic ligands within the High Permeability Sandy Zones were then oxidized due to the introduction of oxygen-bearing precipitates (i.e., amorphous silica phases) into the High Permeability Sandy Zones.

Even after the releases of arsenic ceased, the arsenic plume continued to move farther downgradient, as the arsenic-bearing amorphous silica precipitate provided a continuing source of arsenic to groundwater moving through continuous sand lenses, i.e., along the connected active sand zone flow paths. These connected sand layers are depicted on cross section B-B' (see Figure 2-3 and 2-5). The investigations have confirmed that the sand zones under the release areas on Sherwin-Williams property and under a portion of the former Rifkin property downgradient of the release area contain residual solid-phase arsenic silica precipitates, which through dissolution continue to be a source of arsenic to groundwater. The sand zones that contain residual solid-phase arsenic silica precipitates largely occur within the area bounded by the green line on Figure 2-2; these sand zones and their extents are further discussed in the FS (CDM, 2009b).

Downgradient of the release areas, movement of the arsenic (both arsenite [+3] and arsenate [+5]) in the sand zones appears to be controlled by sorption to aquifer matrix, with arsenate being relatively less soluble and mobile. Investigations have confirmed that in groundwater samples collected from outside the slurry wall system, between the slurry wall and the UPRR lines and areas on the former Rifkin property downgradient of the S-W property, arsenic is more oxidized and reduction-oxidation (redox) conditions are not as reducing as near the release area (CDM, 2008b; CDM, 2007d; CDM, 2007i; CDM, 2005; CDM, 2003; and, CDM, 2002). In the more oxidized

environment downgradient of the release areas, the primary attenuation mechanism for arsenic in groundwater is sorption with, or co-precipitation as, oxyhydroxide compounds within the active sand zone flow paths. Adsorbed arsenic has been observed in samples collected from sandy zones at borings CDM-SB82 and –SB84, and –SB87, located downgradient of the arsenic release areas (CDM, 2008b).

Arsenic (arsenate and arsenite) sorbs to surfaces of a variety of aquifer materials, including iron oxides, aluminum oxides, and clay minerals. Adsorption of arsenate to iron-oxide surfaces is particularly important in reducing groundwater concentrations of arsenic because arsenate adsorbs strongly to iron-oxide surfaces in acidic and near-neutral-pH water. Investigations have also revealed relatively high concentrations of both dissolved iron and manganese in the regions downgradient of the release area which indicates potential for continued sorption of arsenic as iron and manganese oxidation/precipitation is on-going in downgradient, more oxidizing groundwater.

2.4.3.4 Arsenic Distribution in Low Permeability Silt/Clay Zones

The Low Permeability Silt/Clay Zones do not appear to have provided a migration pathway for the released arsenic acid solution plume due to lower hydraulic conductivity, but were subject to diffusion of the arsenic-containing water. Within the clay/silt zones, the organic ligands were isolated from oxidizing surface waters, and together with the natural organic carbon and sulfate in these layers provided conditions favorable for sulfate-reducing bacteria. The organic carbon and sulfate was initially deposited within bay muds and/or salt marsh deposits, which are characterized with hydrogen sulfide (H_2S), indicating the oxidation of organic carbon via sulfate reduction (EKI, 2008; EKI, 1999).

Under sulfate reducing conditions in the low iron/high sulfur environment within the silt/clay zones, which is typical of the bay muds, biological mediated reduction likely resulted in precipitation of orpiment and/or other arsenic sulfides such as realgar. Arsenic sulfides with arsenic to sulfur ratios similar to orpiment were observed in several soil samples analyzed from these silt/clay zones within the arsenic release areas and downgradient areas. Analysis of individual grains from the samples containing arsenic sulfide revealed the presence of arsenic and sulfur within the phases, but no other metals. In addition, oxygen was not present, indicating that the arsenic sulfides being generated within the silt/clay zones did not require the presence of dissolved metals in groundwater.

However, the formation and stability of arsenic sulfide precipitates under reducing conditions, has been described as "quite narrow for relatively high total concentrations of arsenic in groundwater, although site-specific conditions may support precipitation of sulfides" (USEPA, 2007). Yet, others have reported that the specific conditions within the San Francisco Bay margin are ideal for formation of arsenic sulfides where (1) the solubility of the sulfide mineral is exceeded and (2) the groundwater flow rates is slow compared to the arsenic sulfide precipitation rates (O'Day et al., 2004). Also, it is reported that under these conditions the precipitation of arsenic sulfide minerals is often biologically mediated, as certain bacteria (e.g.,

Desulfomaculum) are capable of reducing arsenic (+5) to arsenic (+3) and precipitating orpiment (O'Day et al., 2004).

In addition, under the reducing conditions, arsenic may also sorb onto pyrite, followed by formation of an iron/arsenic/sulfur -type phase, which subsequently converts to As_2S_3 (Bostick et al., 2004). In general, sorption reactions are very fast; on the order of seconds (Langmuir et al., 1985). The redox reaction required to convert sulfate to sulfide is typically slower (half life of minutes to hours). While the abiotic precipitation/dissolution reactions maybe the slowest, occurring on the order of weeks, biological-mediated sulfate-reduction reactions are reported to occur within minutes. Due to the relatively slow groundwater velocity in the low permeability silt/clay zones, there is adequate groundwater residence time for dissolved arsenic within these zones to form arsenic sulfides at the Site. Therefore, the formation of stable arsenic sulfides under the low velocity, high concentration conditions found at the Site is consistent with the findings of other studies of arsenic geochemistry within the San Francisco Bay margin (O'Day et al., 2004).

The bacterially-mediated reaction that forms arsenic sulfide is as follows (O'Day et al., 2004):

$$7CH_2O\ (s)[\text{organic matter}] + 3SO_4^{-2}\ (aq)[\text{from GW}] + 2H_3AsO_4^0\ (aq)\ [\text{from GW}] + 6\ H^+(aq)[\text{from GW}] \rightarrow As_2S_3\ (s)\ [\text{precipitated within the Low Permeability Silt/Clay Zones}] + 7CO_2(g) + 13H_2O(l)$$

The Site samples containing arsenic sulfide minerals had total arsenic concentrations as high as 8,000 mg/kg. However, arsenic sulfides are not a source of arsenic to groundwater at the Site, but a sink. This conclusion is based on the following:

- Under reducing conditions found within the Low Permeability Silt/Clay Zones arsenic sulfides are relatively insoluble, with solubility ranging from less than 0.0075 to 0.750 mg/L (Wilkin et al., 2003).

- The Low Permeability Silt/Clay Zones do not transmit groundwater as fast as the High Permeability Sandy Zones (i.e., the hydraulic conductivity of the Low Permeability Silt/Clay Zones is at least two orders of magnitude less than for the sandy zones).

2.4.3.5 Natural Attenuation Mechanisms for Arsenic

Natural attenuation of arsenic at the Site involves primarily precipitation and sorption. These processes have been influenced by biotransformation of arsenic, specifically arsenic redox cycling. Arsenic has been immobilized by sorption onto aquifer solids and by precipitation of solids incorporating arsenic as a major constituent. The investigations have confirmed that it is the relative ratio of the reactive iron to sulfur that controls the distribution of solid phases of arsenic. The partitioning and stability of the arsenic solids are affected by the redox conditions. Because of the differences in solubility of iron and arsenic sulfides, precipitation of arsenic sulfide is a controlling factor where sulfur predominates under reducing

conditions. Under oxidizing conditions, arsenic is removed from solution by adsorption to or co-precipitation with ferric oxyhydroxides.

The following summarizes the findings from investigations that demonstrate how the natural attenuation processes have been decreasing arsenic concentrations in groundwater downgradient of the release areas. These natural attenuation processes are expected to remain stable over the foreseeable future and are expected to continue decreasing arsenic concentrations in groundwater. This discussion follows the tiered format presented in the Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 1, Technical Basis for Assessment (USEPA, 2007).

Tier I of the USEPA document calls for demonstration that the groundwater plume is stable and that sorption and/or precipitation onto aquifer solids is occurring where immobilization is the predominant attenuation process. Appendix A presents the findings from the Groundwater Monitoring Plan Assessment report (LFR, 2006). An analysis of the groundwater data reveals that concentrations of arsenic in groundwater have been attenuating over time and distance, within and outside the slurry wall system, from the release areas, with stable and/or decreasing concentrations at downgradient wells LF-11, LF-18, LF-20, LF-24, and LF-25, ranging from less than 0.005 to 0.260 mg/L since 1997 (LFR, 2008). Since its installation in November 2006, arsenic in groundwater concentrations appear to be increasing at well CDM-1, which is located on the S-W property along its boundary with the UPRR property, in an area outside of the slurry wall system. Unlike the other wells mentioned above, CDM-1 is screened in the upper portion of the A-zone; the others are screened across both the upper and lower portions of the A-zone. Appendix A presents a summary of 2007 arsenic concentrations and concentration trend analysis results at Site wells (LFR, 2008).

As presented in Section 2.4.3.3 and 2.4.3.4, the primary mechanisms for this attenuation are the precipitation of the arsenic into sulfide compounds and sorption of arsenic to the aquifer solids. A lesser degree of attenuation is observed outside the slurry wall system, specifically between wells LF-3 and CDM-1/LF-11, than inside the slurry wall system. The attenuation of the arsenic plume outside the slurry wall system, originating in the area around LF-3, is likely affected by historical release of organics in this area of the Site and potentially higher connectivity of sand zones between LF-3 and CDM-1 (CDM, 2007i).

Tier II includes determining the mechanism and rate of the attenuation processes. Given the relationship established between arsenic phases and lithology, one of the mechanisms is the precipitation of arsenic sulfide as groundwater moves from High Permeability Sandy Zones through Low Permeability Silt/Clay Zones. The reducing conditions and presence of sulfur in the Low Permeability Silt/Clay Zones has resulted in the precipitation of the arsenic into sulfide compounds.

Biologically mediated formation of sulfides is typically much faster than the abiotic rate (O'Day et al., 2004). However, even when using the abiotic half life of weeks, there is sufficient residence time within the Low Permeability Silt/Clay Zones for the

precipitation of arsenic sulfide to occur. The fact that the groundwater in contact with the Low Permeability Silt/Clay Zones, such as found in monitoring well LF-26, is in approximate equilibrium with orpiment (CDM, 2008b), confirms that the reaction rates are as fast or faster than the residence time of the groundwater as it passes from High Permeability Sandy Zones through Low Permeability Silt/Clay Zones and then back into High Permeability Sandy Zones.

The other mechanism is the adsorption of arsenic to aquifer matrix within the High Permeability Sandy Zones, and to a lesser extent adsorption of arsenic within the Lower Permeability Silt/Clay Zones. However, based on testing conducting to determine the composition of arsenic bound to soil, arsenic sulfide precipitation appears to be dominant process for the attenuation of arsenic (CDM, 2008b).

Tier III, as presented in the USEPA document, includes the determination of the capacity of the aquifer to attenuate the dissolved mass of contaminant within the plume and the stability of the immobilized contaminant to resist re-mobilization.

Arsenic Sulfide Precipitation

As presented in Section 2.4.3.3, precipitation of arsenic in silt/clay zones into arsenic sulfides was determined to be one of the primary mechanisms for the attenuation of the arsenic plume. The naturally-occurring sulfate concentrations within the Low Permeability Silt/Clay Zones, which is typical of the bay muds, are stable under existing conditions and would remain stable under the proposed remedial alternatives. Sulfate within the Low Permeability Silt/Clay Zones will continue to provide an energy source for the resident bacteria and sulfur source for arsenic precipitation.

In addition, changes in redox conditions could affect the re-mobilization of arsenic sulfide precipitate (e.g., orpiment), within the Low Permeability Silt/Clay Zones. At a pH of 6.75 S.U., such as those conditions observed in monitoring well LF-26 and other downgradient margins of the Site, increases in dissolved oxygen within the Low Permeability Silt/Clay Zones could have an impact on the solubility of orpiment.

However, it does not appear that there would be an adequate source of oxygen to oxidize the arsenic sulfide precipitates. Stoichiometrically, six moles of oxygen are required to oxidize one mole of orpiment, i.e., for every gram of dissolved oxygen increase in water, up to 0.78 gram of arsenic would be dissolved. Based on the stoichiometric oxidation of orpiment as follows:

$$As_2S_{3(s)} + 6O_2 \rightarrow 2As^{+3} + 3SO_4^{2-}$$

Due to competing reactions for dissolved oxygen in a groundwater system, considerably more oxygen would be needed to dissolve one mole of orpiment than is actually present in the system.

The potential for changes in redox conditions from addition of oxygen is limited to: 1) diffusion of oxygen at the groundwater surface; 2) infiltration of rainwater with dissolved oxygen; and 3) movement of groundwater from upgradient containing

dissolved oxygen. Based on Fickian diffusion, less than 1 kilogram of oxygen per year would diffuse from atmospheric oxygen through the groundwater surface to the Low Permeability Silt/Clay Zones at the Site. Infiltration of 30 percent of incident rainwater with a dissolved oxygen content of 8 mg/L would result in approximately 3 kilograms of oxygen per year to the subsurface. Based on a groundwater velocity of 0.5 feet per day and 3 mg/L of dissolved oxygen, the movement of groundwater through the Site would add approximately 9.3 kilograms of oxygen per year, resulting in a total addition of approximately 13.2 kilograms per year of oxygen to the Site.

An analysis of the organic content of the Low Permeability Silt/Clay Zones indicates that sufficient organic carbon is present to maintain reducing conditions and limit oxidation of the arsenic sulfide. Sampling has revealed organic carbon in Site saturated zone soil ranging from 385 mg/kg to 16,900 mg/kg, with an average concentration of approximately 3,200 mg/kg and a 95 percent UCL of the mean of approximately 5,100 mg/kg (ENTRIX, 2002). In the presence of sulfate, i.e., electron acceptor, the anaerobic bacteria will facilitate the formation of arsenic sulfides (i.e., orpiment). Therefore, reduction of sulfate in the presence of organic carbon can be expressed, excluding consideration of nutrients, as follows (Metcalf & Eddy, 1979):

$$6CH_2O + 3SO_4^{2-} \text{ (bacteria)} \rightarrow 6CO_2 + 3S^{2-} + 6H_2O$$

Where two moles of organic substrate (CH_2O) are consumed for each mole of sulfate reduced. Combining the oxidation reaction with reduction reaction, one mole of carbon is needed to reduce each mole of oxygen or approximately 0.375 grams of carbon are needed to reduce each gram of oxygen added to the subsurface.

Based on the estimated volume of low permeability material and an average organic carbon of 3,200 mg/kg, there is enough organic carbon present to maintain the sulfate-reducing conditions at the Site for the foreseeable future.

Therefore, given the transport dynamics of the aquifer and identified geochemical conditions, changes in redox conditions are not anticipated to affect the long-term stability of the arsenic sulfide at the Site.

Arsenic Sorption

As presented in Section 2.4.3.2, adsorption of arsenic in sandy zones was determined to be one of the primary mechanisms for the attenuation of the arsenic plume. The sorbed arsenic in the sandy zones, unlike the arsenic sulfide precipitates generated in silt/clay zones, is in equilibrium with arsenic groundwater concentrations, i.e., is a sink for arsenic rather than a source. The partitioning of arsenic onto aquifer solids is strongly affected by redox conditions, pH, and relative abundance of competing ions.

The soil-water partition coefficient (K_d) for arsenic in these zones expresses the relationship between the arsenic present in soil and groundwater. The K_d is affected by the redox conditions. The redox conditions in the more permeable sandy zones have been reducing due to the presence of elevated anthropogenic organic compounds, which has resulted in bacterial consumption of dissolved oxygen and other potential electron donors (sulfate, nitrate, etc.) (see Section 2.4.2.2). As these

organic compounds attenuate, redox conditions could become less reducing in the permeable sand zones. However, even under relatively low redox conditions, sorption of arsenic has been the primary attenuation mechanism in the areas downgradient of the release area.

As redox conditions become more oxidizing, a higher fraction of dissolved iron in groundwater will precipitate as amorphous iron hydroxides, increasing the opportunity for arsenic adsorption and/or co-precipitation with the iron hydroxides. The adsorption capacity of amorphous iron hydroxides has been measured at approximately 34,000 mg of arsenic per kg of iron hydroxide at a pH value of 7 (Pierce and Moore, 1982).

Therefore, given the transport dynamics of the aquifer and identified geochemical conditions, changes in redox conditions in the more permeable continuous sand zones (currently reducing and becoming more oxidizing in the long-term) should act to enhance the attenuation of dissolved arsenic in groundwater downgradient of the release areas.

2.4.3.6 Natural Attenuation of Organic Compounds

Concentrations of organic compounds in groundwater have also attenuated by several orders of magnitude between the release areas and the downgradient property boundary (LFR, 2008). The attenuation is due to several processes, including naturally occurring biodegradation. Remedial investigations and continued groundwater monitoring for organic COCs have demonstrated this attenuation (ENTRIX, 2002 and CDM, 2005). Concentrations of organic COCs from wells near the downgradient property boundary are below Site cleanup goals.

2.4.4 Risk Assessment

Gradient completed a human health risk assessment (HHRA) of the Site in February 2005. This risk assessment supplements the Current Conditions Risk Screen (CCRS), completed by EarthRisk in 2002. The CCRS evaluated the potential human and ecological exposures to Site COCs assuming existing conditions with the interim remedial measures (IRMs) in place (discussed below in Section 2.4.5). The CCRS concluded that VOCs potentially migrating to the surface and into the air do not present an ecological or human health concern with the IRMs in place, under current conditions.

Since the remediation of COCs at the Site is already anticipated, the final HHRA does not follow the format of a typical baseline HHRA, which would calculate risks assuming that no remediation would be done. Instead, the primary goal of the final HHRA was to develop risk-based target levels (RBTLs), for COCs in soil and groundwater using exposure scenarios that correspond with the anticipated future land uses of the Site. These risk-based remediation standards are intended to be protective of potential human receptors after redevelopment of the Site.

2.4.4.1 Identification of COCs

Based on an evaluation of the remedial investigations conducted, the Site HHRA identified 34 COCs in Site soil and/or groundwater (Gradient, 2005):

1,2,3-trichloropropane	ethylbenzene
1,2,4-trimethylbenzene	iron
1,2-dichloroethane	isophorone
1,2-dichloropropane	lead
1,3,5-trimethylbenzene	manganese
2-butanone	methyl isobutyl ketone
4-chloroaniline	methyl tert butyl ether
acetone	naphthalene
antimony	phenanthrene
arsenic	selenium
barium	silver
benzene	tetrachloroethene
benzo(a)anthracene	toluene
benzo(b)fluoranthene	trichloroethene
benzo(b,k)fluoranthene	vinyl chloride
cadmium	xylenes
chromium	zinc

However, this evaluation in the 2005 HHRA did not include the data set from the December 2004 investigation. The methodologies utilized in the HHRA were applied to the December 2004 investigation data set and five additional COCs in soil and/or groundwater were identified:

chloroform	n-nitrosodiphenylamine
copper	thallium
mercury	

This evaluation is summarized in Appendix C.

2.4.4.2 Exposure Pathways

Exposure pathways for COCs at the Site were evaluated in the HHRA to assess the potential impacts to human health. Based on the analysis presented in the HHRA, it has been concluded that potential human exposure to COCs is limited to soil and groundwater (Note: soil and groundwater includes potential volatilization of COCs and exposure to receptors through soil vapor intrusion pathway) and to the following eight types of potential current and future receptors at the Site:

1. Construction Worker
2. Utility Worker
3. Landscape Worker

4. Commercial Worker
5. Teenage Recreational Visitor
6. Resident on the Ground Floor of a Multifamily Dwelling
7. Resident on the Second Floor (or higher) of a Multifamily Dwelling
8. Resident in a Single Family Home (Unrestricted Residential Use Scenario)

Exposure pathways for COCs at the Site for potential impacts to the environment are comprised of migration of COCs in groundwater to aquatic receptors to the Lower Temescal Flood Channel and San Francisco Bay.

2.4.4.3 Exposure Scenarios

The potential exposure scenarios for the COCs were presented in the HHRA. The primary goal of the final HHRA was to develop RBTLs, for COCs in soil and groundwater using exposure scenarios that corresponded with the anticipated future land uses of the Site, including unrestricted residential use. These risk-based remediation standards are intended to be protective of potential human receptors after redevelopment of the Site. An RBTL is that concentration of a COC that poses no significant adverse health effect for individuals at a specified level of risk. An RBTL reflects exposure patterns for the various receptors expected to use portions of the Site. Thus, there are unique RBTLs for each of the eight potential human receptors, reflecting the manner in which each of these receptors would be exposed to soils and groundwater at the Site.

RBTLs were calculated for individual COCs with both a target risk of 10^{-6} and for a target non-cancer hazard of 1.0. RBTLs based on a target risk of 10^{-5} were also calculated because the arsenic RBTL calculated using a target risk of 10^{-6} resulted in a concentration less than the background arsenic concentration for San Francisco Bay area soils. Unique RBTLs were developed for each receptor consistent with anticipated future land use – residents, recreational visitors, commercial/retail workers, utility workers, landscape workers, and construction workers. A total of 23 combinations of human receptor-type and target risk were evaluated for soil and 18 combinations for groundwater. RBTLs are applicable to all areas of the Site where that particular receptor is selected as the basis of risk management and remediation decisions.

2.4.4.4 Vadose Zone Soil

In the HHRA, Gradient developed RBTLs for COCs in vadose zone soil, which apply to all portions of the Site. Table 2-1 presents these RBTLs for commercial worker and unrestricted resident receptors with a cancer risk target of 1.0E-06 and a non-cancer hazard quotient of 1.0. Leaching of COCs from soil to groundwater at the Site poses a potential threat to the beneficial uses of groundwater. The RBTLs for the soil COCs listed in Table 2-1 have been evaluated against concentrations that would be protective of Site groundwater through comparison with USEPA Region 9 PRGs

migration to groundwater using a dilution attenuation factor of 1.0 and USEPA Region 9 PRGs for tap water (Gradient, 2005).

2.4.4.5 Groundwater

In the HHRA, Gradient also developed RBTLs for COCs in groundwater. For a cancer risk target of 10^{-6} and a non-cancer hazard quotient of 1.0, the most conservative RBTL (i.e., lowest RBTL) are presented in Table 2-2.

2.4.5 Interim Remedial Measures

2.4.5.1 Previous Removal Actions

There have been two removal actions at the Site:

- Between 1973 and 1994, the solvent and oil tank farm and the lacquer plant were removed from the Site. This was primarily due to the conversion from oil-based to water-based paint products. Soils in the area of the solvent tank farm impacted with toluene and other solvents were removed and disposed off-site prior to 1990.

- Based on an investigation of soil samples collected adjacent to the S-W Site, in 1997, soils along Horton Street impacted with arsenic and lead were excavated and disposed off-site.

2.4.5.2 Other Remedial Measures

In the early 1990s, S-W implemented the IRMs under the oversight of the Water Board, recognizing the need to control off-site migration of groundwater and human exposure to soils prior to implementation of a final Site remedy. The IRMs consisted of:

- A soil-bentonite slurry wall and a cement-bentonite slurry wall to contain chemically affected areas and to control the migration of chemically affected groundwater at the Site to off-site areas

- An asphalt and concrete cap and storm water collection system to reduce infiltration of storm water runoff into chemically affected soils

- A groundwater extraction and treatment (GWET) system to pump groundwater from inside the slurry wall in an attempt to create an inward hydraulic gradient across the slurry wall and treat the groundwater

S-W started construction of the slurry wall in 1993. The slurry wall was completed in November 1994. Construction of the cap and storm water collection system occurred between March 1995 and September 1995. The GWET system was installed between June and September 1995 and began operation in October 1995. Details on the installation of the IRMs are provided in the Interim Remedial Measures Completion Report dated April 19, 1996 (LFR 1996).

Between 1997 and 1998, S-W upgraded the IRMs:

- In late 1997, a multipoint collection system was installed to isolate the storm water collection system from infiltration of groundwater
- In 1998, an additional groundwater extraction wells were installed for improving hydraulic control of affected groundwater.

In 1998, LFR conducted an evaluation of the Site IRMs (LFR, 1998). LFR concluded in its evaluation that:

- The IRMs have been moderately effective in controlling off-site migration of impacted groundwater, as they have not consistently maintained an inward hydraulic gradient across the slurry wall
- Frequent system shutdowns have hindered the effectiveness of the IRMs
- Human exposure to impacted soils has been reduced through the installation of the asphalt and concrete cap.

Since the 1998 LFR report, changes made to the GWET system have improved the ability to maintain an inward hydraulic gradient and have increased chemical mass removal. The changes recommended and implemented were:

- Installation and operation of additional groundwater extraction wells, increasing the extraction system well count inside the slurry wall from three to 10, and installation of three extraction wells on the former Rifkin property
- Modifications to the groundwater treatment system technology by replacing the electrochemical co-precipitation system for metal removal (and the biological system for organics removal) with a proprietary reductive precipitation technology and activated coconut-shell based carbon

In 2006, CDM conducted an evaluation of the IRMs (CDM, 2006a). CDM concluded that the slurry wall layout was necessarily constrained by property boundaries to the north, east, and west, and most notably constrained to the south by the footprint of the plant's primary warehousing, production and shipping facility (i.e., Building 35). These physical constraints limited the effectiveness of the slurry wall to fully contain affected groundwater as demonstrated below:

- Soil and groundwater data indicate that prior to the IRMs, arsenic migration occurred northward from the S-W property, onto the former Rifkin property.
- Soil and groundwater data indicate that prior to the IRMs, arsenic migration occurred to the northwest and downgradient from the S-W property, onto the Union Pacific Railroad Emeryville Yard and active main line tracks.

- Soil and groundwater data indicate arsenic migration occurred along or under the northern portion of Building 35, outside of the slurry wall installation, in an area where plant operations limited the access for construction of the slurry wall.

- In general, the slurry wall is an effective barrier to migration of groundwater, as demonstrated by the differential groundwater gradients measured across piezometer/well pairs inside and outside the slurry wall; however, there are known weak points in the wall where utilities and other features penetrate the well and seasonal variations in the gradient direction across the slurry wall near Temescal Creek.

- The spur track within the slurry wall layout is a conduit for storm water infiltration.

- The groundwater extraction system is controlling groundwater elevations within the slurry wall layout. However, maintenance of an inward hydraulic gradient is strongly influenced by the proximity of extraction wells to the wall, the spur track, and the areas of the wall in relation to the northwesterly hydraulic gradient.

- The groundwater treatment system requires extensive operational and maintenance efforts, but has been and is effective at treating influent concentrations to comply with permitted discharge limits.

2.5 Summary of Treatability Study Findings

The CSM was used to assess the adequacy of the Site characterization for evaluation of appropriate response actions, and identify whether more information (i.e., data gap assessment) is required to evaluate possible treatment technologies under these response actions. This data gap assessment revealed additional information was required to evaluate retained groundwater and soil treatment technologies. The proposed methods for filling these data gaps were presented in the *Treatability Study Work Plan* (CDM, 2006b) and subsequent addenda (CDM, 2006a; CDM, 2007f; CDM, 2007e; and CDM, 2007a). The findings from the treatability studies, with respect to groundwater and soil, are summarized below.

2.5.1 In Situ Groundwater Treatment

The data gap analysis revealed the need for additional information to adequately evaluate the potential effectiveness of two in situ groundwater remedial technologies; a passive process and an active process. These two processes are described below.

- **Passive Process**: Use of natural or engineered materials can function to remove arsenic from groundwater via processes including physical adsorption, chemical precipitation, and biological precipitation. Various materials are commercially available and have various capacities for adsorption of arsenic(+3) and arsenic(+5). Some materials are also capable of oxidation of arsenic(+3) to arsenic(+5) which can be more strongly adsorbed to these materials.

Groundwater would passively flow through materials placed in the saturated zone and arsenic would be adsorbed. The materials may need to be periodically replaced if their capacity is exhausted or to maintain effective permeability through the media. Given appropriate oxidation-reduction conditions (either naturally occurring or induced), iron-rich materials can promote arsenic co-precipitation with ferric iron oxyhydroxides. Another passive in situ groundwater treatment option is based on biological production of sulfide that can precipitate arsenic. In this option, in-ground biological reactions could be induced via introduction of a slow release biodegradable electron donor and sulfur to produce sulfide. Upon contact with arsenic-containing groundwater, the sulfide would react with arsenic to generate an arsenic sulfide and precipitate the arsenic from the groundwater. The slow release electron donor and sulfur source may need to be periodically replaced and/or the precipitate periodically removed to maintain effective permeability.

- **Active Process**: Arsenic in groundwater can be treated using an active in situ treatment option via air sparging combined with iron addition to promote arsenic co-precipitation with or adsorption onto formed ferric iron oxyhydroxides. Preliminary laboratory studies were conducted by CDM to evaluate the potential for ferrous iron addition and air sparging for arsenic removal from Site groundwater (CDM, 2005). These studies were successful. However, additional data are needed to supplement the initial findings.

The evaluation of these options was conducted in a phased approach (i.e., Phase I - laboratory screening, Phase II - bench-scale-testing, and Phase III - pilot-scale testing).

2.5.1.1 Phase I Testing

As presented in the *Emeryville Facility Groundwater Treatability Study for Laboratory Screening Studies* (CDM, 2007f), materials selected for treatability testing as passive in situ groundwater treatment options included the following:

- Granular ferric hydroxide (e.g., US Filter GFH and Severn Trent Bayoxide E33)
- Taconite iron ore
- Blast furnace slag
- Steel furnace slag
- Zero-valent iron
- Anaerobic biological process option using slow release electron donor and sulfur source (e.g., Regenesis MRC™)

Granular ferric hydroxide, taconite iron ore, blast furnace slag, and steel furnace slag were tested for their effectiveness as arsenic adsorbents (adsorptive media). Zero-valent iron (ZVI) was evaluated for its effectiveness as a reductant and/or adsorbent for arsenic. The anaerobic biological process option was evaluated as a passive system to precipitate arsenic.

Two active in situ arsenic groundwater process options selected for treatability study testing are:

- Ferrous chloride addition and aeration with optional polymer addition
- Ferrous chloride addition and hydrogen peroxide addition

The addition of ferrous chloride addition and aeration of groundwater results in the formation of fresh ferric oxyhydroxides, which are effective for arsenic adsorption. Aeration functions to promote biodegradation of organic contaminants in groundwater and other biodegradable organic carbon, which impacts whether the formed ferric oxyhydroxide arsenic co-precipitates remain in an oxidized and solid-phase state. Polymer addition to this process facilitates larger floc formation, which is important for settling and/or filtration of solids from groundwater. Hydrogen peroxide can also be used to oxidize added ferrous iron to ferric oxides that can co-precipitate or adsorb arsenic

Conclusions of Laboratory Testing

Passive Adsorption

Analytical results showed that adsorptive media, GFH and Bayoxide E33 in particular, had the greatest arsenic removals; followed by ZVI, taconite iron ore, steel furnace slag, and blast furnace slag. GFH, Bayoxide E33, and ZVI were successful in reducing arsenic concentrations to less than 0.010 mg/L.

GFH, Bayoxide E33, and taconite iron ore resulted in the lowest final dissolved iron concentrations, followed by steel furnace slag and blast furnace slag. ZVI resulted in the highest dissolved iron concentrations. An advantage of dissolved iron generation in a field application is that it can migrate downgradient and eventually become oxidized and adsorb or co-precipitate additional arsenic. A disadvantage of elevated dissolved iron is that is can precipitate and potentially cause aquifer plugging. These passive adsorption tests were only conducted for 48 hours. Over a longer period of time, anaerobic microbial activity by iron-reducing bacteria may also lead to reduction of GFH and Bayoxide E33 and possibly taconite iron ore and result in generation of greater amounts of dissolved ferrous iron.

The higher doses of media resulted in greater reductions of dissolved arsenic when compared to the respective lower dose tests. However, both low and high doses of the media resulted in greater than 50 percent arsenic removal, the performance metric for this Phase I study.

Active Precipitation

Arsenic concentrations were reduced by more than 50 percent in tests using groundwater from LF-10 and MW-5 and the active precipitation process. Arsenic concentrations were reduced to less than 0.010 mg/L with LF-10 groundwater. Greater arsenic removal in MW-5 groundwater tests would likely have occurred if buffer was added to control pH reduction. Reduction of dissolved arsenic

concentrations in LF-10 groundwater to less than 0.010 mg/L required addition of 300 mg/L iron. This iron addition rate resulted in generation of 600 to 700 mg/L TSS.

Oxidative Precipitation

Use of iron-containing materials in the presence or absence of a reducing agent (i.e., dithionite) resulted in maximum generation of about 3 mg/L of dissolved iron after about 5 weeks of incubation. This concentration of dissolved iron was less than 10 percent of the baseline dissolved iron concentration in groundwater from LF-10 and did not significantly contribute to arsenic removal. Hydrogen peroxide addition did promote arsenic removal from LF-10 groundwater because it oxidized ambient dissolved iron. Hydrogen peroxide resulted in minor reduction of TOC and COD in LF-10 groundwater.

Biological Reduction

The biological process for arsenic removal was ineffective with groundwater from EX-8, removing more than 50 percent arsenic in some but not all of the tests. However, arsenic removal was also greater than 50 percent in the absence of added MRC™, indicating that arsenic removal was predominately attributable to factors other than MRC addition.

2.5.1.2 Phase II Testing

In Phase II testing, as outlined in the *Treatability Study Report for Phase II In Situ Groundwater Treatment - Groundwater Column Studies* (CDM, 2007a), bench-scale column studies were conducted on several media combinations to determine their suitability for use in treatment of contaminated groundwater at the Site. The groundwater used in this study was extracted from two wells, LF-10 and CDM-1 at the Site (see figures presented in Appendix A).

Column packing materials were selected based on results from Phase I of the treatability study. In Phase II of the treatability study, five packing materials were studied. The materials used and rationale behind their selection are described below:

- 20% zero valent iron (ZVI), 20% organic compost, 20% gypsum, 40% sand (columns 1, 6, 11, and 16) – This mixture was designed to reduce the quantity of ZVI tested (and thus the full-scale cost) and to provide a source of sulfate (i.e., gypsum) and electron donor (i.e., compost) to promote biogeochemical reduction of sulfate to sulfide and effective arsenic removal. One potential risk from the mixture was the potential for the formation of hydrogen sulfide. ZVI usually precipitates sulfide, but this risk was evaluated during the study.

- 20% ZVI, 20% organic compost, 60% sand (columns 2, 7, 12, and 17) – This mixture was similar to the previous mix but replaces the gypsum with sand. This mixture would not benefit from any positive attributes of the gypsum, but it also would not carry the risk of hydrogen sulfide formation.

- 20% ZVI, 80% taconite (columns 3, 8, 13, and 18) – This mixture was intended to test the potentially synergistic effects of ZVI and taconite while reducing cost compared to pure ZVI. Both materials were effective in the Phase I test. The first batch of taconite procured for the study contained an excessive level of fine particles not consistent with the particle size distribution of ZVI. Only material retained in a #20 sieve was used in the TS. The second batch of taconite used for the study was pre-sieved off-site using the same sieve size.

- 100% Taconite (columns 4, 9, 14, and 19) – This test was intended to further evaluate this material. As noted above, only material retained in a #20 sieve was used in the TS.

- 20% ZVI, 80% sand (columns 5, 10, 15, and 20) – This test was intended to further evaluation of ZVI, but at a lower volumetric fraction to reduce the cost of the mixture.

- 100% Sand (columns 21, and later, 22) – These columns were used as controls to determine any positive or negative effects of the testing configuration that are independent of the packing material.

Testing Setup

Columns 1 through 10 were operated with groundwater from well LF-10 and Columns 11 through 22 were operated with groundwater from well CDM-1. Columns 1 through 5 and 11 through 15 were designed to operate at a hydraulic residence time of approximately 1 day. Columns 6 through 10 and 16 through 21 were designed to operate at a hydraulic residence time of approximately 7 days. Samples were taken from the sampling port installed at the inlet and outlet of the columns.

Conclusions

- All columns with mixtures of 20% ZVI and 80% sand produced effluent with non-detect levels of arsenic for the first month of operation (approximately 50 pore volumes).

- One column with the mixture of ZVI, sand, gypsum and compost, demonstrated arsenic breakthrough above 0.036 mg/L after approximately 50 pore volumes of water from the more contaminated well (CDM-1).

- One column with the mixture of ZVI, sand, and compost, demonstrated arsenic breakthrough above 0.036 mg/L after approximately 50 pore volumes of water from the more contaminated well (CDM-1). A duplicate of this column and other columns with this material and less arsenic loading did not break through.

- All columns containing taconite or taconite mixtures except one demonstrated arsenic breakthrough. One column had arsenic breakthrough at levels below 0.036 mg/L, but the remainder had effluent arsenic concentrations above 0.036 mg/L with less than 1 pore volume of total flow.

Constant head tests indicated that columns filled with 100% taconite had the highest permeability constant, 1.44 centimeters/second (cm/s), while columns containing gypsum had the lowest observed permeability on average (0.011 cm/s). The sand control column had higher permeability as expected (0.96 cm/s). The addition of ZVI and/or compost to sand also reduced its permeability, although not as significantly as the gypsum.

Based on these data collected during the first month, the best-performing material or mix of materials to date is the 20% ZVI and 80% sand mixture. Dilution of this mixture with additional compost or compost and gypsum in place of sand did not provide any measurable benefit with respect to arsenic removal during this first month.

In addition, the Phase II testing results, along with an economic analysis, concluded that an active in situ treatment process may be as cost-effective for in situ treatment of arsenic in groundwater as the tested passive treatment process materials and that an active treatment process involving precipitation should be carried forward into Phase III testing.

2.5.1.3 Phase III Testing

Phase III testing of the passive treatment process, as outlined in the *Treatability Study Report for Phase III In Situ Groundwater Treatment - Groundwater Column Studies* (CDM, 2008c), involved long-term operation of select Phase II testing columns, primarily those with ZVI, sand, and/or compost mixtures, for potential remedial design evaluation.

The Phase III testing of the active treatment process tested a precipitation, coagulation, and flocculation process for either an in situ or ex situ treatment system. In the Phase III testing system, groundwater entered the first stage of the active treatment where iron in the form of ferric chloride or ferrous sulfate was mixed in the groundwater. Air sparging to promote mixing and oxidation of iron and arsenic was also be introduced in stage one. This oxidation step results in iron precipitation and subsequent arsenic precipitation. Polymer, also injected in the first stage of the process, was injected to help the iron oxides form a flocculate to aide in precipitation. The groundwater was then discharged into the second stage of the active treatment, which was designed to provide sufficient residence time for the flocculent to settle out of the groundwater. The final stage, stage 3, provided additional settling for carry over of particulate from stage 2.

In an in situ active treatment system, the treatment stages would be achieved through a series of concrete vaults placed within each of three breaches in the existing slurry wall. Flow through the vaults would be driven by the hydraulic gradient. The aboveground active treatment system would pump groundwater through above ground tanks and clarifiers comprising the 3 treatment stages and into Temescal Creek. An additional option for either active treatment system that was tested was the addition of permanganate in the first stage to break potential arsenic-organic complexes and reduce sludge production.

Conclusions

- One column with the mixture of ZVI, compost, and sand removed high concentrations of arsenic from well CDM-1 groundwater to nondetectable concentrations for approximately 110 pore volumes. However, a duplicate of this column demonstrated arsenic breakthrough above 0.036 mg/L after approximately 45 pore volumes of water.

- Columns with mixtures of sand and ZVI remove arsenic from well CDM-1 groundwater to less than 0.036 mg/L for approximately 50 pore volumes.

- When subjected to the lower concentrations of arsenic from LF-10, both the ZVI/sand and ZVI/sand/compost mixtures continue to remove arsenic to below detection limits for the duration of the study and at least 175 pore volumes of groundwater.

- A larger 6-inch column filled with the ZVI/sand mixture demonstrated similar performance to the corresponding 3-inch column with respect to potential number of pore volumes that could be treated.

- An active process can effectively precipitate arsenic from groundwater extracted from wells CDM-1 and LF-10. Consistent reduction in dissolved concentrations below the 0.036 mg/L threshold was accomplished.

- In the active process, total concentrations were reduced below 0.10 mg/L, but not 0.036 mg/L. It is expected that additional optimizations in chemical dosage and the proportionally larger settling basins that would be used in a full scale system would be sufficient to reduce total concentrations below the 0.036 mg/L threshold consistently.

- In the active process, the optimal chemical doses for treatment of groundwater from LF-10 were approximately 20 mg/L of ferric chloride and 0.078 mg/L of organic polymer. The optimal chemical doses for treatment at CDM-1 were 59 mg/L of ferric chloride, 37 mg/L of sodium hydroxide, 2.6 mg/L of potassium permanganate, and 0.053 mg/L of organic polymer.

With respect to long-term arsenic removal with a PRB process option, the ZVI/compost/sand and ZVI/sand mixtures performed best at the conclusion of Phase III testing. For the purposes of conceptual remediation design within the FS evaluation, the 20% ZVI and 80% sand mixture, with a conservative number of 50 pore volumes of groundwater treatment prior to arsenic breakthrough, will be used as the basis for a PRB process option.

2.5.2 In Situ Soil Treatment

The data gap analysis revealed the need for additional information to adequately evaluate the potential effectiveness of two soil remedial technologies: grout injection and soil mixing. Under both of these in situ soil treatment options, the primary

objective for reducing the mobility of arsenic is decreasing the permeability of the targeted soil mass.

2.5.2.1 Grout Injection

Grout injection can be used to improve soil strength and reduce permeability of targeted soils via injection of grout into the soil through driven probes at low to moderate pressures to permeate the voids. This is accomplished without significantly changing the soil's structure or volume. Effectiveness of this technique is dependent upon the volume or percentage of voids that can be penetrated by the grout mixture. Grout mixture design and proper spacing of the injection points are critical to the effectiveness of the treatment technique.

The grout injection treatability study (CDM, 2007b) followed the procedures outlined below:

1. Pre-grout injection aquifer testing, including installation of an extraction well and two piezometers in the test area.

2. Abandonment of the extraction well and two piezometers in the test area.

3. Grout injection.

4. Post-grout injection aquifer testing, including installation of a new set of one extraction well and two piezometers in the test area.

Grout injection testing consisted of 25 grout injection points in a 5 by 5 grid, within an area approximately 12 feet by 12 feet (plus one additional point outside of this grid). This spacing pattern was selected after a review of the pre-injection aquifer testing results which yielded a higher than expected net aquifer permeability.

The original grout injection treatability plan called for Ultrafine cement in a 3:1 to 5:1 by weight to water grout mixture to be injected at all 25 grout locations. However, due to the lithologies encountered during the installation of the pre-grout injection extraction well and piezometers and the pre-injection aquifer testing results, Type III cement was hypothesized to be potentially suitable in a grout mixture for injection. Therefore, Type III cement was substituted for Ultrafine cement at two grout injection locations.

Results

In summary, the grout injection had a distinct affect on aquifer hydraulics. Using the pre-grout pumping rate of approximately 1 gallon per minute (gpm), the post-grout draw down was so rapid in the pumping well that the extraction lasted only 23 minutes in the May 2007 and only 19 minutes in the July 2007 testing. During pre-grout injection aquifer testing conducted in February 2007, significant draw down of the well was not achieved over an 8-hour pumping period.

However, grout injection only achieved an overall permeability reduction to 10^{-5} cm/sec, which was less than the data quality objective of 10^{-7} cm/sec. In addition, grout injection was accompanied with temporary fluctuations of pH, which may contribute to a release of arsenic into groundwater from the sandy lithologies (i.e., source material for arsenic to groundwater).

2.5.2.2 Soil Mixing

The practice of mixing soil with various reagents, such as cement, lime, and bentonite, has been used in the United States since the mid 1930s. Early applications were used for improving the engineering properties of soil for civil construction projects, including road and dam construction. Current soil mixing techniques involve construction of overlapping piles by injecting cement mixed grout from the tip of a drill rig's auger into the soil.

A bench-scale study for assessing the effectiveness of soil mixing for reducing soil permeability was conducted (CDM, 2007g). The testing included seventeen (17) potential grout mixes with various proportions of potable water, Site groundwater, cement, bentonite and a cement plasticizer. This was performed not only to test a variety of potential cement and bentonite mixes but also to determine whether Site soil and/or groundwater had any adverse effects on the slurry. Nine (9) grout mixes were composed of 100 percent potable water, bentonite content of 2 or 4 percent, cement ranging from 10 to 30 percent and 0 to .3 percent of a cement plasticizer. Eight (8) grout mixes were composed of 50 percent potable water and 50 percent Site water with the same percentage of bentonite, cement and cement plasticizer.

Based on this testing, two grout mixes were selected for permeability testing. The selected grout mixes consisted of a 1:2 grout soil ratio with 4% bentonite, 20% cement and 0.2 cement plasticizer. One mix was composed a 100% potable water and other mix was composed 50% potable water and 50% Site groundwater. Additionally, two samples were prepared at a 1:4 grout to soil ratio, both having 40 percent cement and 0.4 percent cement plasticizer at a 100 percent potable water and a 50-50 potable/groundwater and no bentonite. The second set of samples was tested to evaluate how bentonite affects the hydraulic conductivity of the soil.

Hydraulic conductivity testing was performed on these samples. Test results showed that samples mixed with bentonite achieved lower hydraulic conductivities than samples that did not have bentonite. Soil-grout mixtures exhibited hydraulic conductivities of 10^{-7} cm/sec.

Long-term hydraulic conductivity testing was performed on these soil-grout samples. Testing was conducted over 76 days and readings were recorded every two to four days. Long-term permeability is lower than short-term permeability and range from 4.6×10^{-8} to 7.3×10^{-9} cm/sec.

In both cases the soil-grout mixes with bentonite had a lower hydraulic conductivity than the sample without bentonite. The hydraulic conductivity was not affected by the water conditions.

Results

The bench-scale studies demonstrated that soil mixing can achieve a reduction in permeability of less than 10^{-7} cm/sec. While soil mixing caused an increase in pH due to the bentonite and cement in the mix, this was offset by actual mixing of the sandy lithologies containing the amorphous silica phase with more reducing sandy clay and clay material,. Analyses of both potable and Site groundwater run though the bench-scale mixes showed no increase in arsenic concentration in the leachate.

In support of including soil mixing within potential remedial action alternatives based solely on the favorable results from the scale testing, CDM presented DTSC with a memorandum (CDM, 2008a) presenting an overview of soil mixing technology, including:

- History and use of soil mixing,
- Its use as the industry standard for improving soil characteristics and for environmental remediation,
- Recognition and acceptance of soil mixing by regulatory agencies, and
- Soil mixing design and construction procedures, including effectiveness bench testing for design and implementation sequence (consistent with the standard of practice in the industry).

Table 2-1
RBTLs for COCs in Vadose Zone Soil
Sherwin-Williams Emeryville Remedial Action Plan

	RBTL (mg/kg)	
	Commercial Worker	***Unrestricted Resident***
Volatile Organic Compounds		
ACETONE	1800000	70000
BENZENE	0.076	0.015
4-CHLOROANILINE	8200	310
ETHYLBENZENE	200000	7800
TETRACHLOROETHENE	0.32	0.063
TOLUENE	440	100
XYLENES	11000	2300
Semivolatile Organic Compounds		
BENZO(A)ANTHRACENE	9.5	1.1
BENZO(B)FLUORANTHENE	9.5	1.1
BENZO(B,K)FLUORANTHENE	9.5	1.1
NAPHTHALENE	41000	1300
PHENANTHRENE	160000	4500
Inorganic Compounds		
ANTIMONY	820	31
ARSENIC	24 (1)	24 (1)
BARIUM	140000	5500
CADMIUM	15	3.1
CHROMIUM (+3)	3100000	120000
CHROMIUM (+6)	41000	1600
LEAD	5600	250
SELENIUM	10000	390
ZINC	610000	23000

Notes:
RBTL - Risk Based Threshold Level
COC - Chemical of Concern
mg/kg - milligram per kilogram
(1) - The RBTL for arsenic in soil is the naturally occurring background concentration, as presented in Human Health Risk Assessment.

CDM

Table 2-2
RBTLs for COCs in Groundwater
Sherwin-Williams Emeryville Remedial Action Plan

	RBTL (mg/L)
Volatile Organic Compounds	
ACETONE	34000
BENZENE	0.046
2-BUTANONE	94
1,2-DICHLOROETHANE	0.35
1,2-DICHLOROPROPANE	0.52
ETHYLBENZENE	35
METHYL ISOBUTYL KETONE	27000
METHYL TERT BUTYL ETHER	0.66
TOLUENE	1100
TRICHLOROETHENE	6.6
1,2,3-TRICHLOROPROPANE	0.036
1,3,5-TRIMETHYLBENZENE	0.46
1,2,4-TRIMETHYLBENZENE	0.14
VINYL CHLORIDE	0.004
XYLENES	64
Semivolatile Organic Compounds	
NAPHTHALENE	7.3
Inorganic Compounds	
ARSENIC	0.8
IRON	5100
MANGANESE	2400
ZINC	8500

Notes:
RBTL - Risk Based Threshold Level from Human Health Risk Assessment
COC - Chemical of Concern
mg/L - milligram per liter

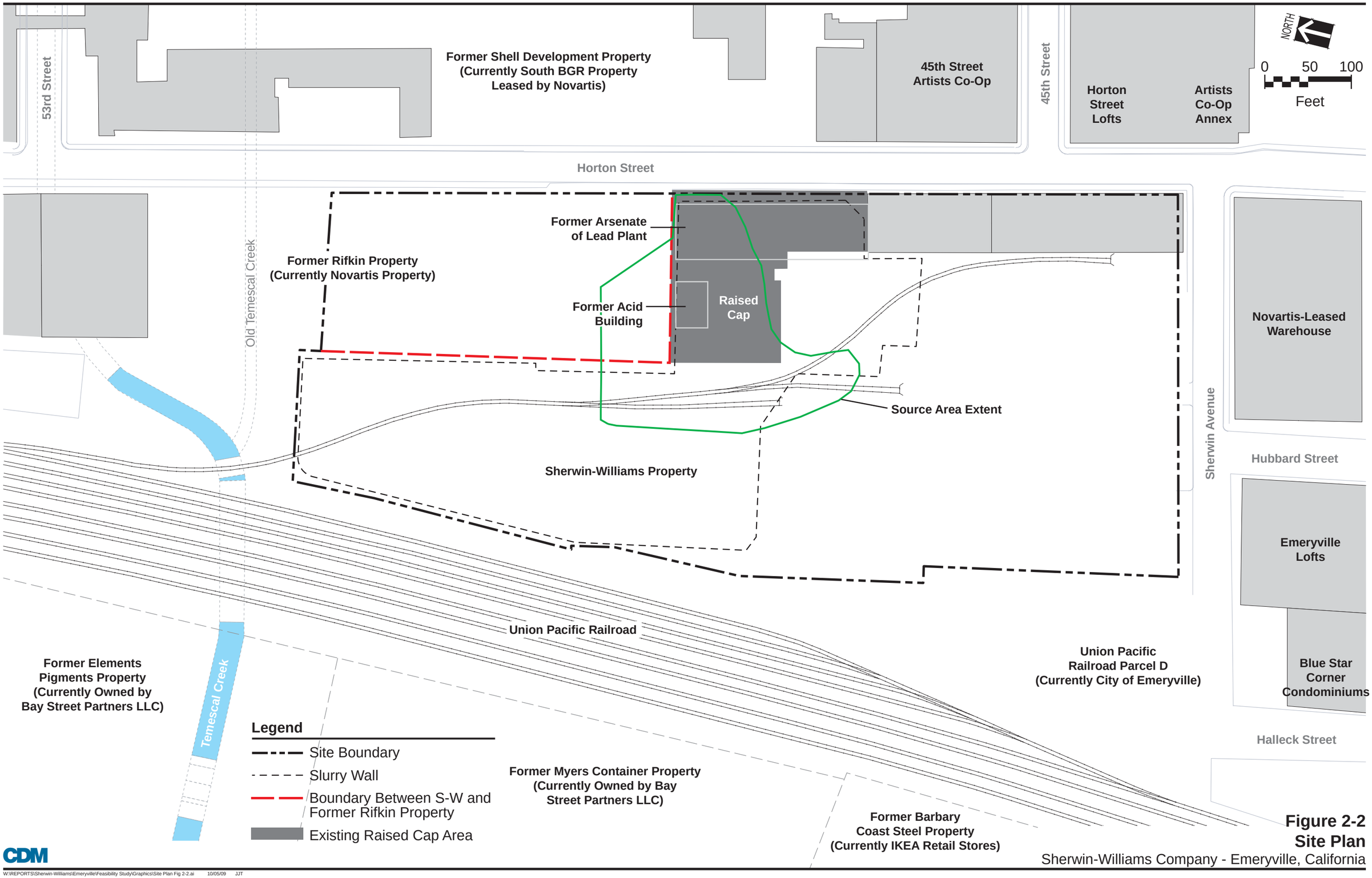
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Figure 2-1
Site Location Map
Sherwin-Williams Company
Emeryville, California

CDM

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CDM

Figure 2-2
Site Plan
Sherwin-Williams Company - Emeryville, California

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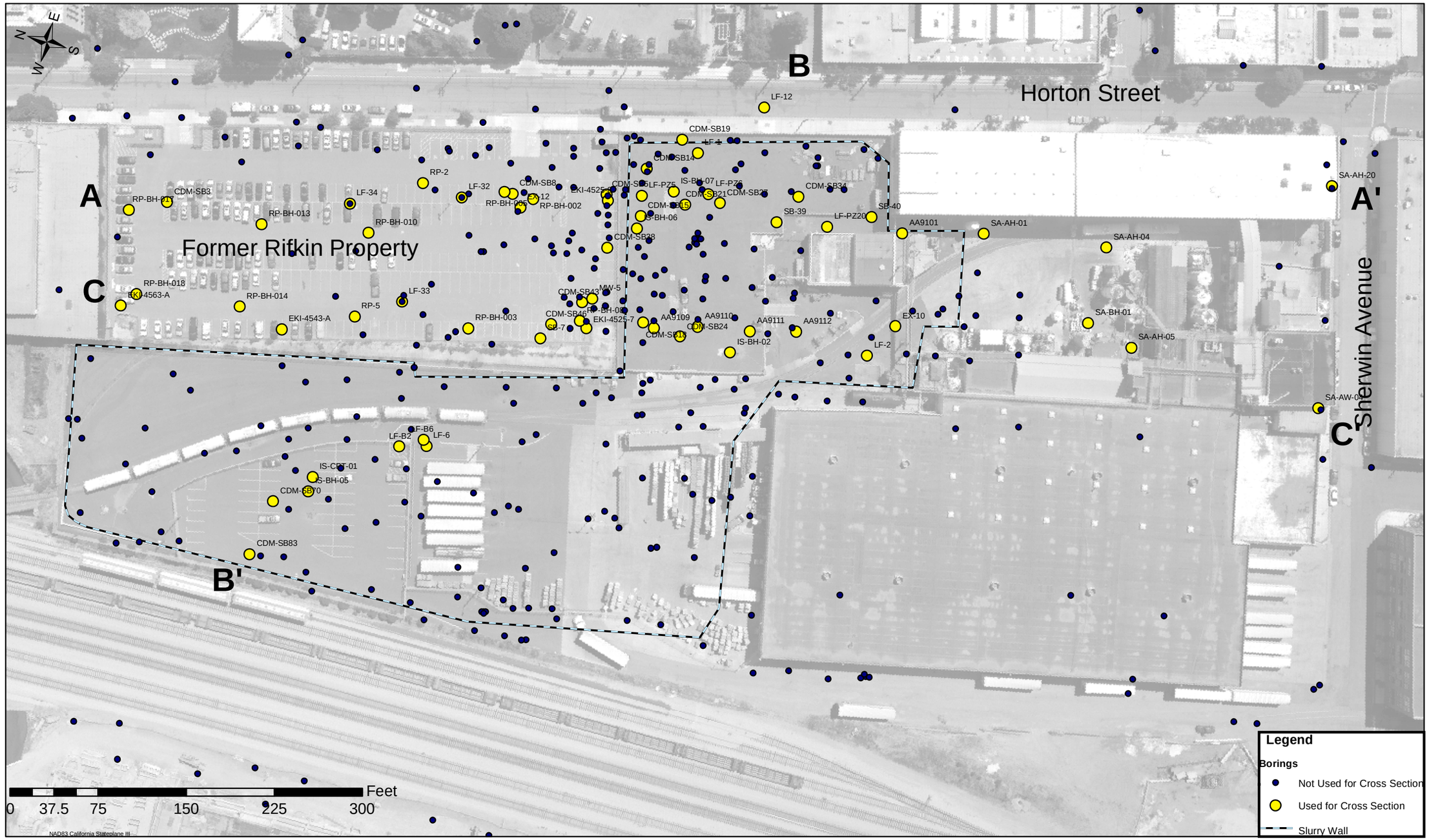
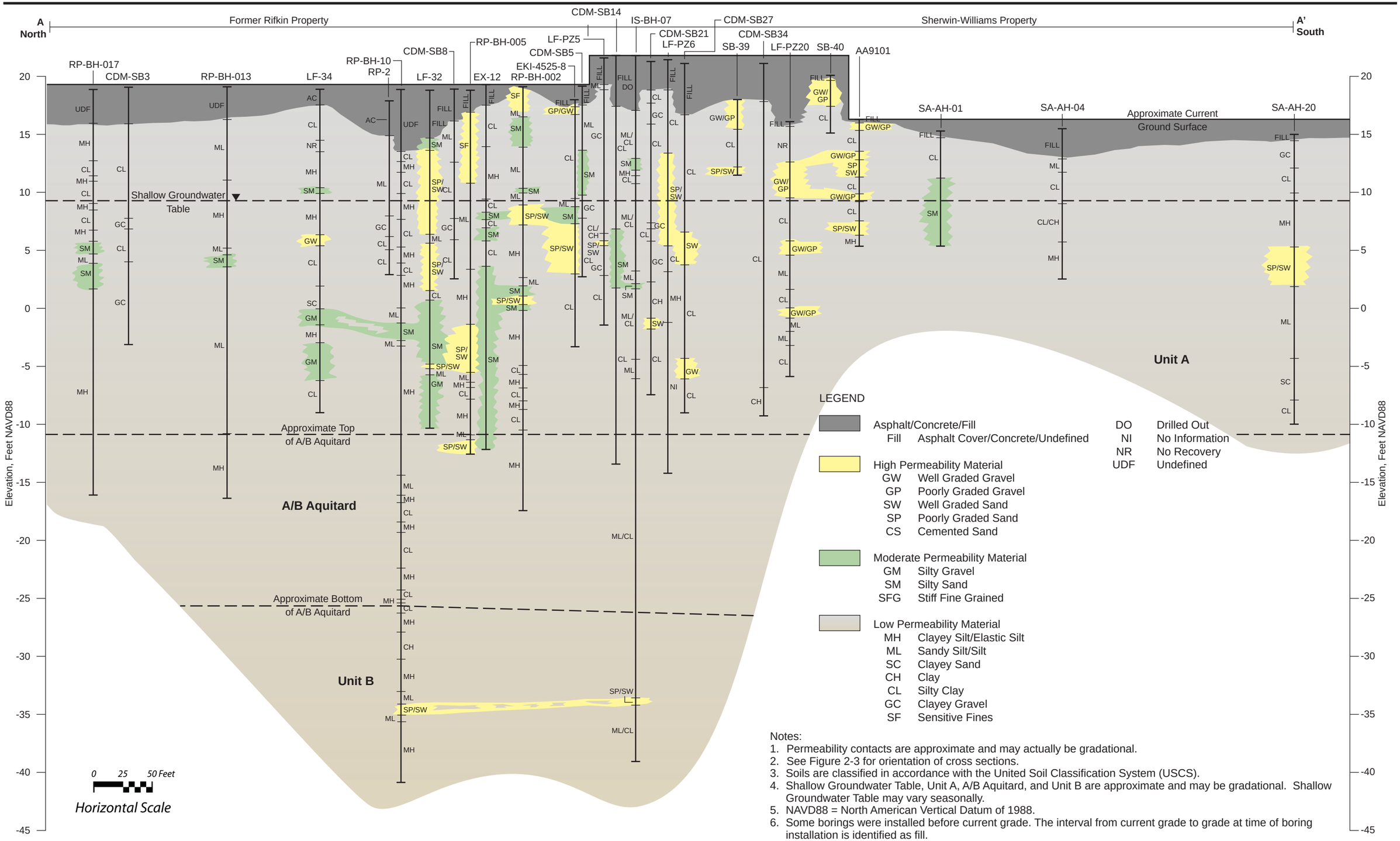


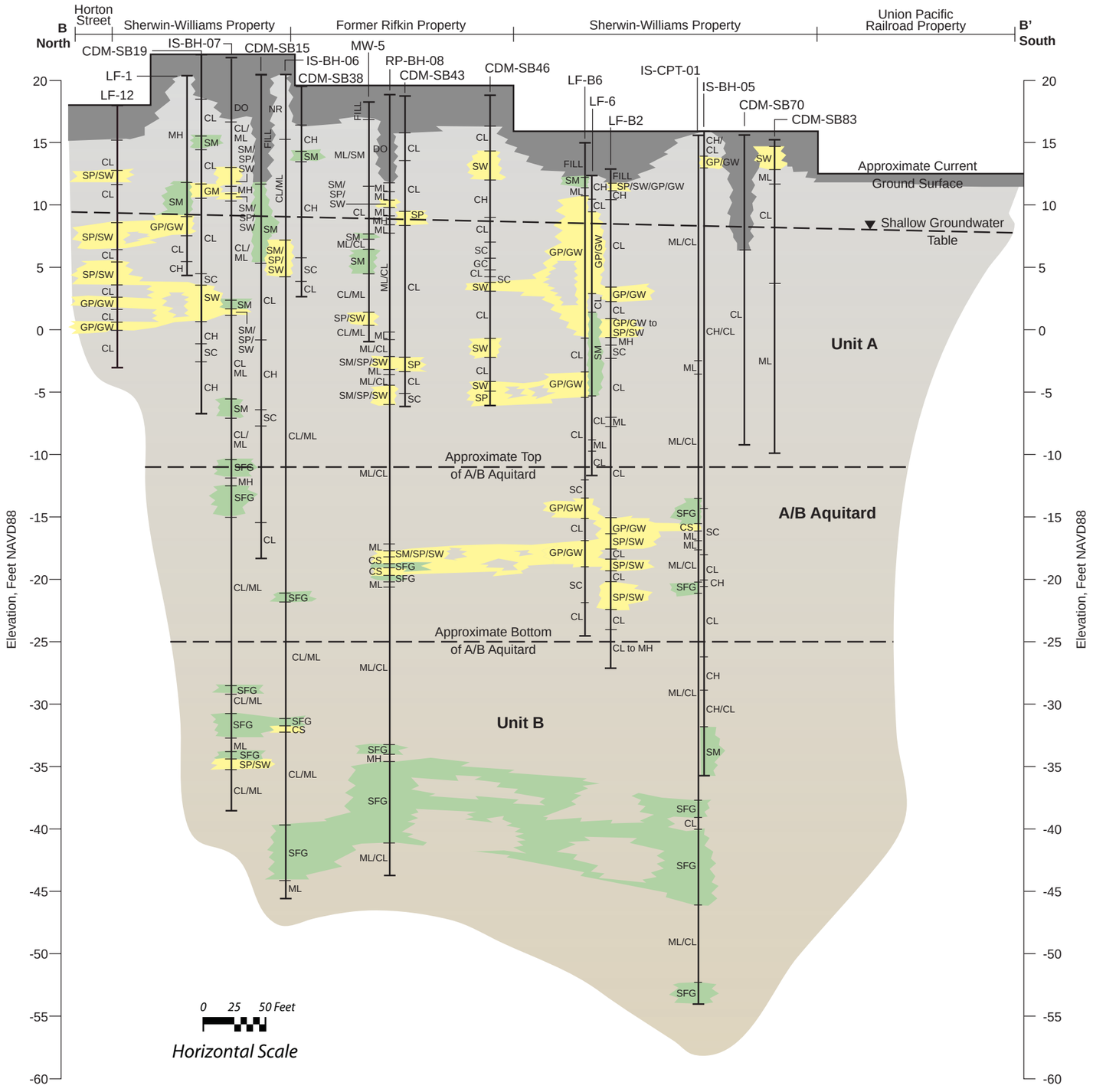
Figure 2-3
Geologic Cross Section Locations
Sherwin-Williams Company - Emeryville, California



Notes:
1. Permeability contacts are approximate and may actually be gradational.
2. See Figure 2-3 for orientation of cross sections.
3. Soils are classified in accordance with the United Soil Classification System (USCS).
4. Shallow Groundwater Table, Unit A, A/B Aquitard, and Unit B are approximate and may be gradational. Shallow Groundwater Table may vary seasonally.
5. NAVD88 = North American Vertical Datum of 1988.
6. Some borings were installed before current grade. The interval from current grade to grade at time of boring installation is identified as fill.

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Figure 2-4
Geologic Cross Section A - A'
Sherwin-Williams Company - Emeryville, California



LEGEND

Asphalt/Concrete/Fill
- Fill — Asphalt Cover/Concrete/Undefined

High Permeability Material
- GW — Well Graded Gravel
- GP — Poorly Graded Gravel
- SW — Well Graded Sand
- SP — Poorly Graded Sand
- CS — Cemented Sand

Moderate Permeability Material
- GM — Silty Gravel
- SM — Silty Sand
- SFG — Stiff Fine Grained

Low Permeability Material
- MH — Clayey Silt/Elastic Silt
- ML — Sandy Silt/Silt
- SC — Clayey Sand
- CH — Clay
- CL — Silty Clay
- GC — Clayey Gravel
- SF — Sensitive Fines

- DO — Drilled Out
- NI — No Information
- NR — No Recovery
- UDF — Undefined

Notes:
1. Permeability contacts are approximate and may actually be gradational.
2. See Figure 2-3 for orientation of cross sections.
3. Soils are classified in accordance with the United Soil Classification System (USCS).
4. Shallow Groundwater Table, Unit A, A/B Aquitard, and Unit B are approximate and may be gradational. Shallow Groundwater Table may vary seasonally.
5. NAVD88 = North American Vertical Datum of 1988.
6. Some borings were installed before current grade. The interval from current grade to grade at time of boring installation is identified as fill.

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Figure 2-5
Geologic Cross Section B - B'
Sherwin-Williams Company - Emeryville, California

C North — Former Rifkin Property — Sherwin-Williams Property — C' South

EKI-4563-A, RP-BH-018, RP-BH-014, EKI-4543-A, RP-5, LF-33, RP-BH-003, CDM-SB46, SB-7, RP-BH-08, EKI-4525-7, CDM-SB18, AA9109, CDM-SB24, AA9110, IS-BH-02, AA9111, AA9112, LF-2, EX-10, SA-BH-01, SA-AH-05, SA-AW-04

Approximate Current Ground Surface

Approximate Shallow Groundwater Table

Unit A

Approximate Top of A/B Aquitard

Approximate Bottom of A/B Aquitard

Elevation, Feet NAVD88

20, 10, 0, -10, -20, -30, -40, -50

LEGEND

Asphalt/Concrete/Fill
- Fill — Asphalt Cover/Concrete/ Undefined

High Permeability Material
- GW — Well Graded Gravel
- GP — Poorly Graded Gravel
- SW — Well Graded Sand
- SP — Poorly Graded Sand
- CS — Cemented Sand

Moderate Permeability Material
- GM — Silty Gravel
- SM — Silty Sand
- SFG — Stiff Fine Grained

Low Permeability Material
- MH — Clayey Silt/Elastic Silt
- ML — Sandy Silt/Silt
- SC — Clayey Sand
- CH — Clay
- CL — Silty Clay
- GC — Clayey Gravel
- SF — Sensitive Fines

- DO — Drilled Out
- NI — No Information
- NR — No Recovery
- UDF — Undefined

Notes:
1. Permeability contacts are approximate and may actually be gradational.
2. See Figure 2-3 for orientation of cross sections.
3. Soils are classified in accordance with the United Soil Classification System (USCS).
4. Shallow Groundwater Table, Unit A, A/B Aquitard, and Unit B are approximate and may be gradational. Shallow Groundwater Table may vary seasonally.
5. NAVD88 = North American Vertical Datum of 1988.
6. Some borings were installed before current grade. The interval from current grade to grade at time of boring installation is identified as fill.

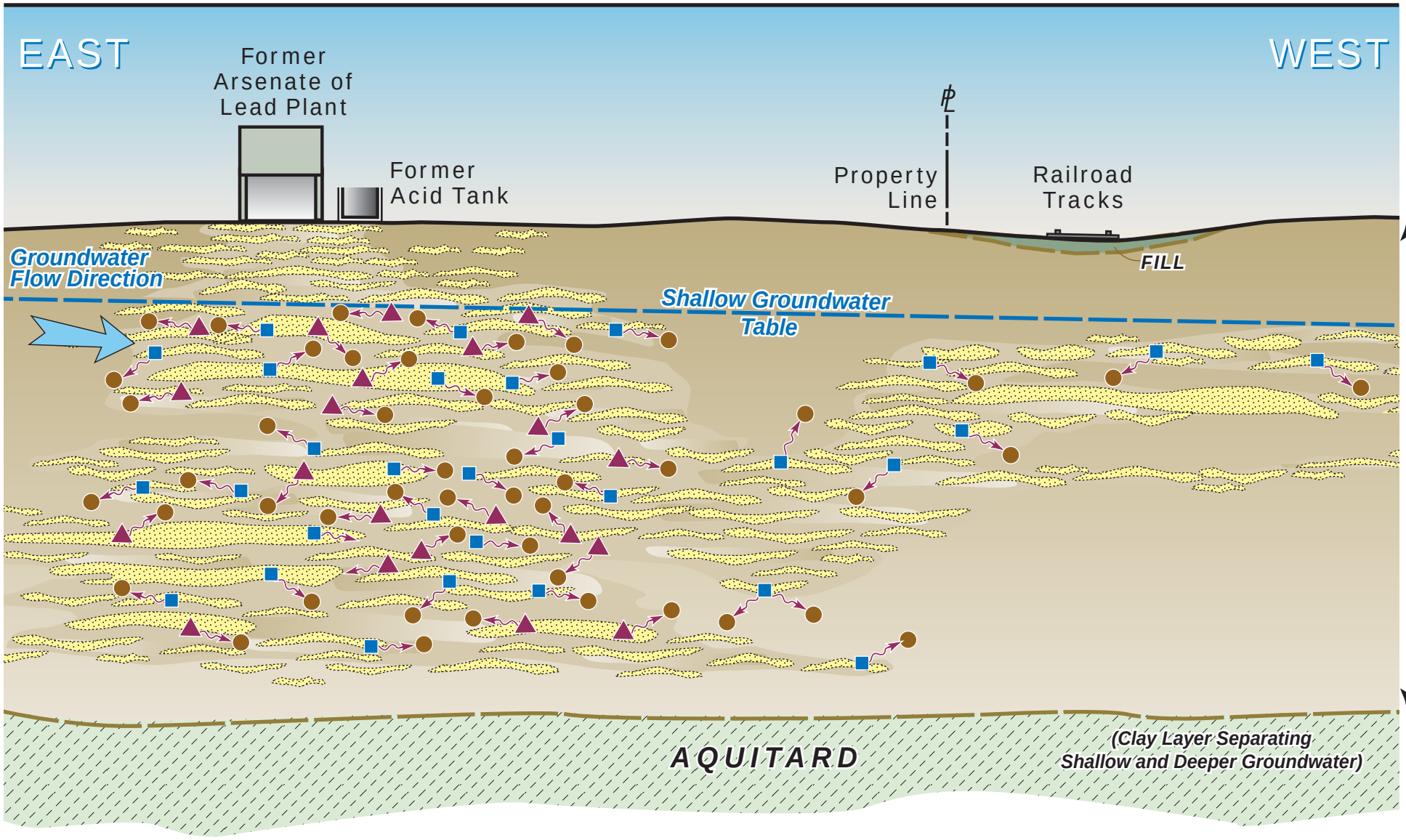
0 25 50 Feet

Horizontal Scale

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Figure 2-6
Geologic Cross Section C - C'
Sherwin-Williams Company - Emeryville, California



Drawing not to scale

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Figure 2-7
Conceptual Site Model
Sherwin-Williams Company - Emeryville, California

Section 3
Remedial Action Objectives

This section presents the remedial action objectives (RAOs) for the remedial action and their associated cleanup goals. RAOs were developed based on action-, location-, and chemical-specific federal and state applicable or relevant and appropriate requirements (ARARs), as well as on appropriate federal, state, and local criteria, advisories, guidance, and proposed standards (i.e., TBCs). RAOs are also based on site-specific human health and environmental exposure concerns identified in the Site RA documents, which are based on the data generated from remedial investigations.

3.1 Applicable or Relevant and Appropriate Requirements

CERCLA, as amended by Superfund Amendments and Reauthorization Act, and analogous California regulations, require that remedial actions achieve a level of cleanup that protects human health and the environment. In addition, cleanup actions generally must attain ARARs, which are standards, criteria, or limits promulgated under federal or state law. Only those state standards that are promulgated, identified by the state in a timely manner, and more stringent than federal requirements may be considered ARARs (40 CFR 300.400 (g) (4)). An ARAR may describe a cleanup requirement that is either "applicable" or "relevant and appropriate." The identification of ARARs is site-specific and involves the following two-part analysis:

- Assessing the applicability of a given requirement; and
- If a given requirement is not applicable, evaluating whether it is relevant and appropriate.

3.1.1 Definition of ARARs

An applicable requirement is a promulgated federal or state standard or other substantive environmental protection requirement, criteria, or limitation that specifically addresses a hazardous constituent, remedial action, location, or other circumstance at a Superfund site. For a requirement to be "applicable," the remedial actions or the circumstances at the site must be within the intended scope and authority of the requirement. For example, MCLs are standards that must be met by owners/operators of public drinking-water supply systems. MCLs are applicable "at the tap" and are enforced by either the USEPA or the state for water supplied by a public water supply system.

A "relevant and appropriate" requirement is a promulgated federal or state standard or other substantive environmental protection requirement, criteria, or limitation that addresses problems or situations similar to those encountered, even though the requirement is not legally "applicable." In some circumstances, a requirement may be "relevant" but not appropriate for the site-specific situation. Such a requirement would not be an ARAR for the Site. If only part of a requirement is "relevant and

appropriate," the portion that is not considered "relevant and appropriate" need not be addressed. If a determination is made that a requirement is both "relevant and appropriate," such a requirement should be given the same consideration as an "applicable" requirement. The criteria for determining relevance and appropriateness are listed in 40 CFR 300.400 (g) (2) of the NCP as follows:

i. The purpose of the requirement and the purpose of the CERCLA action;

ii. The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site;

iii. The substances regulated by the requirement and the substances found at the CERCLA site;

iv. The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site;

v. Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site;

vi. The type of place regulated and the type of place affected by the release or CERCLA action;

vii. The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action;

viii. Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site; and

ix. Non-promulgated federal and state standards, policies, advisories, guidance documents, and local requirements are not ARARs. However, they are considered to be other criteria and guidelines to be considered (TBCs) when remediating to protect human health and the environment.

3.1.2 Types of ARARs

There are three types of ARARs: chemical-, action-, and location-specific:

- Chemical-specific ARARs are health- or risk-based concentration limits for specific hazardous substances or contaminants. Examples of this type of ARAR are federal and state drinking-water standards.

- Action-specific ARARs are technology-based requirements that are triggered by the type of remedial action under consideration. Examples of action-specific ARARs

are the National Pollutant Discharge Elimination System (NPDES) requirements, which prohibit discharge of pollutants to waters of the United States unless a permit is issued in conformance with Clean Water Act standards. RCRA regulations for hazardous waste generation, handling, transportation, storage, treatment, and disposal are another example of an action-specific ARAR.

- Location-specific ARARs impose restrictions on certain types of activities, based onsite characteristics. Examples of location-specific ARARs include restrictions on activities in wetlands, flood plains, and historical sites.

3.1.3 Identification Process for ARARs/TBCs

NCP §300.430 (b) (9) provides for identification of potential ARARs and TBCs to be initiated during the scoping phase of the project. However, the ARAR and TBC identification process continues throughout the RI/FS process, as a better understanding is gained of site conditions, site contaminants, and remedial action alternatives. Table 3-1 provides a summary of ARARs and TBCs for the Site remedial action.

3.1.3.1 Settlement Agreement between Sherwin Williams and Novartis

In Table 3-1, the settlement agreement between S-W and Novartis is identified as a TBC. Therefore, the current provisions of the settlement agreement were used for evaluation purposes in the FS (CDM, 2009b). Based on ongoing discussions, S-W and Novartis are renegotiating this agreement and therefore, the provisions of this TBC will need to change in order to implement the remedial action presented in this RAP. Modification to the agreement will be addressed by DTSC through the RAP review and approval process.

3.2 Remedial Action Objectives

RAOs are media-specific remediation goals for protecting human health and the environment. RAOs specify the compounds of concern, exposure routes and receptors, and remediation goals for each exposure route. They are developed based on action-, location-, and chemical-specific federal and state ARARs, as well as on appropriate federal, state, and local criteria, advisories, guidance, and proposed standards (i.e., TBCs). They are also based on the site-specific human health and environmental exposure concerns identified in the HHRA, which is based on the data generated during the RI.

The following RAOs are identified for the Site remedial actions:

- Minimize direct contact/ingestion by humans with Site soil containing COCs at concentrations exceeding the cleanup goals;

- Minimize migration of and/or inhalation of airborne dust by humans from the Site containing COCs at concentrations exceeding the cleanup goals;

- Minimize exposure to and inhalation by humans of volatile organic COCs at concentrations in indoor air exceeding the cleanup goals;
- Minimize risk to down-gradient ecological receptors from off-site groundwater migration containing COCs at concentrations exceeding the cleanup goals; and
- Minimize on-site human contact with groundwater containing COCs at concentrations exceeding the cleanup goals.

RAOs can be fulfilled by one or more of the following processes: reducing the mass, volume, toxicity, or mobility of the COCs and reducing the potential exposure pathways for the COCs.

3.3 Cleanup Goals

Cleanup goals, serving as quantitative proposed cleanup goals for the RAOs, are developed based on action levels as defined in ARARs, TBCs, and/or the Site HHRA. The cleanup goals are "conservatively calculated threshold values below which particular chemicals are believed to present no significant risk to humans or natural resources that might be exposed to the particular hazardous material." (USEPA, 2004).

Chemical specific-cleanup goals were developed from two general sources: concentrations based on appropriate or relevant and applicable requirements (ARARs); and concentrations based on risk assessments. Concentration-based ARARs for selection of cleanup goals included: USEPA Region IX PRGs; California Environmental Protection Agency (CalEPA) California Human Health Screening Levels (CHHSLs); Regional Water Board Basin Plan numerical water quality objectives; California DHS MCLs; and the Office of Environmental Health Hazard Assessment (OEHHA) Public Health Goals (PHGs).

The development of remedial goals (RGs) constitutes a core component of the development and screening of potential remedial alternatives conducted during the Feasibility Study. It should be noted that until the final remedy is selected, these cleanup goals, whether ARARs-based or risk-based, constitute initial guidelines, not final RGs (NCP, 40CFR 300.430(e)(2)(i)).

As summarized in Section 2.4.5, the HHRA (Gradient, 2005) presented site-specific RBTLs for various human activity and exposure assumptions. The cleanup goals presented in Table 3-2 for soil are based on these RBTLs for the unrestricted resident exposure scenarios, with the exception of arsenic. The arsenic cleanup goal is the proposed naturally occurring background concentration.

For groundwater, concentration-based ARARs/TBCs for selection of cleanup goals included: DTSC California Human Health Screening Levels (CHHSLs); Regional Water Quality Control Board (Water Board) Basin Plan numerical water quality objectives; Water Board Environmental Screening Levels (ESLs); and California

Department of Health Services (CDHS) Maximum Contaminant Levels (MCLs). A summary of groundwater cleanup goals are presented in Table 3-3.

The USEPA advises that exceeding a cleanup goal concentration "suggests that further evaluation of the potential risks that may be posed by site contaminants is appropriate" (USEPA, 1999). The USEPA advises that further evaluation steps may include "consideration of ambient levels in the environment, or a reassessment of the assumptions contained in the screening level estimates (e.g., appropriateness of route-to-route extrapolations)" (USEPA, 1999).

3.3.1 Comparative Analysis

A comparative analysis of laboratory analytical results from soil samples collected was conducted against the soil cleanup goals identified above. All the soil COCs have been detected above their respective cleanup goals within vadose zone soil at the Site. However, the extents of these soil COC detections are bounded within the extent of arsenic.

A comparative analysis of laboratory analytical results from groundwater samples collected through March 2006 was conducted against the groundwater cleanup goals identified above. The following COCs have been detected above their respective cleanup goals within groundwater under the Site (S-W property and portion of the former Rifkin property):

- 1,2-dichloroethane
- 1,2,3-trichloropropane
- acetone
- arsenic
- methyl tert butyl ether
- toluene
- xylenes

The following COCs have been detected above their cleanup goals in groundwater immediately downgradient of the Site (including that portion of the former Rifkin property not considered part of the Site):

- 1,2-dichloroethane
- arsenic
- methyl tert butyl ether
- toluene

Arsenic is the only inorganic COC detected in groundwater above its cleanup goal. The other COCs are organic and attenuate significantly across the Site and are at or near their cleanup goals at the downgradient property boundary. The organic COCs are expected to continue to attenuate into the future and eventually decrease to concentrations below their cleanup goals.

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
FEDERAL								
I. Contaminant Specific								
	A.		Clean Air Act (CAA) (42 USC 7401-7642) (40 CFR 50-69)	Remediation of soil or groundwater that could produce a vapor or dust discharge would be required to meet National Ambient Air Quality Standards (NAAQS).	**X**	**X**	**X-RA**	
	B.		Clean Water Act (CWA) as amended by the Water Quality Act of 1987 (33 USC 1251-1376) (40 CFR 100-149)	Storm run off water, extracted groundwater, or soil remediation process water from the Site discharged to a surface water body (including discharge to a storm drain or flood channel) would require attainment of Water Quality Criteria.	**X**	**X**	**X-A**	
		1	Maximum Contaminant Levels (MCLs)	MCLs may be used to establish water discharge standards and groundwater remediation standards.		**X**	**X-A**	
		2	Maximum Contaminant Levels Goal (MCLGs)	Some contaminants of concern (COCs) present in soil and groundwater may not yet be formally regulated and MCLGs may provide guidance for remediation standards for water discharge.		**X**		**X**
		3	Secondary Maximum Contaminant Levels (SMCLs) (40 CFR 143.3)	The aquifer is a potential drinking water source. Therefore, quality of color or odor of the water source should be considered.		**X**		**X**
II. Location Specific								
	A.		Resource Conservation and Recovery Act (RCRA) as amended by Hazardous and Solid Waste Amendments (HSWA) (42 USC 7401-7462) (40 CFR 260-280)	The treatment facility for remediation of soil or groundwater (if the soil or groundwater is considered to be a hazardous waste) may be required to be a certain minimum distance from a fault and not within a floodplain.	**X**	**X**	**X-RA**	

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
	B.		Executive Order on Flood Plain Management (Exec. Order No. 11,988) (40 CFR 6.302 and Appendix A)	Remedial Actions occurring in a floodplain should avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values. Federal agencies are directed to ensure that planning programs reflect consideration of floodplain management	**X**	**X**	**X-RA**	
	C.		National Archaeological and Historical Preservation Act (16 USC 469) (36 CFR Part 65)	Requires action to recover and preserve artifacts if removal action threatens significant scientific, prehistoric, historic, archeological data. No = historic artifacts are currently known to be present at the Site. However, due to Emeryville's Bay shoreline location and the existence of known nearby archaeological sites, there is a potential of encountering previously unrecorded Native American cultural resources at the Site.	**X**	**X**	**X-RA**	
	D.		National Historic Preservation Act (NHPA) (16 USC 470 et seq.) (36 CFR Part 800)	Established to preserve historic properties. Buildings 1 and 31 are designated Tier 1 (primary architectural significance) in the Park Avenue Overlay District. These buildings contribute to the National Register-eligible Emeryville Historic Industrial District	**X**	**X**	**X-A**	
	E.		Endangered Species Act (16 USC 1531 et seq.) (50 CFR Part 17, 200, 402) (40 CFR 6.302(h))	Remedial actions should avoid disturbance of endangered or threatened species or to terrain which is habitat for endangered or threatened species. No known endangered species or their habitat are present at this Site.	**X**	**X**	**X-RA**	
	F.		Fish and Wildlife Coordination Act (16 USC 661et seq.) (33 CFR Parts 320-330)	Designed to protect waters where fish, plant life, or bird life exist. Water discharge from any potential Site soil or groundwater remediation is not expected to enter surface waters.	**X**	**X**	**X-RA**	

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
	G.		Clean Water Act (CWA) (33 USC 1251-1376) (40 CFR Part 6, Appendix A)	Designed to protect wetlands and the drainage areas which feed wetlands. Water discharge from any potential Site soil or groundwater remediation is not expected to enter any wetlands.	**X**	**X**	**X-A**	
III. Action Specific								
	A.		Resource Conservation and Recovery Act (RCRA) as amended by Hazardous and Solid Waste Amendments (HAWS) (42 USC 7401-7642)(40 CFR 260-280)	Regulates treatment, storage and disposal of hazardous wastes. Soil, which may be considered hazardous waste under RCRA, may be accumulated, stored, transported, treated or disposed.	**X**		**X-RA**	
	B.		Clean Water Act (CWA) as amended by the Water Quality Act of 1987 (33 USC 1251-1376) (40 CFR 100-149)	Storm run off water, extracted groundwater, or soil remediation process water from the Site discharged to a surface water body (including discharge to a storm drain or flood channel) would require attainment of Water Quality Criteria.	**X**	**X**	**X-RA**	
		1	National Pollutant Discharge Elimination System (NPDES) (40 CFR 122-125)	Treated groundwater may require permit for on-site or off-site disposal.		**X**	**X-RA**	
		2	Water Quality Standards [CWA 402 (a)(1)]	Remediation of groundwater may require treatment to promulgated water quality standards.		**X**	**X-RA**	
		3	Discharge to Publicly Owned Treatment Works (POTWs) (CWA 307)	Establishes discharge limits for disposal to the sanitary sewer system. Treated groundwater could potentially be disposed to the sanitary sewer.		**X**	**X-RA**	
		4	Storm Water Discharge Requirements [CWA 402(p)]	Establishes requirements for storm water discharge. Groundwater or soil remedial action should ensure storm water discharge at the Site is in compliance.	**X**	**X**	**X-RA**	

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
	C.		Safe Drinking Water Act (SWDA) (42 USC 300f-300j) (40 CFR 144-146)	Establishes National primary drinking water standards (MCLs) and regulates injection of wastes to the subsurface through wells. MCLs may be used to establish water discharge standards and groundwater remediation standards.		**X**	**X-RA**	
	D.		Clean Air Act (CAA)(42 USC 7401-7642)(40 CFR 60.50-60.54)	Remedial alternatives for soil or groundwater may produce a vapor effluent stream or dusts.	**X**	**X**	**X-RA**	
	E.		Occupational Safety and Health Act (OHSA)(29 USC 651 et seq.) (19 CFR 1910)	Remedial action operations for soil and groundwater remediation are subject to health and safety requirements for protection of workers.	**X**	**X**	**X-RA**	
	F.		Noise Control Act of 1972 as amended by the Quiet Communities Act of 1978 (CFR 204, 205, 211)	Construction, transportation, and treatment equipment may increase noise levels at property boundaries.	**X**	**X**		**X**
STATE AND LOCAL								
I. Contaminant Specific								
	A.		Hazardous Waste Control Act (HWCA) (CH&SC 25100-25395) as administered by the CA Department of Toxic Substance Control (DTSC) under the CA Code of Standards for Management of Hazardous and Extremely Hazardous Wastes.	Establishes standards for management of hazardous waste. Groundwater or soil that may be considered to be hazardous waste, may be treated, stored, transported, and/or disposed.	**X**	**X**	**X-RA**	
		1	Criteria for identifying Hazardous Wastes (22 CCR 66261.1-66262.7)	Establishes criteria for identifying RCRA and non-RCRA hazardous wastes.	**X**	**X**	**X-RA**	
		a)	Persistent and Bioaccumulative Toxic Substances (22 CCR 66262.7)	Regulatory levels have been set for COCs identified at the Site.	**X**	**X**	**X-RA**	
	B.		Porter-Cologne Water Quality Control Act (CWC 13000-13806) as administered by the State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Board (Water Board) under 23 CCR 2200 - 2714	Treated groundwater may be discharged to a surface water source or to an injection well.		**X**	**X-RA**	

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
		1	San Francisco Bay Regional Water Quality Control Board Basin Plan and associated implementation policies	Establishes beneficial uses and water quality objectives. Remediation of soil and groundwater includes consideration of State and regional water quality objectives. Surface water and groundwater designated for use as domestic or municipal supply shall not contain concentrations of COCs at or above MCLs.	**X**	**X**	**X-A**	
	C.		San Francisco Bay Regional Water Quality Control Environmental Screening Levels (ESLs)	ESLs may be utilized to determine potential concern to human health and the environmental from residual concentrations of COCs in Site soil, soil gas, and groundwater.	**X**	**X**		**X**
	D.		California Human Health Screening Levels (CHHSLs)	CHHSLs may be utilized to determine potential concern to human health from residual concentrations of COCs in Site soil and soil gas.	**X**	**X**		**X**
II. Location Specific								
	A.		Fish and Game Code Division 6, Part 1, Chapter 2, Sections 5650-5656	If treated groundwater or processed water from soil remediation is discharged to a surface water source or a storm drain, the discharged water should contain no deleterious compounds that will affect fish, plant, or bird life.	**X**	**X**	**X-RA**	
	B.		State Water Resources Control Board Sources of Drinking Water Supply (Resolution 88-63)	Soil cleanup goals and groundwater numerical water quality objectives may be controlled by applicability of drinking water standards as determined by site-specific yield and total dissolved solids in groundwater.	**X**	**X**	**X-A**	
	C.		Department of Toxic Substances Control (DTSC) Imminent and Substantial Endangerment Determination and Order and Remedial Action Order No. 05/06-007 (the Order)	The Order specifies specific requirements for the development and implementation of remedial actions for soil and groundwater at the Site.	**X**	**X**	**X-A**	

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
	D.		Settlement Agreement between Sherwin-Williams and Novartis regarding the Former Rifkin Property	Establishes criteria for remedial actions on the Former Rifkin Property.	**X**	**X**		**X**
	E.		City of Emeryville Noise Ordinance (Ordinance No. 03-002) http://www.ci.emeryville.ca.us/gov/pdf/ord-noise.pdf	Establishes criteria for noise generation within the City of Emeryville.	**X**	**X**	**X-RA**	
	F.		San Francisco Regional Board Basin Plan and associated implementation policies	Establishes beneficial uses and water quality objectives. Remediation of soil and groundwater includes consideration of State and regional water quality objectives. The Plan sets discharge prohibitions of impacted groundwater containing COCs into clean water.	**X**	**X**	**X-A**	
	G.		Park Avenue District Plan	The Site is within the Park Avenue District. The plan guides redevelopment of sites within the District. As such the planed use of the property with respect to evaluation of remedial actions should be consistent with Park Avenue District Plan.	**X**	**X**		**X**
	H.		Chiron Planned Unit Development (PUD) and Preliminary Development Plan (PDP)	The Former Rifkin Property future use is governed by the City of Emeryville-approved development plan. As such the planed use of the property with respect to evaluation of remedial actions should be consistent with development plan.	**X**	**X**		**X**
	I.		City of Emeryville General Plan	The Site is within the City of Emeryville. The City General Plan. The plan is the blueprint for the future growth and development of the city. As such the planed use of the property with respect to evaluation of remedial actions should be consistent with General Plan.	**X**	**X**		**X**

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
III. Action Specific								
	A.		Hazardous Waste Control Act (HWCA) (Health and Safety Code Section 25100-25395) as administered by the DTSC under CCR Title 22: Standards for Management of Hazardous Wastes	Site soil or groundwater with COCs may be considered hazardous waste which would require compliance with regulations for accumulation, transportation, treatment, or disposal.	**X**	**X**	**X-RA**	
		1	Identification and Listing of Hazardous wastes (22 CCR Division 4.5, Chapter 11, 22 CCR 66261.2-66261.126)	Treated soil or groundwater that is identified as hazardous waste would be identified as "listed" or as "characteristic".	**X**	**X**	**X-RA**	
		2	Standards Applicable to Generators of Hazardous Waste (22 CCR Division 4.5, Chapter 12, 22 CCR 66261.1-66262.7)	Offsite disposal requires characterization of waste	**X**	**X**	**X-RA**	
			Hazardous Waste Accumulation (22 CCR 66262.34)	On-site hazardous waste accumulation is allowed for up to 90 days as long as the waste is stored in containers or in tanks, on drip pads, inside buildings, is labeled and dated, etc.	**X**	**X**	**X-RA**	
		3	Deed Restrictions (22 CCR Division 4.5, Chapter 39; 22 CCR 67390.2)	The property may be restricted from certain future development, if COCs identified on-site, are not addressed to unrestricted standards.	**X**	**X**	**X-RA**	
		4	Corrective Action Management Units and Temporary Units. (22 CCR 66264.552-66264.53)	A temporary treatment unit may be set up at the Site. Soil pending treatment may be stockpiled at the Site.	**X**		**X-RA**	
		5	Hazardous Waste Haulers Act (22 CCR Chapter 30)	Governs transportation of hazardous materials in California.	**X**	**X**	**X-RA**	
		6	Land Disposal Restrictions (22 CCR Chapter 18)	Requires that certain hazardous wastes meet minimum treatment standards prior to land disposal.	**X**	**X**	**X-RA**	

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
	B.		Porter-Cologne Water Quality Control Act, (CWC 13000-13806) as administered by the State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Board (Water Board) under 23 CCR 2050-2836	The San Francisco Regional Water Quality Control Board (Water Board) may require that treatment technology perform at a level near Best Available Technology (BAT) and may establish waste disposal requirements.	**X**	**X**	**X-RA**	
		1	Waste Discharge to Land Requirements (23 CCR Chapter 15) (23, CCR 2260-2597)	Remediation projects are exempt, but regulations should be considered and followed to the extent possible.	**X**	**X**	**X-RA**	
		2	State Water Resources Control Board Antidegradation Policy (Resolution 68-16)	If treated groundwater is disposed to a water source of the state, then the quality of the water source is to be protected.	**X**	**X**	**X-RA**	
		3	Discharge to Sanitary Sewer	Treated groundwater may be disposed to a sanitary sewer.	**X**	**X**	**X-RA**	
	C.		California Safe Drinking Water Act (Cal-SWDA) (CH&SC 4010-4095) (22 CCR 64401-64475)	Treated groundwater may be disposed of to an injection well. The aquifer that the injection well feeds may be a potential drinking source.		**X**	**X-RA**	
		1	Maximum Contaminant Levels (MCLs) (22 CCR 64435, 64444.5)	MCLs may be used to establish the standard for groundwater remediation or water discharge.		**X**	**X-RA**	
		2	Advisory Drinking Water Action Levels (ALs)	Some COCs present at the Site may not yet be formally regulated. Action Levels would provide a non-binding guidance for allowable concentrations.		**X**		**X**
		3	Advisory Applied Action Levels	The risk posed to biological receptors by a potential groundwater remediation system must be evaluated.		**X**		**X**

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
	D.		Bay Area Air Quality Management District (BAAQMD) regulations	The BAAQMD has is that local implementation agency for the Federal Clean Air Act.				
		1.	BAAQMD Regulation 2, Rule 5	This rule addresses conditions where a health screening assessment must be completed. As arsenic is a COC a health screening assessment needs to be addressed. Human health risk criterion is set at ten in a million for this assessment.	**X**	**X**	**X-RA**	
		2.	BAAQMD Regulation 6, Particulate Matter	This rule limits emissions of particulate matter. This rule may apply as air-borne particulate matter may be generated during soil removal and soil handling.	**X**	**X**	**X-RA**	
		3.	BAAQMD Regulation 8, Rules 40 and 47, Volatile Organics	This rule sets limits on the quantity of odorous emissions from any general operation and may be applicable during the implementation of the remedial action. This rule may apply as portions of the source area proposed to be excavated contain odorous organic compounds. These rules may apply as VOC-impacted soils may require on-site aeration or soil vapor extraction prior to off-site disposal.	**X**	**X**	**X-RA**	
		4.	BAAQMD Regulation 11, Lead	This rule limits emission of lead to the atmosphere and may be applicable as excavation and handling of soils may occur.	**X**	**X**	**X-RA**	
	E.		California Safe Drinking Water and Toxic Enforcement Act (Proposition 65) (Health and Safety Code Section 25249.5 et seq.) as implemented under Title 26 CCR Sections 22-12000 et seq.	Some COCs at the Site are identified as carcinogens or reproductive toxins	**X**	**X**	**X-RA**	

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
	F.		California Clean Air Act (CH&SC 39000-44563) as implemented by the local Air Quality Management Districts and overseen by the Air Resources Board under 17 CCR Division 3	Groundwater or soil treatment process may produce a vapor effluent subject to discharge limitations.	**X**	**X**	**X-RA**	
		1	Air Pollution Control District (APCD) Rules and Regulations	Groundwater or soil treatment process may produce a vapor effluent subject to Rules and Regulations of the APCD.	**X**	**X**	**X-RA**	
	G.		California Occupational Health and Safety Act, CLC 6300 et seq.	Remedial actions require appropriate worker protection.	**X**	**X**	**X-RA**	
	H.		City of Emeryville Municipal Code, Title 7, Public Works	Outlines requirements for excavation and grading activities, including obtaining a permit from the City Public Works Department.	**X**		**X-RA**	
	I.		City of Emeryville Stormwater Guidelines for Green, Dense Redevelopment: Stormwater Quality Solutions	Guidelines for complying with stormwater requirements.	**X**	**X**		**X**
	J.		Stockpiling Requirements for Contaminated Soil (CH&SC 25123.3(a)(20))	Establishes standards for stockpiling of non-RCRA contaminated soil.	**X**		**X-RA**	
	K.		California Environmental Quality Act	Mandates environmental review of projects considered for approval by governmental agencies, including DTSC, Water Board, BAAQMD, and others.	**X**	**X**	**X-RA**	
	L.		Land Use Controls (LUCs)	LUCs may be implemented if COCs identified on-site, are not addressed.	**X**	**X**		**X**
		1	ASTM Standard E 2091-00: "Standard Guide for Use of Activity and Use Limitations, Including Institutional and Engineering Controls, American Society for Testing and Materials (ASTM)"	LUCs may need to be evaluated similar to the evaluation criteria of remedial technologies and process options.	**X**	**X**		**X**

Table 3-1
Summary of Applicable or Relevant and Appropriate Requirements
Sherwin-Williams Emeryville Remedial Action Plan

Reference				*Reasons*	*Media*		*ARAR*[1]	*TBC*
					Soil	*Water*		
		2	DTSC Management Memo #EO-02-002-MM: "Response Action for Sites Where Future Use May Include Sensitive Uses"	LUCs may need to be incorporated into remedial alternatives. DTSC expects that any remedial alternative, that includes leaving contaminants at levels not suitable for unrestricted use, include LUCs that protect human health and the environment.	**X**	**X**		**X**

Notes:
ARAR - applicable or relevant and appropriate requirement for the remedial action
TBC - other criteria or guideline to be considered for the remedial action
Abbreviated regulatory codes:
USC - United States Code
CFR - Code of Federal Regulations
CCR - California Code of Regulations
CH&SC - California Health and Safety Code
CWC - California Water Code
CLC - California Labor Code
1 – For ARARs, X-A indicates an applicable requirement; X-RA indicates a relevant and appropriate requirement.

Table 3-2
Cleanup Goals for COCs in Vadose Zone Soil
Sherwin-Williams Emeryville Remedial Action Plan

	Cleanup Goal (mg/kg)	***Basis***
Volatile Organic Compounds		
ACETONE	70000	RBTL
BENZENE	0.015	RBTL
4-CHLOROANILINE	310	RBTL
ETHYLBENZENE	7800	RBTL
TETRACHLOROETHENE	0.063	RBTL
TOLUENE	100	RBTL
XYLENES	2300	RBTL
Semivolatile Organic Compounds		
BENZO(A)ANTHRACENE	1.1	RBTL
BENZO(B)FLUORANTHENE	1.1	RBTL
BENZO(B,K)FLUORANTHENE	1.1	RBTL
NAPHTHALENE	1300	RBTL
PHENANTHRENE	4500	RBTL
Inorganic Compounds		
ANTIMONY	31	RBTL
ARSENIC	24	Background Level
BARIUM	5500	RBTL
CADMIUM	3.1	RBTL
CHROMIUM (+3)	120000	RBTL
CHROMIUM (+6)	1600	RBTL
LEAD	250	RBTL
SELENIUM	390	RBTL
ZINC	23000	RBTL

Notes:
COC - Chemical of Concern
RBTL - Risk Based Threshold Level
Background Level - for arsenic as presented in Human Health Risk Assessment
mg/kg - milligram per kilogram

CDM

Table 3-3
Cleanup Goals for COCs in Groundwater
Sherwin-Williams Emeryville Remedial Action Plan

	Cleanup Goal (mg/L)	***Basis***
Volatile Organic Compounds		
ACETONE	1.5	ESL
BENZENE	0.001	MCL
2-BUTANONE	4.2	ESL
1,2-DICHLOROETHANE	0.0005	MCL
1,2-DICHLOROPROPANE	0.005	MCL
ETHYLBENZENE	0.3	MCL
METHYL ISOBUTYL KETONE	0.12	ESL
METHYL TERT BUTYL ETHER	0.013	MCL
TOLUENE	0.15	MCL
TRICHLOROETHENE	0.005	MCL
1,2,3-TRICHLOROPROPANE	0.005	ESL
1,3,5-TRIMETHYLBENZENE	0.46	RBTL
1,2,4-TRIMETHYLBENZENE	0.14	RBTL
VINYL CHLORIDE	0.0005	MCL
XYLENES	0.02	ESL
Semivolatile Organic Compounds		
NAPHTHALENE	0.017	ESL
Inorganic Compounds		
ARSENIC	0.036	Aquatic Protection
IRON	0.3	secondary MCL
MANGANESE	0.05	secondary MCL
ZINC	0.081	ESL

Notes:
COC - Chemical of Concern
ESL - Water Board Environmental Screening Level
MCL - California Department of Health Services Maximum Contaminant Level
RBTL - Risk Based Threshold Level from Human Health Risk Assessment
Aquatic Protection - Water Board Basin Plan, Marine Water Quality Objective for Arsenic in Surface Waters, 4-day average
mg/L - milligram per liter

CDM

Section 4
Remedial Action Alternatives

In this section of the RAP, the FS is summarized by presenting remedial action alternatives considered in the FS and the basis for the selected action (CDM, 2009b).

Remedial action alternatives were developed using combinations of technologies and process options that passed the screening. These alternatives contain both soil and groundwater treatment options combined to provide Site-wide treatment of contamination.

4.1 Description of Remedial Action Alternatives

The following alternatives were developed from the retained process options (see Appendix B). These options were combined to form alternatives that address groundwater and soil/soil gas contamination rather than presenting separate alternatives for each contaminated media type.

- **Alternative 1 –** No Action
- **Alternative 2 –** Limited Action
- **Alternative 3A –** Vadose Zone Excavation/Active *In-Situ* Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs
- **Alternative 3B –** Vadose Zone Excavation/S-W Source Area Soil Mixing/Active *In-Situ* Groundwater Treatment/Rifkin Excavation /Groundwater Monitoring/LUCs
- **Alternative 3C –** Vadose Zone Excavation/S-W Source Area Excavation/Rifkin Groundwater Extraction and Aboveground Treatment/MNA/Groundwater Monitoring/LUCs
- **Alternative 4A –** Vadose Zone Excavation/Upgradient Interceptor Drain Installation/Passive *In-Situ* Groundwater Treatment/Rifkin Excavation/ Groundwater Monitoring/LUCs
- **Alternative 4B –** Vadose Zone Excavation/Upgradient Interceptor Drain Installation/Active *In-Situ* Groundwater Treatment/Rifkin Excavation/ Groundwater Monitoring/LUCs
- **Alternative 5A –** Vadose Zone Excavation/Excavation Upgradient of Interceptor Drain/Downgradient Interceptor Drain Installation/Passive *In-Situ* Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs

- **Alternative 5B –** Vadose Zone Excavation/Excavation Upgradient of Interceptor Drain/Downgradient Interceptor Drain Installation/Active *In-Situ* Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs
- **Alternative 6 –** Vadose Zone Excavation/Source Area Excavation/MNA/ Groundwater Monitoring/LUCs
- **Alternative 7 –** A-Zone Aquifer Excavation/LUCs

Each alternative is described in detail below.

4.1.1 Alternative 1 – No Action

Alternative 1 would discontinue operations of the existing GWETS and storm water management practices. The Site would be left "as is" after completion of demolition activities in November, retaining the slurry wall and existing paved sections of the Site, and ongoing long-term groundwater monitoring. Under Alternative 1, the raised cap materials would remain on-Site and there would be no immediate cleanup on former Rifkin property. Existing LUCs such as prohibitions on the use of A-zone groundwater as a drinking water source would continue to be applied to future Site development. No new LUCs would be implemented for residual chemical concentration.

4.1.2 Alternative 2 – Limited Action

Under Alternative 2, the IRMs present at the Site, for both S-W and former Rifkin properties, would continue to be managed, including, groundwater elevation monitoring of piezometer pairs along the slurry wall as part of the ongoing long-term groundwater monitoring, GWETS operations and maintenance, and storm water management practices. The existing pavement after completion of demolition activities in November 2007 would be maintained to control infiltration to groundwater. The raised cap materials would remain on-Site. Existing LUCs would be retained and a new set of LUCs would be implemented prohibiting consumptive use of A-zone groundwater from areas where concentrations in extractable groundwater exceed MCLs, restricting subsurface drilling or excavation on the Site, and requiring the use of appropriate personal protective equipment (PPE) for any necessary subsurface work.

4.1.3 Alternative 3A – Vadose Zone Excavation/Active *In-Situ* Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs

Alternative 3A includes several components for addressing contaminated soils and groundwater on both the S-W and former Rifkin properties. Detailed descriptions of these components are presented below and proposed locations for each component are presented graphically on Figure 4-1.

4.1.3.1 Removal of Raised Cap

The raised cap material and old foundations under the raised cap would be removed. Approximately 7,000 cubic yards of debris and soil would be removed and transported to an appropriate disposal/reuse facility. This excavated material is anticipated to contain hazardous waste, which would be transported to a Class I hazardous waste landfill for treatment and disposal.

4.1.3.2 Vadose Zone Excavation

Vadose zone soil on the S-W and former Rifkin properties would be excavated in order to achieve the vadose zone soil cleanup for arsenic of 24 mg/kg on each property. The planned limits of soil excavation extend approximately 285 feet along Horton Street (60 feet on the former Rifkin property and 225 feet on the S-W property) and approximately 330 feet west of Horton Street, or approximately 95,000 square feet. In addition, elevated detections of arsenic in vadose zone soil are present at locations outside these limits, including SA-AH-01 (110 mg/kg), SB-7AB (130 mg/kg), CDM-SB50 (200 mg/kg), and SA-BH-04 (211 mg/kg). Vadose zone soil surrounding these locations would also be removed to a radius of 10 feet surrounding each location. These four locations are presented on Figure 4-1.

The vadose zone soil would be excavated to an average depth of approximately 7.5 feet, the approximate depth to groundwater across this area. Approximately, 26,500 cubic yards of vadose zone soil across the Site would be excavated and transported to and disposed at an appropriate landfill. This excavated soil is anticipated to contain hazardous waste, which would be transported to a Class I hazardous waste landfill for treatment and disposal.

Confirmation sampling and analysis would be conducted to confirm that the vadose zone soil cleanup goal for arsenic is met. In order to meet this goal, additional, excavation beyond the limits presented above may be needed.

4.1.3.3 Backfill, Compaction, Grading, and Installation of Cover

All areas undergoing excavation would be backfilled to grade with fill material, compacted, and graded for storm water management. In order to control infiltration into groundwater, the backfill areas would be re-paved and/or vegetated and would direct water runoff along the Site surface towards the Temescal Creek channel.

4.1.3.4 Active Groundwater Treatment System

Groundwater would pass through slurry wall breaches and be treated through an *In-Situ* treatment system through precipitation, coagulation, and flocculation systems. At each slurry wall breach location, shown on Figure 4-1, would be formed through the existing slurry wall. Breaching would be accomplished by installing the system into the barrier, and sealing the space between the system and the barrier wall with flowable low-permeability backfill.

An *in-situ* active treatment system would be installed at each breach of the slurry wall. The conceptual design of the active treatment system involves the following treatment steps:

- Groundwater would flow into a 25-ft tall drainage maintenance structure through multiple pipes that span the height of the aquifer at the gate.
- Groundwater would be aerated via flow from an air compressor located above ground.
- Ferric chloride, which reacts with dissolved arsenic to form co-precipitants, would be added to the water in the aeration basin through a meter pump and tank.
- Organic polymer to assist with flocculation and settling would be added to the water in the aeration basin through a metering pump and tank.
- Groundwater would flow into one or two additional maintenance structures, where precipitants have sufficient residence time to settle out.
- Treated groundwater would flow out of the settling basins through another series of pipes, and into a gravel distribution trench.

A groundwater flow and fate and transport model was used to develop the design flow rates and arsenic concentrations at these breaches. The model results are presented in Appendix B of the FS.

In order to evaluate the effectiveness of the system, groundwater monitoring wells would be placed within and downgradient of the system. Monitoring of these wells is further discussed below.

4.1.3.5 Extending the Existing Slurry Wall

A slurry wall extension would be constructed in locations shown on Figure 4-1 in order to capture the existing plume that has been identified to the south of the existing slurry wall. The slurry wall extension would be approximately 340 linear feet and tie back into the southern end of the existing slurry wall**.**

A breach in the existing slurry wall near this extension, as shown on Figure 4-1, would be installed to prevent mounding and facilitate impacted groundwater between the existing and extended slurry wall system to migrate across the Site and toward the active groundwater treatment systems at the northern slurry wall breaches.

4.1.3.6 LUCs

LUCs would be established to maintain the long-term permanence of this remedy and to control future human exposure. These LUCs would prohibit the use of A-zone groundwater beneath the Site; restrict the future land use on the S-W portion of the Site; and facilitate continued access to and operation and maintenance of remediation

and monitoring facilities on the Site. LUCs on the former Rifkin property would not preclude proposed redevelopment plan for the former Rifkin property, which includes a high-rise tower option with installation of piles and pile caps.

4.1.3.7 Former Rifkin Property Remedial Actions

Under Alternative 3A, remedial actions on the former Rifkin property would consist of: excavation of vadose zone soils above background (as discussed above), excavation of impacted saturated soils, breaching of existing slurry wall along the south end of the former Rifkin property, installation of two interceptor trenches with associated membrane barriers to control hydraulic gradient on the former Rifkin property by directing groundwater flow toward the S-W property, and groundwater monitoring to support the effectiveness of these interceptor trenches. As part of this alternative, a contingency would be to pump from the trench systems, if needed, to direct groundwater flow toward the S-W property. The proposed redevelopment plan for the former Rifkin property, which includes a high-rise tower option with installation of piles and pile caps, is not inconsistent with, and would not impede implementation or long-term operations, maintenance, and monitoring (OM&M) of this alternative.

Excavation of vadose zone soils with arsenic concentrations greater than 24 mg/kg is included within the 95,000 square-foot area discussed above. Saturated zone soils within the portion of the source area located on the former Rifkin property, estimated to be present to a depth of approximately 18 feet bgs, would be excavated as shown on Figure 4-1. This excavated soil is anticipated to contain hazardous waste, which would be transported to a Class I hazardous waste landfill for treatment and disposal. In addition, saturated zone soils in areas with documented VOCs in soil gas concentrations above the cleanup goals, outside of the arsenic source area, would be excavated to address any soil vapor issues. This saturated soil volume has been estimated to be approximately 5,400 additional cubic yards.

All areas undergoing excavation would be backfilled with low-permeability fill material (approximately 0.283 ft/day under this alternative), compacted, and graded for storm water management. An asphalt cover would be placed over these areas and the area would be returned to current use as a parking lot. The cover would prevent infiltration into groundwater.

Based on the proposed redevelopment plan for the former Rifkin property, it is anticipated that for the high-rise tower option up to 4,000 cubic yards of vadose and saturated zone soils could be excavated during installation of piles and pile caps. For soil excavated and removed for Site development that requires increased handling and disposal due to concentrations of arsenic or other COCs, S-W would be responsible for reimbursement to Novartis of the incremental costs. This incremental increase in this operation is considered part of this alternative and S-W would prepare a risk management plan stating their responsibilities.

The existing slurry wall along the south side of the former Rifkin property along the boundary with the S-W property would be breached and replaced with a high permeability interceptor trench. The interceptor trench would be located on the S-W property and be designed to capture and redirect groundwater flow from S-W property away from the former Rifkin property. The trench would be approximately 325 feet long, extend to approximately 18 feet bgs, and be designed to maintain a hydraulic gradient (as demonstrated by potentiometric data collected from both the S-W and former Rifkin properties) away from former Rifkin property, other than that within the drain itself. A second interceptor drain approximately 150 linear feet in length would be installed to capture and redirect flow from the B-line on the former Rifkin property and onto the S-W property.

These trenches are designed to maintain hydraulic gradient of impacted groundwater away from and minimize potential arsenic mass migration to the former Rifkin property. Based on this design basis, the trenches would be approximately 30 inches wide, approximately 18 feet deep and be located as shown on Figure 4-1. The trenches would be backfilled with 3/8 inch minus material and contain a basal perforated pipe to reduce flow resistance from the backfill material. With this design, the trenches would have an effective permeability of approximately 500 ft/day. Soil excavated from the installation of these trenches is anticipated to contain hazardous waste, which would be transported to a Class I hazardous waste landfill for treatment and disposal.

4.1.3.8 Groundwater Monitoring and MNA of Organic COCs

Groundwater monitoring would be performed after implementation of this alternative. The groundwater monitoring program would consist of three parts, demonstrating the overall effectiveness of the remedy, monitoring the performance of the active treatment systems, and demonstrating hydraulic containment and arsenic concentrations in the interceptor trenches on the former Rifkin property.

Overall effectiveness of the remedy would be demonstrated through groundwater samples collected at upgradient and downgradient points along the existing slurry wall as well as at the drain of the interceptor trenches on the former Rifkin property.

Through sampling and analysis of groundwater, trends in the changes in COC concentrations in groundwater would be demonstrated. These monitoring data would be used to evaluate the effectiveness of the remedy outlined in Alternative 3A, and would serve as a demonstration over time of MNA of all organic COCs through comparison with Site data collected prior to remedial action implementation. This comparison would be conducted annually and summarized as part of the five-year review of the S-W property following completion of remedial action.

The performance of the active treatment system would be demonstrated through the collection and evaluation of groundwater samples from wells immediately upgradient and downgradient of the active system.

4.1.3.9 Operations, Maintenance, and Monitoring of Installed Components

This alternative includes long-term operations, maintenance, and monitoring (OM&M) of several installed components, including the surface cover, groundwater treatment system, slurry wall and/or breach system, interceptor trenches and/or drains, groundwater monitoring well network, and/or LUCs. As such, this alternative would include an OM&M plan, OM&M agreement with Site property owners, and financial assurance to DTSC for continued OM&M of these components.

4.1.4 Alternative 3B – Vadose Zone Excavation/Source Area Soil Mixing/Active *In-Situ* Groundwater Treatment/Rifkin Excavation /Groundwater Monitoring/LUCs

Alternative 3B is the same as Alternative 3A with the exception of the inclusion of soil mixing on the S-W property. The proposed layout of all Alternative 3B components is presented graphically on Figure 4-2.

4.1.4.1 Soil Mixing

In-situ soil mixing, as described in Section 2.5.2.2, would be implemented in the A-zone saturated soil within the source area on the S-W property. Soil mixing on the S-W property will complement the excavation performed on the former Rifkin property. The A-zone saturated soils in the source area would be mixed to a depth of approximately 25 feet bgs and would be tied into the A/B aquitard. The final soil mix will have a permeability of approximately 0.000283 ft/day under this alternative. Since soil mixing increases the total soil volume through introduction of the cement mix, the volume of expanded treated soil within the source mixing area would be excavated, transported to, and disposed at an appropriate landfill consistent with the procedures for the vadose zone excavation. The expanded treated soil located above the groundwater table would not be left in place to serve as backfill for the vadose zone, as it would contain total arsenic concentrations above the remediation goal for vadose zone soil.

A groundwater flow and fate and transport model was used to develop the design flow rates and arsenic concentrations at these breaches. The model results are presented in Appendix B of the FS.

4.1.5 Alternative 3C - Vadose Zone Excavation/S-W Source Area Excavation/Rifkin Groundwater Extraction and Aboveground Treatment/MNA/Groundwater Monitoring/LUCs

Alternative 3C includes the following components for addressing soil and groundwater contamination, as they were described under Alternative 3A:

- Removal of Raised Cap
- Vadose Zone Excavation
- Installation of a Cover

- Extending and Breaching Existing Slurry Wall
- LUCs
- Groundwater Monitoring and MNA of COCs
- Operations, Maintenance, and Monitoring of Installed Components

For the S-W property, Alternative 3C would also include source area excavation; breaching and extending the existing slurry wall; and, MNA for arsenic and other COCs as described below.

For the former Rifkin property, Alternative 3C includes installation of an interceptor trench, located on the S-W property, adjacent to the east/west S-W/Rifkin property boundary. A membrane barrier would be placed on one side of the trench, along the property boundary, to prevent groundwater flow toward the former Rifkin property. The trench would have a similar construction to those presented in Alternative 3A. The trench would be approximately 30 inches wide, approximately 25 feet deep and be located as shown on Figure 4-3 The trench would be backfilled with 3/8 inch minus material and contain a basal perforated pipe to reduce flow resistance from the backfill material. With this design, the trench would have an effective permeability of approximately 500 ft/day.

Alternative 3C also contains provisions for operating and maintaining a GWETS, as described under Alternative 2, however the groundwater extraction and treatment would apply only to groundwater extracted from an extraction well on the former Rifkin property and an extraction well on the S-W property. The two extraction wells would contain the arsenic plume underlying the former Rifkin property, as described below.

The proposed layout of Alternative 3C is presented graphically in Figure 4-3.

4.1.5.1 Source Area Excavation

Alternative 3C includes excavation of source area saturated soils on the S-W property. The limits of this excavation are illustrated on Figure 4-3. The source area saturated soils would be removed down to the A/B aquitard (approximately 25 feet bgs) on the S-W property, corresponding to approximately 25,300 cubic yards of saturated soil. The source area excavation would remove source material to groundwater in order to support natural attenuation of the downgradient arsenic concentrations. The MNA sampling would demonstrate the naturally occurring attenuation of arsenic and other COCs in the groundwater over time following the source removal.

During backfill operations of the saturated zone, a reagent (e.g., organic-based tannin or inorganic powdered sulphite) would be added with the backfill material to minimize the potential adverse affects to arsenic sulfides present in the subsurface. The purpose of the reagent would be to act as an oxygen scavenger so that a minimal amount of dissolved oxygen is introduced to the subsurface. As shown on Figure 4-3, the majority of the areas undergoing excavation would be backfilled with low-permeability fill material (approximately 0.283 ft/day under this alternative),

compacted, and graded for storm water management. The remaining area would be backfilled with high-permeability fill material (approximately 28.3 feet/day for this alternative). The high-permeability fill material would be placed downgradient of the interceptor trench and would serve to collect and distribute groundwater into the surrounding, natural formation.

4.1.5.2 Continued Groundwater Extraction and Treatment for Former Rifkin Property

Active groundwater extraction underlying the former Rifkin property would continue, with aboveground treatment of the extracted water at a treatment facility relocated to the northeast corner of the S-W property, adjacent to Horton Street and former Rifkin property. This continued groundwater extraction would continue to prevent further migration of dissolved arsenic plume on the former Rifkin property.

Groundwater elevation monitoring at the Site would continue, as the means to demonstrate effectiveness of the barrier/trench/extraction system on maintaining an inward gradient towards the S-W property along the east/west S-W/Rifkin property boundary. As part of this alternative, a contingency would be to increase extraction rates from the trench/extraction system and/or install additional extraction points, if needed, to direct groundwater flow toward the S-W property.

The proposed redevelopment plan for the former Rifkin property, which includes a high-rise tower option with installation of piles and pile caps, is not inconsistent with, and would not impede implementation or long-term operations, maintenance, and monitoring (OM&M) of this alternative.

Based on the proposed redevelopment plan for the former Rifkin property, it is anticipated that for the high-rise tower option up to 4,000 cubic yards of vadose and saturated zone soils could be excavated during installation of piles and pile caps. For soil excavated and removed for Site development that requires increased handling and disposal due to concentrations of arsenic or other COCs, S-W would be responsible for reimbursement to Novartis of the incremental costs. This incremental increase in this operation is considered part of this alternative and S-W would prepare a risk management plan stating their responsibilities.

4.1.5.3 Breaching and Extending the Existing Slurry Wall

A slurry wall extension would be constructed in locations shown on Figure 4-3 in order to have the existing plume that has been identified to the south of the existing slurry wall migrate through the Site, toward the breaches in the slurry wall. The slurry wall extension would be approximately 340 linear feet along the western property line toward Sherwin Avenue. Unlike Alternatives 3A and 3B which address S-W source material through containment, Alternative 3C removes source material from the S-W property. Therefore, the slurry wall extension under this alternative does not need to tie back into the southern edge of the existing slurry wall.

In order to restore groundwater flow across the S-W property, the existing slurry wall would be breached at locations shown on Figure 4-3. Breaching would be accomplished by removing and replacing the low-permeability materials in the wall with high-permeability fill.

A breach in the existing slurry wall near this extension, as shown on Figure 4-3, would be installed to prevent mounding of groundwater upgradient of this extension and to facilitate impacted groundwater south of the existing slurry wall and east of the extension to migrate across the Site before exiting the Site at the northern slurry wall breaches. This extended migration across the Site is designed to promote additional attenuation of COCs present in the area of the Site, specifically arsenic, prior to migration to downgradient properties.

A groundwater flow model was used to develop the design flow rates at these breaches. Alternative 3C does not include treatment at the breaches and hence does not require a groundwater fate and transport analysis for design of the breaches. The model results are presented in Appendix B of the FS.

4.1.5.4 MNA of COCs in Groundwater

Under Alternative 3C, COC concentration data in groundwater collected in MNA sampling and analysis would provide lines of evidence supporting the occurrence of attenuation of COCs in groundwater. Sampling and analysis of groundwater samples upgradient and downgradient of the existing slurry wall would be performed after completion of source area excavation. This data set would be compared to historical groundwater data to demonstrate long-term decreasing trends in COC concentrations over time across the Site and in downgradient, off-site groundwater. As part of this alternative, a contingency to treat groundwater, if needed, would be implemented in the event that COC concentrations migrating off-site through the slurry wall breaches are not attenuating to the cleanup goals in a reasonable timeframe.

4.1.5.5 LUCs and OM&M Plan

S-W understands that some additional LUCs are needed for Alternative 3C, as compared to Alternative 3A. S-W has access from the current owner to operate, monitor, and maintain (OM&M) a groundwater extraction system on the former Rifkin property. The proposed redevelopment plan for the former Rifkin property, which includes a high-rise tower option with installation of piles and pile caps, is not inconsistent with, and would not impede implementation or long-term OM&M of this system. However, DTSC has advised S-W that the following LUCs will be required for the S-W property and the former Rifkin property to assure DTSC that potential future changes in land use and property ownership do not impair the effectiveness of this alternative:

- Land use restrictions to facilitate OM&M of a groundwater extraction system on the former Rifkin property;

- Land use restriction to facilitate OM&M of a groundwater conveyance system on the former Rifkin property and treatment system on the S-W property;

- Land use restrictions to prevent interference with and operation and maintenance of a groundwater monitoring well network for the Site; and

- Land use restrictions to prevent interference with and operation and maintenance of interceptor trench, slurry wall and breach systems on the S-W property.

In addition, DTSC has advised S-W that an operations, maintenance, and monitoring (OM&M) agreement with financial assurance for OM&M of the groundwater extraction, conveyance and treatment systems and for any other installed feature incorporated in the alternative will be required. The OM&M agreement would apply for both the S-W property and the former Rifkin property. Financial assurance for implementation of the OM&M agreement for the Site would be provided by S-W.

4.1.6 Alternative 4A – Vadose Zone Excavation/Upgradient Interceptor Drain Installation/Passive *In-Situ* Groundwater Treatment/Rifkin Excavation/ Groundwater Monitoring/LUCs

Alternative 4A includes the following components for addressing soil and groundwater contamination, as they were described under Alternative 3A:

- Removal of Raised Cap
- Vadose Zone Excavation
- Installation of a Cover
- Extending and Breaching Existing Slurry Wall
- LUCs
- Groundwater Monitoring and MNA of COCs
- Operations, Maintenance, and Monitoring of Installed Components

In addition to these common components, Alternative 4A also includes construction of an interceptor drain to capture and direct clean groundwater flow upgradient of the source area. The proposed layout of all Alternative 4A components is presented graphically on Figure 4-4.

A groundwater flow and fate and transport model was used to develop the design flow rates and arsenic concentrations at these breaches and the design flow rates for the interceptor drain. The model results are presented in Appendix B of the FS.

4.1.6.1 Upgradient Interceptor Drain

Alternative 4A includes installation of an interceptor drain to collect groundwater upgradient of the S-W property and route this water around the impacted soils into areas downgradient of the Site. The upgradient interceptor drain would extend along all but the western side of the existing slurry wall and down to tie into the new extension of the existing slurry wall (See Figure 4-4 of the FS in Appendix B) for a

total length of 1575 linear feet. The drain design would consist of a 30-inch nominal drain excavated approximately 25 feet to the A/B aquitard. The drain would contain a membrane liner and concrete barrier on one side, prohibiting collection of any impacted groundwater flow from the S-W property. The interceptor drain would replace the slurry wall sections that border the former Rifkin property. The drain would be backfilled with 3/8 inch minus material and would contain a basal perforated pipe to reduce flow resistance from the backfill material. With this design, the trench would have an effective permeability of approximately 500 ft/day.

4.1.6.2 Passive Treatment System

The existing slurry wall would be breached via caisson installation. The caissons filled with reactive media assumed to consist of 20% zero-valent iron (ZVI) and 80% playground sand based on the Phase II treatability study. The reactive caissons would be surrounded by a corridor of caissons backfilled with bentonite or similar low-permeability material that would act as gates to funnel groundwater through the entire length of the treatment zone.

Gravel or similar high-permeability material would be used to backfill additional caissons located immediately upgradient and downgradient of the reactive caissons, to provide mixing and improved distribution of groundwater through the reactive gate.

Each of these backfills would be installed as flowable slurry with high pressure, so as to avoid the formation of voids during backfill when the caisson casing is removed. The number and configuration of the caissons depends on expected influent flow rates and concentrations at each location in each alternative.

The conceptual design and cost estimate for this type of treatment is based on 30 years of operation. However, because of the relative lack of long-term performance data for this type of removal technology, there is uncertainty in the long-term performance. Therefore, some maintenance and rehabilitation costs are included in the cost estimate as a contingency measure.

4.1.6.3 Rifkin Excavation

Under Alternative 4A, all impacted vadose and saturated soil material on the former Rifkin property upgradient of interceptor drain would be excavated, up to 15 feet bgs. The volume of saturated soil contained within the limits of this excavation as shown on Figure 4-4 would be approximately 14,300 cubic yards. The excavation would encompass that portion of former Rifkin property extending from the S-W property north to the B-line. The excavated area would be backfilled with low-permeability fill material (approximately 0.283 ft/day under this alternative).

This excavation would effectively remove all contaminated source material in contact with A-zone groundwater. Installation of the upgradient interceptor drain would prevent migration of impacted groundwater from the S-W property to the former Rifkin property.

4.1.7 Alternative 4B – Vadose Zone Excavation/Upgradient Interceptor Drain Installation/Active *In-Situ* Groundwater Treatment/Rifkin Excavation/ Groundwater Monitoring/LUCs

Alternative 4B is identical to Alternative 4A except that downgradient groundwater would be treated with an active treatment system, as presented under Alternative 3A. The proposed layout of all Alternative 4B components is presented graphically on Figure 4-5.

The active system for Alternative 4B would be similar in conceptual design as that presented for Alternative 3A.

4.1.8 Alternative 5A – Vadose Zone Excavation/Excavation Upgradient of Interceptor Drain/Downgradient Interceptor Drain Installation/Passive *In-Situ* Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs

Alternative 5A includes several components for addressing soil and groundwater contamination on both S-W and former Rifkin properties described under Alternatives 3A and/or 4A as listed below:

- Removal of Raised Cap
- Vadose Zone Excavation
- Extending and Breaching Existing Slurry Wall
- Passive Groundwater Treatment
- Installation of a Cover
- Rifkin Excavation
- LUCs
- Groundwater Monitoring and MNA of COCs
- Operations, Maintenance, and Monitoring of Installed Components

Alternative 5A also includes construction of an interceptor drain to capture and direct clean groundwater flow downgradient of the source area. The proposed layout of all Alternative 5A components is presented graphically on Figure 4-6.

A groundwater flow and fate and transport model was used to develop the design flow rates and arsenic concentrations at these breaches and the design flow rates for the interceptor drain. The model results are presented in Appendix B of the FS.

4.1.8.1 Saturated Soil Excavation

Under Alternative 5A, all impacted, saturated soil impacted upgradient of the interceptor drain would be excavated, to 25 feet bgs under S-W property and 15 feet bgs on the former Rifkin property. The limits of this excavation are shown on Figure 4-6. The volume of saturated soils removed within these excavations would

correspond to 14,300 cubic yards on the former Rifkin property and 38,600 cubic yards on the S-W property. Excavated areas would be backfilled with clean material, compacted and graded for storm water control. The excavated area would be backfilled with low-permeability fill material (approximately 0.283 ft/day under this alternative) on the former Rifkin property and lower-permeability fill material (approximately 0.0283 ft/day under this alternative) on the S-W property.

4.1.8.2 Downgradient Interceptor Drain

Alternative 5A includes installation of an interceptor drain to collect groundwater downgradient of the Site source areas and route this water downgradient for treatment. The downgradient interceptor drain would extend along the western side of the former Rifkin property and the existing raised cap area and down to tie into the extension of the existing slurry wall for a total length of 1,100 linear feet. The drain design would consist of a 30 inch nominal drain excavated approximately 25 feet to the A/B aquitard. The drain would contain a membrane liner and concrete barrier on one side, prohibiting collection of any impacted groundwater flow from the S-W property. The drain would be backfilled with 3/8 inch minus material and would also contain a basal perforated pipe to reduce flow resistance from the backfill material. With this design, the trench would have an effective permeability of approximately 500 ft/day.

4.1.9 Alternative 5B – Vadose Zone Excavation/Excavation Upgradient of Interceptor Drain/Downgradient Interceptor Drain Installation/Active *In-Situ* Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs

Alternative 5B is identical to Alternative 5A except that downgradient groundwater would be treated via *in-situ* active treatment system described in detail under Alternative 3A. The proposed layout of all Alternative 5B components is presented graphically on Figure 4-7.

4.1.10 Alternative 6 – Vadose Zone Excavation/Source Area Excavation/MNA/Groundwater Monitoring/LUCs

Alternative 6 includes the same components for addressing soil and groundwater contamination described under Alternatives 3A listed below:

- Removal of Raised Cap
- Vadose Zone Excavation
- Installation of a Cover
- Groundwater Monitoring and MNA of COCs
- Operations, Maintenance, and Monitoring of Installed Components

Alternative 6 also includes excavation of source area soils on the S-W and former Rifkin properties and extending and breaching the slurry wall. Alternative 6 also includes MNA for COCs, similar to Alternative 3C. In addition, Alternative 6

contains a contingency plan including a vapor intrusion control system for the former Rifkin property to mitigate potential exposure pathways should future property development include erection of buildings over areas with elevated levels of VOCs in soil gas. The proposed layout of all Alternative 6 components is presented graphically on Figure 5-8.

For the former Rifkin property, Alternative 6 includes installation of an interceptor trench, located on the S-W property, adjacent to the east/west S-W/Rifkin property boundary, as described in Alternative 3C. A membrane barrier would be placed on one side of the trench, along the property boundary, to prevent groundwater flow toward the former Rifkin property. The trench would have a similar construction to those presented in Alternative 3A. The trench would be approximately 30 inches wide, extend to the top of the aquitard, approximately 25 feet deep, and be located as shown on Figure 4-8. The trench would be backfilled with 3/8 inch minus material and contain a basal perforated pipe to reduce flow resistance from the backfill material. With this design, the trench would have an effective permeability of approximately 500 ft/day.

4.1.10.1 Source Area Excavation

In addition to vadose zone excavation, Alternative 6 includes excavation of source area saturated soils on the S-W and former Rifkin properties. The limits of these excavations are shown on Figure 4-8. The source area saturated soils would be removed down to the A/B aquitard (approximately 25 feet bgs) on the S-W property and to 18 feet bgs on the former Rifkin property (Section 4.2.3.1), corresponding to approximately 25,300 and 4,600 cubic yards of saturated soil on each property, respectively.

The source area excavation would remove source material to groundwater in order to support natural attenuation of the downgradient arsenic and other COC concentrations. Saturated soils in areas with documented VOCs in soil gas concentrations above the PRGs, outside of the source area, would be addressed through MNA The MNA sampling described below would demonstrate the naturally occurring attenuation of arsenic and other COCs in the groundwater over time following the source removal.

During backfill operations of the saturated zone, a reagent (e.g., organic-based tannin or inorganic powdered sulphite) would be added with the backfill material to minimize the potential adverse affects to arsenic sulfides present in the subsurface. The purpose of the reagent would be to act as an oxygen scavenger so that a minimal amount of dissolved oxygen is introduced to the subsurface.

As shown on Figure 4-8, the majority of the areas undergoing excavation would be backfilled with low-permeability fill material (approximately 0.283 ft/day under this alternative), compacted, and graded for storm water management. The remaining area would be backfilled with high-permeability fill material (approximately 28.3 feet/day for this alternative). The high-permeability fill material would be placed

downgradient of the interceptor trench and would serve to collect and distribute groundwater into the surrounding, natural formation. As part of this alternative, a contingency would be to pump from the high-permeability fill material and/or trench, if needed, to direct groundwater flow toward the S-W property. As such, backfill design considerations for both the S-W property and the former Rifkin property would be further assessed as part of remedial design of this alternative.

4.1.10.2 Breaching and Extending the Existing Slurry Wall

As presented in Alternative 3C, a slurry wall extension would be constructed in locations shown on Figure 4-8 in order to have the existing plume that has been identified to the south of the existing slurry wall migrate through the Site, toward the breaches in the slurry wall. The slurry wall would be constructed in accordance with procedures described in Section 2.4.5. The slurry wall extension would be approximately 340 linear feet along the western property line toward Sherwin Avenue. Unlike Alternatives 3A and 3B which address source material through containment, Alternative 6 does not. Therefore, the slurry wall extension under this alternative does not need to tie back into the southern end of the existing slurry wall**.**

A breach in the existing slurry wall near this extension, as shown on Figure 4-8, would be installed to prevent mounding of groundwater upgradient of this extension and to facilitate impacted groundwater south of the existing slurry wall and east of the extension to migrate across the Site before exiting the Site at the northern slurry wall breaches. This extended migration across the Site is designed to promote additional attenuation of COCs present in the area of the Site, specifically arsenic, prior to migration to downgradient properties, as discussed below.

A groundwater flow model was used to develop the design flow rates at these breaches. Alternative 6 does not include treatment at the breaches and hence does not require a groundwater fate and transport analysis for design of the breaches. The model results are presented in Appendix B of the FS.

4.1.10.3 MNA of COCs in Groundwater

As in Alternative 3C, COC concentration data in groundwater collected in MNA sampling and analysis would provide lines of evidence supporting the occurrence of attenuation of COCs in groundwater. Sampling and analysis of groundwater samples upgradient and downgradient of the existing slurry wall would be performed after completion of source area excavation. This data set would be compared to historical groundwater data to demonstrate long-term decreasing trends in COC concentrations over time across the Site and in downgradient, off-site groundwater. As part of this alternative, a contingency to treat groundwater, if needed, would be implemented in the event that COC concentrations migrating off-site through the slurry wall breaches or across the former Rifkin property are not attenuating to the cleanup goals in a reasonable timeframe.

4.1.10.4 LUCs

LUCs would be established to maintain the long-term permanence of this remedy and to control future human exposure. These LUCs would prohibit the use of A-zone groundwater beneath the Site; restrict the future land use on the S-W portion of the Site; and facilitate continued access to and operation and maintenance of remediation and monitoring facilities on the Site. LUCs on the former Rifkin property would not preclude proposed redevelopment plan for the former Rifkin property, which includes a high-rise tower option with installation of piles and pile caps.

4.1.11 Alternative 7 – A-Zone Aquifer Excavation /LUCs

Alternative 7 includes the following components in common with Alternative 3A and 4A:

- Removal of Raised Cap
- Installation of a Cover
- LUCs
- Operations, Maintenance, and Monitoring of Installed Components

Alternative 7 also includes excavation of all impacted, saturated A-zone saturated soil from both the S-W property and former Rifkin properties vertically to the A/B aquitard and laterally to the 24 mg/kg background arsenic concentration and/or 0.036 mg/L arsenic concentration for aquatic protection. An estimated 194,000 cubic yards of vadose zone and saturated soils would be excavated, transported off-site, and replaced with clean soil.

The A/B aquitard would remain in place to protect the integrity of the B-zone aquifer. Groundwater monitoring would be postponed until completion of remedial activities. Groundwater monitoring would resume with installation of several new (replacement) wells as necessary and implementation of the groundwater monitoring plan. With the entire affected A-zone aquifer removed and replaced, groundwater monitoring would only be required for a maximum of two or three annual monitoring events to demonstrate residual concentrations in groundwater. The removal of the A-zone aquifer does not include MNA monitoring.

The proposed layout of all Alternative 7 components is presented graphically on Figure 4-9.

4.2 Evaluation of Remedial Action Alternatives

Based on a screening evaluation against effectiveness, implementability, and cost, the following alternatives were retained for detailed analysis:

- **Alternative 1 –** No Action

- **Alternative 2 –** Limited Action

- **Alternative 3A –** Vadose Zone Excavation/Active *In-Situ* Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs
- **Alternative 3B –** Vadose Zone Excavation/S-W Source Area Soil Mixing/Active *In-Situ* Groundwater Treatment/Rifkin Excavation /Groundwater Monitoring/LUCs
- **Alternative 3C –** Vadose Zone Excavation/ S-W Source Area Excavation/Rifkin Groundwater Extraction and Aboveground Treatment/MNA/Groundwater Monitoring/LUCs
- **Alternative 6 –** Vadose Zone Excavation/Source Area Excavation/MNA/ Groundwater Monitoring/LUCs
- **Alternative 7 –** A-Zone Aquifer Excavation/LUCs

A detailed and comparative analysis of these retained alternatives was performed. The comparative analysis is summarized in Table 7-1 of the FS (see Appendix B). This analysis applies nine Federal NCP evaluation criteria to each alternative listed above. These criteria are grouped into the following three categories: threshold criteria, primary balancing criteria, and modifying criteria.

4.2.1 Threshold Criteria

Two threshold criteria relate directly to the statutory compliance of the alternative: (1) overall protection of human health and the environment and (2) compliance with ARARs. A given alternative must meet these criteria to be considered as a remedy.

4.2.1.1 Overall Protection of Human Health and Environment

Under this criterion, the adequacy of the protection afforded by a remedial action must be addressed. How risks will be eliminated, reduced, or controlled through treatment, engineering controls, or ICs must be described.

4.2.1.2 Compliance with ARARs

Under this criterion, the means by which a given remedial alternative will meet the ARARs identified in Section 3 must be established. Compliance with the chemical, location, and action-specific ARARs must be attained by the alternative to be considered as a remedy.

Existing settlement agreement between S-W and Novartis is identified as a TBC. Based on ongoing discussions, S-W and Novartis may renegotiate this agreement and therefore, the provisions of this TBC may change.

4.2.2 Primary Balancing Criteria

Five primary balancing criteria address the technical and cost criteria for each alternative: (1) long-term effectiveness and permanence; (2) reduction of toxicity,

mobility, or volume through treatment; (3) short-term effectiveness; (4) implementability; and (5) cost.

4.2.2.1 Long-Term Effectiveness and Permanence

Under this criterion, the effectiveness and permanence of the remedial action is established in terms of risk remaining at the site after the remedial action. The adequacy and reliability of LUCs required with the alternative are evaluated to determine if appropriate risk management of the treatment residuals or untreated waste is in place.

4.2.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

Under this criterion, the degree and quantity of contaminant toxicity, mobility, and/or volume reduction by use of the specified treatment is evaluated. The anticipated performance of a treatment technology employed by remedial action in terms of long-term reliability of the treatment process and the type and quantity of treatment residuals is discussed.

4.2.2.3 Short-Term Effectiveness

Under this criterion, the impacts on the community, site workers, and the environment during the construction and implementation phase are evaluated. This phase lasts through the construction phase of the remedial action. The duration until protection is achieved is also considered. In addition to the impacts on human health, the potential adverse environmental impacts during the construction are evaluated.

4.2.2.4 Implementability

Under this criterion, the technical and administrative feasibility of implementing the alternative is evaluated. The availability of needed materials and services is also considered. The technical feasibility considerations include the technical difficulties anticipated in construction, reliability of the selected technology, and ease of implementing the remedy. Administrative feasibility considers coordination of interested parties, as well as any required permits.

4.2.2.5 Cost

Under this criterion, estimates are made of capital costs, engineering expenses, and the present worth of future O&M and periodic costs. Cost estimates are developed according to *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 2000). All alternatives have the same future land use and site development cost components. While flexibility has been incorporated into each alternative for the location of remedial facilities, the selection of cleanup levels, the time frame in which remedial action will be completed, and the project scope and duration must be defined in order to provide a cost estimate. As a result, a number of assumptions must be made to provide cost estimates for the various remedial alternatives. Important assumptions specific to each alternative are summarized in the description of the alternative.

The levels of detail employed in making these estimates are approximate, but are considered appropriate for making choices between alternatives. The information provided in the cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. The cost estimate is expected to be within +50/-30 percent of the actual cost. The costs are discussed with respect to the following items:

- Capital costs consist of direct (construction) and indirect (non-construction and overhead) costs.
- O&M costs refer to post-construction cost items necessary to ensure the continued effectiveness of a remedial action and typically consist of long-term labor, power, and material costs.
- Periodic costs include items that are required intermittently at greater than 1-year intervals.

A present worth analysis has been used to normalize all capital, O&M, and periodic costs of a remedial alternative. In this analysis, all capital costs are assumed to be incurred within the first year of implementation. Future O&M and periodic costs are included and reduced by the appropriate future value/present worth discount factor of 3 percent.

4.2.3 Modifying Criteria

Two modifying criteria relate directly to the regulatory and community acceptance of the alternative. These criteria will be addressed by DTSC through the RAP review and approval process.

4.3 Basis for Selected Remedial Action

Based on the individual and comparative analyses performed in the FS, the selected alternative is Alternative 6 - Vadose Zone Excavation/Source Area Excavation MNA/ Groundwater Monitoring/LUCs (CDM, 2009b).

The following summarizes the rationale for selection of Alternative 6 as the preferred alternative:

- It provides for the best combination of overall protection to both human health and the environment, and long-term effectiveness and permanence. It is equal to the other alternatives with respect to the other NCP criteria, excluding cost evaluation.
- It provides the best fit with the RAOs, in particular for minimizing risk to downgradient ecological receptors from off-site groundwater migration. As Alternative 6 removes the source of arsenic to groundwater, it provides for the best assurance for long-term protection of ecological receptors. In addition, the removal of the source will prevent further migration of arsenic onto the former Rifkin property.

- Alternative 6 also does not include long-term operation of a treatment system (aboveground or in place) at the Site. This attribute is favorable as it reduces potential need for future evaluation and intrusive operations/modifications to remedy elements (i.e., removal of sludge, change out of reactive media, rehabilitation of extraction wells, etc.).

- It provides the flexibility with respect to S-W plans for future redevelopment of the facility. Other than Alternative 7, Alternative 6 removes the most impacted soils at the Site and reduces the areas within the Site that require LUCs for future redevelopment.

4.4 State Evaluation Process

The evaluation and selection of Alternative 6 as the preferred remedial alternative through the NCP process complies with State evaluation process identified in California H&SC Section 25356.1(c). The six State evaluation criteria correlate with the nine NCP criteria as presented above. A draft statement of reasons for selection of the preferred alternative, correlating to the six State evaluation criteria, is included in Appendix D. The statement of reasons also proposes a preliminary non-binding apportionment of responsibility for the Site, which is included in Appendix E.

4.4.1 Health and Safety Risks

This criterion evaluates the current and future health and safety risks associated with no remediation and with implementing the preferred alternative. This criterion is fully considered under NCP evaluation criterion of Overall Protection of Human Health and Environment.

4.4.2 Beneficial Uses of Site Resources

This criterion evaluates present and potential future beneficial uses of Site resources. This criterion is fully considered under the NCP criterion of Overall Protection of Human Health and Environment and Compliance with ARARs. In the development of RAOs for this Site (Section 3.2), a Site beneficial uses analysis was conducted.

4.4.3 Effect of Remedial Actions on Groundwater Resources

This criterion evaluates the effect of the preferred alternative on Site groundwater resources. The NCP criterion of Overall Protection of Human Health and Environment and Compliance with ARARs fully incorporate this State criterion.

4.4.4 Site-Specific Characteristics

This State criterion requires remedy selection evaluation to consider Site-specific characteristics. Remedy selection considered all Site-specific characteristics, such as Site geology, hydrogeology, chemicals, and previous remedial actions. Extensive Site characterization has been conducted. This State criterion is fully considered in the NCP criterion of Long-Term Effectiveness and Permanence, Short-Term Effectiveness, and Implementablity.

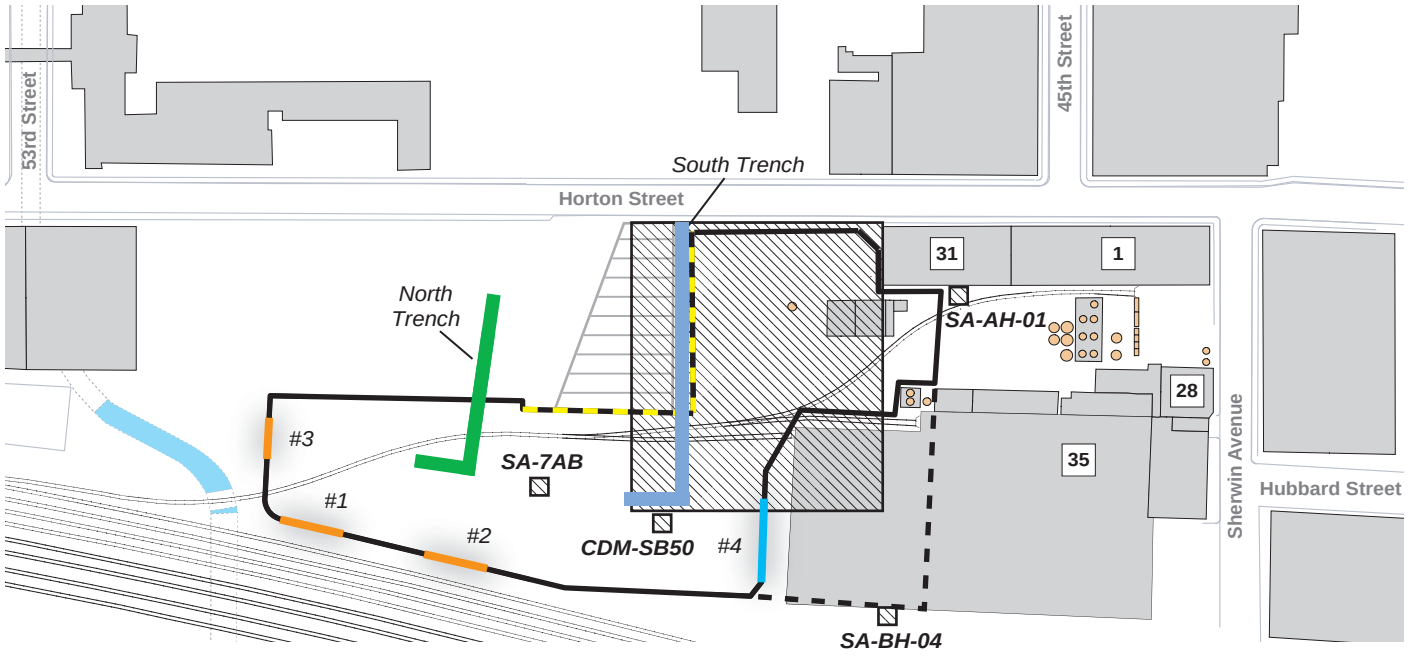
4.4.5 Cost-Effectiveness of Alternative Remedial Action Measures

This criterion evaluates the relative cost-effectiveness of various remediation alternatives in light of their expected success in meeting RAOs. This State criterion is fully considered in the NCP criteria entitled Long-Term Effectiveness and Permanence, and Cost.

4.4.6 Potential Environmental Impacts of Remedial Action

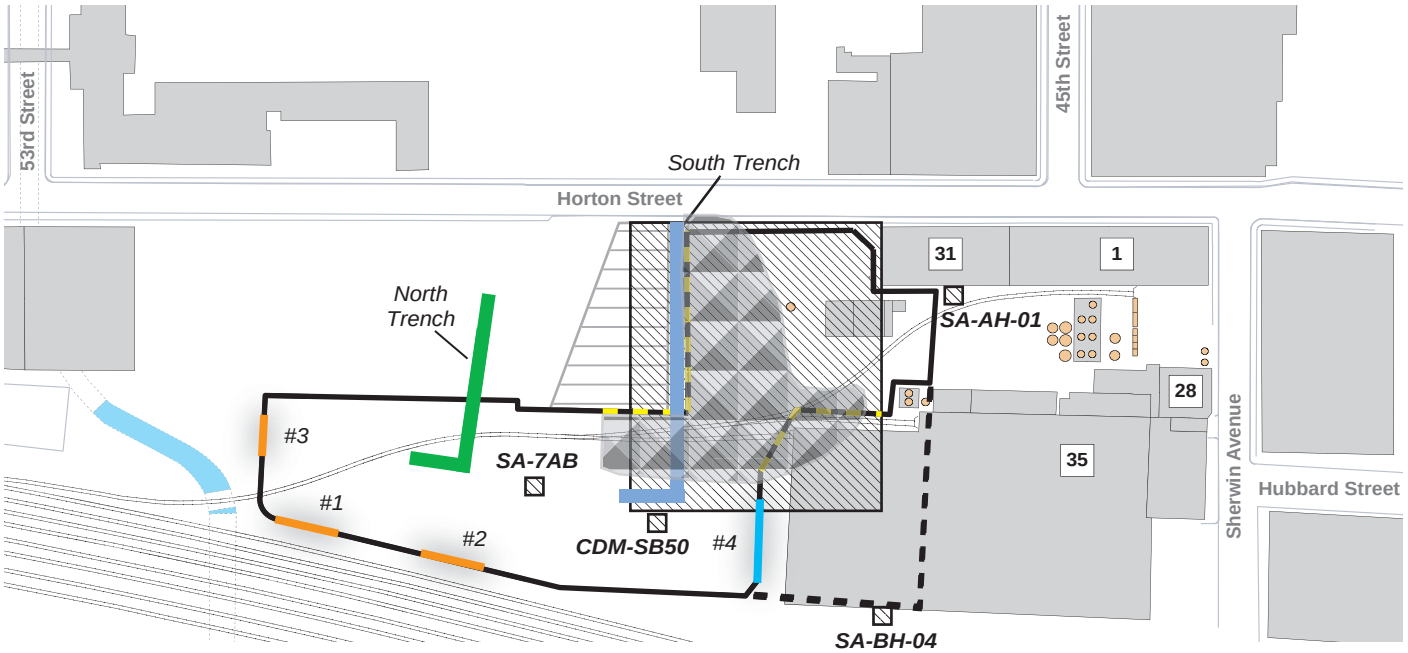
This criterion evaluates the potential environmental impacts of the preferred alternative. The NCP criteria of Short-Term Effectiveness and Long-Term Effectiveness and Permanence consider environmental impacts during and after remedy implementation. In addition, CEQA documentation (see Appendix F) also evaluates environmental impacts from the remedy.

Figure 4-1
Remedial Alternative 3A: Vadose Zone Excavation/Active In-Situ Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs



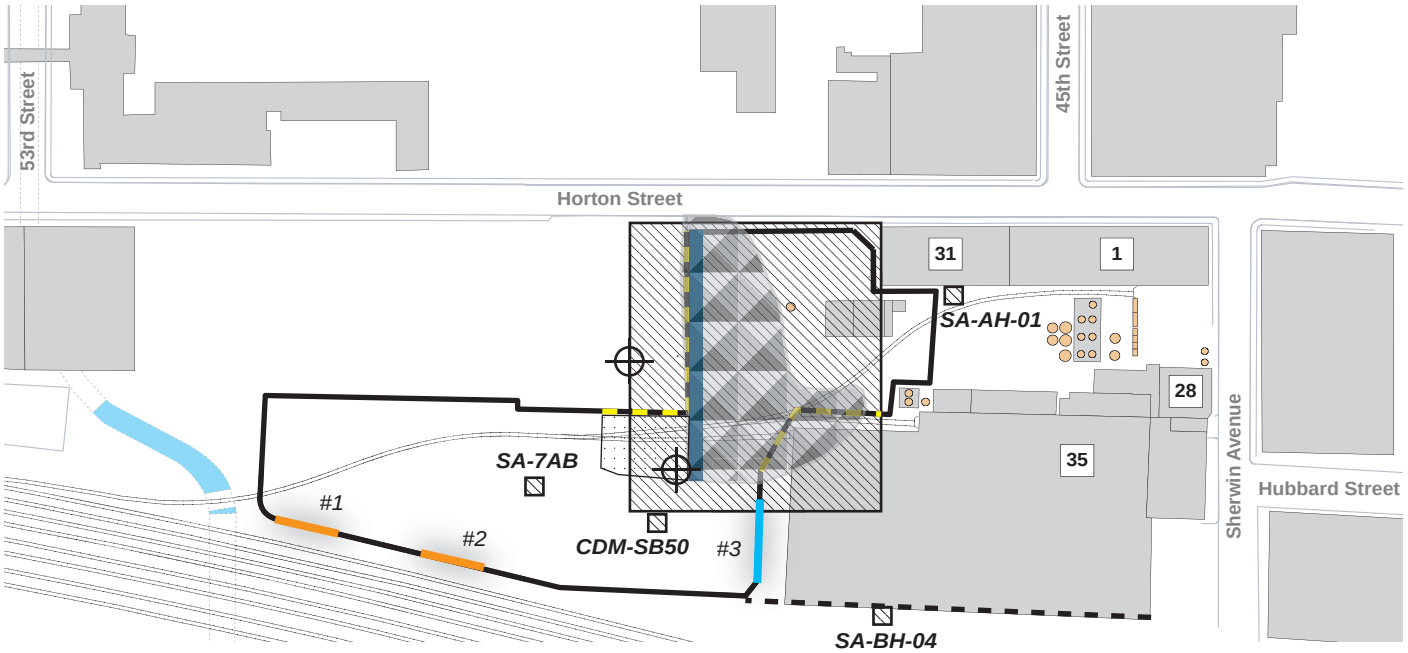
Vadose Zone Soil Excavation
Saturated Soil Excavation on Rifkin
Breach with Active Treatment (#1, #2 & #3)
Gradient Control Trench
Slurry Wall Extension
Breach without Treatment (#4)
Interceptor Trench
Current Slurry Wall
Slurry Wall Removal

Figure 4-2
Remedial Alternative 3B: Vadose Zone Excavation/S-W Source Area Soil Mixing/ Active In-Situ Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs



Saturated Soil Mixing on S-W
Gradient Control Trench
Interceptor Trench
Vadose Zone Soil Excavation
Saturated Soil Excavation on Rifkin
Slurry Wall Extension
Current Slurry Wall
Breach with Active Treatment (#1, #2 & #3)
Breach without Treatment (#4)
Slurry Wall Removal

Figure 4-3
Remedial Alternative 3C: Vadose Zone Excavation/S-W Source Area Excavation/Rifkin Groundwater Extraction and Aboveground Treatment/MNA/Groundwater Monitoring/LUCs



Saturated Soil Excavation on S-W and Low Permeability Backfill

Saturated Soil Excavation on S-W and High Permeability Backfill

Vadose Zone Soil Excavation

Interceptor Trench with Membrane Barrier Along Rifkin Property Boundary

Extraction Well

Slurry Wall Extension

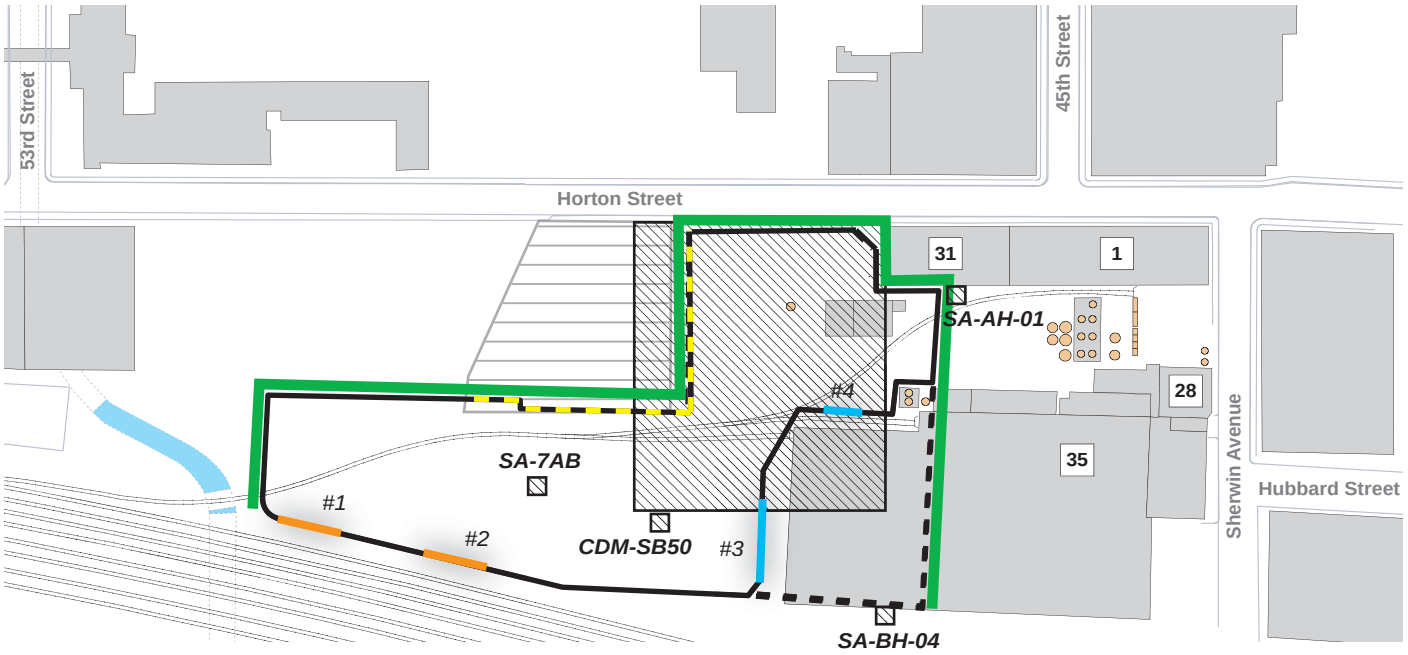
Current Slurry Wall

Breach without Treatment (#1 & #2)

Breach without Treatment (#3)

Slurry Wall Removal

Figure 4-4
Remedial Alternative 4A: Vadose Zone Excavation/Upgradient Interceptor Drain Installation/Passive In-Situ Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs



Current Slurry Wall

Slurry Wall Extension

Slurry Wall Removal

Saturated Soil Excavation on Rifkin

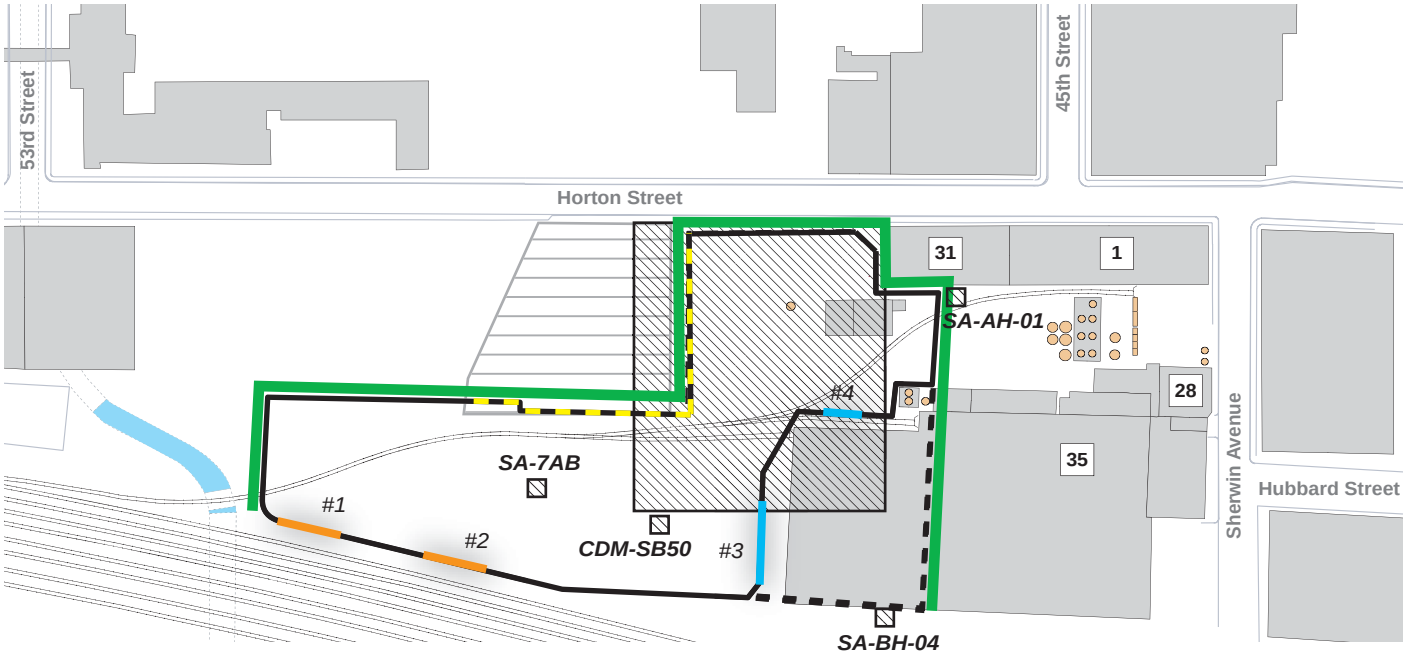
Interceptor Drain

Vadose Zone Soil Excavation

Breach with Passive Treatment (#1 & #2)

Breach without Treatment (#3 & #4)

Figure 4-5
Remedial Alternative 4B: Vadose Zone Excavation/Upgradient Interceptor Drain Installation/Active In-Situ Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs



Current Slurry Wall

Slurry Wall Extension

Slurry Wall Removal

Saturated Soil Excavation on Rifkin

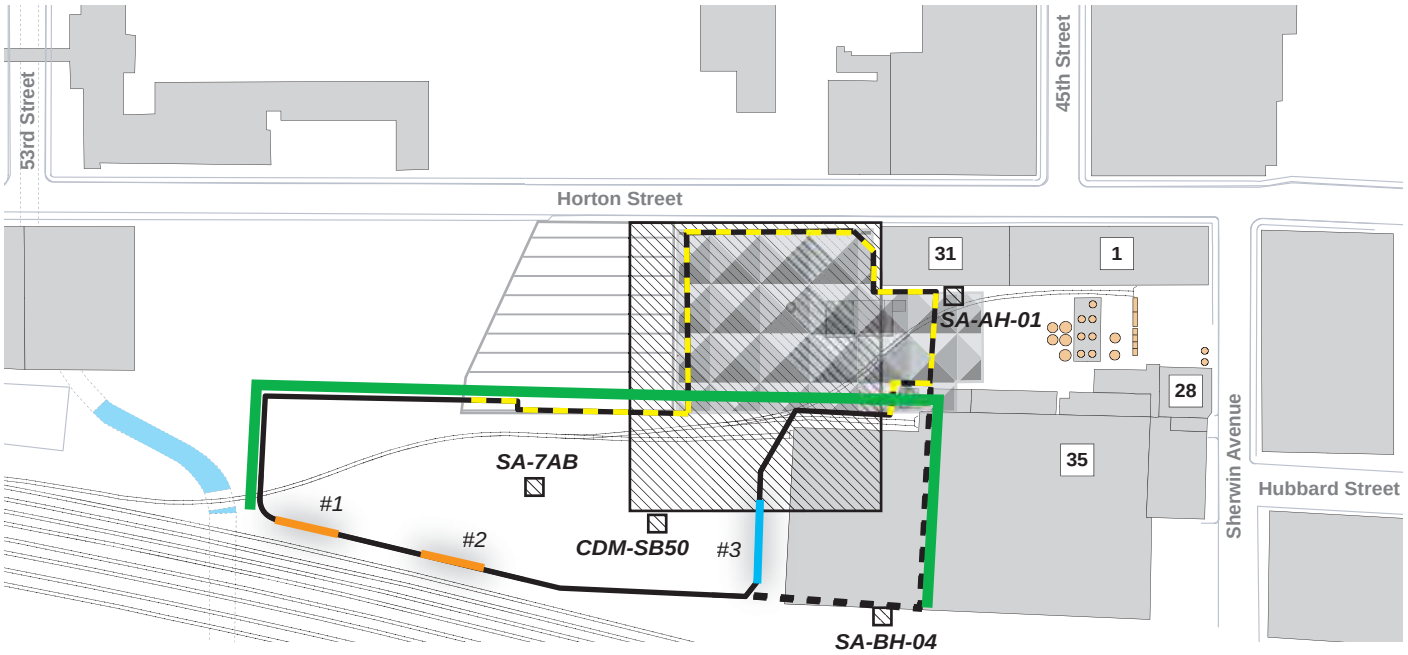
Interceptor Drain

Vadose Zone Soil Excavation

Breach with Active Treatment (#1 & #2)

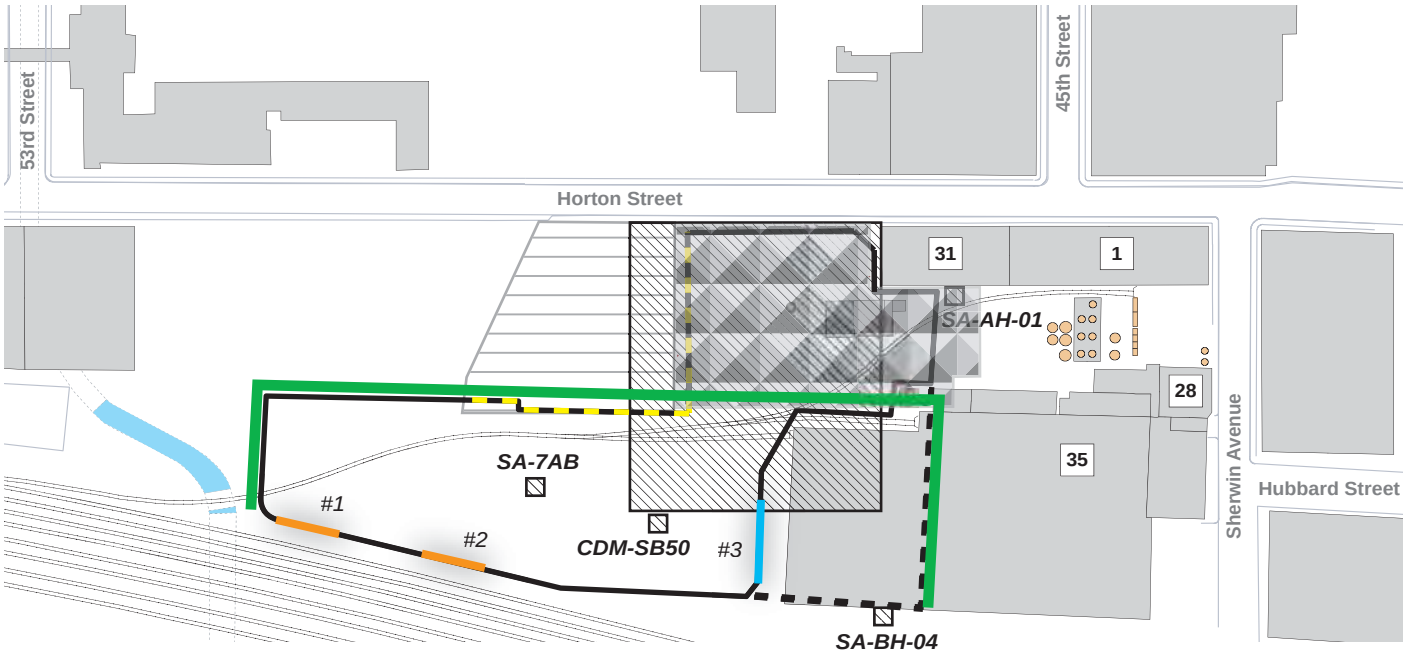
Breach without Treatment (#3 & #4)

Figure 4-6
Remedial Alternative 5A: Vadose Zone Excavation/Excavation Upgradient of Interceptor Drain/Downgradient Interceptor Drain Installation/Passive In-Situ Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs



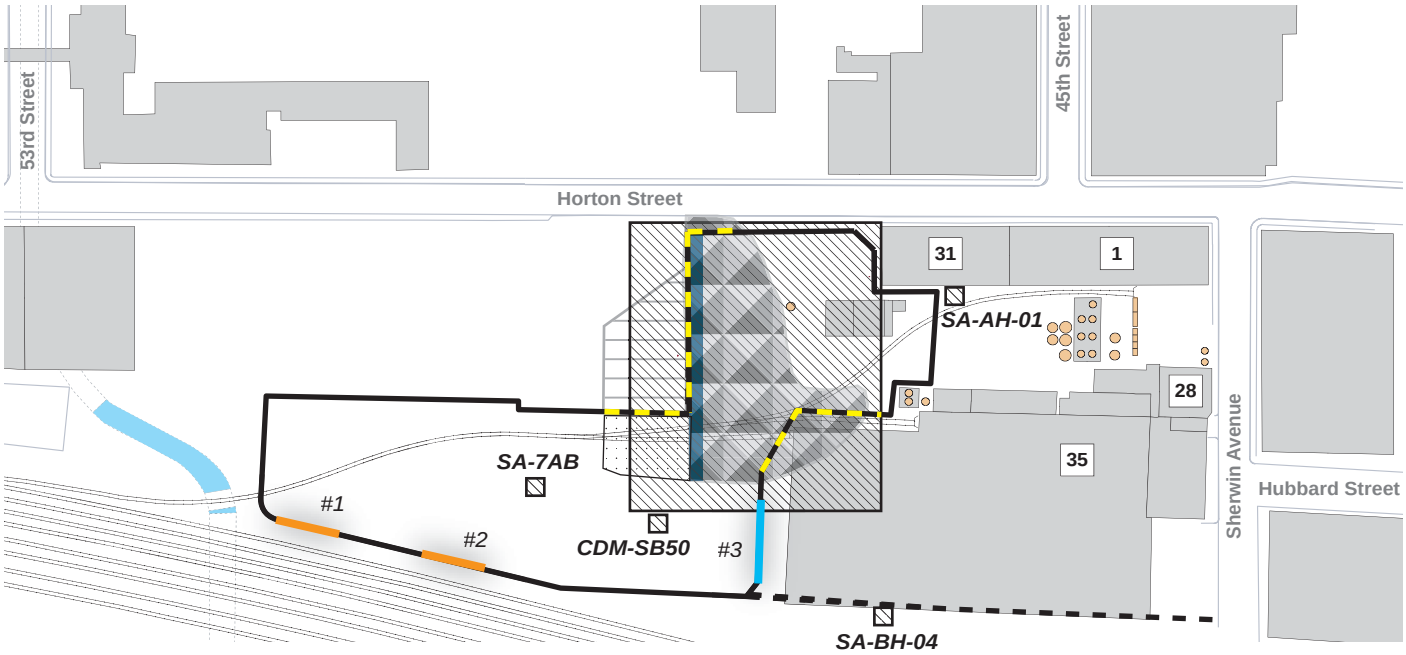
Current Slurry Wall
Slurry Wall Extension
Slurry Wall Removal
Saturated Soil Excavation on Rifkin
Interceptor Drain
Saturated Soil Excavation on S-W
Breach with Passive Treatment (#1 & #2)
Breach without Treatment (#3)
Vadose Zone Soil Excavation

Figure 4-7
Remedial Alternative 5B: Vadose Zone Excavation/Excavation Upgradient of Interceptor Drain/Downgradient Interceptor Drain Installation/Active In-Situ Groundwater Treatment/Rifkin Excavation/Groundwater Monitoring/LUCs



Current Slurry Wall
Slurry Wall Extension
Slurry Wall Removal
Saturated Soil Excavation on Rifkin
Interceptor Drain
Saturated Soil Excavation on S-W
Breach with Active Treatment (#1 & #2)
Breach without Treatment (#3)
Vadose Zone Soil Excavation

Figure 4-8
Remedial Alternative 6: Vadose Zone Excavation/Source Area Excavation/MNA/Groundwater Monitoring/LUCs



Saturated Soil Excavation on S-W and Low Permeability Backfill

Saturated Soil Excavation on S-W and High Permeability Backfill

Saturated Soil Excavation on Rifkin and Low Permeability Backfill

Interceptor Trench with Membrane Barrier Along Rifkin Property Boundary

Slurry Wall Extension

Vadose Zone Soil Excavation

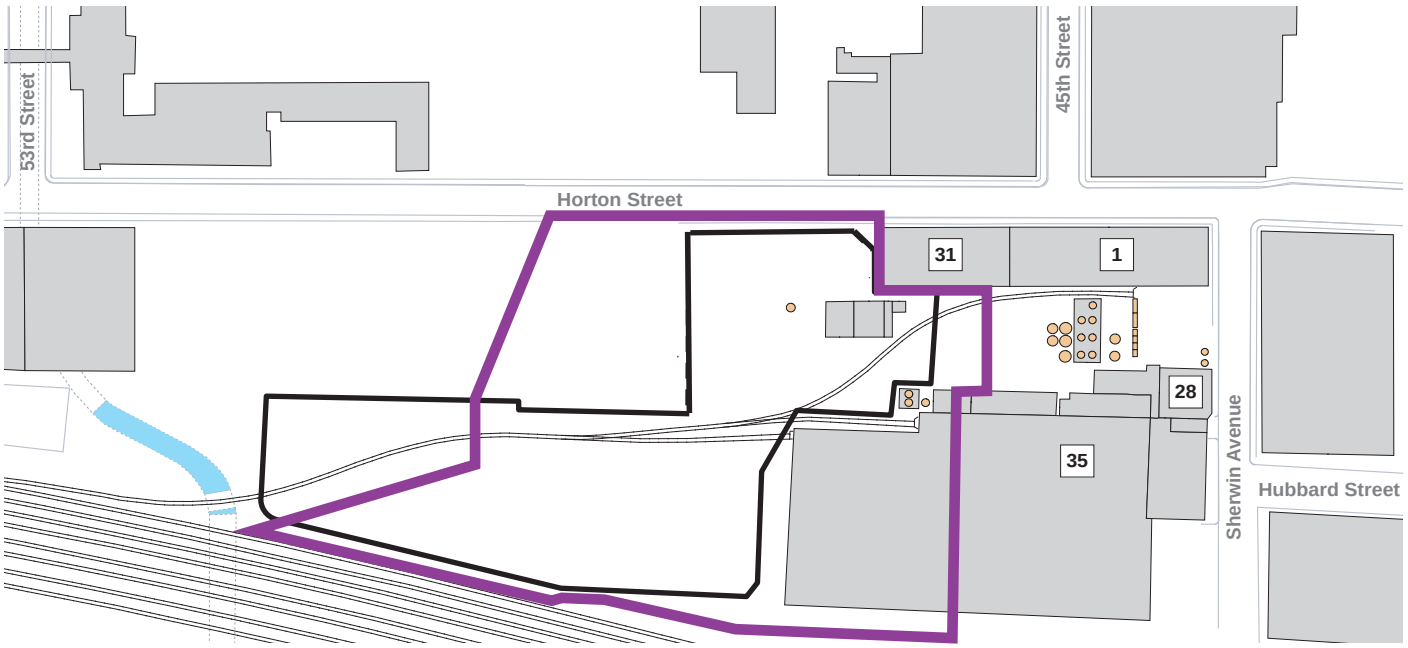
Current Slurry Wall

Breach without Treatment (#1 & #2)

Breach without Treatment (#3)

Slurry Wall Removal With Excavation

Figure 4-9
Remedial Alternative 7: A-Zone Aquifer Excavation/LUCs



A-Zone Aquifer Excavation (vadose and saturated)

Section 5
Planning and Pre-Remediation

This section presents descriptions of the anticipated remedy implementation schedule and details activities to be conducted during the remediation planning stage.

5.1 Preliminary Implementation Schedule

The general remedy implementation schedule described here presents remediation planning and implementation activities in its appropriate time sequence. Following approval by DTSC, the remedy will be implemented in accordance with the planning and design elements presented in this section. Remedy implementation is divided into five sets of activities:

- Planning,
- Pre-remediation,
- Remediation,
- Restoration, and
- Reporting.

Figure 5-1 presents a preliminary schedule for the remedy implementation. The schedule may change upon review and approval of the RAP. Further changes to the schedule may become apparent during preparation of the remedial design implementation plan (RDIP), submittal of remediation contractor plans, coordination with other Site activities, and/or procurement of local permits.

Work hours at the Site during remedy implementation activities will be 7:00 a.m. to 6:00 p.m. Work and transportation days are anticipated to be Monday through Friday, although weekend work may occur depending upon the schedule of activities. Weekend work hours will be 9:00 a.m. to 6:00 p.m., if necessary. These hours and work days may be modified based on conditions encountered during remediation.

5.2 Planning

Key activities to be conducted during the remediation planning stage include:

- Publication of the Public Notice and Fact Sheet;
- Preparation of Remedial Design Implementation Plan (RDIP); and,
- Selection of the remediation contractors.

These planning activities are identified on the preliminary project schedule presented in Figure 5-1.

5.3 Pre-Remediation

Key activities to be conducted during the Pre-Remediation stage include:

- Procurement of appropriate construction-related permits, including but not limited to: the Bay Area Air Quality Management District's Permit to Construct and Permit to Operate and Rule 8 Notification; Water Board's Notice of Intent for Coverage under the General Construction Storm Water Permit; Alameda County's well abandonment and construction permits; and appropriate wastewater discharge permit(s);
- Shutdown of the onsite groundwater extraction and treatment system. The system cessation would occur four weeks prior to remediation contractor mobilization to allow for adequate time to remove piping and equipment;
- Proper abandonment of Site wells within the excavation limits and wells not included in the post-remedy implementation groundwater monitoring[1], a list of existing wells proposed for abandonment is presented in Table 5-1 and their locations shown on Figure 5-2;
- Submittal of required RDIP for DTSC review and approval. Components of the RDIP will include: Dust and Vapor Control Plan (DVCP), Perimeter Air-Monitoring Plan (PAMP), and Transportation Plan; Health and Safety Plan (HASP); Operations, Maintenance and Monitoring Plan (OM&M Plan); Storm Water Pollution Prevention Plan (SWPPP); and, an updated schedule for remedy implementation; and
- Coordination of remediation construction-related activities with Novartis operations, including communication protocols, use of the former Rifkin parking area, schedule constraints, and Site security.

5.3.1 Health and Safety Plans

A Site HASP for onsite workers and a Community Safety Plan will be developed and included in the RDIP.

The Site HASP will generally consist of: identification of physical and chemical hazards; minimum training requirements for Site workers; criteria for upgrading levels of personal protective equipment (PPE); emergency information (e.g., directions to the nearest hospital and emergency telephone numbers); and administrative requirements (e.g., documentation of training and safety tailgate meetings).

During most of the remediation construction, PPE for Site workers is anticipated to be Level D (i.e., hard hats, steel-toed boots, chemical resistant gloves, ear protection, and

[1] Certain wells outside the excavation limits are not suitable for a long-term groundwater monitoring program due to their construction as large-diameter wells that would require large volume purge prior to sampling, monitoring wells not screened properly across the aquifer, or located away from critical post-remedy implementation groundwater flow patterns.

eye protection). Level C PPE (i.e., respiratory protection) may be required in some areas until the results of personal air monitoring indicate that it is unnecessary. Dust and vapor control measures will be implemented to limit exposure to COCs. Personal air monitoring will be performed using individual air pumps and hand held ionizing detectors for selected Site workers.

The Community Safety Plan will provide information for the community regarding the measures to control exposures to chemicals in soil and groundwater that could be released during the implementation. In addition, the Community Safety Plan will present the protocols for implementing the PAMP and for providing the air monitoring results from the PAMP. The substance of the Community Safety Plan will be presented to the community during a meeting prior to remediation.

5.3.2 Storm Water Pollution Prevention Plan

A SWPPP will be developed to address issues that could arise during rainfall events. A Notice of Intent (NOI) will be filed with the State Water Resources Control Board for coverage under the State's General Permit for Construction Activities. State guidelines for storm water control will be followed, including, but not limited to, silt fences and hay bales to limit erosion and/or off-site movement of sediment. The detailed methods for sediment control will be provided in the SWPPP.

Table 5-1
Existing Wells Proposed for Abandonment
Sherwin-Williams Emeryville Remedial Action Plan

Well Number	Well Construction Details and Other Information														*Basis for Abandonment*
	Type	*Location Relative to Current Slurry Wall*	*Existing Well Status or Condition*	*Hydraulic Zone Monitored*	*Date Constructed*	*Top of Casing Elevation* (feet NAVD88)	*Total Depth* (feet bgs)	*Casing Material*	*Casing Diameter* (inches)	*Screen Slot Size* (inches)	*Screen Interval Depths* Top (feet bgs)	*Screen Interval Depths* Bottom (feet bgs)	*Screen Interval Elevations* Top (feet NAVD88)	*Screen Interval Elevations* Bottom (feet NAVD88)	
EX-1	Extraction	Inside on SW	Active extraction	A	7/17/1995	12.78	20.0	SS	6	0.010	5.0	20.0	7.8	-7.2	Large diameter well
EX-10	Extraction	Inside on SW	Active extraction	A	8/27/1998	14.49	23.0	SS	6	0.010	8.0	23.0	6.5	-8.5	Within excavation limits
EX-2	Extraction	Inside on SW	Active extraction	A	7/17/1995	12.78	19.0	SS	6	0.010	4.0	19.0	8.8	-6.2	Within excavation limits
EX-3	Extraction	Inside on SW	Active extraction	A	7/17/1995	17.60	20.0	SS	6	0.010	5.0	20.0	12.6	-2.4	Within excavation limits
EX-4	Extraction	Inside on SW	Active extraction	A	8/31/1998	13.11	26.0	SS	6	0.010	7.0	25.0	6.1	-11.9	Large diameter well
EX-5	Extraction	Inside on SW	Active extraction	A	8/31/1998	13.04	23.5	SS	6	0.010	6.0	21.5	7.0	-8.5	Large diameter well
EX-6	Extraction	Inside on SW	Active extraction	A	8/28/1998	12.46	21.5	SS	6	0.010	6.0	20.5	6.5	-8.0	Large diameter well
EX-7	Extraction	Inside on SW	Active extraction	A	8/28/1998	14.02	23.5	SS	6	0.010	6.0	21.0	8.0	-7.0	Within excavation limits
EX-8	Extraction	Inside on SW	Active extraction	A	9/1/1998	18.98	29.5	SS	6	0.010	9.0	29.0	10.0	-10.0	Within excavation limits
EX-9	Extraction	Inside on SW	Active extraction	A	9/2/1998	20.15	26.0	SS	6	0.010	11.0	25.5	9.2	-5.4	Within excavation limits
EX-16	Extraction	Outside on Rifkin	Active extraction	A	12/29/1999	17.88	17.5	SS	6	0.010	7.5	17.0	10.4	0.9	Within excavation limits
LF-10	Monitoring	Inside on SW	Active monitoring	A	10/27/1989	13.69	18.0	PVC	4	0.020	5.0	15.0	8.7	-1.3	Within slurry wall breach
LF-17	Monitoring	Inside on SW	Active monitoring	A	2/1/1996	15.26	14.5	PVC	2	0.010	8.0	14.0	7.3	1.3	Within excavation limits
LF-22	Monitoring	Inside on SW	Active monitoring	A	1/30/1996	21.86	23.0	PVC	2	0.010	12.0	22.0	9.9	-0.1	Within excavation limits
LF-26	Monitoring	Inside on SW	Active monitoring	A	1/30/1996	15.60	18.5	PVC	2	0.010	8.5	18.0	7.1	-2.4	Within slurry wall breach
LF-4	Monitoring	Inside on SW	Active monitoring	A	5/17/1989	15.31	14.5	PVC	2	0.010	6.0	11.0	9.3	4.3	Improperly screened
LF-6	Monitoring	Inside on SW	Active monitoring	A	5/16/1989	13.37	24.0	PVC	2	0.010	6.0	11.0	7.4	2.4	Improperly screened
LF-7	Monitoring	Inside on SW	Active monitoring	A	5/17/1989	17.14	20.0	PVC	2	0.010	7.0	17.0	10.1	0.1	Historically non detect for COCs
LF-8	Monitoring	Inside on SW	Active monitoring	A	11/2/1989	15.61	15.0	PVC	4	0.020	5.0	15.0	10.6	0.6	Large diameter well
MW-4	Monitoring	Outside on Rifkin	Active monitoring	A	12/9/1994	18.26	18.5	PVC	2	0.010	7.0	17.0	11.3	1.3	Within excavation limits
MW-5	Monitoring	Outside on Rifkin	Active monitoring	A	12/9/1994	17.94	17.0	PVC	2	0.010	7.0	17.0	10.9	0.9	Within excavation limits
CDM-1	Monitoring	Outside on SW	Active monitoring	A	11/27/2006	13.60	12.0	PVC	1	0.020	7.0	12.0	6.6	1.6	Within slurry wall extension
LF-11	Monitoring	Outside on SW	Active monitoring	A	10/30/1989	12.75	15.5	PVC	4	0.020	5.0	15.0	7.8	-2.3	Within slurry wall extension
LF-20	Monitoring	Outside on SW	Active monitoring	A	2/5/1996	14.47	18.3	PVC	2	0.010	8.0	18.0	6.5	-3.5	Within slurry wall breach
LF-3	Monitoring	Outside on SW	Active monitoring	A	5/18/1989	14.70	11.5	PVC	2	0.010	6.0	11.0	8.7	3.7	Within excavation limits
SA-AW-01	Monitoring	Outside on SW	Active monitoring	A	6/24/2001	12.33	15.0	PVC	2	0.010	5.0	15.0	7.3	-2.7	Within slurry wall extension
SA-AW-05	Monitoring	Outside on SW	Active monitoring	A	6/22/1999	15.42	15.0	PVC	2	0.010	5.0	15.0	10.4	0.4	Historically non detect for COCs
SP-AW-06	Monitoring	Outside on SW	Active monitoring	A	?	21.42	?	?	?	?	?	?	?	?	Historically non detect for COCs
LF-PZ1	Piezometer	Inside on SW	Active monitoring	A	11/4/1997	17.62	25.0	PVC	3/4	?	5.0	20.0	12.6	-2.4	Within excavation limits
LF-PZ10	Piezometer	Inside on SW	Active monitoring	A	10/30/1997	14.96	19.5	PVC	3/4	?	4.5	19.5	10.5	-4.5	Within excavation limits
LF-PZ13	Piezometer	Inside on SW	Active monitoring	A	10/31/1997	13.63	19.5	PVC	3/4	?	4.5	19.5	9.1	-5.9	Within excavation limits
LF-PZ14	Piezometer	Inside on SW	Active monitoring	A	10/31/1997	12.91	19.0	PVC	3/4	?	4.0	19.0	8.9	-6.1	Piezometer not needed
LF-PZ15	Piezometer	Inside on SW	Active monitoring	A	10/31/1997	17.03	16.0	PVC	3/4	?	6.0	16.0	11.0	1.0	Piezometer not needed
LF-PZ16	Piezometer	Inside on SW	Active monitoring	A	11/3/1997	13.73	17.0	PVC	3/4	?	3.0	13.0	10.7	0.7	Within excavation limits
LF-PZ17	Piezometer	Inside on SW	Active monitoring	A	11/3/1997	12.82	17.0	PVC	3/4	?	3.0	13.0	9.8	-0.2	Piezometer not needed
LF-PZ18	Piezometer	Inside on SW	Active monitoring	A	11/3/1997	15.71	19.0	PVC	3/4	?	3.0	13.0	12.7	2.7	Piezometer not needed
LF-PZ19	Piezometer	Inside on SW	Active monitoring	A	11/3/1997	16.37	19.0	PVC	3/4	?	5.0	15.0	11.4	1.4	Piezometer not needed
LF-PZ20	Piezometer	Inside on SW	Active monitoring	A	11/4/1997	16.15	22.0	PVC	3/4	?	5.0	20.0	11.2	-3.9	Within excavation limits
LF-PZ26	Piezometer	Inside on SW	Active monitoring	A	11/14/2000	21.40	22.0	PVC	3/4	0.010	7.0	22.0	14.4	-0.6	Within excavation limits
LF-PZ29	Piezometer	Inside on SW	Active monitoring	A	1/6/2000	14.45	16.0	PVC	2	0.020	7.0	16.0	7.5	-1.6	Within excavation limits
LF-PZ3	Piezometer	Inside on SW	Active monitoring	A	12/28/1997	20.70	23.0	PVC	3/4	?	8.0	23.0	12.7	-2.3	Within excavation limits
LF-PZ34	Piezometer	Inside on SW	Active monitoring	A	1/4/2000	21.45	17.0	PVC	2	0.020	7.0	17.0	14.5	4.5	Within excavation limits
LF-PZ6	Piezometer	Inside on SW	Active monitoring	A	10/28/1997	21.14	23.0	PVC	3/4	?	8.0	23.0	13.1	-1.9	Within excavation limits
LF-PZ8	Piezometer	Inside on SW	Active monitoring	A	10/39/97	19.73	23.0	PVC	3/4	?	8.0	23.0	11.7	-3.3	Within excavation limits
LF-PZ9	Piezometer	Inside on SW	Active monitoring	A	10/30/1997	15.46	19.5	PVC	3/4	?	4.5	19.5	11.0	-4.0	Piezometer not needed
LF-PZ2	Piezometer	Outside on Rifkin	Active monitoring	A	10/30/1996	20.74	23.0	PVC	3/4	?	8.0	23.0	12.7	-2.3	Within excavation limits
LF-PZ27	Piezometer	Outside on Rifkin	Active monitoring	A	12/28/1999	19.08	16.0	PVC	2	0.020	7.0	16.0	12.1	3.1	Within excavation limits
LF-PZ28	Piezometer	Outside on Rifkin	Active monitoring	A	1/6/2000	14.83	16.0	PVC	2	0.020	7.0	16.0	7.8	-1.2	Within excavation limits
LF-PZ30	Piezometer	Outside on Rifkin	Active monitoring	A	12/28/1999	18.41	15.0	PVC	2	0.020	7.0	15.0	11.4	3.4	Within excavation limits
LF-PZ31	Piezometer	Outside on Rifkin	Active monitoring	A	12/28/1999	18.25	26.5	PVC	2	0.020	17.5	26.5	0.8	-8.3	Within excavation limits
LF-PZ32	Piezometer	Outside on Rifkin	Active monitoring	A	1/3/2000	19.19	16.0	PVC	2	0.020	7.0	16.0	12.2	3.2	Piezometer not needed
LF-PZ33	Piezometer	Outside on Rifkin	Active monitoring	A	1/4/1999	21.59	17.0	PVC	2	0.020	7.0	17.0	14.6	4.6	Within excavation limits
LF-PZ11	Piezometer	Outside on SW	Active monitoring	A	10/30/1997	15.49	19.5	PVC	3/4	?	4.5	19.5	11.0	-4.0	Piezometer not needed
LF-PZ12	Piezometer	Outside on SW	Active monitoring	A	10/31/1997	13.71	19.0	PVC	3/4	?	4.0	19.0	9.7	-5.3	Within excavation limits
LF-PZ7	Piezometer	Outside on SW	Active monitoring	A	10/29/1997	21.74	23.0	PVC	3/4	?	8.0	23.0	13.7	-1.3	Within excavation limits

Table 5-1
Existing Wells Proposed for Abandonment
Sherwin-Williams Emeryville Remedial Action Plan

Well Number	Well Construction Details and Other Information														*Basis for Abandonment*
	Type	*Location Relative to Current Slurry Wall*	*Existing Well Status or Condition*	*Hydraulic Zone Monitored*	*Date Constructed*	*Top of Casing Elevation* (feet NAVD88)	*Total Depth* (feet bgs)	*Casing Material*	*Casing Diameter* (inches)	*Screen Slot Size* (inches)	*Screen Interval Depths* Top (feet bgs)	*Screen Interval Depths* Bottom (feet bgs)	*Screen Interval Elevations* Top (feet NAVD88)	*Screen Interval Elevations* Bottom (feet NAVD88)	
LF-B3	Monitoring	Inside on SW	Active monitoring	B	11/3/1989	13.00	39.5	PVC	2	0.010	34.0	39.0	-21.0	-26.0	Within slurry wall breach
LF-B5	Monitoring	Inside on SW	Active monitoring	B	2/2/1996	20.99	44.0	PVC	2	0.010	34.0	44.0	-13.0	-23.0	Within excavation limits
LF-B6	Monitoring	Inside on SW	Active monitoring	B	2/2/1996	14.69	39.0	PVC	2	0.010	28.0	38.5	-13.3	-23.8	B-zone well not needed
LF-B4	Monitoring	Outside on Horton	Active monitoring	B	6/29/1990	17.25	48.0	PVC	2	0.020	36.0	46.0	-18.8	-28.8	B-zone well not needed
RP-BW-02	Monitoring	Outside on Rifkin	Active monitoring	B	7/9/1999	18.67	44.0	PVC	2	0.010	34.0	44.0	-15.3	-25.3	Within excavation limits
SA-BW-01	Monitoring	Outside on SW	Active monitoring	B	6/9/1999	12.77	45.0	PVC	2	0.010	35.0	45.0	-22.2	-32.2	Within slurry wall extension

Notes:
NADV88: North American Vertical Datum of 1988
bgs: below ground surface
toc: top of casing
PVC: polyvinyl chloride
SS: stainless steel

ID	Task Name	Duration	Start	Finish
1	**Remediation Planning**	**105 days**	**Tue 9/7/10**	**Tue 2/1/11**
2	Submittal of Remedial Design Implementation Plan	0 days	Tue 9/7/10	Tue 9/7/10
3	Contractor Selection	3 mons	Fri 10/8/10	Thu 12/30/10
4	Distribute Fact Sheet	0 days	Tue 2/1/11	Tue 2/1/11
5	**Pre-Remediation**	**20 days**	**Tue 2/1/11**	**Mon 2/28/11**
6	Permits, Plans & Submittals	1 mon	Tue 2/1/11	Mon 2/28/11
7	**Remediation**	**161 days**	**Tue 3/1/11**	**Tue 10/11/11**
8	Contractor Mobilization	5 days	Tue 3/1/11	Mon 3/7/11
9	GW Monitoring Well Abandonment	20 days	Tue 3/8/11	Mon 4/4/11
10	Soil Vapor Extraction Implementation and Operation	20 days	Tue 3/8/11	Mon 4/4/11
11	Establish Public Protection and Security	10 days	Tue 3/8/11	Mon 3/21/11
12	Set up Air Monitoring and Determine Background Levels	10 days	Tue 3/8/11	Mon 3/21/11
13	Implement SWPP and Waste Stockpile Berms	5 days	Tue 3/22/11	Mon 3/28/11
14	Install Dewatering System	15 days	Tue 3/22/11	Mon 4/11/11
15	Operate Dewatering System	121 days	Tue 4/12/11	Tue 9/27/11
16	Remove Raised Cap	11 days	Tue 4/12/11	Tue 4/26/11
17	Install Shoring	20 days	Thu 4/21/11	Wed 5/18/11
18	Excavate Vadose & Saturated Soil	90 days	Wed 4/27/11	Tue 8/30/11
19	Backfill	90 days	Wed 5/11/11	Tue 9/13/11
20	Install Slurry Wall Breaches	20 days	Wed 8/31/11	Tue 9/27/11
21	Extend Slurry Wall	20 days	Wed 8/31/11	Tue 9/27/11
22	Site Restoration and Demobilization	10 days	Wed 9/28/11	Tue 10/11/11
23	**Post-Remediation**	**40 days**	**Wed 9/28/11**	**Tue 11/22/11**
24	Install New GW Monitoring Wells	30 days	Wed 9/28/11	Tue 11/8/11
25	Remedy Completion Report	40 days	Wed 9/28/11	Tue 11/22/11

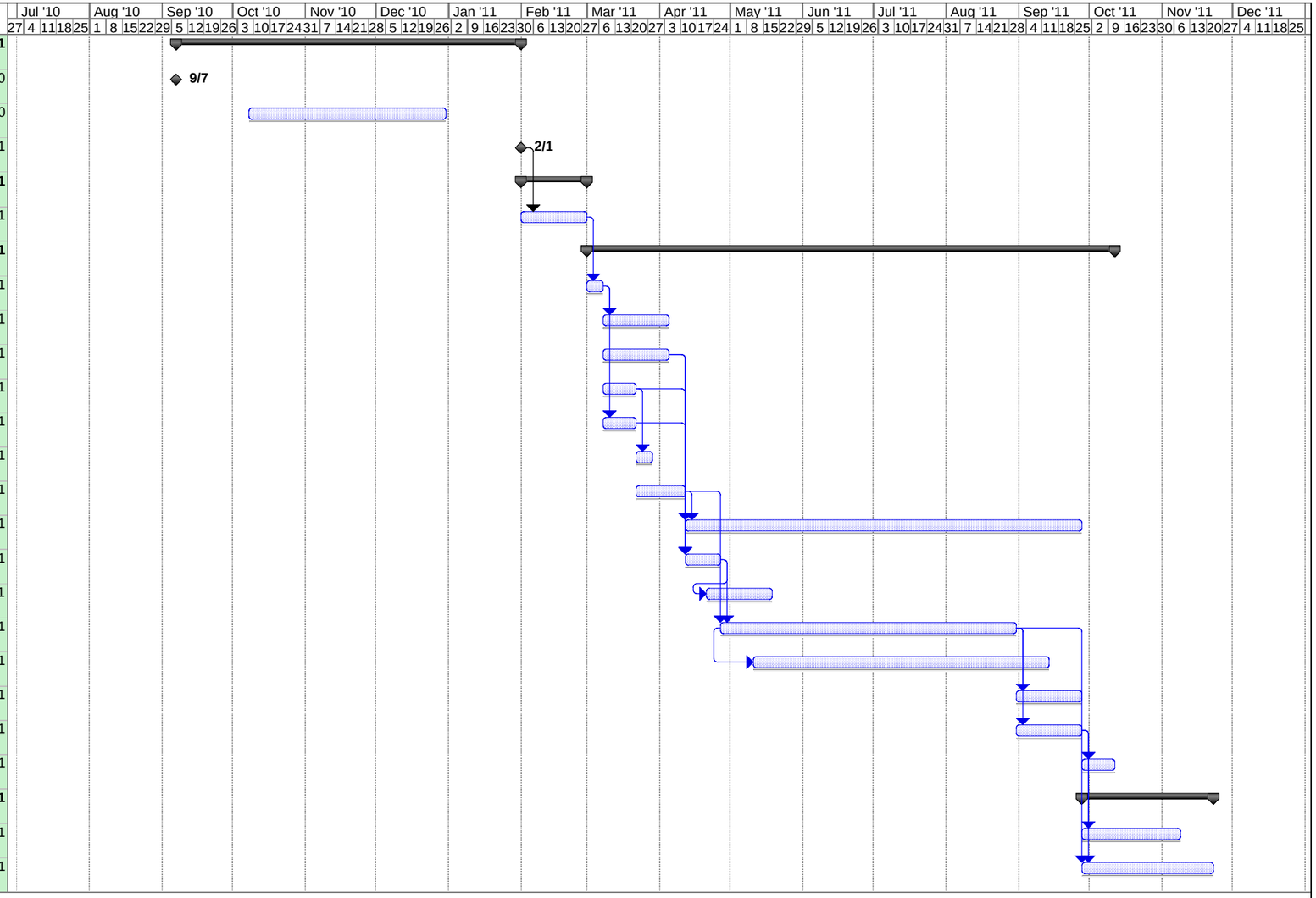


Figure 5-1
Preliminary Project Schedule
Sherwin-Williams Company - Emeryville, California

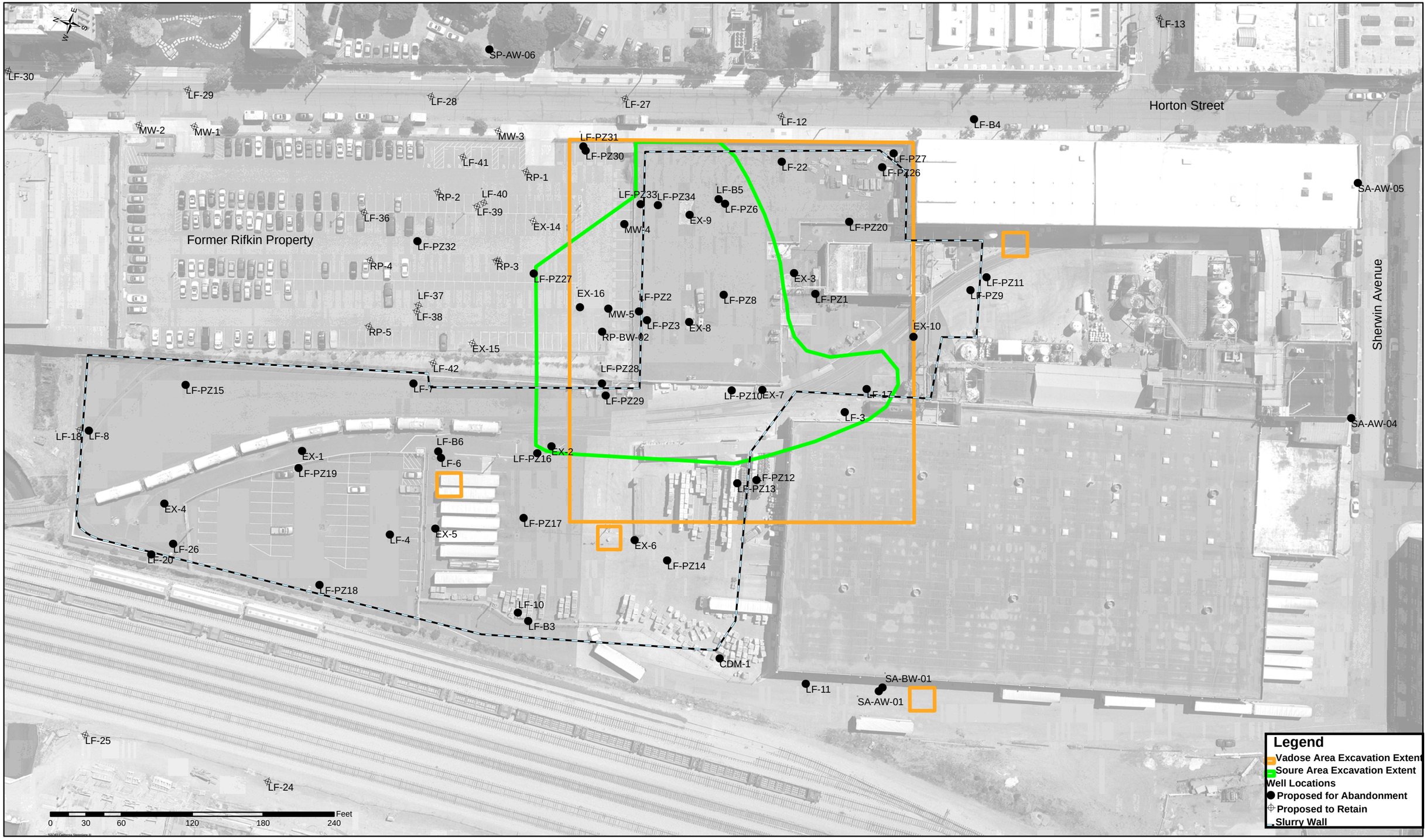


Figure 5-2
Existing Wells Proposed for Abandonment
Sherwin-Williams Company - Emeryville, California

Section 6
Remediation and Restoration

This section provides an expanded description for the implementation of the selected remedy (FS alternative 6, see Section 4). While this section describes specific design and technical components for remedy implementation, the final design, as presented in the RDIP, may be different, but will achieve the identified objectives.

During remedy implementation, potential exposure to COCs could occur from inhalation of dust and organic vapors generated during soil handling. The DTSC-approved Public Health Evaluation of the Remedial Alternative (PHERA) (CDM, 2009a) document determined that use of appropriate emission control technologies (e.g., dust, vapor, and odor controls) can effectively control potential exposure of the community to unacceptable concentrations of COCs during remedy implementation. This section provides additional details on the emission control and monitoring procedures.

Major activities to be conducted during remedy implementation are:

- Establishment of Site exclusion zones, security areas and signage;
- Mobilization of contractor equipment to the Site;
- Establishment of the Site construction office;
- Installation of monitoring systems;
- Installation of roadway within the Site and within roadway easement along western Site boundary;
- Abandonment of selected groundwater monitoring wells;
- Extraction and treatment of soil vapors within and underlying the Raised Cap;
- Removal, handling, and off-site disposal of the Raised Cap;
- Installation of shoring system for excavation along Horton Street;
- Dewatering of groundwater from the excavation and on-site water treatment;
- Excavation, handling, and off-site disposal of material;
- Installation of slurry wall breaches;
- Extension of existing slurry wall;
- Backfilling and compaction of imported fill in the excavation;
- Installation of groundwater monitoring wells; and
- Demobilization of remediation equipment.

6.1 Construction Area Layout and Controls

Remedy implementation activities will utilize many of the remaining building slabs for equipment and supplies storage, waste stockpiling and handling prior to off-site transport and disposal. Building foundations that do not interfere with the excavation will be left in place pending further redevelopment of the Site.

Figure 6-1, Preliminary Site Layout and Controls, presents a preliminary layout of work areas and general Site controls for the remedy implementation activities. This figure is intended as a general guideline. The final layout is subject to refinements during preparation of the RDIP and will be established by the remediation contractor.

6.1.1 Engineered Controls During Remediation

Remedy implementation activities will include engineered controls to reduce short-term exposure risks from releases of COCs to the environment and/or community in the form of dust, vapors, and/or surface water runoff. Remedy implementation activities are presented in Table 6-1, under individual rows. Categories of potential emissions are listed as column headings in the table. Engineered controls for these emission types comprise the columns in Table 6-1.

6.1.1.1 Dust Control

A Dust and Vapor Control Plan (DVCP) will be prepared in accordance with the remediation specifications and compliance requirements as applicable. The DVCP will identify techniques, supplies, and equipment needed to control dust emissions during remedy implementation. The DVCP will include but are not limited to the following elements for dust control: water sprays/mist, surfactants, wetting agents, dust suppressants, covers, and windscreens. The DVCP will be reviewed by the DTSC prior to remedy implementation as part of the RDIP. The DVCP will be consistent with the findings presented in the PHERA regarding appropriate use of dust controls.

If observations or measurements, or complaints from people in the community indicate a need for more stringent dust control, the contractor will increase the magnitude and frequency of the dust control. If further dust control measures are needed due to winds, the contractor may be required to stop certain portions of the work until conditions improve or the contractor employs satisfactory compliance methods.

6.1.1.2 Vapor and Odor Control

The highest VOC concentrations are anticipated to be encountered during excavation in the northwest portion of the planned excavation area. The DVCP will identify techniques, supplies, and equipment needed to control vapor emissions during remedy implementation. The DVCP will include, but not be limited to, the following elements for vapor and odor control: water spray/mist; vapor suppressant foam; and covers. The DVCP will be reviewed by the DTSC prior to remedy implementation as part of the RDIP.

Prior to removal of the Raised Cap, a network of vapor extraction wells will be installed on the Raised Cap and surrounding vadose zone soil excavation area. These vapor extraction wells will be utilized to remove stagnant VOCs present in the Raised Cap material and vadose zone soils prior to excavation. The vapor stream will be treated through a combination of adsorption media. The soil vapor extraction and treatment system will be operated pursuant to a BAAQMD permit.

The vapor extraction system is expected to operate for up to four weeks prior to excavation activities. The total VOC concentrations are expected to decrease and stabilize (as monitored at the influent of the vapor treatment system) to equilibrium with mass transfer processes that are generating the vapors from VOCs absorbed to soil and dissolved in water. The extracted soil vapor will be field monitored for total VOC concentrations. Removal of the Raised Cap and soil excavation will be initiated when total VOC concentrations reach relatively stabilized levels. Portions of the soil vapor extraction system will continue to operate during the removal of the Raised Cap and soil excavation activities. Vapor extraction wells will be removed as the Raised Cap removal and soil excavation proceeds. In addition, during Raised Cap removal and soil excavation, potential volatilization of VOCs will be managed through engineering controls.

Perimeter air monitoring will be used to confirm the effectiveness of vapor control methods. If vapor emission concentrations at the perimeter are detected above pre-set action levels (as presented in Section 6.2.1), vapor control methods will be modified until vapor concentrations are reduced below the action levels.

During Raised Cap removal and soil excavation, odors associated with Site COCs will be managed through engineering controls. During remedy implementation, odors unrelated to impacted soil/debris (i.e., odors not associated with COCs) could also be generated. These types of odors will also be controlled during remedy implementation, using the same engineering controls as those for odors associated with COCs.

6.1.1.3 Surface Water Runoff Control

An array of isolated sumps, pumps, and hoses are used currently at the S-W Site for storm water management. This current storm water management system would continue under a construction SWPPP during remedy implementation, as discussed in Section 5.

This current storm water management system replaced the former underground piping network. This former network has been plugged through installation of temporary plugs at several locations in the main storm sewer connecting to Temescal Creek channel. These plugs are routinely monitored for effectiveness. Storm water is collected in the sumps and pumped directly to the Temescal Creek channel.

The construction SWPPP will be developed to address issues that could arise during rainfall events during remedy implementation. As part of the SWPPP, sections of the

main storm sewer connecting to Temescal Creek channel will be removed and filled with grout to create permanent plugs. The remaining parts of the existing system will continue to operate as needed during remedy implementation.

Water that has been in contact with impacted materials, and water extracted from the excavation, will be isolated from non-impacted storm water by construction and maintenance of berms. This contact water will be treated on-site and discharged to Temescal Creek, discharged to the sanitary sewer (if permitted), or transported off-site for treatment and discharge.

6.2 Monitoring of Engineering Controls

The engineered controls for limiting potential short-term exposures from releases of COCs to the environment and/or community in the form of dust, vapors, and/or surface water runoff, will be monitored to confirm their effectiveness. In addition to health-based exposure risks, monitoring is needed to confirm control of noise, odor, and vibration.

The DTSC-approved Public Health Evaluation of the Remedial Alternative (PHERA) (CDM, 2009a) document determined performance standards to be used during air monitoring for evaluating the effectiveness of dust and vapor controls. The performance standards are concentrations of respirable COCs in air that should not be exceeded, as defined in Table 6-2 and 6-3. Adherence to performance standards helps to provide protection of people in the community from unacceptable exposure to COCs. The performance standards established in the PHERA for the COCs are summarized in Tables 6-2 and 6-3.

Action levels for respirable dust and total VOCs were developed by which COCs can be evaluated immediately as remedy implementation activities proceed. Particulate matter with an effective diameter of less than or equal to 10 microns (µm) (PM10) is considered respirable (National Ambient Air Quality Standards). The action levels established in the PHERA for total VOCs and PM10 are summarized in Tables 6-2 and 6-3, respectively.

6.2.1 Perimeter Air Monitoring and Sampling

As discussed in Section 5, a Site safety plan will be developed to address personal protective equipment (PPE) for Site workers and visitors and personal air monitoring for Site workers to evaluate the potential for exposure. This section focuses on perimeter air monitoring and sampling to evaluate potential exposure to the community.

During material handling activities (i.e., excavation, loading, stockpiling, etc.), perimeter air monitoring will be conducted to confirm the effectiveness of dust and vapor controls. As presented on Figure 6-1, air monitoring stations are anticipated to be placed along all perimeters of the Site. Final number and location of the stations is subject to refinements during preparation of the RDIP.

S-W has operated a meteorological station at the Site since August 2002. The station records wind speed, direction, temperature, and rainfall at 30-minute intervals. The station, was originally located in the approximate center of the S-W property at the end of the then existing rail car loading dock extending north from the northeast corner of former Building 35 and was positioned approximately 20 feet above ground. The station was relocated to a nearby utility pole in July 2007, prior to Site demolition activities. The station data collected between August 2002 and July 2007 confirmed a predominantly on-shore wind direction from the west northwest, with average wind speeds of 3 mph and recorded gusts as high as 9 mph from this direction. Existing Site wind data indicate maximum recorded winds from the south southeast at 18 mph. The existing meteorological station, or a replacement unit, will remain operational to monitor changes in wind direction during remedy implementation.

As part of the RDIP, a Perimeter Air-Monitoring Plan (PAMP) will be prepared for review and approval by DTSC and implemented. The PAMP will include the following tasks (subject to DTSC approval):

- **Real-time dust monitoring –** This task will involve using fixed-location direct-reading monitor at the perimeter air monitoring stations to measure PM10 concentrations at the Site boundaries. The dust monitors will consist of ThermoMIE brand DataRam units or equivalent that reliably respond to PM10 concentrations as low as 0.1 microgram per cubic meter (µg/m3). The dust monitors will be used to automatically record PM10 concentrations, and provide an alert if the PM10 action level is exceeded. The proposed locations for these monitors during remedy implementation are shown on Figure 6-1, subject to refinements during preparation of the RDIP. Additionally, during construction operations, portable dust monitors will be utilized near on-site activities so that real-time feedback can be provided to adjust construction operations and/or dust controls to limit potential exceedance of the PM10 action level at the perimeter air monitoring stations.

- **Real-time VOC Monitoring –** Volatile organic compounds (VOCs) concentrations will be measured utilizing portable field gas chromatographs (GCs) such as a Photovac Voyager GC or equivalent. The GCs measure volatile organic compounds by passing the air sample through an analytical detector and electronically measuring the resulting response. The GCs will be configured to operate in total and compound-specific modes so that total and individual VOC concentrations can be quantified and compared to the VOC action levels. The GC instrument will be selected to reliably respond to total VOC concentrations as low as 1 part per billion by volume (ppbv). Additionally, during construction operations, portable total VOC monitors will be utilized near on-site activities so that real-time feedback can be provided to adjust operations and/or vapor controls to limit potential exceedance of the VOC action levels at the perimeter air monitoring stations.

- **Time-integrated ambient air sampling and analysis for VOCs –** During the initial weeks of remedy implementation, 24-hour time-integrated perimeter air samples will be collected daily for VOC analysis. Collection will be performed using high-volume size selective inlet (SSI) samplers located in the predominantly downwind position. This high-volume air sampling will be performed each work day during removal of the Raised Cap material. Data collected from these sampling events will be compared to VOC performance standards and correlated with real-time total VOC concentrations. Once a reliable correlation is established, a modified, reduced sampling frequency will be proposed to DTSC and implemented after DTSC approval. Daily sampling will be maintained on periods of work during which the highest VOC-impacted soil excavation activities will occur.

- **Time-integrated ambient air sampling and analysis for Arsenic –** During the initial weeks of remedy implementation, two consecutive 4-hour time-integrated perimeter air samples during dust generating work hours (8:00 a.m. to 4:00 p.m.) and one 16-hour time-integrated perimeter air samples during non dust generating hours will be collected daily will be collected daily for respirable arsenic analysis. As needed on any given day, a third four-hour sample will be collected if dust generating work persists outside these hours, and the non-work hour sample will become a 12-hour time-integrated sample. Collection and analysis of these samples on a daily basis will allow for confirmation that both the acute (4-hour) performance standard and subchronic performance standard for arsenic are being met. Collection will be performed using high-volume size selective inlet (SSI) samplers located in a predominantly downwind position. This high-volume air sampling will be performed each work day during removal of the Raised Cap material. Data collected from these sampling events will be compared to performance standards for arsenic to correlate real-time PM10 readings with respirable arsenic concentration. Daily sampling will continue at the start of the soil excavation activities. Once a reliable correlation is established, a modified, reduced sampling frequency will be proposed to DTSC and implemented after DTSC approval. Daily sampling will be maintained on periods of work during which the highest arsenic-impacted soil excavation activities will occur.

- **Time-integrated ambient air sampling and analysis for Lead–** During the initial weeks of remedy implementation, 24-hour time-integrated perimeter air samples will be collected daily for respirable lead analysis. Collection and analysis of this sample on a daily basis will allow for confirmation that the performance standard for lead is being met. Collection will be performed using high-volume size selective inlet (SSI) samplers located in a predominantly downwind position. This high-volume air sampling will be performed each work day during removal of the Raised Cap material. Data collected from these sampling events will be compared to performance standards for lead to correlate real-time PM10 readings with respirable lead concentration. Once a reliable correlation is established, a modified, reduced sampling frequency will be proposed to DTSC and implemented after DTSC approval. Daily sampling will be maintained on periods

of work during which the highest lead-impacted soil excavation activities will occur.

Comparison of detected COC concentrations in air with its respective performance standards will be used to confirm the validity of the developed action levels. Action levels will also be compared to real-time dust and vapor levels. Comparison of measured dust and vapor levels with the action levels and VOC odor thresholds will be used to adjust the dust, vapor, and odor control measures, if needed.

6.2.1.1 Action Level Exceedance and Adjustment

If the air monitoring action levels are exceeded, Site air emission controls will be evaluated and adjusted, as necessary. If during a consecutive 4-hour period in a single work day the average PM10 measurements exceeds the acute PM10 action level or if the rolling-average PM10 and/or total VOC measurement exceeds the respective subchronic action level, operations will be reviewed, the cause for the exceedance determined, and appropriate actions taken. As necessary, remedy implementation activities will be suspended until the cause is identified and additional control measures are implemented.

The action levels are based on calculations that utilize existing Site Raised Cap material, soil, and groundwater data. As the air samples to be collected during remedy implementation are analyzed to determine actual COC concentrations in air during remedy implementation, the action level calculations may be revised based on the correlation between soil/groundwater COC concentrations to those in air, i.e., update the VOC action levels.

6.2.2 Noise Monitoring

Emeryville Noise Ordinance No. 03-002, dated August 19, 2003, specifies the requirements for minimizing noise-related impacts during remedy implementation. Specifically, general construction noise (Section 5-13.05 of the Noise Ordinance) shall be limited to weekdays from 7:00 am to 6:00 pm. Although not anticipated for this remedy implementation, pile driving and similarly loud activities are limited to weekdays from 8:00 am to 5:00 pm. More restrictive hours for allowable construction noise may be established as appropriate, given the surrounding neighborhood and type of noise.

Weekend work, and/or work outside the established weekday time limits, may be allowed at the discretion of the City Manager, the Planning and Building Director, or the Public Works Director. Weekend construction work, if allowed, would be limited to 9:00 am to 6:00 pm.

Remedy implementation activities are anticipated to be conducted during the allowable weekday construction noise time limits. Activities related to Site security, such as stockpile maintenance, may be conducted during night-time hours, if needed. If activities are proposed outside of the weekday allowable construction noise time limits, the remediation contractor will apply to the City for a waiver, as described in

Section 5-13.06 of the Ordinance. The procedures for waiver application require submittal of a description of the type of work to be performed, the type of equipment to be used, notifications to neighbors, and, among other requirements, a description of the types of construction practices to be used to minimize noise.

As appropriate, the source(s) of the noise will be identified and additional noise reduction methods and supplies will be used including, but not limited to, those presented below:

- Relocate stationary equipment (if feasible) to minimize noise impacts on the community;
- Provide portable enclosures for stationary equipment and particularly noisy areas on the Site;
- Use self-adjusting ambient-sensitive back-up alarms, manually-adjustable alarms on low setting, use of observers, and/or schedule activities so that alarm noise is minimized;
- Install and maintain intake and exhaust mufflers on all equipment, particularly pneumatic impact tools;
- Install acoustically attenuating shields, shrouds, or enclosures on noise producing equipment;
- Line or cover hoppers, conveyor transfer points, storage bins and chutes with sound-deadening media;
- Minimize the use of air or gasoline-driven hand tools;
- Maintain all equipment such that parts of vehicles and loads are secure against rattling and banging; and/or
- Use shields, impervious fences, or other physical sound barriers, to inhibit transmission of noise to sensitive receptors.

6.3 Vapor Extraction and Treatment

Prior to removal of the Raised Cap, a network of vapor extraction wells will be installed from the surface to above the groundwater table on the Raised Cap and surrounding vadose zone soil excavation area. These vapor extraction wells will be utilized to remove stagnant VOCs present in the Raised Cap material and vadose zone soils prior to excavation. The vapor stream will be treated through a combination of adsorption media, including zeolite and activated carbon. The soil vapor extraction and treatment system will be operated pursuant to a BAAQMD permit.

The system as currently developed consists of a network of vapor extraction wells each piped to a corresponding vapor extraction-blower unit (SVE Unit). Figure 6-2 shows a plan view of the soil vapor extraction area and the proposed locations for extraction wells, SVE units, and treatment system. The proposed well locations are based on preliminary design data and the spacing of the vapor extraction wells will be refined during preparation of the RDIP.

It is anticipated that up to three electric-powered SVE units will operate simultaneously to extract soil vapor from across the Site. The SVE units will consist of a positive displacement blower; a liquid-vapor separation tank with auto discharge pump and level switches to remove moisture from vapor stream; and a heat exchanger to allow vapor stream temperature adjustment for optimum treatment efficiency.

Effluents from each SVE units will be directed to the treatment system, which is anticipated to include both zeolite and granular activated carbon vessels to effectively capture the range of anticipated organic vapors. The effluent will not be thermally treated. Treated vapor with COC concentrations below BAAQMD's emission trigger levels will be discharged to the atmosphere. The treated vapor emission will be monitored per BAAQMD permit requirements.

The SVE and treatment system will operate for up to four weeks prior to initiation of excavation activities. During this time, the initially stagnant total VOC concentrations are expected to decrease and stabilize (as monitored at the influent of the vapor treatment system) to an equilibrium with mass transfer processes that are generating the vapors from VOCs absorbed to soil and dissolved in water. The extracted soil vapor will be field monitored for total VOC concentrations. When total VOC concentrations reach relatively stabilized levels, the extracted soil vapor will be sampled and the samples analyzed by a State-certified laboratory for VOC concentrations. These VOC concentrations will be compared to those modeled in the PHERA, and as appropriate VOC actions levels modified.

Portions of the SVE system will continue to operate as excavation activities are initiated with the removal of the Raised Cap and vadose zone soil excavation. Phased shutdown of the SVE system will be performed as the excavation proceeds to encompass the entire SVE area.

6.4 Removal of Raised Cap

After the implementation, operation, and subsequent removal of the vapor extraction system, the first stage of excavation will be the removal of the Raised Cap material, down to the underlying former building foundations and piping where encountered. The RDIP will present the techniques, supplies, and equipment to conduct the removal of the Raised Cap. The RDIP will be provided to DTSC for review prior to remedy implementation.

The combination of impacted soil, concrete rubble, and possibly other material will be loaded for off-site transport and disposal. It is estimated that approximately 7,000 cubic yards of Raised Cap material will be removed. It is anticipated that surface asphalt and some of the concrete can be segregated for off-site recycling. For evaluation purposes it is assumed that all other Raised Cap material will be hazardous waste and will therefore require transport under hazardous waste manifests to an appropriate disposal facility.

The types of heavy equipment anticipated to be used during removal of the Raised Cap will include:

- Tracked diesel-powered excavator to excavate soil and segregate concrete;
- Tracked diesel-powered excavator with hydraulic attachments (jack hammer & nibbler) for breaking and processing concrete foundations for shipment;
- Front-end loader, for placing excavated soil and processed concrete into a dump truck; and
- One or two 25-yard off road dump trucks, for transporting soil from the excavation to the stockpile area.

6.5 Shoring Along Horton Street

Due to Site constraints and the proximity of the excavation to Horton Street and Building 31, shoring systems will be required. The design for the shoring system(s) will be provided to DTSC as part of the RDIP. It is anticipated that two different systems will be utilized.

For areas along Horton Street with excavation up to 25 feet in depth, it is anticipated that a retaining wall utilizing a solider pile with lagging system will be constructed. The location of this deep shoring wall is presented on Figure 6-1 and will be approximately 60 feet in length.

Specialized equipment using vertical augers will be utilized to generate large-diameter boreholes on the Site along Horton Street. It is anticipated that the boreholes will be installed at approximately eight-foot centers. In the area of vadose zone excavation, the boreholes will be less than 25 feet deep (typical depth of the A/B aquitard). In the area of the saturated zone excavation, the boreholes (a total of nine) will be approximately 50 feet deep.

Soldier piles will be installed in the bottom of the boreholes. In the area of the vadose zone excavation, it is anticipated the soldier piles will be up to 25 feet deep with the lower portion encased in structural concrete. In the area of the saturated zone excavation, it is estimated the soldier piles will be about 50 feet long with the lower 25 feet encased in structural concrete. For these deeper soldier piles, boreholes will be installed using casing and bentonite slurry to control heave.

Excavation of vadose and saturated zone soils along Horton Street will be completed to allow installation of lagging between soldier piles as the excavation is lowered. The lagging will consist of steel plates behind the soldier pile flanges driven in advance of the excavation. As the excavation is advanced into the saturated zone, additional lagging will be installed.

As the excavation proceeds deeper into the saturated zone, a dewatering system will be implemented (see Section 6.6). Counterforts will be installed to provide lateral support to the retaining wall. Each counterfort will be perpendicular to the soldier piles and installed at alternating soldier piles (for a total of up to 6 counterforts). The length of counterfort slots is estimated at 25 to 35 feet and the depth will be to the top of the A/B aquitard. Fill slots will be filled to form the counterfort buttresses for the soldier pile wall. After installation of the counterforts, the saturated soil between the counterforts will be excavated, to a maximum depth equal to the depth of the counterforts. Details on excavation implementation are discussed in Section 6.7.

For areas along the west side of Building 31, vadose zone soil along the building will be excavated and sloping, instead of retaining wall utilizing soldier piles with lagging system, will be installed. The slope will have a horizontal to vertical distance ratio of 1.5: 1 outside the base of building 31's footing. After installation of the slope, the vadose zone soil in areas north of building 31 will be excavated.

It is anticipated that the entire shoring activity, including soil excavation and handling, will take up to four weeks. After this has been completed, remaining saturated soils will be excavated. Shoring on other sides of the excavation will consist of benching and over-excavating with a 1.5:1 horizontal to vertical slope.

Upon completion of excavation/backfilling, counterforts will be removed and soldier piles will be cut flush to the surface.

6.6 Excavation Dewatering

Dewatering of the excavation will consist of using one or more sump pumps installed at the bottom of the excavation on the S-W property. Water collected within the sump(s) will be pumped to the Dewatering Equipment Storage and Pretreatment Unit, and subsequently the groundwater treatment system (Figure 6-1). By pumping water from sumps installed on the S-W property, the water table on the S-W property will be lower compared to the former Rifkin property, inducing groundwater flow towards the S-W property. As a result, contaminated groundwater from the S-W property will not migrate towards the former Rifkin property. Based on groundwater pump tests conducted at the Site, it is anticipated that a maximum of 10 gallons per minute of groundwater will be generated from the dewatering system.

Groundwater extracted from the sump will be conveyed into a dewatering settling tank system (the Dewatering Equipment Storage and Pretreatment Unit) and subsequently pumped to the existing and/or a new groundwater treatment system prior to discharge to Temescal Creek or to the POTW under permit, or transported

offsite for treatment and disposal/reuse. Figure 6-1 presents the preliminary locations of the pretreatment and treatment units. The final layout is subject to refinements during preparation of the RDIP and will be established by the remediation contractor.

The excavation dewatering activities will be limited to the A-zone aquifer and are anticipated to have a de minimis effect on the distribution of contaminants in groundwater near the Site.

6.7 Soil Excavation and Handling

Approximately 57,000 cubic yards of soil will be excavated for off-site disposal. Some of the excavated soil is anticipated be hazardous waste and will require transport under hazardous waste manifests to an appropriate disposal facility. The RDIP will present the techniques, supplies, and equipment to conduct the excavation and soil handling activities. The RDIP will be provided to DTSC for review prior to remedy implementation.

The types of heavy equipment needed during soil excavation are anticipated to include:

- Tracked diesel-powered excavators;
- Front-end loaders, for managing stockpiles and placing excavated soil into a dump truck;
- Two or more 25-yard off road dump trucks, for transporting soil from the excavation to the stockpile staging area;
- Dewatering system including sump within the excavation, above-ground pump, settling tank system, and groundwater treatment system (treated water will be discharged to Temescal Creek);
- Water trucks for spraying/misting for dust control; and
- Foam unit for applying vapor suppressant foam.

Vadose zone soil on the S-W and former Rifkin properties will be excavated in order to achieve the vadose zone soil cleanup for arsenic of 24 mg/kg on each property. The planned vadose zone excavation limits are presented on Figure 6-1. The planned limits of soil excavation extend approximately 285 feet along Horton Street (60 feet on the former Rifkin property and 225 feet on the S-W property) and approximately 330 feet west of Horton Street, or approximately 95,000 square feet. In addition, elevated detections of arsenic in vadose zone soil are present at locations outside these limits, including SA-AH-01 (110 mg/kg), SB-7AB (130 mg/kg), CDM-SB50 (200 mg/kg), and SA-BH-04 (211 mg/kg). Vadose zone soil surrounding these locations would also be removed to a radius of 10 feet surrounding each location. The vadose zone soil would

be excavated to an average depth of approximately 7.5 feet, the approximate depth to groundwater across this area.

Confirmation sampling and analysis, as described in Appendix H, would be conducted to confirm that the vadose zone soil cleanup goal for arsenic is met. In order to meet this goal, additional, excavation beyond the limits presented above may be needed.

In addition to vadose zone soil, the excavation includes removal of saturated zone soil identified as source of COCs to groundwater (CDM, 2009b). The planned saturated zone excavation limits are presented on Figure 6-1. The source area saturated soils would be removed down to the A/B aquitard (approximately 25 feet bgs) on the S-W property and to 18 feet bgs on the former Rifkin property. Confirmation of final source area removal extents will be based on geologic observation for permeable materials along the sidewalls of the excavation below the groundwater table.

6.8 Waste Stockpiles

Waste stockpiles will be used during remedy implementation. The design criteria for managing the stockpiles will be detailed in the RDIP and is anticipated to include the following:

- The waste stockpiles will be located on the former Building 35 concrete slab.
- If additional area is needed, additional waste stockpiles will be located on areas covered by existing asphalt pavement, as shown on Figure 6-1. The final layout is subject to refinements during preparation of the RDIP and will be established by the remediation contractor.
- This exterior paved area will first be inspected for cracks, and repairs will be made as necessary to create or maintain an integral surface.
- Berms and lined cement barriers (i.e., k-rails) will be constructed around the waste stockpile area as needed to control possible water run-on and runoff. The existing surface grade and pumping system will be used to control and capture water. The design of berms around these areas, and the construction supplies used for the berms & barriers, will be provided in the RDIP.
- Any accumulated water within the bermed area(s) will be pumped into a dewatering settling tank and subsequently pumped to the groundwater treatment system prior to discharge or off-site disposal.
- Waste stockpiles will be covered with nylon-reinforced polyethylene or sprayed with stabilizing foam each night, on weekends, and all other non-work days, or when the pile is not being actively worked. If polyethylene covers are used they will be secured with ties or a sufficient number of sandbags or other weighted objects designed to keep the cover in place.

- While the stockpiles are in operation, the berms and cover will be inspected several times daily, including non-work days, to detect evidence of tears, loose seams, punctures, and the presence of water and proper functioning of water collection and removal systems.

The use of waste stockpiles is intended to accommodate scheduling imbalances between relatively continual excavation activity and intermittent loading and transport as well as allow for sampling and profiling as described in Appendix I. It is anticipated that the volume of stockpiled material will be equivalent to 5 days of excavation, i.e., up to an estimated 5,000 cubic yards. If the rate of accumulation exceeds this amount, excavation activities will be slowed down and, if possible, loading and transport activities will be accelerated until material handling flow rates are approximately equal.

6.9 Loading and Off-Site Transport

Materials removed from the Site for off-site disposal is anticipated to vary in waste classifications. The determination of waste classifications will be made in accordance with applicable regulations and disposal facility acceptance criteria.

The testing, manifest tracking, and record-keeping requirements will be conducted in accordance with Title 40 CFR Section 268.7 and 22CFR Chapter 18, Article 332 CCR. A manifest will be generated for each load of hazardous waste leaving the Site. The weight of material will either be recorded by on-site scales, or will be estimated at the Site and confirmed by weigh tickets generated at the receiving disposal facility. The manifest will be signed by an authorized S-W representative or agent and will accompany the load of material to the disposal facility.

Materials removed from the Site will be transported by rail and/or truck. The RDIP will identify the techniques, supplies, and equipment needed to perform the loading and transport of the materials. The RDIP will be provided to DTSC for review prior to remedy implementation. General descriptions of loading and transport activities for each transport modes are discussed below.

6.9.1 Rail Car

To the extent possible, materials removed from the Site will be loaded into rail cars for transport for off-site disposal. Rail cars may be loaded on the existing spur track within the Site as shown on Figure 6-1. However to maintain efficient production, an additional rail spur on the S-W property may be needed. To the extent rail cars can be used for off-site transport, S-W will work with UPRR and the transport/disposal contractor to utilize the UPRR Emeryville Yard tracks for rail car staging. Both empty rail cars and rail cars containing excavated soil would be staged at the UPRR Emeryville Yard tracks.

The estimated duration of rail car loading is dependent on the availability and location of the rail cars.

It is anticipated that off-site transport of some portion of the materials removed from the Site may occur by truck. Not all disposal facilities accept material by rail car as they are not located along railroads.

6.9.2 Truck

Figure 6-1, Preliminary Site Layout and Controls, depicts the plan for trucking of excavated materials off-site and the trucking of clean backfill onto the Site. The final layout is subject to refinements during preparation of the RDIP and will be established by the remediation contractor.

If all materials removed from the Site were to be trucked, the duration for truck loading and off-site transport is estimated at 9 to 18 weeks. This duration is based on the approximate 64,000 cubic yards of materials to be excavated, an in-place material density of 1.4 tons per cubic yard, 20 tons of material per truckload, and 50 to 100 truck trips per day. The actual rates of loading will vary due to on-site logistics and/or truck availability.

Material will be loaded into truck trailers, which will be covered and secured prior to leaving the Site to limit dust or odor emissions. Truck and trailer wheels will be decontaminated and inspected prior to leaving the Site. A Transportation Plan will be prepared in accordance with Health and Safety Code Section 25169.3 and DTSC's Guidance for Developing Transportation Plans for Removal or Remedial Actions (DTSC, 2001). The Transportation Plan will present the procedures to be used by the hauler to protect the public during the transportation process. Specific aspects to be addressed in the Transportation Plan include: container selection, Site entry and egress, routing and supervision of transportation activities. The Transportation Plan will be included in the RDIP for review and approval by DTSC.

It is anticipated trucks will approach the Site northbound on Halleck Street to Sherwin Avenue, and then enter into the property, as shown on Figure 6-1. Once on-site, the trucks will follow roadways identified by the contractor. It is anticipated that loaded trucks will leave through the plant truck entrance north of former building 35, cross the easement on the City's property and proceed southbound on Halleck Street, across Park Avenue, under 40th Street, and south to 32nd Street. From 32nd Street, trucks will access Mandela Parkway to Grand Avenue and freeway connections. Necessary traffic or encroachment permits for use of these streets will be obtained from the Cities of Emeryville and Oakland. Figure 6-3, Preliminary Truck Transportation Route Map, shows the regional truck route anticipated for transport of excavated materials from the Site and backfill to the Site.

6.9.3 Decontamination

A decontamination station will be setup (see Figure 6-1) at the Site. During excavation and material handling activities, equipment and vehicles will be decontaminated and inspected prior to leaving the Site. Trucks, rail cars, and equipment will be decontaminated using dry brush and/or wet rinsing. Rinse water will be collected, tested, and disposed of in accordance with applicable regulatory

requirements. Trucks, rail cars, and equipment exiting the Site will be inspected and logged for compliance with the Site decontamination requirements.

6.10 Slurry Wall Breach and Extension

As excavation and backfill operations are nearing completion, the slurry wall will be breached in two locations along the western, down gradient property boundary and one up gradient location near the north end of former building 35, and extend the existing slurry wall south along the western property boundary to Sherwin Avenue (see Figure 6-1). The detailed design for the slurry wall breaches and extension will be provided to DTSC prior to remedy implementation as part of the RDIP. General descriptions of these activities are discussed below.

The existing slurry wall will be breached to provide an outlet for groundwater that accumulates within the formerly closed slurry wall system, or to provide a pathway for groundwater flow from areas outside the formerly closed slurry wall system into these areas, specifically the arsenic-impacted groundwater in the vicinity of well LF-3.

The slurry wall breaches will consist of three components: an upgradient collection zone; a connector zone crossing the existing slurry wall; and, a distribution zone to disperse the flow back into the regional flow system. The locations for the slurry wall breaches have been selected to be placed in areas where permeable soils are present to provide a hydraulic connection with the existing groundwater flow. Figure 6-1 presents the locations of the breaches and Figure 6-3 presents details of the slurry wall breaches.

The upgradient, or the collection portion, of the breach system will be excavated to the top of the A/B aquitard, using an appropriate method to maintain the stability of the excavation and allow placement of a high permeability backfill (i.e., a graded sand or gravel) and drain pipe. A drain pipe will be placed at a depth of 5 feet below the seasonal low water table (approximately 0 feet NAVD88). This collector trench will be installed a minimum of 10 feet upgradient of the confirmed location of the existing slurry wall, approximately parallel to the orientation of the wall. The downgradient distributor trench will be constructed in a similar manner on the downgradient side of the existing slurry wall. This distributor trench will overlap the upgradient collector trench by approximately 30 percent of its length. Two to three connector trenches will be excavated, using the same methods, to a minimum depth of 2 feet below the elevation of the drain pipe in the collector and distributor trenches (approximate trench bottom elevation of -2 feet NAVD88). These connector trenches will be excavated to cross the slurry wall at a right angle, and intersect the collector and distributor trenches. The connector trenches will also include the drain pipe, which will either be directly connected to the drain pipes in the adjacent trenches, or be placed in contact with the other lines in the open trench to allow efficient hydraulic communication between all segments of the breach system.

The backfill in the breaches will consist of a graded sand or gravel to control the potential mobilization of fines from the formation into the trenches. The permeability of this backfill will be specified at a minimum of 500 ft/day. Piezometers will be installed into the collector and distributor trenches to allow monitoring of the hydraulic performance of the breaches.

The slurry wall breach backfill will be delivered by truck. It is estimated 35 truckloads of backfill will be needed for the breaches.

In conjunction with the breaching operation, the existing slurry wall will be extended south along the western property boundary to Sherwin Avenue (see Figure 6-1). This wall extension will modify groundwater flow through the upgradient slurry wall breaches. It is anticipated that this slurry wall will be constructed using a long reach tracked excavator and the installation of a bentonite slurry mixture or flexible membrane. As with the breaches, the excavated material will be sampled and if found acceptable will be reused on-site. If off-site disposal is required and the material is transported by truck, approximately 70 truckloads will be required. On-site mixing and staging of bentonite slurry may be performed in the area designated as the waste staging area (see Figure 6-1). The importation of the bentonite slurry will require the delivery of approximately 70 truckloads.

Together, the three slurry wall breaches, surrounding existing slurry wall segments along Temescal Creek channel and UPRR tracks, and the slurry wall extension will be used to control groundwater flow at the Site. The other existing slurry wall segments that will remain after remedy implementation, along the former Rifkin property boundary and within the Site, are not required to maintain appropriate groundwater flow conditions. Groundwater monitoring to assess the performance of the slurry wall segment and breach system is discussed in Section 7.

6.11 Excavation Backfilling

Backfilling below the groundwater table will occur concurrently with excavation. Geotechnically appropriate backfill will be delivered to the Site in trucks or rail cars. Figure 6-3, Preliminary Truck Transportation Route Map, shows the regional truck route proposed for transport to and from the Site.

If possible, backfill will be brought to the Site in the trucks or rail cars used for off-site disposal of excavated materials. Backfill stockpiles will be kept separate from the waste stockpiles (see Figure 6-1). The RDIP will present the techniques, supplies, and equipment needed to perform the backfilling activities.

Truck traffic into and out of the Site will follow the Transportation Plan and as described in Section 6.9. Import fill will be unloaded on-site. It is anticipated that one or more loaders and 25-yard off road trucks will be used to move fill from the stockpile area to the excavation for placement and compaction.

As shown on Figure 6-1, the majority of the areas undergoing excavation will be backfilled with low-permeability backfill (approximately 0.283 ft/day). The remaining area will be backfilled with high-permeability fill backfill (approximately 28.3 feet/day). The high-permeability backfill will be placed downgradient of an interceptor trench and will serve to collect and distribute groundwater into the surrounding formation. During backfill operations of the saturated zone, a reagent (e.g., organic-based tannin or inorganic powdered sulphite) will be added with the backfill. The purpose of the reagent is to act as an oxygen scavenger to control oxidation-reduction conditions in the subsurface. Increased oxidation has the potential to mobilize solid phase arsenic that may be present in the surrounding, natural formation. The reagent will be selected to minimize potential detrimental impacts to the soil or groundwater quality and to avoid generating odors. The RDIP will present the techniques and equipment needed to confirm the backfill operations meet the designed permeability values.

As part of the selected remedy, a contingency would be to pump from the high-permeability backfill and/or trench, if needed, to direct groundwater flow toward the S-W property. As such, backfill design considerations for both the S-W property and the former Rifkin property will be included as part of the RDIP.

During backfill operations, an interceptor trench will be placed on the S-W property, adjacent to the S-W/Rifkin property boundary as shown on Figure 6-1. A membrane barrier will be placed on one side of the trench, along the property boundary, to prevent groundwater flow toward the former Rifkin property. The trench will be approximately 30 inches wide, approximately 25 feet deep and be located as shown on Figure 6-1. The trench will be backfilled with 3/8 inch minus backfill and contain a basal perforated pipe to reduce flow resistance from the backfill. With this design, the trench will have an effective permeability of approximately 500 ft/day. The trench will be closed on the Horton Street side with the membrane barrier. The membrane barrier will be tied into the aquitard without compromising its integrity, i.e., the excavation will be limited in extent and, as appropriate, conducted through slurry to maintain adequate downward force to prevent heaving.

Final surface elevation following excavation and backfill will conform to redevelopment plans, if appropriate, and/or target Site elevations, to the extent practical. If redevelopment construction will not immediately follow completion of remedy implementation, then the S-W property will be graded to an elevation consistent with the Horton Street sidewalk and the adjoining Site elevation along the rail spur. The area will be sloped and re-paved and/or vegetated, and would direct water runoff along the Site surface towards the Temescal Creek channel. The remaining portions of the spur track outside of the excavation limits will be removed and/or paved as part of remedy implementation. The former Rifkin property will be backfilled to a final elevation consistent with the remaining parking area, repaved, and striped.

6.12 Reporting

During remedy implementation activities, summaries of work activities will be provided to DTSC. These summaries will include material excavation locations, results from waste characterization of excavated materials, results from confirmatory soil samples, and results from air monitoring and sampling.

After remedy implementation is completed, a completion report will be prepared and submitted to DTSC. The report will document all activities performed, including definition of the actual extent of excavation, collection of soil samples, classification and/or treatment of waste, final disposition of waste, air monitoring and sampling, and all analytical reports of waste characterization, soil confirmatory samples, and air sampling.

Photographic documentation will be provided including pictures of excavated materials prior to removal and the final configuration of the excavation. The report will detail deviations from this RAP or the RDIP, if any, and provide an explanation for the deviations.

Table 6-1
Summary of Engineered Controls for Short-Term Exposure Risks
Sherwin-Williams Emeryville Remedial Action Plan

Implementation Activity	*Dust Control*	*Vapor Control*	*Surface Water Runoff Control*
Excavation	Water sprays/mist, surfactants, wetting agents, dust suppressants, covers, and windscreens.	Water spray/mist, vapor suppressant foam, covers, and vapor extraction and treatment.	Water runoff entering excavation will be pumped to holding tanks and pretreatment prior to being routed to a groundwater treatment system along with other water from excavation dewatering.
Shoring	Water spray/mist system.	Shroud over auger to collect vapors and direct vapors through treatment system, if needed, and/or use of vapor suppressant foam or vapor oxidation media will be applied.	Berms will divert surface water runoff contacting Site materials towards the excavation so it may be collected and sent to groundwater holding and treatment system.
Stockpiling and Handling	Water spray/mist; covers on stockpiles; slow vehicle speeds to control dust.	Vapor suppressant foam, vapor oxidation media, covers, and vapor extraction and treatment.	Berms and lined k-rail barriers will divert water runoff from contaminated stockpiles towards the excavation so it may be collected and sent to groundwater holding and treatment system. Berms and k-rail will divert water runoff from clean backfill stockpiles through filter system for discharge to surrounding storm water system.
Loading	Water spray/mist; covers over loaded trucks and/or rail cars; slow vehicle speeds to control dust; minimize drop heights during loading.	Bag contaminated soils in transports. Covers over loaded trucks and/or rail cars; minimize drop heights during loading.	Berms will divert water runoff contacting contaminated Site materials towards the excavation so it may be collected and sent to groundwater holding and treatment system.
Backfilling	Water spray/mist.	Not Applicable.	Berms will divert water runoff away from the excavation. Excess precipitation into the excavation will be pumped so it may be collected and sent to groundwater holding and treatment system.

Table 6-2
Action Levels for Volatile Organic Compounds
Sherwin Williams Emeryville Remedial Action Plan

Volatile Organic Compounds	BAAQMD Regulatory Limit ($\mu g/m^3$)	AIHA Odor Threshold ($\mu g/m^3$)	Selected Noncancer Performance Standards[1] ($\mu g/m^3$)	Selected Cancer Risk-Based Performance Standards[1] ($\mu g/m^3$)	Selected Subchronic Action Level in Air[2] ($\mu g/m^3$)	Selected Acute Action Level in Air[3] ($\mu g/m^3$)
Volatile Organic Compounds						
Benzene	60	4,792	10	0.6	0.6	29
1,2-Dichloroethane	NE	45,331	607	0.03	0.03	45,331
Ethylbenzene	2,000	9,986	608	8.9	8.9	9,986
Methyl ethyl ketone	NE	737	1,000	NA	737	737
Tetrachloroethylene	35	41,852	88	0.2	0.2	1,358
Toluene	300	603	1,167	NA	300	603
Trichloroethylene	600	7,309	90	0.7	0.7	7,309
1,2,4-Trimethylbenzene	NE	11,798	12	NA	12	11,798
1,3,5-Trimethylbenzene	NE	11,798	12	NA	12	11,798
Vinyl chloride	26	647	19	0.01	0.01	647
Xylenes	700	1,302	434	NA	434	1,302
Total Volatile Organic Compounds[4]					1,505	

BAAQMD - Bay Area Air Quality Management District Rules and Regulations.

AIHA - American Association of Industrial Hygienists, 1989, Odor thresholds for Chemicals with established occupational health standards.

NE - Not established.

NA - Not applicable.

levels.

2. Selected Subchronic Action Level in Air is based on the more stringent of the BAAQMD regulatory limit, MRL, AIHA odor threshold, and the cancer and noncancer perform

3. Selected Acute Action Level in Air is based on the more stringent of the BAAQMD regulatory limit, MRL, AIHA odor threshold, and Cal/EPA RELs.

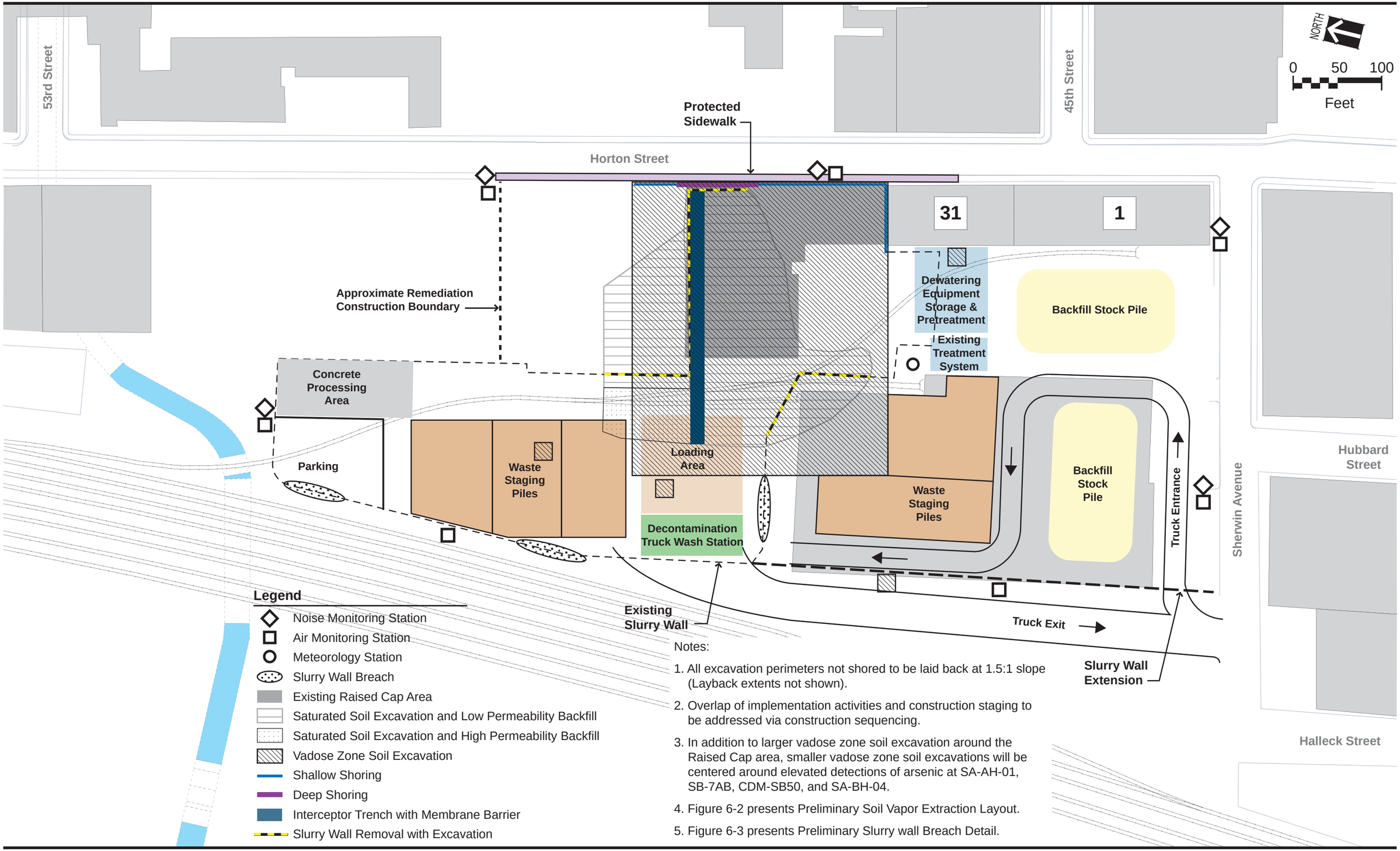
4. Total VOCs Action Level is based on the total sum of each VOC Action Level.

Table 6-3
Action Levels for PM10, Arsenic, and Lead
Sherwin Williams Emeryville Remedial Action Plan

Chemical	Source Concentration (mg/kg)	BAAQMD Regulatory Limit ($\mu g/m^3$)	Performance Standard ($\mu g/m^3$)	Action Level as PM_{10} in Air ($\mu g/m^3$)
Arsenic Acute REL-Based Performance Standard [1]				
Raised Cap Materials	110,000	NA	0.2	1.8
Vadose Zone Soils	3,898	NA	0.2	51
Soils for Shoring Installation	1,237	NA	0.2	162
Saturated Soils	3,782	NA	0.2	53
Arsenic Subchronic Risk-Based Performance Standard [2]				
Raised Cap Materials	110,000	NA	0.015	0.6
Vadose Zone Soils	3,898	NA	0.015	16
Soils for Shoring Installation	1,237	NA	0.015	51
Saturated Soils	3,782	NA	0.015	17
Other Performance Standards [3]				
Lead Subchronic Performance Standard	4,687	0.15	NA	134
Total PM_{10} Subchronic Performance Standard	NA	50	NA	50

BAAQMD - Bay Area Air Quality Management District Rules and Regulations.
REL - Reference Exposure Level
NA - Not applicable.

1. Based on arsenic acute inhalation REL and arsenic concentration in each excavation event.
2. Based on arsenic risk-based performance standard and arsenic concentration in each excavation event.
3. Lead is based on National Ambient Air Quality Standard for chronic exposure. Total PM_{10} based on chronic exposure, per BAAQMD rules and regulations.



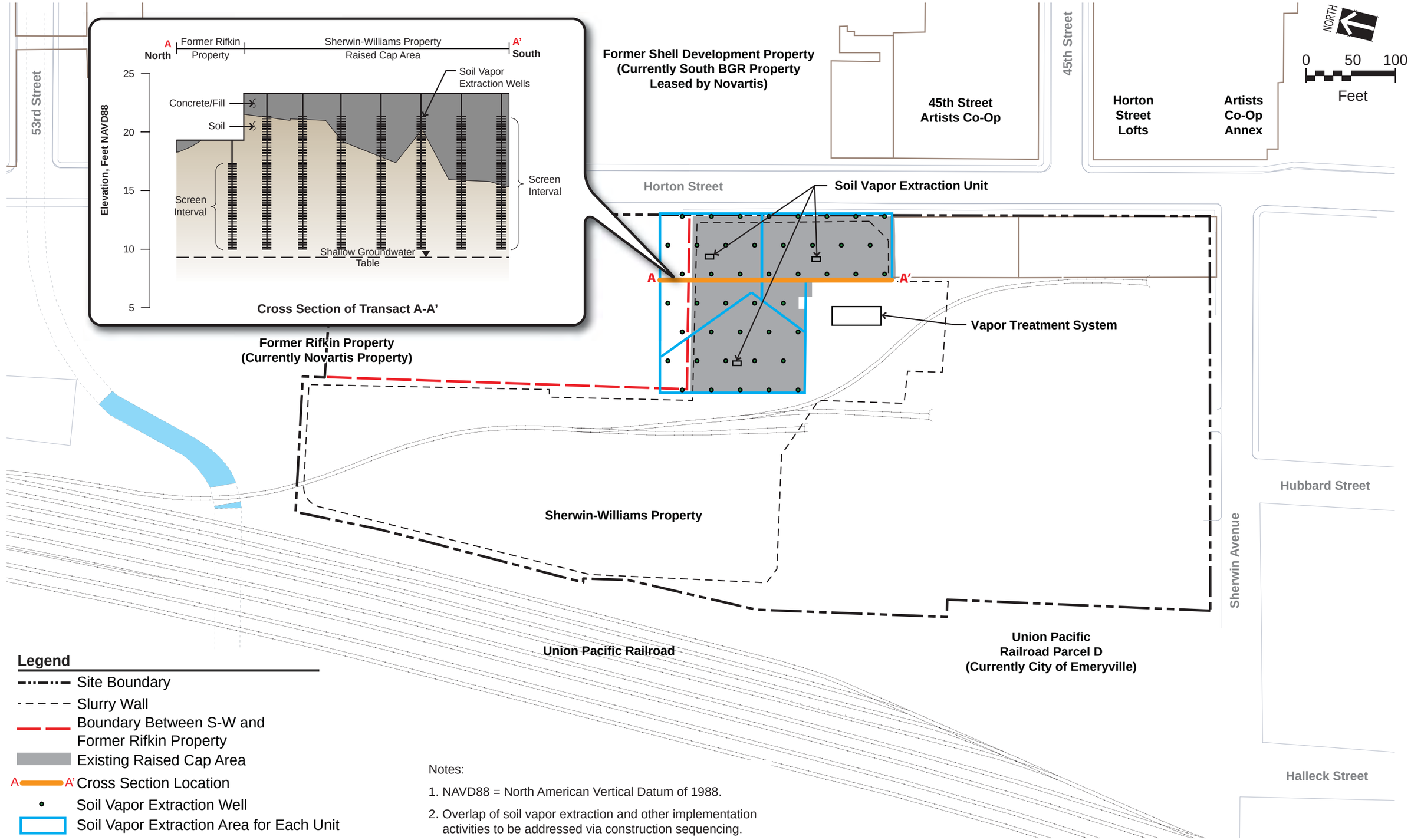
Notes:

1. All excavation perimeters not shored to be laid back at 1.5:1 slope (Layback extents not shown).
2. Overlap of implementation activities and construction staging to be addressed via construction sequencing.
3. In addition to larger vadose zone soil excavation around the Raised Cap area, smaller vadose zone soil excavations will be centered around elevated detections of arsenic at SA-AH-01, SB-7AB, CDM-SB50, and SA-BH-04.
4. Figure 6-2 presents Preliminary Soil Vapor Extraction Layout.
5. Figure 6-3 presents Preliminary Slurry wall Breach Detail.

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Figure 6-1
Preliminary Site Layout and Controls
Sherwin-Williams Company - Emeryville, California



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Figure 6-2
Preliminary Soil Vapor Extraction Layout
Sherwin-Williams Company - Emeryville, California



Legend

- Breach without Treatment
- Slurry Wall Removal with Excavation
- Current Slurry Wall
- Slurry Wall Extension

NORTH

0 75 150

1" = 150 Feet

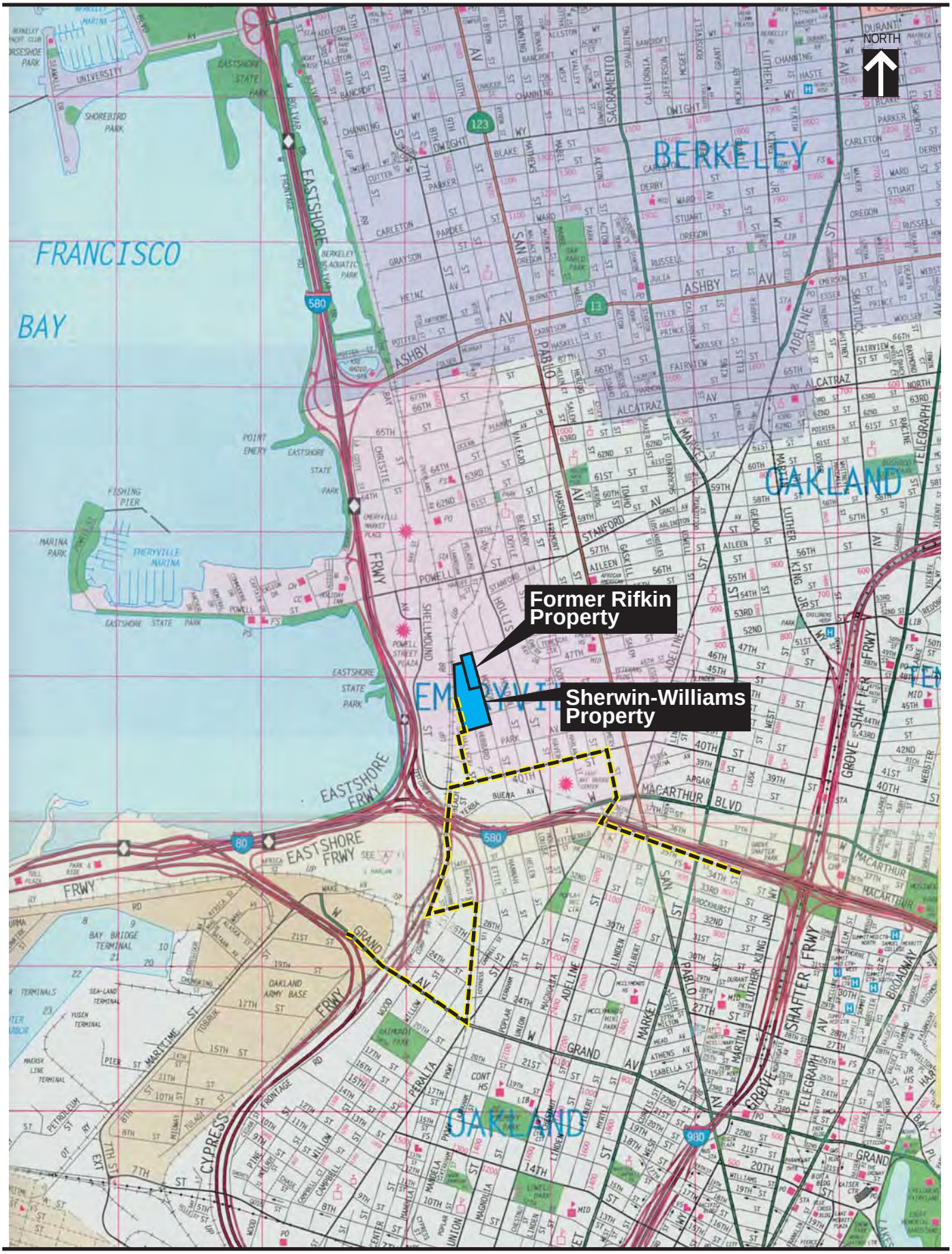
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Figure 6-3

Preliminary Slurry Wall Breach Detail

Sherwin-Williams Company - Emeryville, California

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Figure 6-4

Preliminary Truck Transportation Route Map

Sherwin-Williams Company - Emeryville, California

CDM

Section 7
Post Remediation Monitoring

This section presents descriptions of the anticipated post remediation activities. These activities will include OM&M of installed components, including a Land Use Covenant (LUC); groundwater monitoring; remedy effectiveness evaluation; and, annual reporting.

7.1 Operations, Maintenance, and Monitoring Program

Along with the remedy implementation completion report (as discussed in Section 6.12), an Operations, Maintenance & Monitoring Plan ("OM&M Plan") will be submitted to DTSC after remedy implementation. The OM&M Plan will outline provisions for long-term operations, maintenance, and monitoring (OM&M) of installed components of the remedy. These components include the surface cover, slurry wall and breach system, interceptor trench with membrane barrier, groundwater monitoring well network, and a LUC. A draft of the OM&M Plan will be included with the RDIP for DTSC review.

The OM&M Plan will present background information on Site conditions, remedial actions, and residual COCs in the subsurface above cleanup goals. The OM&M Plan will include Site maps depicting areas of known subsurface COC extents. The OM&M Plan will provide a soil gas evaluation strategy, soil management plan and updated construction HASP for potential post-remediation activities (e.g., Site development). The OM&M Plan will include financial assurance for OM&M of the installed components and an agreement between Site property owners for continued access.

7.1.1 Soil Gas Evaluation

The OM&M Plan will outline the strategy, locations, methods, and protocols for evaluating soil gas conditions at the Site after excavation and backfilling are completed. In addition, the plan will include appropriate engineering controls that would be implemented as part of redevelopment if post-excavation sampling reveals that residual soil gas is present above indoor air protective levels. Engineering controls could include: increased building indoor air ventilation; sub-slab depressurization; and/or vapor barriers in combination with other controls.

7.1.2 Soil Management

During post-remediation activities (e.g., Site development) and OM&M, soil and/or groundwater containing residual Site COCs may be encountered. The OM&M Plan will outline the procedures for managing soil and groundwater generated from Site activities, including: dust control; excavated soil stockpile management; soil sampling procedures and disposition characterization procedures; and, groundwater dewatering and treatment. In addition, the OM&M Plan will outline procedures for implementing storm water pollution control measures at the Site during construction

activities and Site maintenance activities. Best management practices to control storm water runoff at the Site will include, where necessary: 1) covering of soil stockpiles; 2) berming the Site to contain runoff; 3) installation of storm drain filters to remove sediments prior to discharge; and 4) installation of hay bales at appropriate locations to contain storm water runoff and to enhance settling of solids. The OM&M Plan will include a listing of agencies to be notified prior to initiating onsite activities, which may expose or disturb soil or groundwater containing residual Site COCs.

7.1.3 Health and Safety

The HASP will address worker health and safety during implementation of future activities that require excavation in areas of the Site where residual COCs are present. The HASP will provide personal air monitoring requirements during subsurface activities, dust control, and PPE. The HASP will be prepared in accordance with Occupational Health and Safety Administration (OSHA) 29 CFR 1910.120 guidelines and Title 8 CCR Section 5192. The HASP will be submitted separately detailing health and safety procedures, compliance with OSHA and air monitoring during construction.

7.1.4 Site Maintenance

Current and future owners, occupants, managers, and contractors, who are delegated or authorized to perform property maintenance or construction will be required to comply with the measures identified in the OM&M Plan for long-term maintenance of the Site. The provisions of the Site maintenance will also be incorporated into the LUC.

7.1.5 Land Use Covenants

As part of the OM&M Plan, Land Use Covenants (LUCs) will be recorded to identify specific land use restrictions associated with the Site. The LUCs will preclude owners, operators or occupants of the property from drilling, boring, or otherwise encountering the water table through excavation or other means unless expressly permitted in writing by the DTSC.

The LUCs will require that the Site be developed in a manner that maintains and preserves the integrity of the remedy, allows OM&M of installed features of the remedy, controls potential future human exposure to residual COCs in the subsurface, and controls potential future pathways from the Site to Temescal Creek channel (e.g., storm sewers). The LUCs will also require future utilities to be placed above the groundwater table, or with engineering controls if below the groundwater, to limit potential preferential movement of groundwater toward Temescal Creek channel along the utilities. Future development must be consistent with the assumptions for future use of the Site that were developed to constrain the groundwater model design conditions on which the remedy is based, particularly for implementation of natural attenuation to achieve the cleanup goals within a reasonable time period (CDM, 2009b).

The LUCs will be designed so that future owners/occupants will not have direct contact with the shallow groundwater during either redevelopment or future use unless permitted in writing by the DTSC. The LUCs will include language that indicates owners or occupants of the property should not drill, bore, otherwise construct, or use a well for the purpose of extracting water for any use, including, but not limited to, domestic, potable, or industrial uses, unless expressly permitted in writing by the DTSC. It will also require access to and non-interference with installed features of the remedy and the groundwater-monitoring network. In addition, the LUCs will also require unfettered access to and non-interference with the DTSC's access to the Site to conduct inspections, surveillance, monitoring or other activities necessary to protect public health safety or the environment.

Engineering controls will be used to support the LUCs. When the Site is developed, engineering controls will be used to limit surface water infiltration and potential exposure to residual COCs at the Site. Engineering controls will consist of the use of hardscape surfaces, including soil, asphalt, concrete, aboveground planters and building foundations.

The LUCs will not preclude redevelopment of the former Rifkin property in a manner consistent with the Novartis (formerly Chiron) Preliminary Development Plan (PDP) approved by the City of Emeryville on June 7, 1996. The PDP includes a high-rise tower option with installation of piles and pile caps (CDM, 2009b).

7.2 Groundwater Monitoring Program

A Groundwater Monitoring Plan will be prepared that outlines provisions for a long-term groundwater monitoring program. The purpose of the groundwater monitoring program is to collect data to evaluate the effectiveness of the soil excavation, backfill, and slurry wall breaches/extension. The effectiveness of this remedy will be evaluated based on its ability: (1) to promote natural attenuation of residual COCs in groundwater, primarily arsenic; (2) to achieve Site cleanup goals within a reasonable timeframe; and (3) to control groundwater movement through the Site without producing long-term groundwater mounding.

The groundwater monitoring program will consist of:

- Designation of a well network;
- Collection and evaluation of depths to groundwater and concentrations of COCs in groundwater in the well network;
- Development of criteria and methodologies to evaluate data that are collected; and
- Development of contingency actions with a decision framework for their initiation.

To the extent feasible, depths to groundwater and concentrations of COCs will be evaluated in the same monitoring well network. Statistical analysis will be used to

evaluate trends in the concentration data. The depth to groundwater, and COC concentrations and concentration trends will be evaluated to determine if contingency action(s) are needed to achieve Site cleanup goals.

Based on the timing and nature of future redevelopment and future construction activities, and/or results from the groundwater monitoring program, it may be necessary to modify the groundwater monitoring network or monitoring requirements at some point in the future. As such, at any time after implementation of the remedy, S-W may provide written recommendations to DTSC to modify the groundwater monitoring program presented in this document. S-W will implement the changes to the groundwater monitoring program only after approval by DTSC.

7.2.1 Groundwater Monitoring Well Locations

After soil excavation, backfill, and installation of slurry wall breaches/extension, twelve (12) additional groundwater monitoring wells (CDM-101 thru CDM-112) and three piezometers (PZ-101, PZ-102, and PZ-103) will be installed at the Site. Also, a contingent groundwater monitoring well (CDM-113) may be installed (see Section 7.2.2.1). In addition, 27 existing Site monitoring wells will continue to be utilized as part of the groundwater monitoring network. Figure 7-1 provides the tentative locations for these 12 additional groundwater monitoring wells, the contingent monitoring well, and 3 additional piezometers, along with the existing monitoring wells that will remain.

Tables 7-1 and 7-2 provide a summary of construction details and locations for the wells to be included in this monitoring program during and after remedy implementation, respectively. As discussed in Section 5 of the RAP, all other existing wells associated with the Site will be destroyed prior to remedy implementation. Table 5-1 provides a listing of wells that will be destroyed. Proposed additional groundwater monitoring wells on the former Rifkin property will be installed at the same time that the proposed wells on the S-W property are installed, unless the property owner initiates redevelopment on the former Rifkin property that would require a separate installation schedule.

The new groundwater monitoring wells will be similar in construction to the remaining A-zone wells present at the Site. Specifically, they will be 2-inch diameter wells screened across the upper portion of the A-zone, approximately 10 feet in total screen length from an elevation of approximately 8 to -2 feet NAVD88 (North American Vertical Datum of 1988). The new piezometers will be 1 inch in diameter, screened across the upper portion of the A-zone, approximately 10 feet in total screen length from an elevation of approximately 8 to -2 feet NAVD88. For selected monitoring wells, soil boring and grab groundwater investigations in these respective well location areas may be conducted after remedy implementation to confirm the locations and design of the wells prior to their installations.

7.2.1.1 Excavated and Backfilled Area on Former Rifkin Property

Two (2) of the new proposed wells (CDM-101 and CDM-102) will be installed within the excavated and backfilled area on the former Rifkin property, at or near the locations shown on Figure 7-1. CDM-101 and CDM-102 will be installed within low permeability fill.

7.2.1.2 Excavated and Backfilled Area on S-W Property

Two (2) of the new proposed wells (CDM-103 and CDM-104) and the new proposed piezometer (PZ-101) will be installed within the excavated and backfilled area on the S-W property, at or near the locations shown on Figure 7-1. PZ-101 and CDM-103 will be installed within low permeability fill and CDM-104 within high permeability fill.

7.2.1.3 North Side on Former Rifkin Property

Selected existing wells on the former Rifkin property located outside of the excavated and backfilled area will be retained (see Figure 7-1). These existing wells to be retained are: EX-14, EX-15, LF-35, LF-36, LF-37, LF-38, LF-39, LF-40, LF-41, LF-42, MW-1, MW-2, MW-3, RP-1, RP-2, RP-3, RP-4, and RP-5. Six (6) of these existing wells on the former Rifkin property (RP-1, LF-41, LF-36, RP-2, RP-4, and RP-5) will be used as "Rifkin Guard Wells" to verify that additional migration of arsenic and other S-W COCs is not occurring northward across the former Rifkin property.

These wells discussed above are located outside and to the north of the excavated and backfilled area, and will be protected during remedy implementation.

7.2.1.4 North Side on Horton Street

Six existing wells on Horton Street will be retained: LF-12, LF-13, LF-27, LF-28, LF-29, and LF-30 (see Figure 7-1). These wells are located outside and upgradient or cross gradient to the excavated and backfilled area on the SW property and former Rifkin property. Of these wells, LF-12 and LF-28 will be utilized to monitor conditions not affected by the source area.

7.2.1.5 Central Site on S-W Property

Two (2) of the new proposed wells (CDM-105 and CDM-106) will be installed in the central area of the S-W portion of the Site, at or near the locations shown on Figure 7-1. Based on groundwater modeling of conditions after remedy implementation, as presented in Appendix B of the FS (CDM, 2009b), these wells are projected to be downgradient of excavated and backfilled area wells CDM-103 and CDM-104 and upgradient of the slurry wall breaches.

In addition, two (2) of the new proposed wells (CDM-110 and CDM-111) will be installed outside and cross gradient to the excavated and backfilled area on the S-W property, at or near the location shown on Figure 7-1. These proposed wells will be utilized to monitor conditions not affected by the source area.

Two (2) new proposed piezometers will be installed, one near the northeast corner of the S-W property (in the vicinity of existing piezometer LF-PZ-15) and one west of Building 31 (in the vicinity of existing piezometer LF-PZ-11). The piezometers will assist with evaluating the groundwater movement patterns.

7.2.1.6 West Side on S-W Property

Two (2) of the new proposed wells (CDM-107 and CDM-108) will be installed within the downgradient portions of the slurry wall breach locations, at or near the locations shown on Figure 7-1. These two wells will be located within the S-W property.

In addition, one (1) of the new proposed wells (CDM-109) will be installed west, on the downgradient side, of the slurry wall extension, at or near the location shown on Figure 7-1. This proposed well will be located within the S-W property.

7.2.1.7 West Side on Union Pacific Railroad Property

Existing wells LF-24 and LF-25, located on the western, downgradient side of the Union Pacific Railroad property, will be retained (see Figure 7-1). Based on groundwater modeling of conditions after remedy implementation, as presented in the FS (CDM, 2009b), wells LF-24 and LF-25 are projected to be downgradient of wells CDM-107, CDM-108, and CDM-109, and upgradient of the Temescal Creek channel.

7.2.1.8 North Side on S-W Property

Existing well LF-18 on the S-W property will be retained (see Figure 7-1). LF-18 is located outside of the slurry wall system, near the Temescal Creek channel.

7.2.1.9 South Side on Sherwin Avenue

One (1) of the new proposed monitoring wells (CDM-112) will be installed along Sherwin Avenue, at or near the location shown on Figure 7-1. The well will be used to constrain the southern plume extent and assist with evaluating the groundwater movement patterns.

7.2.2 Monitoring Frequency and Sample Analysis

This section presents the monitoring and analysis programs 1) during remedy implementation and 2) for the first four years after remedy implementation.

7.2.2.1 Groundwater Quality Sampling and Analysis

During Remedy Implementation

Table 7-1 provides a summary of the groundwater well monitoring program during remedy implementation.

Dewatering during soil excavation and backfill is expected to temporarily alter groundwater movement paths and, as a result, may draw impacted, upgradient groundwater onto or further onto the former Rifkin property (i.e., drawing groundwater from the east side of Horton Street towards the former Rifkin property). This water movement may also result in the movement of offsite chemical(s) toward

the former Rifkin property. As such, the six Rifkin Guard Wells and well MW-3, which are located closest to apparent source(s) of upgradient, offsite plume(s), will be sampled quarterly during remedy implementation. Results from these samples will be used to assess potential impacts to groundwater on the former Rifkin property from potential spreading of upgradient, offsite plume(s). Any changes in arsenic concentrations for these seven wells that occur during remedy implementation can thus be evaluated.

Groundwater samples from these seven wells will be collected in accordance with methodology for well sampling presented in the existing project Groundwater Monitoring Plan Assessment (LFR, 2006a) and Quality Assurance Project Plan (LFR, 2006b). The samples will be analyzed for arsenic by EPA Method 6010B and VOCs by EPA Method 8260B. In addition, the samples will be measured for the following field parameters during sample collection:

- Temperature
- pH
- Turbidity
- Dissolved Oxygen
- Oxidation-Reduction Potential
- Specific Conductivity

The field parameter results will be used to support the representativeness of the well samples and monitor the relative distribution of oxidizing/reducing conditions.

After Remedy Implementation

Table 7-2 provides a summary of the groundwater well monitoring program after remedy implementation.

With the exception of wells CDM-103, CDM-104, and CDM-112 which will be sampled annually, new monitoring wells installed on the S-W property will be sampled on a semi-annual basis for the first two years after remedy implementation. Following these two years, data from the well samples and the data quality objectives will be used to determine if semi-annual sampling should continue or whether the frequency can be reduced to annual.

If the arsenic concentration for a Rifkin Guard Well or well MW-3 increases above its respective historical maximum detection during remedy implementation, the frequency of groundwater sampling for that well will continue on a quarterly basis after remedy implementation. Quarterly sampling for the well will continue until statistical analysis of the results demonstrates that the arsenic concentration for the well is stable or decreasing; the frequency of sampling for the well will then be

adjusted to semi-annual. Historical maximum arsenic detections for the Rifkin Guard wells and well MW-3 are listed in Table 7-1.

If no increases in arsenic concentrations are observed for these seven wells during remedy implementation, the frequency of groundwater sampling and analysis for arsenic for the Rifkin Guard Wells and all other Site wells for the first four years after remedy implementation will be in accordance with Table 7-2.

If arsenic concentrations in groundwater samples collected from any of the six Rifkin Guard Wells or well MW-3 increase to greater than 500 µg/L during remedy implementation, an additional monitoring well (to be designated CDM-113) would be installed on the former Rifkin property, near former grab groundwater sampling locations RP-BH-012 and CDM-SB1, approximately 120 feet northwest of MW-3 along Horton Street. Well CDM-113 would be similar in construction to the 10 proposed new wells for the Site and would monitor the migration of arsenic in groundwater that could have been pulled onto the former Rifkin property from upgradient, offsite plume(s) during remedy implementation. The frequency of groundwater sampling for CDM-113 would be on a quarterly basis until such time that the data demonstrate that arsenic concentrations are stable or decreasing for CDM-113. The frequency of sampling would then be adjusted to semi-annual.

Groundwater samples will be collected in accordance with the methodology for well sampling presented in the existing project Groundwater Monitoring Plan Assessment (LFR, 2006a) and Quality Assurance Project Plan (LFR, 2006b). The samples will be analyzed for arsenic by EPA Method 6010B and VOCs by EPA Method 8260B. In addition, the samples will be measured for the following field parameters during sample collection:

- Temperature
- pH
- Turbidity
- Dissolved Oxygen
- Specific Conductivity
- Oxidation-Reduction Potential

The field parameter results will be used to support the representativeness of the well samples and monitor the relative distribution of oxidizing/reducing conditions.

7.2.2.2 Depth to Groundwater Measurements

During Remedy Implementation

Table 7-1 provides a summary of the groundwater well monitoring program during remedy implementation.

Dewatering during soil excavation and backfill is anticipated to alter groundwater movement paths and, as a result, may draw upgradient, offsite plume(s) onto or further onto the former Rifkin property. As such, groundwater elevation data will be collected monthly from the six Rifkin Guard Wells and well MW-3. These seven wells are located closest to apparent source(s) of upgradient, offsite plume(s). The monthly data sets will be used to assess potential impacts to groundwater movement conditions on the former Rifkin property regarding potential spreading of upgradient, offsite plume(s) and potential changes in arsenic concentrations for these seven wells.

After Remedy Implementation

Table 7-2 provides a summary of the groundwater well monitoring program for the first four years after remedy implementation.

As the remedy has been designed to control groundwater movement, groundwater elevation data will be collected monthly for the first year from the six Rifkin Guard Wells and well MW-3 to monitor whether groundwater movement patterns are consistent with projected design groundwater model conditions for the remedy, as presented in the FS (CDM, 2009b). The first year's data set will be used to evaluate the effectiveness of the slurry wall segments to divert groundwater, and the effectiveness of the slurry wall breaches to facilitate groundwater movement. After the first year, if groundwater elevations and movement patterns are consistent with projected design conditions, the frequency of groundwater elevation monitoring will be revised to quarterly. The quarterly elevation monitoring data sets will be utilized to continue evaluation of potential seasonal variation in groundwater movement. The frequency of groundwater elevation monitoring will be reevaluated annually.

Should future construction activities affect groundwater movement or rates of infiltration (e.g., redevelopment of the former Rifkin property or S-W property), monthly monitoring will be reinitiated during and post-construction for a period of at least one year to monitor whether groundwater movement patterns continue to be consistent with projected design groundwater model conditions.[1] If groundwater elevations and movement patterns are consistent with projected design conditions, groundwater elevation monitoring will return to its previously established frequency.

Changes to the frequency of groundwater elevation monitoring resulting from a determination that groundwater movement patterns are inconsistent with projected design conditions are further discussed in Section 7.2.5.3.

[1] Based on the type and location of future construction activities, there may be a future need to modify the groundwater monitoring network. As such, S-W may provide written recommendations to DTSC to modify the groundwater monitoring program presented in this document. S-W will implement the changes to the groundwater monitoring program only after approval by DTSC.

7.2.3 Groundwater Quality Effectiveness Criteria

After remedy implementation, samples from the groundwater monitoring wells will be analyzed to evaluate the effectiveness of the remedy. Table 7-3 provides a summary of the groundwater quality effectiveness criteria to be utilized to evaluate the effectiveness of the remedy. The criteria are discussed below.

7.2.3.1 Excavated and Backfilled Area on Former Rifkin Property

It is anticipated that COC concentrations in groundwater within this area will fluctuate after remedy implementation, as the groundwater comes into equilibrium with the backfill material and surrounding groundwater conditions. Samples from wells CDM-101 and CDM-102 will be analyzed to evaluate whether COC concentrations in groundwater in this area are stable or decreasing by no later than four years after remedy implementation. In addition, samples from these wells will be analyzed to evaluate whether arsenic concentrations in this area are less than 5,000 µg/L by no later than four years after remedy implementation.

7.2.3.2 Excavated and Backfilled Area on S-W Property

It is anticipated that COC concentrations in groundwater within this area will fluctuate after remedy implementation, as the groundwater comes into equilibrium with the backfill material and surrounding groundwater conditions. Therefore, samples from wells CDM-103 and CDM-104 will be analyzed to evaluate whether, COC concentrations in groundwater in this area are stable or to decreasing by no later than four years after remedy implementation.

7.2.3.3 North Side on Former Rifkin Property

Samples from the Rifkin Guard Wells will be analyzed to evaluate whether arsenic concentration trends are statistically stable or decreasing after remedy implementation.

7.2.3.4 Central Site on S-W Property

Samples from wells CDM-105 and CDM-106 will be analyzed to determine if there is potential movement of COCs in groundwater toward the west side groundwater monitoring wells CDM-107 and CDM-108.

Samples from wells CDM-110 and CDM-111 will be analyzed to determine if there is potential change in groundwater quality outside of the area affected by the excavated and backfilled area.

7.2.3.5 West Side on S-W Property

Samples from wells CDM-107 and CDM-108 will be analyzed to evaluate whether trends of COC concentrations in groundwater migrating offsite through the slurry wall breaches toward the Union Pacific Railroad property are statistically stable or decreasing, and whether arsenic concentrations exceed 250 µg/L for CDM-107 or 500 µg/L for CDM-108. These arsenic concentration criteria are based on protection of Temescal Creek channel and further discussed in Section 7.3.1.2.

Samples from well CDM-109 will be analyzed to evaluate the effectiveness of the slurry wall extension in containing the onsite groundwater plume and to evaluate whether trends of COC concentrations in groundwater present outside the slurry wall are statistically stable or decreasing.

7.2.3.6 West Side on Union Pacific Railroad Property

Samples from wells LF-24 and LF-25 will be analyzed to evaluate whether COC concentrations in groundwater near the Temescal Creek channel are less than Site cleanup goals or whether their trends are statistically stable or decreasing. Since installation in 1996, arsenic concentrations in samples from these wells have been stable or decreasing. Arsenic concentrations in samples from monitoring well LF-24 since the time of installation in 1996 have been less than 36 µg/L. Arsenic concentrations for LF-25 have been less than 36 µg/L since 2006 and are currently demonstrating a decreasing trend.

7.2.3.7 North Side on S-W Property

Samples from well LF-18 will be analyzed to evaluate whether COC concentrations in groundwater near the Temescal Creek channel are less than Site cleanup goals or whether their trends are statistically stable or decreasing.

7.2.3.8 South Side on Sherwin Avenue

Samples from well CDM-112 will be analyzed to evaluate whether COC concentrations in groundwater in this area are less than Site cleanup goals or whether their trends are statistically stable or decreasing.

7.2.4 Groundwater Movement Effectiveness Criteria

Table 7-3 provides a summary of the groundwater movement criteria to be utilized to monitor the effectiveness of the remedy. The criteria are further discussed below.

7.2.4.1 Groundwater Movement Patterns

Measurements of depths to groundwater in Site wells will be monitored to determine if long-term groundwater movement patterns within the S-W property are consistent with projected design groundwater model conditions for the remedy, as presented in the FS (CDM, 2009b), or as updated during preparation of the RDIP. These conditions include groundwater movement towards the slurry wall breaches and the absence of long-term, localized groundwater mounding.

7.2.4.2 Depths to Groundwater

Groundwater elevation measurements will be evaluated to determine if the depths to groundwater are sufficient to avoid a surface expression of groundwater with a goal of minimizing potential inundation of subsurface utility corridors.

7.2.4.3 Arsenic Mass Flux between CDM-101, CDM-102, CDM-104, and PZ-101

Groundwater elevation measurements, along with concentrations of arsenic in groundwater, from CDM-101, CDM-102, CDM-104, and/or PZ-101 will be evaluated to determine if the net arsenic mass flux within the excavated and backfilled area between the locations of these proposed wells is towards the S-W property west of the former Rifkin property.

As appropriate, the criterion of net mass flux towards the S-W property could be evaluated for other COCs. However, it is not likely to be needed for other COCs as their concentrations for these wells are anticipated to be approximately equal.

7.2.5 Remedy Effectiveness Evaluation

After remedy implementation, the groundwater monitoring data sets will be utilized to evaluate the effectiveness of the remedy and determine if contingency action(s) are needed to achieve Site cleanup goals. The following text summarizes the evaluation process and criteria to be used to determine the need for contingency actions.

7.2.5.1 Groundwater Quality for Wells CDM-101 thru CDM-104, CDM-107 thru CDM-109, CDM-112, LF-18, LF-24, LF-25, and Rifkin Guard Wells

COC concentration trends for these 17 wells will be evaluated by statistical testing, including but not limited to the Mann-Kendall (Gilbert, 1997) nonparametric statistical test. Consistent with U.S. EPA guidance (EPA, 1994), a significance level of 0.05 (i.e., a 95% confidence level) will be used in applying the Mann-Kendall nonparametric test. If an increasing COC concentration trend is found, the frequency of monitoring for the well will be increased to monthly for three months and the 95% UCL concentrations from these four events (the previous scheduled event and subsequent three monthly events) will be used in the Mann-Kendall nonparametric test in place of the previous quarterly event result. If this re-evaluation demonstrates a return to a stable or decreasing COC concentration trend, the frequency of monitoring for the well will return to its previously established frequency listed in Table 7-2. Otherwise, S-W will provide written recommendations to DTSC for implementation of a contingency action (see Section 7.3).

If during establishment of a statistical arsenic concentration trend for wells CDM-107 and CDM-108, arsenic concentrations exceed 250 µg/L for CDM-107 or 500 µg/L for CDM-108, S-W will provide written recommendations to DTSC for implementation of a contingency action (see Section 7.3). These arsenic concentration criteria are based on protection of Temescal Creek channel and further discussed in Section 7.3.1.2.

7.2.5.2 Groundwater Quality for Wells CDM-101 and CDM-102

If four years after remedy implementation the arsenic concentration threshold criterion of 5,000 µg/L is exceeded in samples from either wells CDM-101 or CDM-102, S-W will provide written recommendations to DTSC for implementation of a contingency action (see Section 7.3).

7.2.5.3 Groundwater Movement Patterns

An estimate of groundwater flow direction and hydraulic gradient will be performed following each groundwater elevation monitoring event. The groundwater flow direction and measured hydraulic gradient then will be compared to the projected design groundwater model conditions for the remedy, as presented in the FS (CDM, 2009b), or as updated during preparation of the RDIP. As discussed in Section 7.2.2, the first assessment of this criterion will be conducted after the first year of monthly groundwater elevation monitoring. The groundwater movement conditions that will be monitored as part of the annual assessment will include:

- The slurry wall extension controls groundwater movement to the north and south in the area south of CDM-111;
- Net groundwater movement within the Excavated and Backfilled Area on S-W Property is toward the interceptor trench or the wall breaches near the Union Pacific Railroad property, and not toward Horton Street;
- Net groundwater movement within Excavated and Backfilled Area on Former Rifkin Property is to the north-northwest;
- Net groundwater movement from the high permeability fill area surrounding CDM-104 is toward the slurry wall breaches near the Union Pacific Railroad property, and not toward the former Rifkin property; and
- Mounding of groundwater, to the extent it occurs, is seasonal and generally follows above average precipitation events and does not result in net groundwater movement toward the Rifkin property, movement of water over the top of the slurry wall, or flow around the slurry wall extension.

If the first assessment determines that groundwater movement patterns are consistent with projected design conditions, the frequency of groundwater elevation monitoring will proceed to quarterly as discussed in Section 7.2.2.

If the first assessment or any subsequent annual assessment determines that groundwater movement patterns differ significantly from projected design conditions, S-W will provide written recommendation to DTSC for either implementation of additional monitoring/investigation steps or a contingency action.

Additional monitoring/investigation may include but is not limited to continued/return to monthly groundwater monitoring for an additional year, at

which time a follow up assessment would be made and the monitoring revised as appropriate. Possible contingency action is discussed in Section 7.3.

7.2.5.4 Depths to Groundwater

If one year after remedy implementation the depth to groundwater in any well is measured at or less than four (4) feet bgs, monthly monitoring will be reinitiated for the well to determine if depth to groundwater is exhibiting a rising trend. If the depth to groundwater from three consecutive monthly events is greater than four (4) feet bgs, the frequency of monitoring for the well will return to its previously established frequency. Otherwise, monthly monitoring will continue. If the depth to groundwater in any well is measured at or less than three (3) feet bgs, S-W will provide written recommendations to DTSC for implementation of a contingency action (see Section 7.3).

7.2.5.5 Arsenic Mass Flux between CDM-101, CDM-102, CDM-104, and PZ-101

The projected groundwater model design conditions are intended to prevent long-term (steady-state) groundwater and residual COC movement within the excavated and backfilled area between the locations of these proposed wells towards the former Rifkin property. This additional criterion for monitoring the effectiveness of the remedy includes maintaining a positive mass flux from the former Rifkin property to the S-W property for each COC. As discussed in Section 7.2.4.3, this criterion is anticipated to apply only to arsenic.

After each groundwater elevation monitoring event for the three wells and one piezometer, the hydraulic gradient within the excavated and backfilled area on the former Rifkin property and the contiguous backfilled area to the west, on the S-W property will be calculated. Using the transect method (API, 2003), the arsenic mass flux in groundwater through the cross-sectional area underlying the Rifkin/S-W property line between these wells will be calculated for each event by the following equation:

$$w = (C)(K)(i)(A)(CF)$$

where, w = chemical mass flux through the transect (g/day)
C = concentration of chemical through the transect (mg/L)
K = hydraulic conductivity at the transect (cm/sec)
i = hydraulic gradient at the transect (cm/cm)
A = cross-sectional area associated with the transect (ft^3)
CF = conversion factor, 80.3 (ft/cm)/(sec/day)(L/ft^3)(g/mg)

The calculated mass flux, w, value for each event will include both the magnitude and direction. The direction will be based on assigning a positive hydraulic gradient, i, if groundwater movement is toward Rifkin and negative for movement away from Rifkin. The concentration, C, for each event will be either (1) the concentration of CDM-104 if the groundwater movement is toward Rifkin, or (2) the average of the

arsenic concentration of CDM-101 and CDM-102 if groundwater movement is away from Rifkin.

Due to the uncertainty introduced by variations in percent recovery; quality control; and matrix interferences, there will be inherent variations in the precision and bias of laboratory analytical results for the groundwater samples from the wells used in the flux calculations. Therefore, a default tolerance limit of 20 percent will be used to determine if concentrations are considered different for use in calculating mass flux, i.e., mass flux, w, will be set at zero for each event where arsenic concentrations from wells CDM-101, 102, and CDM-104 differ by or less than 20 percent. As appropriate, this criterion would be applied to other COCs, if concentrations of other COCs for these three wells differ by more than 20 percent.

After the first year of monthly groundwater monitoring, the monthly arsenic mass flux values will be summed to calculate the annual net arsenic mass flux. Each of the monthly mass flux values will represent an approximately equal duration (i.e., one month). If this first year net arsenic mass flux is negative (movement of arsenic away from Rifkin), groundwater monitoring will proceed to quarterly, as discussed in Section 7.2.2.

If the net arsenic mass flux during the first year or any subsequent year is positive (movement of arsenic toward Rifkin), S-W will provide written recommendation to DTSC for either implementation of additional monitoring/investigation steps or a contingency action.

Additional monitoring/investigation may include, but is not limited to, continued/return to monthly groundwater monitoring at these wells for an additional year, at which time a follow up assessment would be made and the monitoring revised as appropriate. Possible contingency action is discussed in Section 7.3.

If the net arsenic mass flux during the first year or any subsequent year exceeds the equivalent to arsenic concentrations of 500 µg/L with a groundwater migration rate of 1 foot/day, S-W will provide written recommendation to DTSC for contingency action (see Section 7.3).

7.3 Contingency Action

Section 7.2.5 presented the criteria for which written recommendations to DTSC for contingency action will be required. The recommendations for contingency action will be consistent with best engineering practices to minimize the potential for any further spread of the COCs and to strive to restore a stable or decreasing groundwater plume. Such contingency action may include, but not be limited to: additional soil excavation and backfill; modifications to permeability of placed fill; in-situ groundwater treatment or in-place geochemistry modifications within the Site or at the slurry wall breaches; modification to the groundwater containment system; and/or active groundwater extraction and treatment.

The submittal to DTSC for the recommended contingency action would also include effectiveness evaluation criteria for the contingency action. S-W would implement the contingency action after approval by DTSC.

7.3.1 Active Groundwater Extraction and Treatment

7.3.1.1 Criteria for Rifkin Guard Wells

If verified arsenic concentrations in samples from any Rifkin Guard Well during evaluation of the contingency action exceed the criteria listed in Table 7-4, S-W will provide written recommendations to DTSC to implement active groundwater extraction and treatment with disposal/reuse of treated water. The objective of the groundwater extraction contingency action, to address exceedance of the Rifkin Guard Well criteria, would be to prevent further migration of arsenic contaminated groundwater onto the former Rifkin property. For this action, further arsenic migration is defined as northerly groundwater movement across the alignment of the Rifkin Guard Wells.

The submittal to DTSC for active groundwater extraction would also include criteria for evaluating the effectiveness of the extraction. Consistent with existing DTSC procedures, S-W would implement active groundwater extraction and evaluate its effectiveness. This evaluation would include consideration of (1) terminating active groundwater extraction and returning to the original remedy (i.e., natural attenuation of arsenic in groundwater) if criteria listed in Table 7-5 are met, or (2) implementation of additional contingency action, if criteria listed in Table 7-5 are not met.

7.3.1.2 Criteria for Wells CDM-107 and CDM-108

If verified arsenic concentrations in samples from CDM-107 or CDM-108 during evaluation of the contingency action exceed the criteria listed in Table 7-4, S-W will provide written recommendations to DTSC to implement active groundwater extraction and treatment with disposal/reuse of treated water. The objective of the groundwater extraction contingency action, to address exceedance of the CDM-107/108 criteria, would be to prevent further migration of arsenic contaminated groundwater through one or both of the slurry wall breaches along the Union Pacific Railroad property, as necessary, to maintain protection of Temescal Creek channel. Supporting information for the contingency action criteria for arsenic listed in Table 7-4 for CDM-107 and CDM-108 is presented in Appendix J.

The submittal to DTSC for active groundwater extraction would also include criteria for evaluating the effectiveness of the extraction. Consistent with existing DTSC procedures, S-W would implement active groundwater extraction and evaluate its effectiveness. This evaluation would include consideration of (1) terminating active groundwater extraction and returning to the original remedy (i.e., natural attenuation of arsenic in groundwater) if criteria listed in Table 7-5 are met, or (2) implementation of additional contingency action if criteria listed in Table 7-5 are not met.

7.3.1.3 Implementation of Active Groundwater Extraction

The objective of the active groundwater extraction contingency action would be to control further migration of arsenic impacted groundwater on the former Rifkin property or through the slurry wall breaches. A contingency action that includes groundwater extraction would be implemented within the area of the higher permeability backfill on the S-W property (as discussed in Section 6). The uniform nature of this higher permeability backfill would facilitate enhanced hydraulic communication with surrounding native materials, backfill in the remainder of the Site, and the interceptor trench.

Using the groundwater model for the Unit A aquifer (A-zone) developed for the FS (CDM, 2009b), a groundwater extraction scenario has been evaluated for conditions anticipated to be present after implementation of the preferred remedy. Based on the groundwater model simulation results, a single groundwater extraction well within the higher permeability backfill on the S-W property would be sufficient to simultaneously meet the objectives of contingency actions for both the former Rifkin property and the slurry wall breaches. Under this selected groundwater extraction scenario, a pumping rate of approximately 3.1 gallons per minute (gpm) from this well would be sufficient to maintain a hydraulic capture zone that extends to the Rifkin Guard Wells and the downgradient slurry wall breach nearest to the source area. The model indicates that of the two downgradient slurry wall breaches along the Union Pacific Railroad property, the one associated with well CDM-108 is the more likely to first have potential increases in COC concentrations that would trigger a need for contingency action.

The groundwater model simulation results include a presentation of the steady-state potentiometric surface contours and particle tracking showing groundwater movement in the A-zone that would develop due to pumping from this single groundwater extraction well within the high permeability backfill on the S-W property. The results demonstrate that this contingency groundwater extraction action would adequately provide control of migration of COCs in groundwater. Details of the groundwater model evaluation and simulation results are included in Appendix K.

7.4 Reporting

Results from post-remediation activities will be provided to DTSC on a quarterly basis for the first four years, at which time an evaluation will be made as to appropriate reporting frequency. These reports will include summaries of OM&M events and results of the groundwater monitoring program. The reports will detail deviations from this OM&M and groundwater monitoring plans, if any, provide an explanation for the deviations and recommendations for future actions or changes to monitoring protocols. If at anytime, data or other information indicates that there is an immediate issue or impact to human health or environment, this data or information will be reported immediately to DTSC.

Table 7-1
Well Construction Details and Monitoring Program During Remedy Implementation
Sherwin-Williams Emeryville Remedial Action Plan

Well Number	Well Construction Details										*Well Monitoring Program During Excavation/Backfill*				*Maximum Arsenic Concentration Detected from Well (ug/L) thru April 2008* [2]
	Date Constructed	*Top of Casing Elevation* (feet NAVD88)	*Total Depth* (feet bgs)	*Casing Material*	*Casing Diameter* (inches)	*Screen Slot Size* (inches)	*Screen Interval Depths* Top (feet toc)	Bottom (feet toc)	*Screen Interval Elevations* Top (feet NAVD88)	Bottom (feet NAVD88)	*Depth To Groundwater*	*Arsenic by EPA Method 6010B*	*Volatile Organic Compounds by EPA Method 8260B*	*Field Parameters* [1]	
Existing Wells															
Former Rifkin Property															
RP-1	7/26/1994	17.84	13	PVC	2	0.010	7.0	12.0	10.8	5.8	Monthly	Quarterly	Quarterly	Each Event	95
RP-2	7/25/1994	17.94	15	PVC	2	0.010	8.5	14.5	9.4	3.4	Monthly	Quarterly	Quarterly	Each Event	37
RP-4	7/25/1994	17.83	17	PVC	2	0.010	7.0	17.0	10.8	0.8	Monthly	Quarterly	Quarterly	Each Event	15
RP-5	7/25/1994	17.74	15	PVC	2	0.010	7.0	15.0	10.7	2.7	Monthly	Quarterly	Quarterly	Each Event	11
LF-36	1/3/2000	18.87	16	PVC	2	0.020	7.0	16.0	11.9	2.9	Monthly	Quarterly	Quarterly	Each Event	65
LF-41	12/29/1999	18.24	15	PVC	2	0.020	7.0	15.0	11.2	3.2	Monthly	Quarterly	Quarterly	Each Event	97
MW-3	12/8/1994	17.30	19.5	PVC	2	0.010	6.5	19.5	10.8	-2.2	Monthly	Quarterly	Quarterly	Each Event	120

Notes:
NADV88: North American Vertical Datum of 1988
bgs: below ground surface
toc: top of casing
PVC: polyvinyl chloride
ug/L: microgram per liter
1 - Field parameters include: temperature, pH, turbidity, dissolved oxygen, and oxidation-reduction potential.
2 - LFR Inc. 2008. Combined Groundwater and NPDES Self-Monitoring Report, Sherwin-Williams Facility, 1450 Sherwin Avenue, Emeryville, California. July 30.

Table 7-2
Well Construction Details and Monitoring Program After Remedy Implementation
Sherwin-Williams Emeryville Remedial Action Plan

Well Number	**Well Construction Details**										***Well Monitoring Program After Excavation/Backfill*** [1]			
	Date Constructed	***Top of Casing Elevation*** (feet NAVD88)	***Total Depth*** (feet bgs)	***Casing Material***	***Casing Diameter*** (inches)	***Screen Slot Size*** (inches)	***Screen Interval Depths*** Top (feet toc)	Bottom (feet toc)	***Screen Interval Elevations*** Top (feet NAVD88)	Bottom (feet NAVD88)	***Depth To Groundwater*** [2]	***Arsenic by EPA Method 6010B***	***Volatile Organic Compounds by EPA Method 8260B***	***Field Parameters*** [3]
Existing Wells														
Horton Street														
LF-12	11/2/1989	17.65	18	PVC	4	0.020	7.5	17.5	10.2	0.1	Monthly/Quarterly	Annually	Annually	Each Event
LF-13	11/2/1989	17.48	18	PVC	4	0.020	7.0	17.0	10.5	0.5	Well retained for possible future monitoring, if needed			
LF-27	12/22/1997	17.83	18	PVC	2	0.010	10.0	18.0	7.8	-0.2	Well retained for possible future monitoring, if needed			
LF-28	12/22/1997	17.09	18	PVC	2	0.010	6.5	18.0	10.6	-0.9	Monthly/Quarterly	Annually	Annually	Each Event
LF-29	12/23/1997	16.40	20	PVC	2	0.010	6.0	19.0	10.4	-2.6	Well retained for possible future monitoring, if needed			
LF-30	12/23/1997	15.86	19	PVC	2	0.010	6.0	18.5	9.9	-2.6	Well retained for possible future monitoring, if needed			
Former Rifkin Property														
RP-1[a]	7/26/1994	17.84	13	PVC	2	0.010	7.0	12.0	10.8	5.8	Monthly/Quarterly	Quarterly/Semi-Annually [4]	Annually	Each Event
RP-2[a]	7/25/1994	17.94	15	PVC	2	0.010	8.5	14.5	9.4	3.4	Monthly/Quarterly	Quarterly/Semi-Annually [4]	Annually	Each Event
RP-3	7/26/1994	17.87	13	PVC	2	0.010	8.0	12.5	9.9	5.4	Monthly/Quarterly	Semi-Annually	Annually	Each Event
RP-4[a]	7/25/1994	17.83	17	PVC	2	0.010	7.0	17.0	10.8	0.8	Monthly/Quarterly	Quarterly/Semi-Annually [4]	Annually	Each Event
RP-5[a]	7/25/1994	17.74	15	PVC	2	0.010	7.0	15.0	10.7	2.7	Monthly/Quarterly	Quarterly/Semi-Annually [4]	Annually	Each Event
LF-35	9/21/199	18.93	27	PVC	2	0.010	24.0	27.0	-5.1	-8.1	Monthly/Quarterly	Annually	Annually	Each Event
LF-36[a]	1/3/2000	18.87	16	PVC	2	0.020	7.0	16.0	11.9	2.9	Monthly/Quarterly	Quarterly/Semi-Annually [4]	Annually	Each Event
LF-37	1/4/2000	18.54	16	PVC	2	0.020	7.0	16.0	11.5	2.5	Monthly/Quarterly	Semi-Annually	Annually	Each Event
LF-38	1/4/2000	18.51	27	PVC	2	0.020	20.0	27.0	-1.5	-8.5	Monthly/Quarterly	Annually	Annually	Each Event
LF-39	1/3/2000	18.97	26	PVC	2	0.020	18.0	26.0	1.0	-7.0	Monthly/Quarterly	Annually	Annually	Each Event
LF-40	1/4/2000	18.84	15	PVC	2	0.020	7.0	15.0	11.8	3.8	Monthly/Quarterly	Semi-Annually	Annually	Each Event
LF-41[a]	12/29/1999	18.24	15	PVC	2	0.020	7.0	15.0	11.2	3.2	Monthly/Quarterly	Quarterly/Semi-Annually [4]	Annually	Each Event
LF-42	1/5/2000	17.29	16	PVC	2	0.020	7.0	15.0	10.3	2.3	Monthly/Quarterly	Semi-Annually	Annually	Each Event
EX-14	12/29/1999	18.74	16	SS	6	0.010	5.5	15.5	13.2	3.2	Well retained for possible future monitoring, if needed			
EX-15	12/29/1999	17.88	17	SS	6	0.010	7.0	17.0	10.9	0.9	Well retained for possible future monitoring, if needed			
MW-1	12/9/1994	16.48	19	PVC	2	0.010	7.0	17.0	9.5	-0.5	Well retained for possible future monitoring, if needed			
MW-2	12/8/1994	16.29	19	PVC	2	0.010	5.0	17.0	11.3	-0.7	Well retained for possible future monitoring, if needed			
MW-3	12/8/1994	17.30	20	PVC	2	0.010	6.5	19.5	10.8	-2.2	Monthly/Quarterly	Quarterly/Semi-Annually [4]	Annually	Each Event
Sherwin-Williams Property														
LF-18	2/5/1996	15.75	19	PVC	2	0.010	8.0	18.0	7.8	-2.3	Monthly/Quarterly	Annually	Annually	Each Event
Union Pacific Railroad Property														
LF-24	4/4/1996	12.92	17	PVC	2	0.010	7.0	17.0	5.9	-4.1	Monthly/Quarterly	Annually	Annually	Each Event
LF-25	4/4/1996	14.01	18	PVC	2	0.010	8.0	18.0	6.0	-4.0	Monthly/Quarterly	Annually	Annually	Each Event

Table 7-2
Well Construction Details and Monitoring Program After Remedy Implementation
Sherwin-Williams Emeryville Remedial Action Plan

Well Number	**Well Construction Details**										***Well Monitoring Program After Excavation/Backfill*** [1]			
	Date Constructed	***Top of Casing Elevation*** (feet NAVD88)	***Total Depth*** (feet bgs)	***Casing Material***	***Casing Diameter*** (inches)	***Screen Slot Size*** (inches)	***Screen Interval Depths*** Top (feet toc)	Bottom (feet toc)	***Screen Interval Elevations*** Top (feet NAVD88)	Bottom (feet NAVD88)	***Depth To Groundwater*** [2]	***Arsenic by EPA Method 6010B***	***Volatile Organic Compounds by EPA Method 8260B***	***Field Parameters*** [3]
Proposed Wells [5]														
Former Rifkin Property														
CDM-101	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually	Semi-Annually	Each Event
CDM-102	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually	Semi-Annually	Each Event
Sherwin-Williams Property														
CDM-103	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Annually	Annually	Each Event
CDM-104	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Annually	Annually	Each Event
CDM-105	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually/Annually [6]	Annually	Each Event
CDM-106	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually/Annually [6]	Annually	Each Event
CDM-107	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually	Semi-Annually	Each Event
CDM-108	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually	Semi-Annually	Each Event
CDM-109	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually/Annually [6]	Annually	Each Event
CDM-110	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually/Annually [6]	Annually	Each Event
CDM-111	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Semi-Annually/Annually [6]	Annually	Each Event
CDM-112	--	--	--	PVC	2	0.010	--	--	8	-2	Monthly/Quarterly	Annually	Annually	Each Event
Proposed Piezometers														
Sherwin-Williams Property														
PZ-101	--	--	--	PVC	1	0.010	--	--	8	-2	Monthly/Quarterly	--	--	--
PZ-102	--	--	--	PVC	1	0.010	--	--	8	-2	Monthly/Quarterly	--	--	--
PZ-103	--	--	--	PVC	1	0.010	--	--	8	-2	Monthly/Quarterly	--	--	--

Notes:

NADV88: North American Vertical Datum of 1988

bgs: below ground surface

toc: top of casing

PVC: polyvinyl chloride

SS: stainless steel

a - Designated Rifkin Guard Well.

1 - Monitoring program is only for the first four years after remedy implementation.

2 - Depth to groundwater measured monthly for first year and then quarterly for next three years; should there be a change in the rate of infiltration that affects groundwater flow conditions, monthly monitoring would be reinitiated for at least one year.

3 - Field parameters include: temperature, pH, turbidity, dissolved oxygen, oxidation-reduction potential, and specific conductivity.

4 - Frequency of monitoring for arsenic for this well will be quarterly if arsenic concentrations for this well increases above its historical maximum detection during remedy implementation; otherwise, the frequency will be semi-annually.

5 - In addition to the 12 proposed wells presented in this table, a thirteenth contingent well (CDM-113) will be installed if arsenic concentrations from any of the Rifkin Guard Wells or MW-3 increase to above 500 micrograms per liter (ug/L) during remedy implementation; CDM-113 would be installed in the vicinity of soil boring locations CDM-SB1 and RP-BH-012, approximately 120 feet northwest of MW-3 along Horton Street. If installed, the well would be monitored and sampled similar to LF-36.

6 - Frequency of monitoring for arsenic for this well will be semi-annually for the first two years; if after two years arsenic concentration is stable to decreasing, frequency of monitoring will be modified to annually; otherwise, it will remain semi-annually.

Table 7-3
Remedy Effectiveness Evaluation Criteria
Sherwin-Williams Emeryville Remedial Action Plan

Groundwater Quality Effectiveness Criteria [1]	
Well	**Remedy Effectiveness Evaluation Criteria**
Former Rifkin Property	
CDM-101	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing four years after remedy implementation, and arsenic is less than 5,000 ug/L four years after remedy implementation
CDM-102	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing four years after remedy implementation, and arsenic is less than 5,000 ug/L four years after remedy implementation
RP-1[a]	Arsenic concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
RP-2[a]	Arsenic concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
RP-4[a]	Arsenic concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
RP-5[a]	Arsenic concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
LF-36[a]	Arsenic concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
LF-41[a]	Arsenic concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
Sherwin-Williams Property	
LF-18	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
CDM-103	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
CDM-104	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
CDM-107	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
CDM-108	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
CDM-109	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
CDM-112	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
Union Pacific Property	
LF-24	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing
LF-25	COC concentrations are less than Site cleanup goals or their trends are statistically stable to decreasing

Groundwater Movement Effectiveness Criteria
1. Long-term groundwater flow patterns are consistent with projected design groundwater model conditions.
2. Long-term arsenic in groundwater mass flux at the Rifkin/S-W property line between CDM-101/CDM-102 and PZ-101/CDM-104 is westward, from the former Rifkin property to the S-W property.
3. Absence of long-term groundwater mounding at the Site.
4. Depths to groundwater at all wells are more than 3 feet below ground surface.

Notes:

COC: chemical of concern

ug/L: microgram per liter

a - Designated Rifkin Guard Well.

1 - Wells not presented do not have groundwater quality remedy effectiveness evaluation criteria. In addition to the wells indentified on the former Rifkin property, contingent well CDM-113 (see Table 7-2), if installed, would be monitored and evaluated for remedy effectiveness, similar to LF-36.

Table 7-4
Criteria for Implementing Active Groundwater Extraction
Sherwin-Williams Emeryville Remedial Action Plan

Well	Criteria for Implementing Active Groundwater Extraction [1]
Former Rifkin Property (Guard) Wells	
RP-1[a]	Increasing arsenic concentration trend with concentration greater than higher of 150 ug/L or 150% of the maximum arsenic concentration detected for the well prior to or during remedy implementation
RP-2[a]	Increasing arsenic concentration trend with concentration greater than higher of 75 ug/L or 150% of the maximum arsenic concentration detected for the well prior to or during remedy implementation
RP-4[a]	Increasing arsenic concentration trend with concentration greater than higher of 75 ug/L or 150% of the maximum arsenic concentration detected for the well prior to or during remedy implementation
RP-5[a]	Increasing arsenic concentration trend with concentration greater than higher of 75 ug/L or 150% of the maximum arsenic concentration detected for the well prior to or during remedy implementation
LF-36[a]	Increasing arsenic concentration trend with concentration greater than higher of 75 ug/L or 150% of the maximum arsenic concentration detected for the well prior to or during remedy implementation
LF-41[a]	Increasing arsenic concentration trend with concentration greater than higher of 150 ug/L or 150% of the maximum arsenic concentration detected for the well prior to or during remedy implementation
Sherwin-Williams Property Wells	
CDM-107	Increasing arsenic concentration trend with concentration greater than 250 ug/L
CDM-108	Increasing arsenic concentration trend with concentration greater than 500 ug/L

Notes:

COC: chemical of concern

ug/L: microgram per liter

a - Designated Rifkin Guard Well.

1 - Wells not presented do not have criteria for implementing active groundwater extraction.

Table 7-5
Criteria to Terminate Active Groundwater Extraction
Sherwin-Williams Emeryville Remedial Action Plan

Well	*Criteria to Terminate Active Groundwater Extraction and Return to Monitored Natural Attenuation* [1]	*Maximum Arsenic Concentration Detected from Well thru April 2008* [2]
Former Rifkin Property		
RP-1[a]	Arsenic concentration less than higher of 100 ug/L or maximum arsenic concentration detected prior to or during remedy implementation	95
RP-2[a]	Arsenic concentration less than higher of 50 ug/L or maximum arsenic concentration detected prior to or during remedy implementation	37
RP-4[a]	Arsenic concentration less than higher of 50 ug/L or maximum arsenic concentration detected prior to or during remedy implementation	15
RP-5[a]	Arsenic concentration less than higher of 50 ug/L or maximum arsenic concentration detected prior to or during remedy implementation	11
LF-36[a]	Arsenic concentration less than higher of 65 ug/L or maximum arsenic concentration detected prior to or during remedy implementation	65
LF-41[a]	Arsenic concentration less than higher of 100 ug/L or maximum arsenic concentration detected prior to or during remedy implementation	97
Sherwin-Williams Property		
CDM-107	Arsenic concentration less than 250 ug/L	Not applicable [3]
CDM-108	Arsenic concentration less than 500 ug/L	Not applicable [3]

Notes:

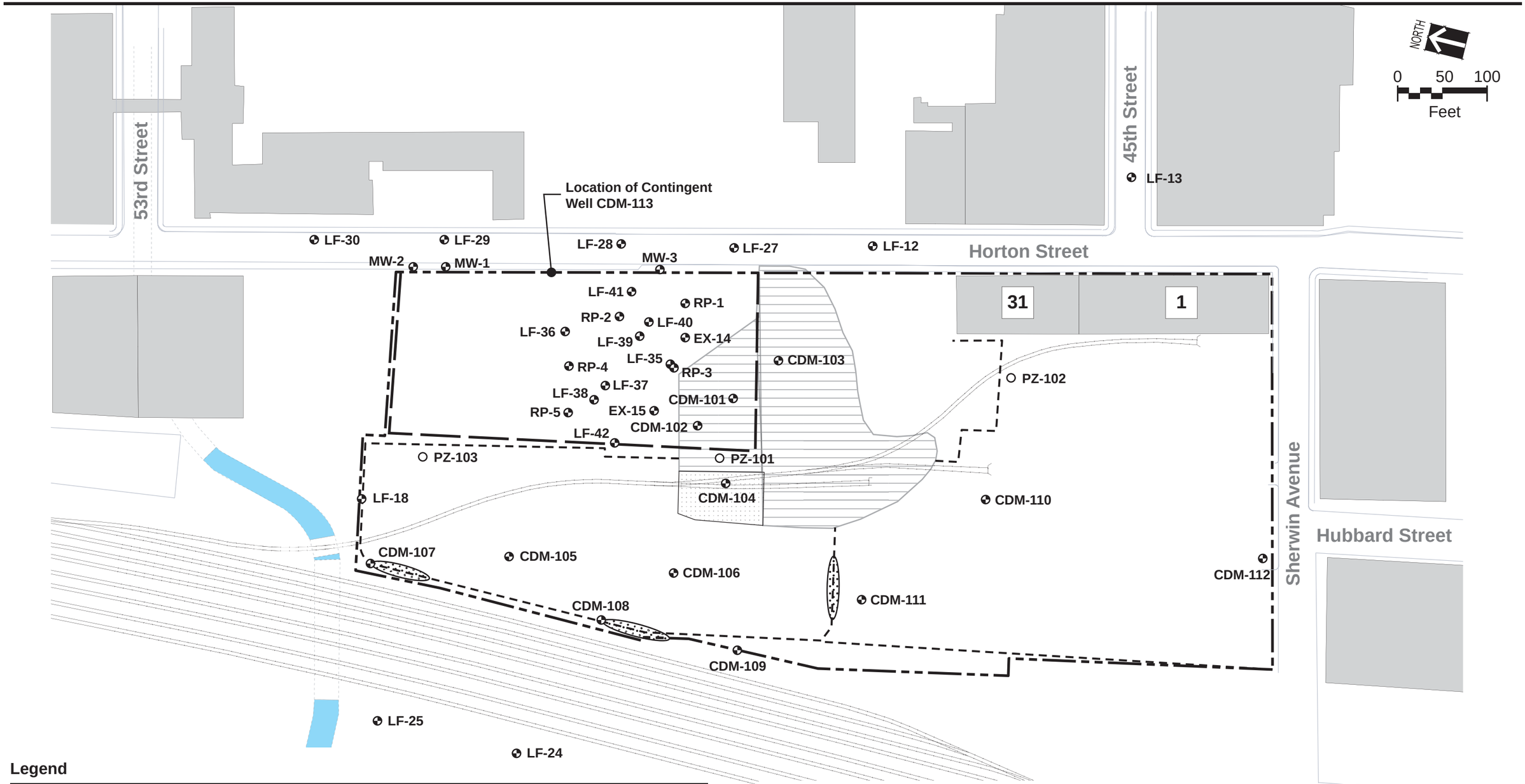
ug/L: microgram per liter

a - Designated Rifkin Guard Well.

1 - Wells not presented do not have criteria to terminate active groundwater extraction and return to monitored natural attenuation.

2 - LFR Inc. 2008. Combined Groundwater and NPDES Self-Monitoring Report, Sherwin-Williams Facility, 1450 Sherwin Avenue, Emeryville, California. July 30.

3 - CDM-107 and CDM-108 to be installed during remedy implementation.



Legend

- Site Boundary
- Slurry Wall
- Post Remedy Implementation Monitoring Well
- Post Remedy Implementation Piezometer
- Slurry Wall Breach
- Saturated Soil Excavation and Low Permeability Backfill
- Saturated Soil Excavation and High Permeability Backfill

Notes:

1. New wells CDM-101 through CDM-112 and piezometers PZ-101 through PZ-103 will be installed at end of implementation activities. All other wells shown are existing and will be protected during implementation activities.
2. Existing site wells not shown will be destroyed before or with implementation activities.

W:\REPORTS\Sherwin-Williams\Emeryville\Remedial Action Plan\Graphics\Monitoring Locations (Fig7-1).ai 05/11/10 JJT

CDM

Figure 7-1

Preliminary Post Remedy Implementation Groundwater Monitoring Locations

Sherwin-Williams Company - Emeryville, California

Section 8
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UNIVERSITY OF CALIFORNIA PUBLICATIONS
AMERICAN ARCHAEOLOGY AND ETHNOLOGY
Vol. 7 No. 1

THE EMERYVILLE SHELLMOUND

BY
MAX UHLE



BERKELEY
THE UNIVERSITY PRESS
JUNE, 1907

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THE EMERYVILLE SHELLMOUND.

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MAX UHLE.

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Introduction.

California has but few characteristic archaeological remains such as are found in the mounds of the Mississippi valley or the ancient pueblos and cliff-dweller ruins of the South. In the shell-mounds along this section of the Pacific coast it possesses, however, valuable relics of very ancient date. These are almost the only witnesses of a primitive stage of culture which once obtained among the early inhabitants of this region.

Some years ago Professor Merriam recognized the necessity of exploring these ancient mounds and represented the facts to the University of California. Mrs. Phoebe A. Hearst generously made the undertaking possible by providing ample financial support for the exploration work.

One of the largest and best preserved shellmounds was selected

as the object of the present investigation, which was entrusted to Professor Merriam and the writer. The mound selected is situated on the eastern side of the Bay of San Francisco at Shellmound Station near Emeryville, and is commonly known as the Emeryville mound. At present it forms a conspicuous feature of the recreation grounds known as Shellmound Park (pl. 1).

The water of the bay rises to within 130 feet of the base of the mound (pl. 3) during high tide. The beach is then only one foot above the water level, while the ground in the immediate vicinity of the mound is from two to three feet higher. This ground is quite level and forms a part of an extensive alluvial flat. A small creek, having its source about three miles away, in the hills back of Berkeley, passes the mound on its south side, at a distance of two hundred feet, and empties into the bay. In summer the creek runs dry, but its bed furnishes a channel for subterranean water. Another, lower mound, containing graves, lay on the site of the Emeryville race-track near by, but it has been leveled down during the construction of the track. The shellmound which was the object of the excavation has the form of a truncated cone, with a diameter of 270 feet at its base and 145 feet at the top, and rising 27 feet above the plain. On the north side its foot extends 100 feet farther over the flat, a few feet higher than the level of the ground about it.

Twenty-five or thirty years ago the shore line of the bay lay fifty feet farther out; a pile set at that time is still to be seen at that distance from the beach. It is above the water during high tide and marks the coast line on this side of which floodland was sold by the State. The top of the mound was not at that time crowned by the wooden pavilion which is there at the present time. It was still ungraded, having its natural conical form, and was covered with a wild growth of bushes and brambles. The creek, as yet unregulated, followed its own course and overflowed the land, causing it to become marshy. In the seventies and eighties of the last century, railroad tracks were laid along the eastern side of the mound, and took in a section of its eastern foot. At that time a number of graves and Indian artifacts were discovered. Few of these, however, found their way into the collections of the University, then but recently founded.



Map of the east shore of San Francisco Bay in the vicinity of Berkeley, showing the location of the Emeryville Shellmound with several others in this region. Scale: 1 inch = about three miles.

Early Settlements in the Region.

Fages, the first traveler who passed through the country, from south to north, traveled along the eastern shore of the Bay of San Francisco in 1774,[1] and came upon Indian settlements where he found a friendly welcome. His account of this expedition, however, fails to throw any light upon the question whether or not the shellmounds were still occupied at that time. The neighboring creek bears the name of "Temescal" from a region between Berkeley and Oakland through which it passes.[2] This name appears to be a mutilation of the Nahua word "temazcalli," hothouse, the name of sweat-houses in Mexico, and the place may have been so named by Mexicans living on the Bay, from an Indian sweat-house standing there. Hence it may be assumed that an Indian settlement was in existence on the banks of this creek at a time from which the name could pass over into the existing vocabulary.

Other evidences of early Indian settlements in this section of the eastern shore country of the Bay are the shellmounds, twelve of which may be found along the coast between Point Richmond and Alameda in a stretch of twelve miles (pl. 1). They may be seen near Point Richmond upon the eastern side, facing the peninsula, upon Brooks Island, near Ellis Landing, northeast from Stege upon a marshy ground intersected by narrow channels, near Seaver's Ranch to the west from Stege, on Point Isabel, in West Berkeley, in Emeryville, and in the eastern section of Alameda between Mound, Central, and Lincoln avenues. There is also said to have been one in East Oakland on the canal between Oakland Harbor and Lake Merritt, but it has disappeared owing to building over that section of ground. In all probability many others may have met with a similar fate.

All these evidences of an early occupation of the country are but a few of the mounds that skirt the Bay upon all sides, continuing along Suisun Bay and the Sacramento and Feather rivers. Besides these, there are numerous mounds dotting the coast land

[1] Cf. H. H. Bancroft, The Native Races, 1886, II, p. 595.

[2] Cf. also "San Francisco Quadrangle" with the topographical maps of California by the U. S. Geological Survey.

of Northern California, those surrounding swamps and rivers along the Tulare and Kern lakes in southern California,[3] and on the shore near Santa Cruz. Others are found in the regions of San Luis Obispo,[4] of Santa Barbara,[5] and the islands opposite that place.

Early References to Shellmounds of Middle California.

All the publications treating of the shellmounds of central and northern California, which from the nature of their contents are different from those of the coast and the islands of southern California, may be condensed into the following bibliography:

The Smithsonian Reports of 1869 mention a collection of artifacts from the shellmounds of Alameda county presented to the Institute by Dr. Yates.[6] J. W. Foster, in 1874, speaks of a newspaper notice concerning a shellmound in the region of San Pablo.[7] James Deans follows in 1876 with a short notice (together with drawings of some artifacts) concerning a mound between Visitacion Valley and Point Bruno on the western shore of the Bay.[8] A short notice by H. H. Bancroft, accompanied by views of four objects, points to the great historical value of the shellmounds.

[3] Warren K. Moorehead, Prehistoric Implements, 1900, p. 258.

[4] Paul Schumacher, Smithson. Reports, 1874, p. 335 ff.

[5] Schumacher, Bulletin of the U. S. Geol. and Geogr. Survey of the Territories (F. V. Hayden), 1877, III, p. 73 ff.; F. W. Putnam, Reports upon Archaeological and Ethnological Collections from vicinity of Santa Barbara, Cal., etc.; Report upon U. S. Geogr. Surveys west of the 100th Meridian (G. M. Wheeler), 1879, VII, Archaeology. From more northern sections of the Pacific Coast may be mentioned specifically the shellmounds of Oregon (P. Schumacher, Bulletin, *l. c.*), of Vancouver, and of the mainland of British Columbia opposite (H. H. Bancroft, Native Races of the Pacific States, 1886, IV, p. 739), also those upon the Aleutian Islands, explored exhaustively by W. H. Dall (in U. S. Geogr. and Geol. Survey of the Rocky Mountain Region, J. W. Powell, Contributions to the North American Ethnology, 1877, I, p. 41 ff.). Together with those of California these shellmounds are an important counterpart to those found along the Atlantic coast, found from Nova Scotia to the Gulf of Mexico, as well as in the river valleys of nearly all the southern states (Charles C. Abbott, Primitive Industry, 1881, p. 439; Short, The North Americans of Antiquity, 1892, p. 106), and almost all of which have been carefully studied in some of their aspects, although not yet conclusively.

[6] Smithson. Reports, 1869, p. 36.

[7] Prehistoric races of the United States of America, 1874, p. 163.

[8] Journal of the Anthropological Inst. of Great Britain and Ireland, 1876, V, p. 489. The majority of these shellmounds have been graded down.

The Marquis de Nadaillac in his well known work mentions the shellmounds in the vicinity of San Francisco.[9] Moorehead in his work gives a few remarks on excavations in shellmounds of central California.

The Nature of the Excavations.

The work of exploration was commenced by Professor Merriam and the writer in February, 1902, toward the end of the rainy season, and was finished early in May. Captain Siebe, the proprietor of Shellmound Park, gave all possible assistance in the investigation. Owing to the presence of the circle of trees around the truncated top of the mound it was necessary to confine the excavations to a lateral section and a tunnel extending from it toward the center of the mound. However desirable a more extended section through the hill might have been, the results obtained in these partial excavations are as a whole similar to those which would have been obtained by a cut through the entire mound.

The western slope of the mound, facing the bay, was selected as the starting point for the operations. The entire work of excavation may in a chronological order be divided into the following four stages.

A. The first lateral cutting in the mound. This was made in the western foot of the mound, seven feet and a half above the level of the bay and at a distance of fifty feet from the plateau. The trench was two feet deep, eighteen feet long and six feet wide, its floor sloped towards the center of the mound.

B. Tunnel construction. The tunnel formed the underground continuation of the trench; it was the means of reaching the interior of the mound and down to its original base. Hence the floor of the tunnel was made to slope steeply inward. The tunnel was extended from the end of the trench *A* for forty-two feet into the interior of the mound, and at its terminal point it sank to two feet below the level of the bay. It was five feet wide and six and a half feet high. Several distinct strata were cut through by the tunnel section. Eleven feet of the length of the tunnel extended under the plateau of the mound. This was still

[9] Prehistoric America, ed. by W. H. Dall, 1885, p. 50.

sixty feet from the vertical center of the hill (pl. 4), but the observations made in this interior part of the mound were of a relatively greater value than those of the outer zone. Many difficulties were met during the construction of the tunnel, among which the porosity of the soil was one of the worst. The tunnel was therefore timbered and its sides sheathed. Another difficulty was the ground water, of which there was often a very strong flow when digging in the lower part of the tunnel. According to the advance of the season, it was encountered at different depths, and it grew less with the approach of summer. A small hand pump was used to exhaust this water, but it barely answered the purpose, and it was often with great difficulty that the inrushing water could be mastered.

C. The upper vertical cut of the entire mound. In order to obtain a view of all the strata contained in the mound this section was undertaken. The lowest parts of the mound having been thoroughly explored by the construction of the tunnel, it was now sufficient to make the upper sectional cut only as deep as the roof of the tunnel, while its terminal point was fixed by the circle of trees on the summit of the mound. Its greatest length from the mouth of the tunnel was twenty-six feet. The sides of the cut were sloped in order to prevent the fall of loose soil and to avoid the cost of timbering. The length of this section at its lower end, near *b* (pl. 4), was reduced from 26 feet to 19 feet, and the width to 10 feet along the entire foot of the trench from a^{9a} to *b*. In pl. 5 there is shown the first cut into the mound, before it had been made wider by five feet throughout its length. In making this cut the earth was removed stratum by stratum. For want of other marks of division, the dividing lines of the various strata (I to VII) were chosen arbitrarily from the several visible lines of structure, and they are marked in the diagram, pl. 4, by asterisks. In order to obtain a uniform classification of the contents of the mound it was thought necessary to introduce the same lines of division in the sectional diagram of the tunnel; objects found there had been marked previously by the distance of their position from the mouth of the tunnel and their relative height.

[9a] *a* seems to have been situated at the intersection of the dotted lines separating divisions *A*, *B*, *C*, pl. 4, fig. 2.—Editor.

These strata in conformity with the numbering of the upper ones were marked as numbers VII to X.

D. A series of pits was dug from the foot of the tunnel out to the bay shore. The pits were made in order to ascertain the general outline of the base of the mound under the cuts already made, as well as under the unexcavated portion of the mound farther out toward its margin. The pits are marked as *h* in the interior of the mound, and as *i, k, l, m,* toward its periphery. The two pits *n* and *o*[9b] are situated on the outside of the superficial foot of the mound, at a distance of 35 feet and 67 feet from the nearest pit, *m*. It was here seen that the terminal point of the foot of the mound lay between the pits *n* and *o,* the pit near *n* showing only the debris of the shellmound, while that near *o* revealed nothing of it. These two pits were connected by a trench, which gave an exceedingly interesting section of the margin of the mound.

The Base of the Mound.

The mound consists mainly of a mass of broken or entire shells, ashes, bits of charcoal, and some artifacts. This mass extends far above the surface of the surrounding land and ends two and a half feet below the level of the ground water and two feet below the general tide level of the bay, and rests immediately upon a sharply defined yellowish alluvial clay stratum. There is no indication of a rocky elevation which might have served as an inducement for the original settlement, and would have helped to raise the mound to its present height. Some of the charcoal and small boulders brought here by man rest upon the clay soil. A slight discoloration of the upper line of the clay stratum may have been caused by a transitory plant growth during some early period, while there is no indication of a crust of good soil which would be a sign of a longer period of vegetable growth upon it.

The base of the mound is horizontal according to all indications gained between pits *h* and *m*. A slight variation of the level of the ground near *h* of but a few inches does not materially change this level. Between *m* and *n*, however, the original

[9b] Pit *o* referred to in the text seems to be represented in pl. 4, fig. 1, by the west end of the cut extending from *n* to *l*.—Editor.

soil lies one foot and seven inches lower for a distance of thirty-five feet, and from *n* to *o* the level drops a foot lower. The mound was originally founded upon a site rising two feet above the adjacent ground on its western side. A gravel stratum of 8 inches in thickness near *o*, and of 4 inches near *p*, but disappearing towards *n*, covered the clay which originally sloped to the west. This gravel stratum was examined by Professor Lawson and considered to be probably a fresh-water deposit and not a deposit formed in the bay, as the gravel is more or less angular instead of much water-worn. The mound terminates near *p*, 177 feet from its center, where it runs to a point between layers of clay, which are above and below it (pl. 4, fig. 1). It rises again toward the outside for the last 17 feet measured from the depression *n*, the difference being one and one-quarter feet, thus varying from the rest of the base which inclines to the west. A stratum of ferruginous clay, the same as that underlying the base of the mound, is here inserted between the gravel stratum and the characteristic mixture of which the mound is composed, and covers it up even with the present surface of the soil. This raises the actual height of the shellmound from 27 feet to 32 feet and the actual diameter to at least 310 feet instead of 270 feet. The volume of the mound, measured as a truncated cone, may be estimated as being 55,000 cubic yards, or about 39,000 cubic meters.[10]

[10] The shellmounds in the vicinity of the bay differ considerably in shape and size. The majority appear as extended plateaus 10 to 12 feet in height, others appear as slight undulations of the ground about five feet in height. The truncated conical form is found more rarely; the mound at Ellis Landing near Point Richmond approaches it somewhat in its proportions. Many of these mounds cover acres of ground, *e.g.*, the mounds of Alameda, of Sausalito, of Sierra Point, of West Berkeley (in its older form, now much changed). In tropical regions many shellmounds are said to reach a height of 100 feet or more; this is known with certainty of some in Brazil (cf. Nadaillac, *l. c.*, p. 54), and also of two near the dried-up mouth of the Ica river in Peru. Shellmounds as a rule are much smaller. On the Atlantic coast near Smyrna a shellmound is said to be thirty feet high (Short, *l. c.*, p. 107), but the majority of these mounds are less than four feet high (cf. Wyman, Amer. Naturalist, 1868, I, p. 56 ff., and Abbott, *l. c.*, p. 440), while many of them extend over areas of more than two or three acres. A shellmound near the mouth of the Altamaha river in Florida is estimated as having a size of over 80,000 cubic yards (Smithson. Rep., 1866, p. 358). The shellmounds of Denmark are only from 3 feet to 10 feet high, although more than a thousand feet long (Ranke, Der Mensch, II, p. 552). Southern California shellmounds generally are from 4 feet to 5 feet high (P. Schumacher, Bull., *l. c.*, p. 38; and Smithson. Rep., 1874 ,p. 337, etc.). The same is the case with those mounds on the Aleutian Islands explored by W. J. Dall. In Oregon there are some of at least 8 feet in height (cf. Schumacher, *l. c.*, p. 29).

From what we know of the situation it is obvious that the mound was founded upon firm though still somewhat marshy land, near the bay shore and close to the creek. The latter was the occasion of its location[11] at this place. The ground must have been dry, since a gently rising slope was selected. The soil was alluvial and relatively new, since it has no overlying cover of good earth, yet it must have been dry long enough to allow a thin growth of vegetation to cover it, causing the slight gray discoloration of this stratum.

The situation of the base of the mound two feet below the water level cannot be explained on the assumption that refuse from a pile dwelling had been the first cause of its formation. This theory would presuppose modes of living to be followed by the Indians of this coast for which there is no parallel elsewhere, and which are not borne out by other evidence obtained in the study of the mound. If the mound has not risen from the water, then the former land surface must have sunk. The mound could not possibly have sunk below the water level from its own weight, for the original ground underneath it is still several feet higher than that to the west, for instance, near *n*, and sections of the base upon which the full weight of the mound rested, such as near *h*, are on the same level with others over which the mound rose only 14 feet. Since the sinking of the mound has not been brought about by local causes, it must have been caused by a general subsidence of this coast region. Similar subsidences of the coast, due probably to sliding motions, are frequent phenomena on alluvial coasts.[12] Evidences of this are furnished apparently by the

[11] Shellmounds in the bay region are mostly in localities where there is fresh water, a creek or a spring, generally the former. W. H. Dall (Contributions, p. 34) observes that for the formation of shellmounds on the Aleutian Islands two conditions are necessary, as a rule: running water or a spring, and a site suitable for boat landing; one or the other of these conditions lacking, no shellmounds are to be found. In Oregon the shellmounds are generally to be found near a creek (cf. Schumacher, *l. c.*, p. 28). The same rule probably governs the shellmounds of the East. D. G. Brinton found shellmounds in Florida generally near running water (Smithson. Rep., 1866, p. 356), but he supposes as the cause of this the greater abundance of shells near the mouths of rivers, while it is certain that the presence of drinking water was the main attraction.

[12] Parts of the eastern coast of the United States are sinking. Several shellmounds on the Jersey coast are being washed away at present (cf. Abbott, *l. c.*, p. 448 ff.). The same may be observed with the shellmounds near Ellis Landing on the Bay of San Francisco.

shores of San Francisco Bay.[13] The ground under the mound having a slope of two feet, it may be assumed that the original foundation of the base was at least one foot above tide level. Accordingly the coast must have sunk three feet since the formation of this mound.[14] This sinkage was leveled up again to its former height by later alluvial deposits, in consequence of which the originally dry base of the mound is now situated two feet below the level of the bay, while the surrounding flats are three feet above it.

It is to be noted that the younger alluvial deposit, near *o* (pl. 4) has a thickness of six feet.

Samples of soil taken from various parts of the clay stratum underlying the base of the mound were subjected by Professor W. A. Setchell to microscopical examinations, but no Diatoms were found in any of them. Hence those strata were probably formed of alluvial deposits of the creek, as Professor Lawson had at first suggested, and not of deposits of the bay. This finding is entirely in accordance with the origin of the gravel stratum as above stated.

The slope of the mound was an obstacle to the course of the creek when it became swollen. In the natural course of things it deposited a bar near the foot of the mound, which, when the edge of the latter gradually extended, grew out over this new obstacle. The creek in the same manner continued to heap up alluvial deposits against the latter. The horizontal growth of the mound and the vertical growth of the surrounding land took place simultaneously. This was the cause of the brim-like upward curve of the edge of the mound as seen in the cross section (pl. 4). While the mound increased about seventeen feet in its periphery, the vertical alluvial accumulation was about one and one-half feet. Hence the base of the mound peripherally increased one foot while the ground grew one inch, showing that the alluvial growth of the soil was much slower than the peripheral growth of the

[13] Near the mouth of the valley of San Rafael a small hill rises from the bay, the isolation of which from the mainland may be explained in this way.

[14] Between the shellmounds of Emeryville and West Berkeley the shore for a long stretch forms a steep bank up to twelve feet high, and broken down by the water of the bay. Possibly the coast at this point formed a promontory on the two sides of which these shellmounds were originally founded, as in sheltered bays, similar to other mounds of this region.

mound. About 310 cubic yards or 240 cubic meters produce a growth of one foot in a mound 9 feet high and about 300 feet in diameter at the base. If the peripheral growth of the mound had continued with the growth of the soil, the foot of the mound would have spread out so that the outer edge would rest in the highest or surface layer of the present alluvium. The wedge-like margin situated between alluvial strata is, however, proof that its peripheral growth ceased a long time before the termination of the alluvial accumulation in this region, as a result of which the alluvium has spread itself over the foot of the mound. The alluvial deposit above the wedged-in margin of the mound (at *p*) being 3 feet 8 inches in thickness, and the alluvium deposited underneath it from the beginning of the formation of the mound measuring only 1½ feet, and assuming the increase to have been absolutely uniform, a period two and a half times as long has passed since the ceasing of its peripheral growth, as had been necessary for a peripheral growth of 17 feet on each side. The cessation of this peripheral growth of the mound, however, is not identical with the cessation of its growth altogether. It took place apparently when the mound began to grow more acutely conical in shape, whereby it increased to twice its former volume. Assuming that the mound was abandoned 100 years before the end of the alluvial growth of the land in the vicinity, then according to formula

$$100 \times \tfrac{2}{3} f = 2\tfrac{1}{2} \times \tfrac{1}{3} f$$

it might be concluded that the mound was probably 600 years old before it was abandoned.[15] Several numerical values upon which the formula is based are unfortunately so uncertain that the result may not be considered as more than suggestive of the possible age.

The sinking of the coast and the alluvial increase of the ground since the first settlement of the mussel-eaters would in themselves give an adequate measure for an estimate of the age of the mound if the measures upon which both depend were not also unknown; according to Professor Lawson, this probably occu-

[15] In that case the sinkage would have amounted to about 6 inches, the alluvial increase to about 9 to 10 inches in a century.

pied centuries at least.[16] At any rate, such observations as have been made furnish good reasons for believing that the founding of a settlement and the beginning of the heaping up of the mound occurred at a remote date.

The Internal Structure of the Mound.

The principal constituents of the mound are the shells. These have nearly all crumbled into small fragments and are slightly mixed with soil, which when damp gives the entire mass the appearance of pure soil. When this is flooded with water the washing away of the sand produces no noticeable change in its volume. This mass has mingled with it bits of charcoal, bones of animals, ashes or cinders, and stones averaging about the size of one's fist and blackened by fire.[17] Marks of stratification may be traced through almost the entire mound. Plate 5, representing a photographic view of the excavation, shows the stratification planes in the walls quite distinctly. The strata consist of compact masses of more or less fragmentary shells, or of beds of ashes or cinders. In many cases the latter seem to extend through the entire mound. They are sometimes not thicker than a sheet of heavy paper, but show the general direction of the bedding planes, and form a clear contrast with the homogeneous, dark mass of broken shells.[18] These planes become somewhat less distinct in the deeper strata.[19] As in other shellmounds,[20] there were observed certain rounded masses of shells intersecting the lines of stratification. These are

[16] The rapidity of the sinkage of alluvial coasts varies greatly owing to local conditions. For the Atlantic Coast the rate of sinkage is 2 feet per century (cf. Abbott, *l. c.*, p. 449). Applying this same rate to the eastern coast of the Bay, we would arrive at the absurd result that the shellmound of Emeryville had begun to form in 1750, while that date was presumably the end of its occupied state.

[17] The descriptions of nearly all the shellmounds explored in other parts of the world tally exactly with this one; cf. Ranke, *l. c.*, II, p. 532, for the Danish Kjökkenmöddinger; Schumacher, on the general similarity of shellmounds of the Pacific Coast with the mounds in Denmark, Smithson. Rep., 1874, p. 355, etc.

[18] Although no shellmound is free from stratification marks, owing to the gradual growth of the strata, Brinton maintains that this is the case with shellmounds on the Atlantic Coast (Smithson. Rep., 1866, p. 356).

[19] Compare the interesting observations of Wyman (Amer. Naturalist, I, p. 571) concerning shellmounds of New England, that there the shells of the lowest stratum were softer and more crumbled than those of the upper strata.

[20] Cf. Wyman, *l. c.*, p. 365, on a shellmound in the vicinity of Portland, Me.

caused by holes, made by moles or other burrowing animals, being afterward refilled with shells.[21]

In some shellmounds in other regions strata of earth and sand were found between the shell layers. These give evidence of a temporary evacuation of the shellmound. No evidence of this character was obtained in the study of the Emeryville mound, where the only occurrence of a natural vegetable soil is the surface cover of 1 to 2 inches in thickness, which has formed since the mound was finally abandoned.[22] It is possible that slight differences in the state of preservation of the shell deposits which now mark the strata lines may have been caused by differences in the length of time of occupation. Other explanations might, however, be offered.

The lines of stratification mark clearly the gradual development of the strata of the mound from the base until the present truncated cone was formed. It is apparent that two different principles governed the growth of the mound. At certain periods it tended to take on a shallow plateau form. At other times a conical shape developed without the corresponding increase around the base. According to the first principle the mound grew in the form of a plateau to a height of from 9 to 10 feet. Near *C* in pl. 4 the edge of the plateau still seems to be traceable, from which point the strata inclined downward. At that period the mound resembled in its proportions the old Indian camping places of the interior valley, some of which are still occupied; or some of the shellmounds along the Bay which have been abandoned at some earlier period. The undulating lines of the strata, such as seen near *f* and *g*, suggest irregularities of the old plateau surface, similar to those which may be observed in the surfaces of camp locations of the interior, which have been abandoned for decades. The hollows from 20 to 40 feet in length

[21] Similar holes made by moles may be observed occasionally upon old shellmounds along the Bay, which if they had been refilled with shells might also have assumed a rounded form. In such a manner may be explained the finding of a modern steel knife, with the wooden parts still well preserved, in one of the strata of the shellmound of West Berkeley in a place to all appearances undisturbed.

[22] Cf. also Wyman, *l. c.*, p. 571. The absence of true soil from the interior of the mound is proof that at no time was the mound abandoned by its occupants long enough to allow of the formation of such a stratum.

mark the sites of former sweat-houses or council-halls; these curves, such as that from *f* to *g*, may have a similar origin.[23]

The manner in which the mound was occupied for habitation varied in the upper strata. With the growth of the mound the diameter of the plateau decreased instead of expanding. From line *b* upward the strata incline obliquely toward the sides. This change in the manner of forming the mound signifies a change in the character of its occupants. It would be interesting to determine, if possible, the exact line where these two types of growth have met. It might have been about 12 feet above the base, so that the mound grew in the shape of a shallow plateau as far as the middle of stratum V in pl. 4, and that it changed after this period to its conical form.

Constituents of the Mound.

Shells.—The shell layers of the mound are composed principally of the following species:

Oysters, *Ostrea lurida.*
Mussel shells, *Mytilus edulis* and *Mytilus californianus.*
Clams, *Macoma edulis* and *Macoma nasuta.*

Many other kinds of shells, including the following species, were found scattered through the mound:

Purpura crispata and *canaliculata.*
Cerithidea californica.
Helix, two species indet.
Cardium corbis.
Standella, sp.
Tapes staminea.

Of these last species, the cockle, *Cardium corbis,* and the clam, *Tapes staminea,* occur quite frequently.[24] All of these were used as food by the occupants of the mound. The various species of *Helix* were probably also used, as they were in more recent times eaten by the California Indians.[25] It may be, however, that this species lived on the mound.

[23] Somewhat smaller but quite similar hollows are still preserved upon the surface of the shellmound of Ellis Landing, and are doubtless sites of houses of that nature.

[24] Eight-tenths of all the shells found in the Oregon shellmounds belong to the species of *Mytilus californianus, Tapes staminea, Cardium nuttalii,* and *Purpura lactuca* (Schumacher, Smithson. Rep., 1874, p. 335).

[25] As by the Minooks and the Nishinams (Powers, *l. c.,* pp. 348 and 430); and certainly the custom was a very general one.

The state of preservation of the shells is proportional to their natural hardness. Hence the shells of the Macomas are the most conspicuous, those of the mussels, as the most perishable, are the least noticeable ones in the mound. The relative frequency of occurrence in the case of the three most important species depends on different circumstances.

The lower and the upper strata of this mound are composed of the same varieties of shells, in which point it is different from many shellmounds in other regions. It is, however, true that oyster shells predominate in the lower strata, while *Macoma* shells are more numerous in the upper ones.[26]

Visiting the different shellmounds in the vicinity of the Bay, one finds a general similarity in the kinds of shells composing them. Rarely one or another variety of shell, the *Macoma* or the cockle, or some other, is found to predominate. This general homogeneity of composition in the shellmounds around the Bay, and the small differences in the amount of any particular species, indicates as a whole the general similarity of the shell fauna at many points about the Bay during the period of occupation of the mounds.

The Indian camping grounds in the interior, although quite similar in form and origin to the shellmounds on the coast, when opened generally present a great difference in appearance. Traces of shells are almost unnoticed from the outside, yet large quantities supplied as food by the rivers of the interior are doubtless to be found in them. These shells have been found during excavations, or their use has been confirmed by persons who observed the mode of living of the Indians of these regions. The Indians also obtained salt-water mussels by trade, even in quite recent times. From the fact that shells are not in evidence on the surface of the camp grounds, one must conclude that their use diminished.

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[26] We were not so fortunate as was W. H. Dall in the shellmounds of the Aleutian Islands in being able to make "a tolerably uniform division" of the layers in the mound according to the various foods used. (These layers were: "1, Echinus layer; 2, fishbone layer; 3, hunting layer." Contributions to North American Ethnology, I, p. 49.) The shellmound of Emeryville presents a much greater similarity in the kinds of food used during the different periods of its occupancy.

Bones.—Bones of vertebrates are also found in most of the shellmounds. These together with the shells represent the debris of their kitchens. No other shellmound has been seen where so large a quantity of bones was observed as in that at Emeryville. Bones of land and sea mammals, of birds, and of fishes were found in abundance throughout the mound, and fairly evenly distributed in the strata. This fact is the more remarkable since the shellmound at West Berkeley, scarcely two miles distant, does not yield nearly such quantities of bone as this one. The occupants of the mound at Emeryville at all periods were huntsmen to a great degree, besides being fishermen; those of the mound at West Berkeley seem to have depended largely upon fishing; hence the stone sinkers were far more numerous in that mound than at Emeryville.

So far the fauna of only the lowest strata up to 3 feet above the base have been studied. The following species obtained in this horizon were determined by Dr. W. J. Sinclair.

Deer, *Cervus* sp.
Elk, *Cervus canadensis.*
Sea-otter, *Enhydrus lutris.*
Beaver, *Castor canadensis.*[27]
Squirrel, *Spermophilus* sp.
Rabbit, *Lepus* sp.
Gopher, *Thomomys talpoides.*
Raccoon, *Procyon lotor.*
Wild cat, *Lynx* sp.
Wolf, *Canis* sp.
Bear, *Ursus* sp.
Dog, *Canis familiaris.*[28] (*?*)
Seal, *Phoca* sp.
Sea-lion.
Whale.
Porpoise?
Canvasback Duck, *Aythya vallisneria.*
Goose?
Cormorant, *Phlacocorax* sp.
Turtle.
Skates, Thornbacks, and other fish.

[27] Extinct in California, and in fact south of Washington; J. Wyman found the remains of elk, wild turkey, and large auk in the shellmounds of New England. The elk, though still in existence, is no longer to be found east of the Allegheny Mountains; the wild turkey is still in existence, but is not to be found in New England, while the auk lives only in the Arctic regions, or at least not farther south than the northern part of Newfoundland (Amer. Naturalist, I, p. 572).

[28] Also found in the shellmounds of New England.

No traces of cannibalism have been detected. Most of the hollow bones of larger mammals, and even the smaller bones of the foot, were found to have been split to get at the marrow.[29]

Fireplaces.—These were generally known by beds several feet in length consisting of charcoal and yellowish ashes. They occurred in many spots throughout the mound. Numberless scattered bits of charcoal[30] and pebbles, mostly about the size of one's fist and blackened by fire, were further evidences of the continuous use of fire in the preparation of food. In no instance were there any stones set in rows for fireplaces, such as have been observed elsewhere, as in a shellmound near Sierra Point, where stones are plentiful.[31] A very peculiar feature of this mound is a yellowish layer of ashes comprising the entire depth of stratum II in pl. IV, and tapering towards the edge of the mound. Above it lies only the uppermost stratum (I), that of vegetable soil. Though calcined shells[32] occurred elsewhere in the mound, they were especially numerous in this ash stratum, and in some spots all shells were calcined. The origin of this ash stratum will be explained later. A similar bed is to be seen in a central layer of the shellmound at West Berkeley, and another one of similar thickness but shorter in a mound near Sausalito.

Human Remains and Relics.—A large part of the Emeryville mound consists of remains which have been deposited here by man. Among these are mollusean shells with bones of fish and mammals, used as articles of food. In the narrower sense the human relics consist of the bones of man, graves, and artifacts, which are all found in greater or less abundance throughout the whole thickness of the mound. Actual human bones were not found to be common in this part of the mound except in stratum II, and in the graves of stratum VII. The artifacts obtained

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[29] Cf. for shellmounds in Denmark: Ranke, *l. c.*, II, p. 532, for those of the Atlantic Coast, Wyman, *l. c.*, p. 575 (New England) and Abbott, *l. c.*, p. 442 (New York).

[30] Analogous is the statement of Wyman, *l. c.*, p. 564, about the shellmounds of New England.

[31] Cf. also Hellwald, Der vorgeschichtliche Mensch, p. 449, on the Kjökkenmöddinger of Denmark.

[32] Nadaillac, *l. c.*, p. 50, states from uncertain authority that a shellmound near San Pablo was said to consist of calcined shells exclusively, which is certainly an exaggeration.

were only those of very resistant material, such as stone or shell. All other kinds, such as textiles of plant fibre, baskets, and implements of wood, which doubtless have also existed, had disappeared. The more resistant artifacts were distributed throughout all layers of the mound.[33]

About 200 cubic meters of earth were removed and sifted during the excavations, and yielded 600 artifacts of various kinds, averaging three specimens to one cubic meter. The volume of the whole mound we computed to be about 39,000 cubic meters, and it may be assumed that by excavating the entire mound the yield would be about 100,000 specimens, which indicates that many generations must have lived here to deposit such a large number of objects of imperishable material alone.[34]

The same computation was applied to each separate layer in the mound, and it was shown that the yield differed according to the section and the stratum explored. The open cut *A* yielded one specimen to .75 cb. m., and the tunnel *B* and the pits *h* to *m*, six per cb. m. Section *C* yielded three artifacts to one cb. m. This computation shows that sections nearer the center of the mound yielded the greater number, those toward the edge a smaller number. It also appears that the lower strata contained a larger percentage of artifacts than the upper ones. If, however, the number of flaked chert fragments were subtracted from the yield of the lower strata, their percentage would be much the same as that of the higher layers. The following are the contents of the various strata:

Stratum I had 20 artifacts per 15½ cb. m. = 1.3 per cb. m.
Stratum II, 30 cb. m—133 objects = 4.4 per cb. m.

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[33] It is alleged that there are shellmounds in the East which contain no implements at all, and have been used for the gathering of mussels only, and not as dwelling places (Abbott, p. 447, accord. to Charles A. Woodley). Equally uncertain seems to be the distinction made by Schumacher between shellmounds yielding few artifacts and those containing a larger number, as representing a place for temporary or permanent habitation. Similarly dubious is that classification which considers the piling up of shells in various separate heaps as proof of permanent abode and that of single mounds for the use only as temporary stopping places (Smithson. Rep., 1874, pp. 337 to 338).

[34] W. J. Dall (contrib. *l. c.*, I, p. 47) states that during his excavations of the shellmounds of the Aleutian Islands he found on the average one object in one-half ton of earth. This would be 2.63 objects to one cb. m. The yield of the Emeryville shellmound is three objects to one cb. m.

Stratum III, 20⅔ cb. m.—27 objects = 1.16 per cb. m.
Stratum IV, 11¾ cb. m.—41 objects = 3.5 per cb. m.
Stratum V, 9⅔ cb. m.—34 objects = 3.5 per cb. m.
Stratum VI, 4⅕ cb. m.—9 objects = 2.1 per cb. m.
Stratum VII, 2⅘ cb. m.—10 objects = 3.5 per cb. m.

The specimens contained in the graves in strata VI and VII were not counted in with the rest. This comparison shows mainly that stratum II is the richest in implements. The connection of this fact with the preponderance of ashes will be pointed out later.

Burials.

Shellmounds originate on the accumulated refuse deposited by people who have lived in the place when the heap has formed, and the mounds may therefore be regarded as sites for dwelling places, or abodes for the living, and not as mounds set aside as burial grounds by people living elsewhere in the vicinity. Whenever these mounds were used for burials it was not done in spite of their being dwelling places, but rather because they were such.[35]

Many tribes of a low grade of civilization follow the custom of burying their dead underneath their feet in the ground upon which they live, to protect the graves of their dead against being disturbed and also to enjoy the protection of the spirits of the departed against their enemies. Wherever graves are found in shellmounds, in all parts of the world, their presence is generally to be explained in this way.[36]

Ten graves containing skeletons were found during the excavations. They were found only in the middle layers of the mound in a zone extending from stratum VI to stratum VIII. The two lowest layers and the five upper ones contained no evidence of interment, indicating that the custom of burial underneath the

[35] See P. Schumacher, Bull. *l. c.*, p. 38, for burials in the mounds on the Island of San Miguel.

[36] Virchow found them in the Spanish shellmounds (Ranke, *l. c.*, II, p. 533), while in those of Denmark they are absent. Schumacher (Smiths. Rep., 1874, p. 337) states that he observed shellmounds in Southern California which had been temporary abodes only and were devoid of graves; while D. G. Brinton asserts that in Florida graves occurred in natural shellmounds, while artificial shellmounds were free of them (*l. c.*, 1866, p. 357). Such general statements cannot be accepted unless they are supported by observations over larger fields than these.

dwelling places was observed in one period only. We have no evidence concerning the location of the burials previous to that period or subsequent to it. A burial site slightly elevated above the plain was unearthed some years ago under a shellmound near the principal mound in Emeryville, but as this probably dated from the same period as the graves in the shellmound no light is thrown upon the question.

In the upper strata of the mound there is, however, furnished evidence of a different manner of disposing of the dead, which was observed during the period of the deposition of strata II, III, and IV. During the period represented by strata VI to VIII the dead were buried in the ground. It has already been shown that stratum II consists mainly of ashes and calcined shells, which cannot be regarded as kitchen-midden deposit or as the remains of fireplaces, the latter forming an inconspicuous part of the stratum. Another characteristic feature of this layer is the high percentage of calcined bone implements found there. Very common among them are awls, of which stratum II contained 44 calcined specimens, or 72 per cent. of the whole number. In the other layers a much smaller number has been found, but the percentage of calcined specimens is high. The supposition that these were accidentally burned cannot be considered an adequate explanation, but the fact that a number of human bones were found at the same place in the strata gives weight to the theory that during the deposition of the upper beds the inhabitants of this region practiced cremation of their dead, a custom common among the California tribes of today. Then as now they were accustomed to burn all personal belongings with the body.[37] This accounts for the large number of calcined bone objects and shells in stratum II. Doubtless a large number of shell-fish were thrown into the fire as food for the departed on their long journey into the next world.

Doubtless the practice of cremation was not confined alone to the period of stratum II. The percentage of calcined awls in other strata than this suggests that the builders during the ac-

[37] H. C. Yarrow, Introduction to the mortuary customs among the North American Indians, 1880, p. 58, points out that this custom was general among those Indians who cremated their dead.

cumulation of stratum I, and probably also of III and IV and parts of V, practiced this custom, but to a less extent than in the period of stratum II, or mainly at other places than the mound.

Eight of the ten graves containing skeletons lay close together in the narrow space of the middle section of the excavation. Four were found in strata VI and VII of the upper cut *C*. Four of the graves were those of children, lying at different depths in the line of the tunnel. Two other graves were isolated from the others, lying in the edge of the mound. None of the burials were less than nine feet below the present surface. The lowest grave, No. 10 (pl. IV, fig. 2), was 21 feet below the surface. In accordance with the stratification lines of the mound, graves 1 and 2, as well as 6, 8, and 9, may be considered as belonging to the period of strata VII and VII*a*. The eight graves which lay close together in the middle of the main excavation were distributed over a space of about 90 square feet. The vertical distance from the uppermost to the lowest of these was nine feet. As the tunnel inclines toward the center of the mound it is not certain whether the cemetery extended through the entire mound or was only around the margin of a settlement on the summit of the mound at the time when it was in use. From the depths at which the different graves were found, varying about nine feet, it is clear that they were not constructed within a short period, but that long periods intervened, during which the mound grew very considerably through the deposition of refuse. P. Schumacher explored the graves of Oregon, which lay at a depth of from 1½ to 2½ feet below the surface, and probably the tribes of the Pacific Coast buried their dead in comparatively shallow graves.[38] In the case of a child's grave (No. 9, pl. 4, fig. 2) it was seen by the stratification lines that it was not made deeper than 1½ feet below the surface. Assuming this as being the general depth of the graves throughout the mound, then the graves varying between 2½ and 12½ feet above the base of the mound were dug at periods when the entire height of the mound was about 5 to 14 feet, hence the period of these burials would have to be placed

[38] Bulletin U. S. Geol. and Geogr. Survey, III, p. 34. In other places shellmound graves lie deeper; thus sometimes three to six feet on the Island of San Miguel (P. Schumacher, Bull. *l. c.*, p. 38).

entirely during the time of the earlier plateau-like growth of the mound. This period of burial is very closely followed by that of cremation, the two possibly overlapping.

The preparation of the graves was not elaborate. A simple pit sufficed. It was made large enough to place the body in it with the knees drawn up. The sides of the grave were left bare. If a covering existed originally it must have been of perishable materials, for none have been found in excavation. The bottom of the grave, however, was prepared somewhat like a bed. A layer of charcoal from one-half inch to one inch thick is found at the very bottom, above that another layer of like thickness of iron oxide. Upon this the body was laid on its side. It is evident that the body was buried with its clothing and personal ornaments, in exceptional cases with utensils or implements only. The body was tightly bound at the knees before burial. Owing to climatic conditions, causing excessive moisture in the strata, the greater part of the material buried with the corpse has decayed and disappeared. Five of the ten graves were entirely lacking in implements or other artifacts.

Before burial the body was entirely covered with the red earth mentioned above. This settled down upon the bones after decomposition and is still adhering to them in some cases like a thick crust. The hands were placed on the body in different ways. In several instances the left hand rested upon the knees, while the other was raised to the mouth or to the crown of the head. The corpse is usually laid upon the right side, generally facing northeast. Associated with a number of skeletons were a variety of interesting ornaments, including beads made from shells of *Olivella* and other molluscs and from sections of bird bones strung together. With skeleton No. 4 were associated a large number of perforated mica flakes. The flakes of mica may originally have been fastened to a garment which shrouded the dead, and when this decayed in the earth the flakes remained there about the body. Beads of bird bone were found in the mouth also, but their presence there might be explained by the settling of the skull in the earth. Mica was much used by the Indians for ornamentation. It has been observed in Peru in a number of cases in the vicinity of graves, but circumstances did not show whether

its presence there was purely accidental or not. In the mounds of the middle west of the United States there have sometimes been found ornaments of thin plates of mica of round or oval form, provided with holes to fasten them to the clothing.[39] Similar objects were found in West Virginia and elsewhere. Pieces of mica 2 or 3 inches in size are reported to have been found in mounds or in places suggestive of their use for religious purposes.[40] Beads like the above mentioned from California, both from graves and from living Indians, were pictured by Holmes.[41] With burial six was a bone ring set with shell beads fastened on with asphalt. In burial seven were numerous bone rings similarly decorated with shell beads. Also in burial seven was found a large quartz crystal. One end of the crystal is preserved unbroken. The other end is capped with asphaltum in which numerous small shell beads are set. Quartz crystals have been found elsewhere in California in graves.[42] The above mentioned crystal, however, reminds us most strongly of a number of crystals one foot in length and of the thickness of one's arm, found during the excavation of the western wall of the Temple of the Moon at Moche (Trujillo), in Peru, now in the collection of the University of California. These, too, had the coating of red coloring earth, the same as the object shown on pl. 11, fig. 9, and were found under peculiar conditions pointing strongly to their religious significance.

Several peculiar bone implements were obtained in burial eight.

The mode of burial seen here resembles that observed elsewhere in the shellmounds of California, for example, near San Luis Obispo, and that of other regions on the Pacific Coast (Oregon), and it is still followed among the California Indian tribes. The burial of the corpse with its knees drawn up has also been observed in Southern California[43] and Oregon.[44] From the latter

[39] Charles Rau, Ancient Aboriginal Trade in North America, Smithson. Rep., 1872, p. 361 (from G. Squier).

[40] *l. c.*, p. 360.

[41] Art in Shell, Second Annual Report of the Bureau of Ethnology, 1880 to 1881, pl. XXIII, fig. 6.

[42] P. Schumacher, Smithson. Rep., 1874, p. 349.

[43] Central California, cf. also Moorehead, *l. c.*, p. 259.

[44] P. Schumacher, Bull. *l. c.*, p. 34.

region also the varying positions in which the corpses face is confirmed by Schumacher.[45]

To the layer of charcoal and red iron oxide which generally formed the bed of the dead may be compared the "thick burned brick-like crusts" and the "thin light colored crusts" found by Schumacher in Southern California graves.[46] A large number of lumps of red coloring earth were found throughout the mound, some of these showing marks of scraping or cutting. In Southern California graves we find conditions resembling these almost identically.[47] Up to recent times the California Indians very generally painted their bodies, and there is undoubtedly a religious significance in this practice of daubing the corpses and associated objects with red coloring material, besides depositing them on red earth. The custom of putting red coloring matter on the body of the dead is found with many aboriginal tribes. So the Caribs in Jamaica[48] paint the entire body of the corpse. The Santees of South Carolina[49] painted face, neck, and hands of the corpse. The Dakotas[50] painted the face alone. In a number of Peruvian mummies the faces were painted red. Crania from ancient Peruvian graves that had been disturbed at some early time were also found covered with red paint.

The absence of implements is explained by Schumacher by the analogous custom of the lower Klamath tribes, where the implements are laid upon the grave instead of being buried with the dead.[51] This custom may have prevailed in this shellmound.

It was an unfortunate circumstance that the exploration in Emeryville occurred at a season of the year when the interior of the mound was still very damp from preceding rains. For this reason none of the skulls could be secured intact, and they will need to be carefully prepared before use can be made of them for

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[45] F. W. Putnam, Rep. upon U. S. Geogr. Surveys, *l. c.*, p. 30; Schumacher, Smithson. Rep., 1874, p. 341.

[46] Smithson. Rep., 1874, p. 342.

[47] Putnam, *l. c.*, p. 22; Schumacher, Smithson. Reports, 1874, p. 350.

[48] Yarrow, Introduction to the Study of Mortuary Customs among the North American Indians, 1880, p. 54.

[49] Schoolcraft, Archives of Aboriginal Knowledge, 1860, IV, p. 156.

[50] Yarrow, *l. c.*, p. 71.

[51] Bulletin *l. c.*, p. 34.

anthropological study. It may be noted that none of them show striking eccentricities of form.

Following is a detailed statement of the occurrence and the contents of each of the ten burials excavated.

No. 1, pl. IV, fig. 2, was found 9 feet below the present surface; it may be contemporaneous with the graves of stratum VII (as 6 and 9). The skeleton was that of an adult, drawn up in the usual manner. It was laid on its right side and was facing east. The left arm rested upon the knee, the right hand on the crown of the head, where also was found a cockleshell. The skeleton lay on a bed of red soil; the bones were slightly reddened. No associated objects.

No. 2. Skeleton of an adult, found at a depth of 9 feet in the outer part (*A*) of the excavation; neither red earth nor associated objects present. The burial dated probably from the same period as the preceding.

No. 3. Grave of a young person, about 15 years of age, in stratum VI. The skeleton was facing northwest. No artifacts or other associated objects.

N. 4. Grave of an adult, in stratum VI. The skeleton lay from east to west upon a double bed of charcoal and red earth. Interspersed in the soil were found a great quantity of flakes of mica 1 to 1¾ inches in diameter, rhomboidal, triangular, and irregular in shape, and each with a hole at one end (see pl. II, fig. 18); also a quantity of beads made of bird bones were found upon the cranium as if they had formed part of a net drawn over it; others lay along the sides of the head and along the temples.

No. 5. Skeleton of an adult lying from east to west and facing north. Stratum VI. The cranium shows a lupus-like mutilation of the nose (fig. 2). No ornaments.

No. 6. Grave of a child a little over a year old, found in the tunnel in stratum VII*a*, at a depth of 17 feet below the surface. It lay from north to south upon a bed of charcoal and red earth. Various ornaments and other articles were taken from this grave, all covered with red earth. A number of shell beads, both flat (cf. pl. 11, figs. 6*a* and 6*b*), and concave forms (pl. 11, figs. 5*a* and 5*b*) lay in rows from the neck down along the body, and were originally necklaces; two bored round pieces and two oblong ones

(pl. 11, figs. 1 and 2) of *Haliotis* shell had completed the necklace. An unusual object (pl. 11, fig. 8) found here was a flat ring three-eighths of an inch wide, three-sixteenths of an inch thick, neatly made of stone, both surfaces being decorated with a number of shell beads, originally 11 to 12 on each side, fastened with asphaltum. This object may have been a pendant, but doubtless it possessed talismanic virtues.

Shell beads like the larger convex ones of *Olivella* sp. have been pictured by Holmes as objects belonging to early and modern Indians of California. Possibly they also resemble the shell coin "Kolkol" of the modern Indians, which is made of *Olivella*

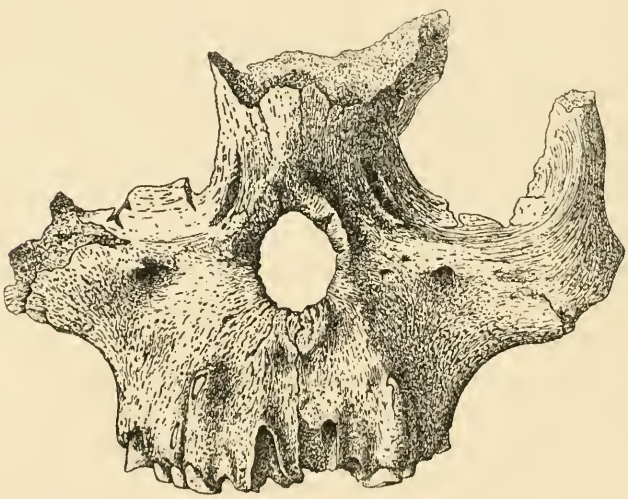


Fig. 2.* Skull showing lupus-like mutilation of the nose. × ½.

biplicata, according to Powers, and was strung in such a manner that the beads faced each other in pairs, but are not much in use in modern times.

A shell ring of similar proportions as above, but differing through its inferior material and the absence of decoration, has also been pictured by Holmes as coming from Illinois, and as being an ear ornament presumably, while the object described above could not have served that purpose.

* Fig. 1 has been omitted owing to double references in the manuscript.—Editor.

No. 7. Grave of a child about one year old, found in stratum VIII, about 21 feet below the surface of the mound. The body lay upon the usual bed of charcoal and of red earth and all the little bones were thickly covered with red coloring matter. The grave was as rich in artifacts as the preceding one. A number of small shell beads (as in pl. 11, fig. 6) were found near the wrist. The following objects were taken from the earth about the body:

Three oblong ornaments, bored, of *Haliotis* shell (pl. 11, fig. 1), a number of very small shells of *Olivella* sp. having bored ends, which fact shows that they were used as ornaments; 11 bead-like rings of bone, each being about one inch long and seven-sixteenths of an inch thick; each has a band of asphaltum in which three or four small shells were imbedded (pl. 11, figs. 10, 11). While these rings may have been mere ornaments, the following unusual object (pl. 11, fig. 9) taken from the same grave must without doubt have talismanic importance. It is a piece of quartz crystal $2\frac{15}{16}$ inches long and $1\frac{1}{2}$ inches thick, having perfect lateral edges and points; the broken base of the crystal is capped with asphaltum in which numerous small shell beads are set.

All these objects were thickly coated with red coloring matter. For the small ornamental *Olivella* shells compare similar ones from Santa Rosa Island, California, pictured by Holmes (l. c., fig. 7). The bone ring resembles the thick bead-like bone ring taken from another of the graves, stratum VII*a*, of the mound.

No. 8. Burial of an adult, in stratum VII, found above the tunnel. The body in the usual squatting position was placed from north to south, facing east, upon a bed of red earth and was itself colored red. This grave contained besides objects of personal adornment a number of bone implements. The former consisted of a number of beads made of bird bone (types similar to object pl. 11, figs. 15 to 17) and a like number of *Olivella* shells bored at the lower end (pl. 11, fig. 3); they were scattered in the earth about the body. One of the *Olivella* shells was perforated on its side (pl. 11, fig. 4). Several of the bone beads were connected in twos by thinner bones (pl. 11, fig. 15). It may be assumed that the bone beads and shells had been fastened to a garment that served as a shroud for the body but has now disappeared.

The bone implements taken from this grave have the shape of paper cutters; there are five in all, representing two distinct types. Three are made of a hard bone (pl. 8, fig. 4) and are imperfect at their upper ends; the form is that of a horn, the worn edges show their use as tools; the other two objects (pl. 8, fig. 5) are made of a much softer bone; they are unfinished at their lower ends. The two types are distinct, although it is difficult to compare them in their very imperfect condition. The upper end of the implement of the second type shows two hooked projections connected by an outward bending of their rims. They have each a hole on the lower edge of such a size as to admit a finger, to facilitate the handling of the tool. Neither of these types was met in other parts of the mound.

An *Olivella* shell with side perforation similar to that of plate 11, fig. 4, from a grave on Santa Rosa Island has been represented by Holmes.[52] Bone beads similar to that of figs. 16 and 17 on plate 11 were found in nearly all the strata of the mound; two of these are shown in figs. 13 and 14 of the same plate, the former, 1–8702, from stratum IV, the latter, 1–8743, from stratum V. It also has a remnant of a former axle-like connection with another bead as was shown in fig. 15 from stratum V. Bone beads have been widely used as objects of adornment by the California Indians, as is the case with many tribes in other parts of the world.[53] With the Yokuts bird bone pieces of 2½ inches in length at one time represented a value of 12½ cents.

No. 9. A child's grave, in stratum VII*a*, in the tunnel about 18 feet below the surface. The associated objects were convex shell beads (cf. pl. 11, figs. 5*a* and 5*b*) and a cockleshell upon the crown of the head (cf. grave No. 1).

No. 10. Grave of an infant with very delicate bones. It was found in the lowest part of section VIII, 23 feet below the surface.

Age of the Mound.

The shellmounds of the environs of San Francisco Bay are almost the only witnesses of a practically unknown period in the

[52] Art in Shell, pl. XXXII, fig. 2.

[53] W. H. Dall, for instance, found them among other places in shellmounds on the Aleutian Islands (Smithson. Contrib., 1878, No. 318, pl. 10, No. 17261.

early history of this region.[54] They appear to us at first investigation unintelligible, both as regards the beginning and the end of the period during which they served as human abodes. For a solution of the problem before us the most diverse kinds of investigations must be carried on, before the principal facts of this history can be clearly brought out.

Shellmounds can be found along almost all parts of the inhabited coast. In California as well as in other parts of the world they originate by the accumulation of remnants of food, especially the shells of the mollusca which are used as articles of diet. In the midst of the remnants of food cast aside by him, man clung to his place of abode, raising it more and more above the general level of the ground through the gradual accumulation of these materials. Hence these localities represent, in certain stages of human development, true but nevertheless low types of human dwelling places. The manner of procuring the essentials of life by collecting shells in itself indicates a low form of human existence. In all parts of the world, even today, people may be seen on the shore at low water gathering for food the shells uncovered by the retreating tide; and although under the changed conditions of life they raise no shellmounds, these people always belong to the lower classes of society, and lead in this manner a primitive as well as a simple life. Peoples depending for food upon collecting shells are usually not agriculturists, but fishermen, and perhaps hunters as a secondary occupation. Their implements are of the rudest kind, made of bone, stone, wood, and the like. Industries of a more highly developed kind, *e.g.*, the dressing of ore and working it up into various implements, remained unknown to them, except in perhaps a few instances.

Thus it seems natural to connect the origin of shellmounds in general with the work of prehistoric generations, *i.e.*, man of the stone age. The only condition necessary for their origin is, that the people who raised them lived somewhat close together and therefore possessed a certain social organization. For only in many centuries or even in tens of centuries could even large groups of men pile up such enormous quantities of kitchen debris

[54] Powers, *l. c.*, p. 375.

into hills which come to form prominent features of the landscape. Though little is definitely known, the beginnings of human social organization evidently reached back into Quaternary time, just as is the case with the beginnings of human ornamentation. There is therefore no good reason why the origin of the shellmounds could not date back to Quaternary time. In this connection mention must be made of the fact that, according to Cook,[55] stone implements of argillite, which would consequently be attributed to the palaeolithic man, were found in a shellmound of New Jersey. The well known shellmounds of Denmark, the so-called "Kjoekkenmoeddings" (*i.e.*, "Kitchen debris"), which first attracted the attention of scientists to the remnants left by prehistoric men, are not so old.[56] Nevertheless, it has been possible to prove by them that Denmark had at the time of their origin a flora considerably different from that of the present, and that the Auerhahn, too, lived there, which does not exist in Denmark to-day. J. Wyman, a very careful explorer of the shellmounds of New England, does not consider the Atlantic shellmounds of this continent as old as those of Denmark.[57] He seems to have taken this view because he met with no authentic proofs of a greater age. These were difficult to obtain. Yet he calls attention to the finding of traces of the auk, the wild turkey, and the elk in those shellmounds, *i.e.*, animals which no longer exist in the region of shellmounds investigated by him. According to him, their disappearance took place in historic times.

In determining the age of the Emeryville mound we note first the fact that no traces of typical Quaternary animals were found in it. It is interesting to find that this mound resembles those just mentioned in regard to the finding of traces of the beaver, an animal no longer met with in this region. It was found in one of the lower strata of the mound. How far it reaches upward cannot as yet be decided, since the large number of bones taken from the upper beds have not all been examined. Since the time that remains of this animal were deposited in the lower strata of

[55] Quoted by Abbott, *l. c.*

[56] Cf. J. Ranke, Der Mensch, II, p. 536. These shellmounds are placed in the earlier stone age of the current geologic periods.

[57] *l. c.*, p. 571.

the mound, the beaver has retreated from this region, in fact from the whole of California, in a northerly direction, possibly up to Washington. When it left this region is not known. We cannot, however, be certain that this retreat may not have commenced in recent times.

Another fact of importance in fixing the age of this mound is found in the apparent change of level of the strata upon which the original layers of the mound were placed. As nearly as can be determined, the original fundament upon which the mound stands has sunk at least three feet. The base of the mound, formerly probably one foot above the usual high water level[58] of the bay, lies at present two feet below. If the mound with its environs had not since grown above the level of the original floor, it would be inundated completely for several hours twice a day. The length of time required for such a subsidence we can of course not determine with any exactness, as no measure of subsidence is available. In all probability it is to be taken as an indication of considerable antiquity.

Further facts upon which an approximation of the age of the mound may be based are of a purely anthropological nature. Usually the early period in which man made use solely of flaked stone tools is contrasted with the later age when polished as well as chipped stone implements were used. In the very lowest stratum of the hill, almost down at the base, there were found stone implements of the well known palaeolithic turtle-back form. A pestle fragment which came from the lower stratum of the mound, though having a completely disintegrated exterior, seems to have originally been artificially rounded. A mortar fragment found low down may have originated from an implement which was formed, as is often the case, out of a common boulder. But before it broke from this object the mortar was deeply worn out, just as others that have come down to our times. Also, the deep concavity of its rims speaks for long continued wear. The next stratum (two to four feet above the base of the mound) yielded the fragment of a pestle of irregular, not rounded cross-section. Here a common oblong pebble may have been used as a pestle.

[58] On an average once in every 14 days the high tide reaches a higher mark, which, however, is not considered here.

Besides these, the two lower strata furnished only an oval, flattened pebble, probably used as a hammer, the only one of its kind in the whole mound.

These four stone implements represent the only specimens of the two lowest strata of the mound which are not chipped. A little above these the excellently polished tool 1–8925 (pl. 10, fig. 9) was found (in stratum VIII). This is the only one of such workmanship before the IVth stratum upwards. Therefore it is by no means impossible that rubbed or polished stone implements, excepting mortars and pestles, were unknown at the time of the origin of the lower strata, and that their use was rather limited in the succeeding strata. But the presence of mortar fragments and pestles in the lowest strata points toward a higher development of the human type than is usually expected of men who use flaked tools only.

It will have become evident from the foregoing remarks that the general zoological, geological, and anthropological facts which are available for fixing the age of the mound offer only indefinite evidence; uncertain even for an approximate dating of the time of the mound's beginning. They do not preclude the possibility of an age numbering many centuries; neither do they prove it. Under such circumstances it seems proper to take into account some more general considerations which appear in a study of the shellmounds of the bay as a whole.

We shall probably not make too great a mistake if we estimate the number of the larger shellmounds around the Bay of San Francisco to be over 100. So many and such enormous shellmounds can not possibly have been constructed by human hands unintentionally in any small number of centuries. Furthermore, they form a link of a larger chain of similar mounds which stretch northerly along the coast and inland from Southern California to beyond Vancouver and possibly still farther; *i.e.*, a distance of 18 degrees of latitude. The extension of such a similar manner of life over so great an area speaks of itself for the work of a great number of centuries. Even the complete development of this peculiar mode of existence, as represented in these mounds, must have taken centuries. And this is the more probably true since in those earlier stages of cultural evolution advances in the

manner of living were infinitely more difficult than they were later. Under these circumstances it is only possible to assume that the origin of the shellmounds in this region represents a historical development of more than a thousand, possibly many thousand years.[59] If this holds good generally for the origin of shellmounds among which the one at Emeryville is, judged by its height, the character of its contents in the lower strata, and the observed geological facts, by no means the youngest, we have still to consider on the other hand the limits of the time up to which these mounds may have been inhabited.

For a long time it has been customary to consider the last as well as the first occupation of the shellmounds as belonging to the remote past. The fact that in California no shellmound is known which is now inhabited or has been inhabited in historic time would speak for this assumption. However, many instances point to habitation of the mounds in the most recent times, not only in a few places, but in different parts of the whole inhabited world. And this cannot surprise us; for we can see primitive man reach into the most recent, nay, even the present time, in various parts of the globe. Thus, as is well known, the first discoverers described the Indians of the Gulf of Mexico as men "living in houses of mats erected upon hills of oysters."[60] R. Schomburgh attributes a large number of mounds made of snail shells, observed by him near the mouth of the Orinoco river, to the Warrow Indians, who are still living in that neighborhood. In the desolate coast lands of the at present dry mouths of the Ica river in Peru there are two enormous shellmounds which the writer has visited. Even now there remain large parts of the wooden huts which were left behind on these shellmounds by the last shell-eaters. Painted pot-fragments, patches of woven fibres, and all

[59] In a similar manner, Abbott, *l. c.*, p. 449, closes a long general exposition of the reasons which speak either for or against a relatively great age of the shellmounds on the Atlantic coast, with the estimate of an age of at least 1,000 years. His deductions are based upon geological reasons (the sinking of the coast) and the dissimilarities of the cultural remains found in the mounds. Peculiarly enough, D. G. Brinton, reasoning from the analogy of the cultural character of the shellmounds with that of the Indian tribes which the explorers met in this country, thinks he has found an argument against a comparatively high age of the shellmounds. W. H. Dall considers the lower strata of his well-explored Aleutian shellmounds to have an age of about 1,000 years. (Contributions, *l. c.*, p. 53.)

[60] Abbott, *l. c.*, p. 44.

kinds of bones lie scattered about. It would be an easy matter to show that the last inhabitants of the hill exhibited the later cultural conditions which prevailed during the time of the Incas in the valleys of Pisco and Ica, about 1460 A.D.

Returning to California, there can be no doubt that the hill-like camp places of the Indians in the interior of the country represented a local variation of the shellmounds along the shore. The form and structure of these camping places resemble the shellmounds of the coast. The material differs in part, since the inhabitants of the inland had fewer shells at their disposal. These camping places were inhabited by the Indians quite recently, or are even now inhabited.[61] The time when the shellmounds of the Bay shore were vacated by their owners was therefore probably not very long ago. With this view coincides the fact that in the upper strata of the shellmound burial is represented by cremation; a form of burial observed up to the most recent times among the Indians of California. The white immigrants settled first on the seacoast, and it is therefore natural that the aborigines retreated earlier from their shellmounds than their brethren in the interior did from their camp places.

Thus, while the history of the shellmounds of this region probably reaches back more than a thousand years into the past, it must have extended almost to the threshold of modern times. The fact that their roots reached far back into the prehistoric period of California does not prevent our seeing the tops developing almost to the present day.

Cultural Stages Represented.

If we attribute to the shellmound an age representing many centuries, cultural differences should be indicated in the successive strata. For it is impossible that the cultural state of one and

[61] The old Indian camping place at Knight's Landing (on the Fair Ranch), at the mouth of a tributary of the Sacramento river, was inhabited, according to authentic information (T. Coleman), as late as 1849 by 150-200 "Digger" Indians. They departed in 1865. The shells, of which only a small number have been found, are of *Mytilus*. A similar mound in Colusa county, 20 miles to the northwest, is still populated by Indians. The Wintun Indians are still accustomed to obtain shells for food by diving into the river. This caused Powers (*l. c.*, p. 233) to surmise that a race somewhat like theirs might have erected these shellmounds.

the same place should have remained stationary for many centuries and, even judging by the mass alone, the mound could not have reached such a height in less than a considerable number of centuries. In attempting to discover possible cultural differences we unfortunately meet with several difficulties. The action of the climate has destroyed in all the strata the objects which consisted of perishable materials. Only the more resistant things remained. But the perishable materials are frequently those in which the decorative sense of man expresses itself most easily, and in which cultural differences are most distinctly shown. A further unfortunate circumstance arises from the general trend to simplicity and primitiveness of the tools of the inhabitants of all shellmounds. So that the visible cultural differences which would generally appear with a people of changing forms of life are imperfectly expressed. Finally, many objects give only partial evidence as regards form and use, for they were often mutilated previous to their deposition in the strata.

In examining the implements of successive layers of the mound we find that awls and certain knife-like tools found in nearly all known shellmounds are met with in all of the strata, while ornaments consisting of *Haliotis* shells and other simple objects of decoration made of shells, corresponding in general appearance to those which are still in use among the Indians, are met with in the graves of the VIth to the VIIIth strata. In the deepest strata, however, there have not been found any bone beads, ornaments of *Haliotis* shells, or saw-like tools such as are known above the VIIIth stratum. Thus there is some support for the suggestion that cultural differences are expressed in the history of the mound.

One of the most striking differences indicating a change in the character of the people whose cultural stages are represented in the successive strata is found in the different forms of burial. The use of cremation appears for the first time in the 4th stratum and extends to the upper, completely undisturbed stratum (II). In the IVth stratum out of 11 bone awls only 4 are calcined, while in the IInd stratum 44 in 61. In the latter the great amount of ash intermingled with calcined human bones becomes very noticeable. Powers relates in his great work on the California tribes

that most of them practiced cremation, and concerning the Karok, Yurok, and Wintun he relates that they bury their dead, while the Yokuts under certain circumstances make use of both customs. The inhabitants of the upper strata of the mound may undoubtedly be assumed to have followed the customs of the majority of modern Californian tribes in the disposal of their dead. Contrasting with this custom is burial in the ground. In this connection interesting evidence is furnished by the strata of this mound: here at least cremation was preceded by interment. In strata IV to VIII of this mound we find this custom prevailing, and we are forced to assume it to have been practiced by the population living on the mound during the time from the deposition of the lower part of stratum VIII to that of the middle of stratum V. In their manner of burial the knees were drawn up, resting upon the side, resembling on the whole the mode of burial in the shellmounds of Santa Barbara county in California, and in those found in Oregon. Instead of suggesting that the mode of burial is a recent one, the findings in the lower strata of the mound at Emeryville might hint that possibly the shellmounds of Southern California and Oregon are older than is at present believed. The Yokuts likewise bury their dead with drawn-up knees, but whether lying on one side is not mentioned. Also of the Wintun detailed information as regards their mode of burial is missing. But even if a majority of tribes should still practice the form which prevailed in the middle strata of the mound, this would not change the fact that the whole mode of burial at this place designates an earlier ethnical stage. The manner in which the inhabitants of the lower strata of the mound—say from the bottom portions of the VIIIth stratum to the bottom of the Xth—buried their dead is not known, because no graves or other evidences of burial appear in them. It is not impossible that their mode of burial differed again from the two kinds of burial found in the strata lying above.

Another striking difference between the upper and lower layers is found in the characteristic implements of the strata. This difference is best represented by a comparative table. In order to understand this better, we give the relative volume of earth moved for each stratum. In the table the volume of the VIIth

stratum (about 100 cubic feet) has been taken as the unit. Bracketed figures in the different columns denote the number of objects which might have been expected as the proportional content of one of the middle strata. In the last two columns the contents of the IXth stratum have for practical purposes been used as a basis.

Layers	Relative Contents	Rubbed* stone implements	Obsidians	Flaked stone implements excepting obsidian		Knife-like implements		Rough awl-like implements
I	5.5	2[5]	2[2]	—		[6]		—[8]
II	10.6	24[10]	11[5]	6[10]		[13]		—[16]
III	7.3	3[7]	4[4]	4[7]		[9]		—[11]
IV	4.2	4	2	4		[5]		—[6]
V	3.4	4[4]	1[1]	5(2)		[4]		—[5]
VI	1.5	—[1]	—[1]	3		[1]		—[2]
VII	1	—[1]	2[1]	6		[1]		—[1]
VII[a]	2.2	—[2]	—[-]	9		1[2]	5	[11]
VIII	7.4	1[7]	1[4]	24	(28)	1[9]		—[3]
IX	3.3	—[3]	1[2]	62		4[4]		5[5]
X	1.8	—[2]	—[1]	17		—[2]		4[3]

Parentheses in the 4th column denote the number of chipped stones which may actually be assumed as tools.

It is evident that the character of the objects in the upper strata is entirely different from that of the implements which are found in the lower beds. Well polished stone implements and obsidians diminish the nearer we come to the bottom. The sporadic occurrence of a well polished stone implement in the 8th stratum of the first column has an entirely abnormal aspect, in view of the otherwise complete absence of such objects from the VIth stratum downward. The abnormal increase of objects of the 1st and 2nd kinds in the IInd stratum is doubtless due to the custom of throwing their possessions into the fire during the cremation of the dead. Still, the IInd stratum yielded a sufficient number of fragments of similar objects which were evidently lost in other ways. So few are furnished by the contents of the lower strata that their limited use is apparently indicated. In fact, even the Vth stratum shares this poverty, for its four polished implements are only represented by fragments of metate-like stones and a tablet of slate, polished on one side. In the lower strata flaked stones (of local materials), bone splinters of an awl-

* Except mortars and pestles.

like shape, and knife-like tools of bone predominate. Among the flaked stones, real implements are very numerous; they are missing in the upper strata. Their technique is primitive. On one side they are flat and are worked on the other side only. This working, too, is crude, and the finishing primitive. The turtle-back form is present. Different kinds of scraper-like tools of primitive form, and of drill-like sharpened stone fragments, must have been more common implements in the hands of the inhabitants of this stage than among the dwellers on the upper strata, where these tools are lacking.

A well formed implement of flaked stone, worked on both sides, was found low down in stratum VIII (a spear-like blade, pl. 10, fig. 14). Strata IX and X offer nothing similar. The leaf-like blade from stratum VIII (pl. 6, fig. 20), where a crude workmanship is paired with an attempt at more regular sharpening of the edges, does not favor the view that the inhabitants of the mound had been well versed from the beginning in the production of chipped implements.

Very remarkable is the occurrence together of crude splinters of bone, which show from long use their real value as tools, and the neat, almost elegant, knife-like implements. Among the latter we find the only ornamental fragment of a tool of bone obtained during the whole course of the excavation. The people who used the splinters of bone for their tools were not so primitive but that they possessed elegant objects of bone, and not so far advanced but that they were often satisfied with such primitive implements as common bone splinters. But both classes of these typical tools are markedly different from what the upper strata of the mound offer in the line of implements. Hence the people of the lower strata must have represented a somewhat different mental type or a different degree of mental training.

It seems advisable, from what we know, to separate the older inhabitants who had settled here and raised the foundations of the mound up to the middle part of the VIIIth stratum, from the later population of the grave period. They may have been neolithic, they may have been connected with the following generation by some common traits, although there is little evidence for this; but the two people certainly differed in cultural characteristics.

The race that commenced building in the middle of the 8th stratum was apparently less different from the population of the upper strata than from its predecessors. But differences can here, also, be discovered. The chipped tools of local materials still continue for some time (about to VII*a*), and obsidian seems to have come to them as a rather rare material. Only a few bone implements from grave 8 are extant in this group of strata. Contrasted with the usage of the people of the upper strata is also the use of bone arrow blades, which the last inhabitants of the mound apparently did not possess. They had not yet departed from an extended employment of bone as a working material; a fact usually more characteristic of a primitive people than of one further advanced.

One observation should still be made in this connection. It is a striking fact that in the fifth stratum and its immediate proximity a number of objects appear, the likeness of which was not found elsewhere in the whole mound. They are:

(1) Fragments of metate-like stones, stratum V.
A long, dull, chisel-like tool of horn, from stratum V.
A tablet of slate polished on one side, stratum V.

(2) Pieces of antlers, truncated for use as tools, stratum V, and a knife-like implement, stratum V.

It seems possible that such sporadic types of tools were left by a people that only temporarily inhabited the mound. Since, however, up to the present time parallel investigations have furnished but little material, such an hypothesis cannot be tested as to its exactness; nor is it possible to state from what region they might have come.

PART II.—ARTIFACTS UNEARTHED AT THE EMERYVILLE SHELLMOUND.*

The artifacts, complete and fragmentary, unearthed during the excavation of the Emeryville shellmound are of stone, bone or horn, and shell.[62] In number, the objects of bone and horn about equal those of stone, or if the large quantity of chipped stone in the lower strata be deducted, being mainly workshop chips, the bone specimens are even in the majority. Although shell heaps usually abound in bone implements, the large number of such implements recovered in this mound is quite remarkable, especially since the mound at West Berkeley, only two miles distant, seems to possess a much smaller number of them. There the bone implements recovered bear the proportion of from 1:5 to 1:10 of those of stone, so in the case of bone implements we find verification of the observation regarding the less frequent occurrence of the bones of animals as waste in proportion to other waste.[63] The occupants of the West Berkeley mound being essentially fishermen, apparently gave less time to the chase, and as a result may have neglected handicrafts in which bone implements were used.

A. Implements made of Stone.

a. Made by Grinding.

1. Mortars.

Stone mortars were among the most common and most useful implements that the ancient inhabitants of the land possessed, being used for the preparation of meal and for other purposes.

* For the final literary form of the second half of this paper P. E. Goddard is responsible.

[62] Remains of pottery are found in quantities in the shellmounds on the Atlantic Coast (cf. Abbott, *l. c.*, p. 43*a*), and also in those of other localities (Brazil, Peru). They do not, of course, appear in California shellmounds since stone pots and baskets were used in their place at all times.

[63] The specimens of bone implements recovered in shellmounds are of great importance in the study of the use of such implements among primitive peoples, since they are so rarely found in other fields of research (cf. also Abbott, *l. c.*, p. 205). Still shellmounds greatly differ in this respect. While bone implements are "quite abundant" in the shellmounds of New England, the same as here (Wyman, Am. Naturalist, 1, p. 581), the mounds in New Jersey yield only one bone to every 3,000 stone implements. (Abbott, *l. c.*)

Correspondingly numerous therefore are these objects, found mostly in fragments, and scattered through nearly all the strata from the second to the tenth. There are three perfect specimens and eleven fragments in our collection, nearly all made of lava. The largest of the mortars, 1–9102, fig. 3, was recovered quite accidentally near g in plan III at the extreme western end of

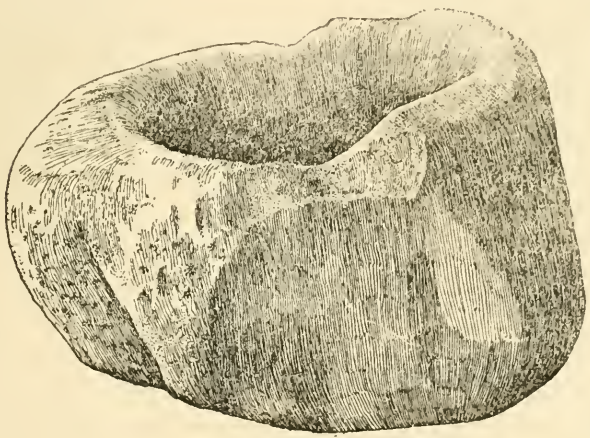
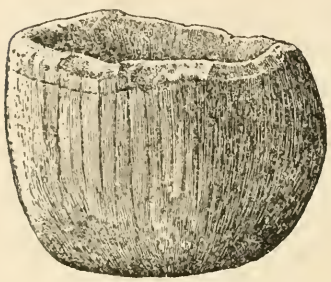


Fig. 3. × ¼. A large mortar.

the mound. Judging from the place of its discovery, about 3½ inches below the surface, the mortar must have been lost in about the middle period while the foot of the mound was increasing from n to p. Its outside surface is rough like the natural boulder, it is 1 foot long by 9 inches wide and 7½ inches high. Within it is oval and measures 6 to 7 inches in diameter and 5 inches in depth. The smaller mortar, 1–8705, fig. 4, was found in stratum VI. On the outside it is rounded off and ornamented with engraved vertical lines, which are intersected near the edge by a horizontal one. The edge is partly worn away by use. Such simple lines as an ornamentation of the outside are occasionally observed on California mortars.

1–8664, fig. 5, a small mortar from stratum III, is of different shape, oval both in its outline and in cross section, the bottom being slightly flattened; it has a rather small round cavity, 1½ inches in diameter and one-sixth inch deep. It may have served

for the pounding up of substances which were used only in small quantities, such as color pigments. The width of this mortar is 2½ inches, its height and thickness 1⅞ inches. Powers presents a view of a similar specimen from California, a proof that this type occurred in this region. A fragment, 1–8810 of the collection from stratum VIII, may be the bottom of a similar utensil.



4

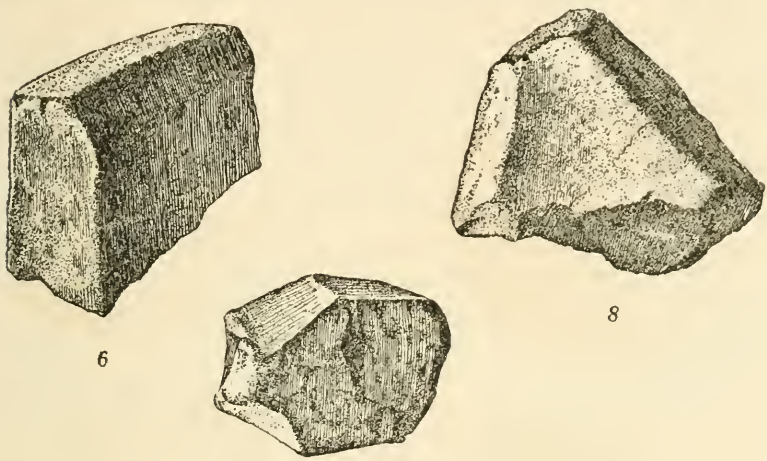


5

Fig. 4. About one-half natural size. Fig. 5. × ¾. Small mortars.

Some additional types of mortars are represented among the fragments; they will be given below in the order in which they were recovered. 1–8594, fig. 6, from stratum II, is one of several fragments of this stratum and belongs to a relatively advanced type, resembling a vessel. These stone vessels had a fairly even thickness of the sides of about an inch, and were fashioned quite regularly without and within. This rim is flattened and slopes inward. The diameter of the complete mortars may have been a foot. This type of mortar is quite common in California. The collection from Santa Rosa Island in the University Museum made by Dr. Jones contains several similar specimens. 1–8707 fig. 7, stratum IV, is an odd fragment. Its well fashioned bottom part is surrounded by a rim which in turn is bordered by two chambers which exactly correspond; the surface between them is broken. This fragment may also have been part of a mortar, although it is not possible now to restore it to any shape represented among the familiar types. Fig. 8, 1–9077, shows a fragment of a mortar recovered in the Xth stratum, and it is the only one found lower than stratum VIII. It lay hardly an inch from the base of the mound. It has a peculiarly jagged shape; the

convex exterior is the rough bowlder stone, as are the uneven sides, but the inner concave surface is ground down smooth. The peculiar jagged shape may be explained by the fact that it is a piece of a mortar, the rim of which by long usage had been worn away in places, and as a result points were formed. The collec-



Figs. 6, 7, and 8. × ½. Fragments of mortars.

tion of Dr. Jones from Santa Rosa contains a mortar with a jagged rim, caused probably also by wearing away, but in that case the points of the rim show some decoration, unlike the present fragment. 1–8848, fig. 9, stratum VII*a*, may throw some



Fig. 9. × ⅔. Fig. 10. × ½. Fragments of mortars.

light on the possible cause of these indentations resulting from long usage. In the latter specimen the surface of the bulging portion is rough, as in 1–9077.

The small fragment, 1–8621, fig. 10, stratum II, has to be included also in the class of mortar-like utensils. It is made of a soft material resembling steatite, it curves as if it were a handle and is broken off at one end, while the other rounded end shows marks of blows. This object may be compared to the handle of the cup-shaped vessel of steatite from Dos Pueblos in Southern California and shown by Professor Putnam, l. c., pl. VI, fig. 5 (cf. l. c., p. 110). Similar utensils from Santa Catalina Island and other places are mentioned there; hence it may be assumed that this type of utensils was used by the occupants of the mound during its last period.

Fig. 11, 1–8533, from stratum I, shows a stone fragment, hollowed out like a mortar. The upper rim of the specimen must have had a sharp angle, as the outer surface is almost vertical while the concavity is rather shallow, forming a cup with a considerable diameter.



11



12

Fig. 11. × ½. Fragment of a mortar. Fig. 12. × ½. Fragment of a stone used for grinding.

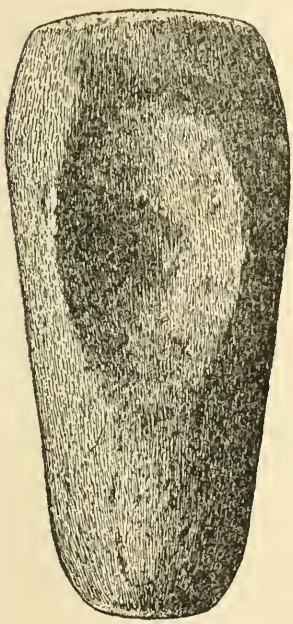
2. Flat Stones.

It is only from three small fragments that the presence of this type within the mound may be inferred. All three were recovered in stratum V; one of them, 1–8751, is shown in figure 12. Judging from the fragments, these grinding stones were square in shape, about 1½ to 2 inches in thickness and were worn smooth, both on the horizontal surface and on the sides and ends. The occurrence of flat grindstones is not unprecedented in California: some have been found in Sonoma county[66] and elsewhere. They were perhaps used in the manufacture of shell ornaments and beads.

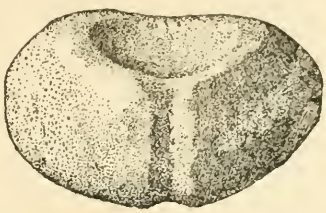
[66] Moorehead, *l. c.*, p. 291.

3. Pestles.

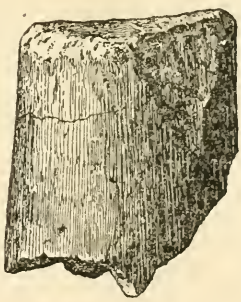
Many fragments having the usual form were found, but only one was perfect, and that of unusual shape. 1–8670, fig. 13, was recovered in cut A, 6 inches below the surface. It is 6⅜ inches long, 3 inches wide, and 2⅛ inches thick, tapering toward the pestle-like rounded end, the other end being flat. Marks on it show that it was also used as a hammer. Sunk into one of the sides, at about the center of gravity, is a long conical groove about one-third of an inch deep; the opposite side shows the beginning of another such groove. They may have been worn into the stone by using the broad side of the implement in driving stakes, etc.



13



14

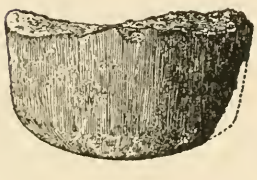


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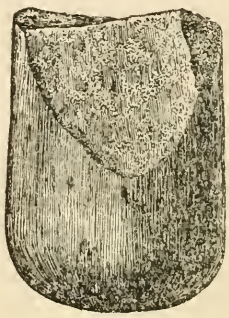
Fig. 13. × ½. Pestle with depression on one side. Fig. 14. × ½. A grooved sinker. Fig. 15. × ½. Upper end of a pestle.

The beginning of a second groove, otherwise superfluous, on the opposite side seems to bear this out, as do the marks on the surface of the broad end. These latter indications are a proof that the utensil was not used as a pestle only. This is not the only instance of a pestle with side grooves. Ch. Rau pictures a very

similar one from Tesuque in New Mexico.[67] Mr. Stevenson's opinion that the side grooves served for holding the pigment which had just been ground by the pestle seems to be merely a conjecture on his part. A stone was found in the West Berkeley shellmound which seems arbitrarily to combine several purposes, —a groove encircling it shows its use as a sinker, a semispherical cavity which at its widest part breaks into the groove points to its use as a mortar.



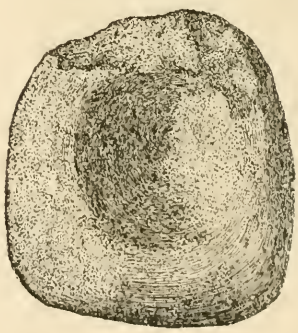
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17



19



18

Fig. 16 and 17. × ½. The lower ends of pestles. Fig. 18. × ½. Stone used for hammer with depression for fingers. Fig. 19. × ½. A new type of implement of unknown use.

[67] Observations on the cup-shaped sculpture in Contrib. to North American Ethnology, 1882, V, fig. 39, with p. 47 repeated by Stephen D. Peet in The Moundbuilders, 1892, I, p. 5, fig. 5.

The 17 fragments of pestles of usual shape were fairly uniformly distributed throughout all the strata, as was the case with the mortars. However, 7 of these came from stratum II alone. There were no peculiarities to be noted in the fragments as to their forms. They were about 2½ inches thick and were rounded off at the lower end. The upper end sometimes tapered after a conical swelling immediately next the grinding surface. They were cut straight off at the upper end, unless indeed the abruptly cut surface is the result of a previous breaking. Sharply pointed or button-like ornamentations at the upper ends which are usual in those found in California[68] were not noticed. Figures 15 to 17 show three fragments,—1–8882, 1–8597, and 1–8666 from strata VIII, II, and from the cut A. Of these, the first illustrates the upper end of a pestle, the other two, lower ends.

The little object 1–8620 from stratum II, plate 12, fig. 11, seems to be best included under pestle stones. It is made of fine grained stone, which would point to its use for more delicate purposes. It is a truncated cone, with oval section, 1⅛ inches wide and 1$^{3}/_{16}$ inches thick. The lower base is slightly arched and, as can plainly be seen, is scratched slightly by use; a small middle cavity in the narrow upper surface shows traces of asphaltum. It may have been used as a pestle.

4. Hammer-like Stones.

Strangely enough, only two such implements were found in this mound, while in the West Berkeley mound several that conclusively belonged to this class were unearthed.

One of these, a boulder stone the size of one's fist, oval in shape and flattened, was found in the lowest stratum, X. The marks of blows making the side edges uneven show its use as a hammer. The other, 1–8720, fig. 18, from stratum IV, is one of the familiar type having a groove for the insertion of the fingers. It is a stone 3¼ inches long, 3 inches wide, and of an uneven thickness not exceeding 1⅝ inches, flattened off at its thickest (lower) end. There is a depression in each of the broad sides. The surface of the indentations is dotted with small holes. Similar stones have been found in many places in the United States.—in

[68] Putnam, *l. c.*, pp. 87-89; Moorehead, *l. c.*, p. 290.

New Jersey, Pennsylvania,[69] on the Aleutians,[70] and elsewhere. Abbott has pointed out the fact that the edges of some of these stones could not very well have been used for hammering since they do not show the signs of such usage. The stone in question was evidently used in two ways,—as a hammer at the lower flat surface, which is from five-eighths to 1⅛ inches wide and in this case provided with indentations serving for the insertion of the finger; and as a hammer at the flat sides for the driving of stakes, etc., in which case it was grasped by the rims. The pits in the depressions were probably the result of this latter use of the implement. The writer has noticed that just such flat stones were used in Bolivia for the driving of stakes, and there, too, the broad side which gave the blow was pitted. The material used is hard sandstone.

5. Flat Stones Pointed at both Ends.

Two objects of this form, coming from stratum II, represents a new type of implement. They are almost identical in shape. One of them, 1–8604, is shown in fig. 19. They consist of long, flat, quadrangular boulder-stones, 3⅝ and 3⅞ inches long, with an even width and thickness of 1⅝ inches. Both ends are simply sharpened to a point, and the broad sides, top and bottom, are shaved off as far as the middle of the stone. In form, the stones are similar to a wooden top of today.

6. Sinker-like Stones.

Stones of this description form a large class, exhibiting, however, great diversities of shape. They all seem to have served the same purpose since most of them show indisputable signs of such usage.

About 18 stones of this kind were found in the mound. As regards their varying form and utility, they may be classed as follows:

I. Spherical and oval stones with a peripheral groove: Fig. 20, 1–8669, shows a spherical stone of this kind, found at a depth of 5 feet in cut A. 1–8534, fig. 21, a fragment of an oval stone with a groove about its largest circumference is from stratum I.

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[69] Abbott, *l. c.*, pp. 425 to 431, figs. 399 to 404. Chas. Rau, *l. c.* Smithson. Contrib., No. 297, Vol. XXII, p. 20, figs. 80 to 81, and p. 22.

[70] Dall, *l. c.*, p. 55.

II. Flat boulder stones with notches in the corresponding sides for fastening them: Two of these were found in the upper strata; one, from stratum IV, is shown in figure 22.

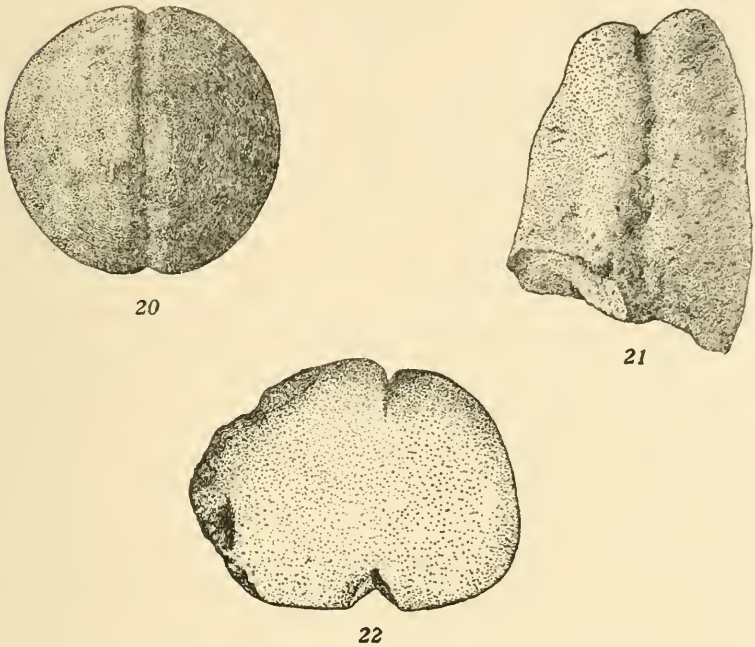


Fig. 20. × ½. Figs. 21 and 22. × ¾. Sinker-like stones.

III. Stones with holes pierced through them by which they were suspended: These form the type that may with the most certainty be classed as sinkers. 1–8535, plate 12, fig. 7, from stratum I, is the only specimen of this class found.

IV. Pear-shaped and kindred stones; also conical pendant stones: The fourth class is the largest, in that the greatest number of shapes may be included in it. The following are to be counted in with this class:

a. Pear-shaped stones and others, though slighter, still very like them. This type is represented by:

1. A perfect pear-shaped stone, 1–8611, plate 10, fig. 2, from stratum II.

2. More or less fragmentary bits, 1–8612, 3, the first without a doubt, the second probably from stratum II. See 1–8613, plate 10, fig. 1.

3. Five fragments of stones of a slenderer, less perfect though similar form, 1–8614, 5 and 6 (plate 10, figs. 5, 3, 8), 1–8617 and 1–8718 (plate 10, fig. 4), the latter one from stratum IV, the others from II.

b. Inverted pear-shaped stones, some flat. This shape is related, though distantly, to the above. Two fragments, 1–8618 and 1–8619, from stratum II, see 1–8618, plate 10, fig. 6.

c. A conical stone with slanting lower surface (1–8719, plate 10, fig. 7) from stratum IV. It is very similar in shape to the upper part of the pear-shaped stones.

d. A pointed stone, 1–8925, from stratum VIII, plate 10, fig. 9, which is only very distantly related to the pear-shape forms.

These stones belong to that class of objects which have been interpreted at different times as being:

1. Weights for determining the vertical.
2. Weights for weaving apparatus.
3. Weights used in spinning.
4. Weights used for fishing nets or lines.
5. Ornaments.
6. Medicine stones or charms.[71]

A number of articles under class IV (Form IV*a*) are made of hematite.[72] Of the objects under consideration, 1–8925 (plate 10, fig. 9) is made of the same. The use of hematite generally presupposes that an implement is going to be employed as a weight. Since the forms that belong to this class merge into one another in an uninterrupted series, one is justified in assuming that they were all weights.

It is further clear that the shape of the pear-like stones, which have caused so much speculation, must have been fitted for some particular purpose. This is to be inferred from the fact that stones of like shape have been found in widely separated parts

[71] Dr. L. G. Yates, Smiths. Rep., 1886, pt. I, p. 296, further explained in Bulletin of the Santa Barbara Soc. of Nat. History, No. 2; Moorehead, *l. c.*, pp. 249 to 250, etc.

[72] Abbott, *l. c.*, p. 232, fig. 220, from Illinois; Rau, Smith's Contrib., p. 27, No. 101, from Tennessee (cf. for both pl. VIII, fig. 2); Moorehead, *l. c.*, p. 251, fig. 29, from Santa Barbara, Cal.

of the United States outside of California, in Maine,[73] Massachusetts,[74] Ohio,[75] Illinois,[76] and elsewhere.

Furthermore, H. H. Bancroft[77] has made the important assertion that such implements are usually found in a mutilated condition. This is borne out by the fact that out of the nine pear-shaped and inverted pear-shaped stones represented by groups 4*a* and 4*b*, there is only one which is perfect. It is to be inferred from this that, however elaborately they are ornamented, these implements were put to essentially practical uses. Hence the theory that they were worn as ornaments or charms is untenable.[78]

The supposition that they were used on the end of a plumb line is also invalid, since civilization was not far enough advanced among the Indians for that sort of thing. Weaving and spinning apparatus requiring the use of the stones as weights are so rarely found that we cannot explain the presence of such a large number of stones in that way. And especially not in California since the Indians there have never spun nor woven.

Hence the only explanation left is that they were used in fishing. The great quantities of such implements found on the coast has often been noted.[79] That nine were found in a shellmound such as the one at Emeryville substantiates this theory. They have also been noticed in a number of other shellmounds about the bay (even though these have been little excavated), as at Ellis Landing and in Visitacion Valley,[80] and their shape is identically the same (plate 10, fig. 2). There is one from a shellmound on Seaver's Ranch with exactly the same shape, plate 10, fig. 1. Drawings were made by J. Deans of two other objects

[73] Moorehead, *l. c.*, p. 92, fig. 113.

[74] Rau, *l. c.*, p. 27, figs. 105-106, Abbott, pp. 228 and 230, figs. 216 and 218.

[75] Abbott, *l. c.*, p. 233, fig. 222, Rau, fig. 103.

[76] Abbott, *l. c.*, pp. 232 and 233, figs. 221 and 223.

[77] Native Races, IV, p. 711.

[78] According to Dr. L. G. Yates, Bulletin 2 of the Santa Barbara Soc. of Nat. Hist., the California Indians regard such pear-shaped stones as charms and use them as such. This is analogous to their superstitious belief concerning stone hatchets whose original significance has long been forgotten and hence is no explanation of the original use to which these articles were put.

[79] Cf. F. W. Putnam, *l. c.*, p. 195.

[80] See Illustration in H. H. Bancroft's Native Races, IV, p. 711.

which were also taken from the same shellmound in Visitacion Valley and which had like forms.[81] If we accept the hypothesis that these stones in general are sinkers, there are of course difficulties in the case of individual stones, that must be explained away. The following peculiarities which appear must be mentioned:

1. Occasional peculiarities in material: Some are not very heavy, some rather soft; and in others the ornamentation either in color, grain, or crystalline markings is so prominent that an ornamental use is suggested. 1–8615, plate 10, fig. 3, seems to be a stone of this description,—the material of which it is made is reddish and fine-grained, and ornamented to some extent.

2. The occasional absolute lack of any contrivance by which the implement might have been suspended: 1–8925, plate 10, fig. 9, is, for instance, of this kind. It is for the greater part of its length absolutely round and gradually tapers to a point. The outer end is in the form of a handle which is flattened to about one-half inch wide and one-quarter inch thick and is rough from the marks of blows; the main part of the instrument is smooth. The handle-like part must, from its form and roughness, have served to fasten it by. It looks, however, more as though it were intended to fit into a shaft, rather than to be suspended. It is important to note that one of the long sides is entirely covered with asphaltum. This fact excludes the possibility that it was fastened into a shaft. It must further be called to mind that, as in the case of the California Indian dancing costume, various rod-like bits of stone are sometimes fastened on by means of hangers, the provision for their suspension being made on the stones themselves. The use of asphaltum in securing them often did away with otherwise necessary changes in their form. At any rate it allowed great imperfection in form.

Fragment 1–8616, plate 10, fig. 8, is an example of the above; it is pear-shaped and the upper conical point is encircled by a broad band of asphaltum which served for its attachment.

The sinker-like stones of classes I-III present fewer difficulties in their explanation than do the pear-shaped and kindred ones.

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[81] Journal of the Anthropological Institute, *l. c.*, p. 489.

The use of flat boulder stones with side grooves as net-sinkers is agreed to by all.[82] The fact that here as in the East, and as in the shellmound of West Berkeley, many of these have been found in groups, points almost conclusively to their use as net weights.

Professor Putnam has already called attention to the use of spherical stones (fig. 20), with a peripherally encircling groove as sinkers.[83] Similar stones are also found in shellmounds in Massachusetts and in the Aleutian Islands.

Dr. Yates[84] was informed by an Indian that such was the use of a stone found in Napa (California).[85] The use of the oval stones (as fig. 21) is in general to be explained in the same way. A stone of that kind is, for example, known to have been found in Oregon.[86] Another one has been found in California (supposedly at Spanish Flat). It has been pictured by H. H. Bancroft.[87]

The stone, 1–8535, plate 12, fig. 7, from stratum I, is a sinker, judging from its general shape; it is long and oval, pierced at the upper end. Stones of like form have been found in numbers in the shellmound at West Berkeley. They are probably sinkers like many other stones found there.[88] The upper eyelet has been broken off in the stone under consideration. The stone is slightly flattened; one of the end surfaces is more curved than the other and one of the broad sides more elaborately adorned. On one side a lattice-like ornamentation joins on to a deep groove. On the other side may be seen several somewhat ruder lines like hatchings. The material is that commonly used. Abbott describes an ornamented stone pendent as a gorget and another one

[82] Cf. particularly Abbott, *l. c.*, p. 237.

[83] *l. c.*, p. 203.

[84] Bulletin, *l. c.*, pl. III, fig. 22, and p. 17.

[85] Spherical and oval stones with a peripheral groove are implements of a very simple form and hence they lend themselves to different uses. The old copper fac-simile of a stone hammer in the Museum of Science and Art in Philadelphia shows conclusively for the region in which it was found, *viz.*, Lake Titicaca, Pako Island, in Bolivia, that similar stones were used as hammers.

[86] Rau, Smiths. Contrib., No. 318, p. 27, fig. 110.

[87] Native Races, IV, p. 705.

[88] Sinkers provided with a hole and of like shape are in use among the Western Eskimos. See J. Murdock, in IX, Am. Rep. of Bur. of Ethnology, 1887 to 1888, p. 282, fig. 273. They are found in great numbers in the United States.

from Illinois with plastic ornaments, as a sinker.[89] Compare this with a picture of a pendent stone from San Clemente Island.[90] The fact that these stones are ornamented seems to make their use as sinkers doubtful but not impossible, since fish-hooks are sometimes much ornamented.[91]

Plate 12, fig. 8, 1–8630, is somewhat sinker-like, but in many respects it diverges from the general class. It is made of very light, soft stone, and is an elongated oval in shape, with five grooves parallel to one another cut in about the edge. It is elaborately ornamented with oblique hatch-like lines on the edges between the grooves. Hence it is improbable that it was a sinker —it cannot, however, as yet be assigned to another use.

7. Cylindrical Stones.

These differ from the pestles in that their diameter is smaller and that they bulge out only slightly toward the middle. Two objects of this kind came from stratum II, of which 1–8609 is shown in plate 10, fig. 10. Both are broken at their ends. They are respectively $4\frac{13}{16}$ inches and $2\frac{5}{8}$ inches long and fifteen-sixteenths inch and 1 inch thick. The surface of the break in the shorter one was subsequently smoothed off; perhaps by using it as a pestle. Long cylindrical stones of this kind partly flattened on one side and having encircling grooves at the tapering ends have been pictured by Yates[92] and Moorehead[93]; these were found at Santa Barbara, Southern California. To these may also be compared a stone pendant from Tuolumne county[94] pictured by Moorehead, since the lack of complete ends in the stones gives considerable room for speculation as to what the whole form might have been. On the other hand, the tentative designation of them by Moorehead and Yates as charms is in no way justified. The better interpretation of their use would be that of sinkers especially in the case of those provided at both ends with grooves

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[89] *l. c.*, pp. 398 and 234.

[90] Putnam, *l. c.*, p. 209, fig. 81.

[91] Among the Thlinkites conys Niblack.

[92] *l. c.*, pl. IV, figs. 32, 33, so. Smiths. Reports, 1886, I, partly, pl. IV, figs. 32, 33, pp. 296 to 305.

[93] *l. c.*, p. 251, fig. 381, Nos. 30 to 33.

[94] *l. c.*, p. 249, fig. 380, No. 1.

for attachment,[95] since stones coming from Peru[96] which are undeniably sinkers are very like these in many respects.

8. Needle-like Stone Implements.

An awl, 1–8608, plate 12, fig. 10, of stone, comes from stratum II. Plate 12, fig. 9, 1–8711, from stratum IV, is piereed and similar to the above though needle-shaped.[97] From seratches appearing on 1–8608 we infer that it was used on rather hard materials.

9. Tobaceo Pipes.

It is remarkable that tobacco pipes were found only in stratum II; of these we have five perfect speeimens and one fragment. This bears out the statement made above, that stone utensils well-made and smoothed off were found only in the upper strata of the mound and partieularly in stratum II. Since it is not probable that the inhabitants of the lower strata were ignorant of the practice of smoking, the absence of pipes must be explained in some other way. On the one hand it is possible that many of the older pipes were made of wood. Powers has described a number of wooden pipes in use among the Indians of today. On the other hand, it is possible that the practice of smoking was not so common in remoter periods and therefore it would be likely that fewer pipes would be found. There is a third possibility, that the large number of pipes found in stratum II is dependent on the method of disposing of the dead, so characteristic of this stratum and which caused articles to be preserved which would otherwise have disappeared. The pipes described below represent two primitive types, with some insignificant variations.

Plate 12, figs. 2*a* and (eross seetion) 2*b*, 1–8622, represents one type. It is made of a soft serpentine-like material, gray on the broken surface and reddish brown on the outside. It is one and seven-eighths inches long and incomplete. There is a broad bowl-like part and a narrow neck or stem, a prolongation of it. The bowl is conical, one and one-eighth inches long and of inconsiderable width, being three-fourths of an inch in diameter. The "boring" of the stem portion is cylindrical and eccentric.

[95] Cf. V. A., also flat specimen, Smiths. Rep., I, pl. IV, fig. 30.

[96] In the Museum of the Univ. of Philadelphia.

[97] Prof. Putnam, p. 211, in figs. 87, 88, from Santa Barbara.

Plate 12, figs. 3*a* and 3*b*, 1–8623, is the only representative of the second type. It is made of green serpentine, and is two and one-sixteenth inches long, tapering into a tubular shape. The hole in the stem is as above, only at the mouth end it is conical and shorter. A groove is cut into the tapering end.

Plate 12, figs. 1*a* and (in section) 1*b*, 1–8624, is made of soft gray stone and is very similar to the preceding one, except that it lacks the groove at the mouth end and that it is shorter and thicker.

Plate 12, figs. 4*a* and (in section) 4*b*, 1–8626, is a small cylindrical object only nine-sixteenths of an inch long and seventeen-thirty-seconds of an inch wide. The seven-sixteenth inch conical hole takes up nearly the whole width of the stem so that the rim surrounding it is sharp. The short conical boring at the stem end is only five-sixteenths of an inch wide. The proof that this too was used as a tobacco pipe lies in the fact of the disparity of the two conical borings and in that the entire width of the bowl end of the pipe is used to the best advantage. It seems to have been more of a miniature or toy than an article in common use. However, the quantity of tobacco needed to fill any of the pipes could not have been great since the cone-shaped cavity in the bowl is so small. One is here reminded of Schumacher's entertaining description of the way in which a Klamath tipped back his head in order to raise his pipe vertically that he might lose none of the tobacco. The stem ends of the pipes are equally imperfect. They must certainly all have been fastened to a pipe-like mouth-piece similar to the stone pipes which Professor Putnam has pictured and described and which when unearthed still had the mouth-pieces attached by means of asphaltum.[98] Some Indian pipes of today are fastened to the mouth-pieces by means of ligatures,[99] as was evidently the case with pipe shown in plate 12, fig. 3, and with another one of the collection (1–8625) the stem of which had been broken. A rude notch was cut into the outside of the stem to facilitate the rebinding and to give it a better hold. At any rate, the means of attaching the mouth-piece (comp. particularly figs. 1 and 4) was as inadequate as was the receptacle

[98] *l. c.*, pl. IX.

[99] Powers, *l. c.*, fig. 43, opp. p. 426.

for the tobacco at the front end. Short reed-like tobacco-pipes are particularly characteristic of the middle portion of California. A stone tobacco pipe coming from a shellmound in Visitacion Valley south of San Francisco, pictured by H. H. Bancroft,[100] is very similar to plate 12, fig. 3. The fourth one in the plate, pictured by Powers, is also analogous. Short pipes are of course also found in southern California,[101] but the longer reed-like variety is more usual. A tobacco pipe pictured by Marquis de Nadaillac and coming from the cliff dwellers[102] is somewhat similar to plate 12, fig. 2, but here the stem was so slight that there was no need of a special mouth-piece. The short pipes as well as the long ones of southern California[103] are also found in the eastern part of the United States. Several clay pipes from New Jersey[104] may be compared to them; also two objects merely classified as "pipes," but most probably tobacco pipes, from West Virginia[105] and Tennessee.[106]

10. Various Polished Stone.

In the mound were found different kinds of stones,—some isolated specimens showing good workmanship but as yet unclassified, and others, of the common kinds which were, of course, in use at the same time with the more perfect implements.

Those of the first kind were all found in stratum II. One of these is 1–8671, plate 12, figs. 12*a* and (front view) 12*b*. It is made of soft serpentine. Its shape is that of a flat cylinder of not entirely uniform height, with flat or almost imperceptibly curved ends; there is a perforation which extends inward in the form of a cone from both ends.[107] In the gentle curving-out of its peripheral surface it is particularly like ear-pegs. It is worthy of note that Moorehead shows two objects from the neigh-

[100] *l. c.*, IV, p. 711.

[101] Comp. two of Putnam's views in pl. VIII.

[102] *l. c.*, p. 256, fig. 112. The one drawn by Peet, *l. c.*, I, p. 282, shows the same object.

[103] Cf. Abbott, *l. c.*, p. 330, fig. 322, from Massachusetts.

[104] Abbott, *l. c.*, pp. 336 and 340.

[105] Fewkes, p. 128, fig. 155.

[106] Rau, Smiths. Contrib., *l. c.*, p. 44, fig. 176.

[107] As regards its form it may be compared to the objects shown by Moorehead, *l. c.*, p. 279, fig. 418, Nos. 2 (from Napa county) and 7, from North and Central California.

borhood of Stockton analogous to it in many respects and designated by him as lip-pegs,[108] and that barbed, bone spear-heads like those used on the northwest coast were found in the vicinity of Stockton, according to Mr. Meredith, in close proximity to a lip-peg[109] of the kind used on the northwest coast. The possibility, therefore, of an ethnological connection between the ancient inhabitants of the vicinity of the central California water basins and those of the north cannot well be denied.

The small object, 1–8628, plate 12, fig. 13, seems similar in size and form to the object shown in plate 12, fig. 12. This similarity is only a superficial one, aside from the difference in the material of which it is made,—burnt clay, rare in California and not carved but modeled; it is further different in the fact that its cross section is oval and that its slightly arched end is covered with marks of blows, and that the perforation is absent.

Plate 12, fig. 6, 1–8631, is of quartz-colored material, flat and tongue-shaped. It is broken off at the broad end, the lower surface is flat, the upper slightly arched, and the edge blunt. Judging from its form and the brittle nature of the material of which it is made, it must have been an ornament.

Plate 12, fig. 5, 1–8850, of chalcedony, looks like a neckless head of a bird resting on a bust-like body; the bill is linear; the eye is represented by a deep hollow. That this object is not an artifact is the conclusion suggested by the presence of a crust over the entire object from beak to eye, formed by its weathering. In relation to other products of human workmanship, such an object has worth only in so far as its shape was of undoubted significance to the inhabitants, and carefully preserved for that reason.

Besides this, various flat, smooth stones of chert and agate were found, one of which, 1–8849, from stratum VII, is shown in fig. 23. It is made of fine grained sand-stone, has but one smooth side and was used as a whet-stone. A thin oblong sheet of mica-slate was unearthed, but it must have been used only as an ornament.

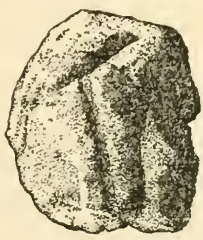
[108] *l. c.*, p. 285, fig. 426, Nos. 3 and 5.

[109] The use of lip-pegs has never been observed in that region between Mexico and the northwest coast of North America. W. H. Dall, Public of the Bur. of Ethnology, 1881-82, III, p. 86.

Fig. 24 (1–8721 from stratum V) illustrates one of two analogous objects from the upper strata of the mound. It is a common stone with about seven groove-like lines of varying breadth and depth on the sides. Two of them form an angle which though purely accidental might seem to be ornamental. The grooves come probably from its use as a whet-stone for bone awls, etc. To this purpose the hard, sandy substance easily lent itself. Long bars could not have been fixed to this stone, since for that purpose the grooves are neither broad nor straight enough. Several drawings by Rau[110] and by Moorehead[111] may here be compared.



23



24

Fig. 23. × ⅓. Fig. 24. × ½. Stones, probably used for whetting.

b. Chipped Stones.

A great number of these were found in the mound. As regards their shape they fall into two classes, either finished implements or chips from the workshop. As regards the material of which they are made, they also fall into two large separate classes: those of the usual, light stone natural to the place such as flint, chert (in green or brown variety), horn-stone, jasper, etc., and those of obsidian (volcanic glass), which was not to be had in the immediate locality, although it was the preferred material. The classification according to material is the more important. There were found about twenty-five obsidian objects (among them a very few rough pieces or waste bits from the work-shop, the latter all small) and about 140 hewn stones of other kinds of material. Most of these were waste from the work-shop, all of

[110] Smiths. Contrib., *l. c.*, p. 304.

[111] *l. c.*, p. 338, fig. 493.

the size of implements, but relatively few (about one-fourth) complete tools.

The obsidian implements came from the Ist to the IXth strata, but most of them were found in the upper layers. Nearly three-fourths of them were taken from the three upper strata. In stratum II alone there were ten implements and one piece of obsidian in the rough. It can certainly be inferred that the great quantity of obsidian tools from II was connected with the custom of burning the dead and of casting their belongings into the flames. In addition, the great number found here shows a broader and more universal use of obsidian in the making of implements.

They are all of very simple form, such as arrow- and spear-heads,[112] spear-like points and a flat knife-like blade, made from the rough stone by polishing off bits[113] (see plate 10, figs. 11 to 16). Arrow-heads of obsidian were found only in stratum II, comp. 1–8676, plate 10, fig. 13, the blade-like knife. 1–8633, fig. 11, and the spear-like knife end, 1–8634, fig. 16, which were found there. 1–8926 from stratum VIII, fig. 15, may have been either a spear-head or a knife. Fragment 1–8536 from stratum I, fig. 12, by virtue of its two unevenly arched surfaces, and 1–8883, fig. 14 of the plate, from stratum VIII (found nineteen feet down in the tunnel between parts 8 and 9 of the shaft frame) on account of its long peg-like lower end, may be parts of knife-like implements. They were fastened on rod-like shafts similar to the fine-handled knives of southern California shown by Professor Putnam and which are in an excellent state of preservation.

From a technical standpoint, it is worthy of note that implements of such perfect workmanship as figs. 12[114] and 13 were not found among the obsidian implements of the lower strata of the mound. A proportional decrease in obsidian implements of good workmanship can be noted as one approaches the lowest strata.

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[112] For the use of spears in California comp. Powers, *l. c.*, pp. 221, 321, etc.

[113] No decorative or fantastic shapes were found among the obsidian objects as elsewhere in central California. Moorehead has shown some of these in *l. c.*, p. 262. A curved hook-like object was found in the shellmound at Ellis Landing.

[114] Moorehead, *l. c.*, p. 265.

In northern California obsidian is found near Mt. Shasta, on the north side of Mt. St. Helena and in pieces to the size of an ostrich egg in Napa Valley.[115] It is a product of volcanic eruptions, phenomena which were of frequent occurrence during the tertiary period. The material of which the implements found about the bay in all the shellmounds were made must have come from one of the above-named sources through trading. The small number of such implements found in the shellmounds is probably the result of the comparative rarity of the obsidian in this locality and the resulting care with which it was hoarded.

It is to be inferred that at no period was obsidian exclusively the material used for chipped stone implements, since workshop waste composed of materials found in the neighborhood has been discovered up to stratum II. Since, however, waste and no finished implements of local materials have been found above stratum V, the instances of the use of such must have been relatively isolated in the upper strata. Toward the lower strata, from about the VIIth but practically from the VIIIth on, there is a great increase in workshop waste. Stratum V is the uppermost one out of which one or two single objects (among them 1–8756, plate 6, fig. 21) may be considered finished implements. Of the thirty-nine implement-like objects obtained in excavating, only one is of unusual workmanship, an arrow-head of chert, 1–8815, plate 6, fig. 19, which comes from stratum VII, at the lowest part of cut C. The extraordinary accumulation of objects of chipped stone which can be termed implements begins with stratum VIII and continues down to the lowest stratum X. A considerable number of these is shown in plate 6. It is, however, remarkable that of these not one shows in its workmanship complete mastery in the handling of the material. The implement which, though still crude, shows the next best workmanship is the leaf-like point of crystalline rock, 1–8929, plate 6, fig. 20, from stratum VIII, found at the innermost end of the gallery.[116] All of the remaining implement-like objects of chipped stone bear the marks of crudity as do all of those that come from strata IX and X. It is

[115] Cf. Rau, Smiths. Rep., 1874, p. 358.

[116] It is similar in form to a point shown by Abbott, *l. c.*, p. 92, fig. 67, found in New Jersey, which he called a knife (p. 90).

very noticeable that because of this crudity in most of them, the line between implement and waste is very vague. It was therefore difficult to decide in the case of many objects whether they were to be regarded as tools at all. On the other hand, it is probable that a number of pieces included under rubbish may have really served as tools.[117]

Resulting from the discovery of obsidian, plate 10, fig. 15, chipped stones of good workmanship were found as far down as the upper part of stratum VIII. It is extremely doubtful whether they appeared at all in the strata below this. The objects made of material from the vicinity of the mound were certainly made during its settlement. A characteristic mark of the uniform crudity of all of these tools made of local materials and found in the lower strata is that they all are worked from but one side and that the elaboration of that side is accomplished by but a very few strokes. The only exception to this is the point, from stratum VII, pl. 6, fig. 19, which as to technique belongs in another place. Pl. 6, fig. 18, 1–9012, shows a ridge-like elevation on its lower side, thus forming an unimportant and superficial exception. The point, 1–8929, pl. 6, fig. 20, is also entirely even on its under side. In this they have a peculiarity characteristic of the well-known "turtle-backs."[118] This latter kind which in the eastern states of the United States has been found typical of the implements of the palaeolithic age is to be recognized in two objects in our collection, 1–9095, of green chert, pl. 6, fig. 2, from stratum X, and 1–9007 of a crystalline substance, pl. 6, fig. 1, from stratum IX. The first of these is without a doubt an implement, and the second is probably one. The palaeolithic turtle-backs of the East are unmistakably to be differentiated from the two objects under question in the material of which they are composed, which is argillite. In any case, however, the presence of these two objects proves that primordial species of stone implements existed into the neolithic period (for the mound rests on alluvial soil) and they may give ground for the estab-

[117] Comp. a similar remark in Abbott, *l. c.*, p. 93, concerning the doubtful nature of chipped stones as implements; from the stones in their vicinity they were conjectured to be implements.

[118] Cf. Abbott, *l. c.*, pp. 492 ff., and the same, Report of the Peabody Museum, 1876 to 1879, II, p. 33 ff.

lishing of the period from which such implements date, which is even farther back than that. The conical piece of jasper brought to a point by chipping, 1–8851, pl. 6, fig. 3, from stratum VII*a*, illustrates how implements were made by chipping from larger pieces of stone, and may even be itself a tool. It cannot be stated indisputably that the greater number of the common forms of chipped stones shown on pl. 6 were obsolete among the latter inhabitants of the mound. But it must be noted that the greater number and the most characteristic of them do not appear in the upper strata. We may surmise that as far as they did occur among the founders of the upper strata they had a better form. In addition to the pointed (pl. 6, figs. 19 to 20) and knife-like implements (fig. 21) the following important types are represented.

1. Long scrapers sharpened on one side, 1–9012, fig. 18, from stratum IX, and 1–9093, fig. 17, from stratum X.

2. Chisel-like tools terminating in front in a straight sharp edge. 1–8857, fig. 14, from stratum VII*a*, and 1–9080, fig. 15, from stratum X.

3. Scrapers, more or less rounded off or oval. 1–9023, fig. 8, from stratum IX, 1–9053, fig. 9, from stratum IX, 1–9085, fig. 10, from stratum X.[119]

In a like manner the following irregularly shaped objects might have been used as scrapers.

1–9043, fig. 7, from stratum IX.

1–8966, fig. 11, from stratum VIII or IX.

1–9012, fig. 12, from stratum IX.

1–9040, fig. 13, from stratum IX.[120]

4. Oval stones with high "turtle-back" backs with the encircling edges sharpened, probably too large for use as the usual scrapers:

1–9007, fig. 1, and 1–9095, fig. 2 .

5. Drills or awl-like, pointed stones, with a more or less thick base.

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[119] A hide-scraper fastened into a wooden shaft from the Thuswap Indians in British Columbia in the Jessup collection shown by Moorehead, *l. c.*, p. 255, fig. 388.

[120] Pictures of scrapers, see Abbott, *l. c.*, pp. 12 to 138.

1–8961, fig. 6, from stratum VIII or IX.

1–9005, fig. 5, from stratum IX.

1–9031, fig. 4, from stratum IX.

Instruments like the last have been found in many parts of the United States.[121] Several of these bear a great resemblance to those here shown, one such is pictured by Rau[122] from Santa Cruz Island, and one of like origin by Putnam,[123] one from Santa Rosa Island.[124] Traces of asphaltum found on the broad base of many similar ones would point to the fact of their once having been fastened to a shaft.[125]

B. Utensils of bone, horn, and the teeth of animals.

Implements of Bone.

Artifacts of animal derivation appear in great numbers and in a great variety of form among the objects recovered in excavating. This diversity in form is of course partly the result of the different kinds of bone used in their manufacture, partly of their varied manipulation, and partly of the uses to which they were put. There are all grades of elaboration from the most common splinter of bone to the tool whose shape is almost entirely different from that of the bone employed. All the objects found, however, may be reduced to the principal types of bone instruments which have been found in the United States under the most varying circumstances. In addition to awls, needles and paper-cutter-like knives of bone, there are instruments of horn used principally for chiseling and instruments of a secondary nature. They were the usual tools used in making clothes,[126] in weaving baskets,[127] etc., not to mention several subordinate uses to which they were put.

1. Awl-like tools.

This is a large class containing more than 100 objects having

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[121] Comp. Moorehead, *l. c.*, pp. 146, 170, 308; Abbott, *l. c.*, Chap. VII, pp. 97 to 119.

[122] Smiths. Contrib., *l. c.*, p. 90, fig. 318.

[123] F. W. Putnam, *l. c.*, p. 68, fig. 15.

[124] Moorehead, *l. c.*, p. 340, fig. 372, fig. 1.

[125] Rau, *l. c.*, p. 91, after P. Schumacher.

[126] Schoolcraft called them "moccasin-needles."

[127] The broom-binders of Mark Brandenburg to this day use bone awls, see Ranke, *l. c.*, II, p. 509.

various secondary forms and it is the most conspicuous class of bone instruments. They may be classified as follows:

a. Common awls with a good point.

These comprise more than 100 perfect and fragmentary specimens. They were scattered through almost all the strata in the following way:

Stratum I—8 objects.
Stratum II—61 objects.
Stratum III—8 objects.
Stratum IV—11 objects.
Stratum V—3 objects.
Stratum VI— — objects.
Stratum VII-VIII—5 objects.
Stratum IX—5 objects.
Stratum X—4 objects.

The remarkable preponderance in stratum II is probably again the result of the practice of cremation of bodies.

When one remembers that awls were the principal tools used in making baskets and that baskets took the place of pottery in the household of the California Indians, one will not wonder at their great number.

Their shapes vary. Four of them are shown in plate 9, figs. 1 to 4. Fig. 1, from stratum I, gives the type by far the most common in the 3 or 4 upper strata; the other three, fig. 2, 1–8686, from stratum IV, fig. 3, 1–8897, from VIII, fig. 4, 1–8972, from IX, give examples of the many secondary forms and illustrate the diversity of form occurring in the lower strata. Although fig. 4, as regards its shape, reminds us of the type of the tool of the upper strata (cf. fig. 1), not a single implement was found in the lower strata that was the exact counterpart of those in the upper. Manifestly it was the inhabitants of the upper strata who developed and established the latter form. Its distinctive feature is this, that only one side of the bone (mostly tibia of deer) is used, that a foot-like portion of the joint is left, and that the awl is sharpened and well finished off on all sides, even to the inner channel. Usually there is a slight bulging out in the middle of the tool which increases its strength.

The characteristic feature of pl. 9, fig. 2, is that only the shaft of the bone is open, the joint being left intact. In pl. 9, figs. 3

and 4, the foot-like supports are missing; whether originally they were there or not is a question. They seem to have been missing from the very beginning, at least the one shown in pl. 9, fig. 3. The whole shape of the instrument is crude. In several awl-like implements of the lower strata, as in text-fig. 25, 1–8797, from stratum VII, the canal in the bone is not even opened, but kept intact through the whole instrument.[128]

b. Blunt awl-like implements.



25

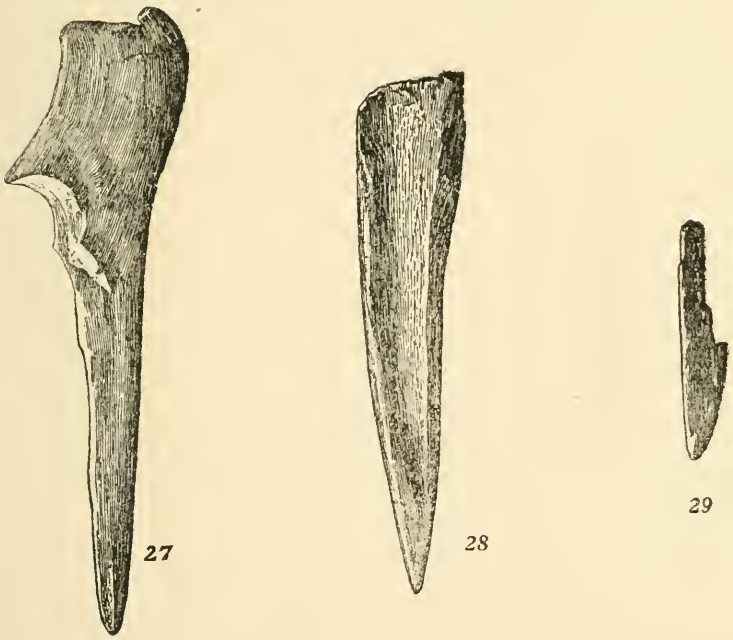


26

Fig. 25. × ½. A bone, probably used for an awl. Fig. 26. × ½. Bone implement of unknown use.

[128] Numbers of awl-like bone implements of this kind coming from the United States have been depicted. For those from California, see H. H. Bancroft, Native Races, IV, p. 711, No. 1 (the other so-called tool, No. 2, is a natural bone without value as a tool); Moorehead, *l. c.*, p. 271, fig. 410; F. W. Putnam, Rep. of U. S. Geogr. Survey, *l. c.*, pl. XI, figs. 13 to 15 and 19; p. 227, fig. 104; Nadaillac, *l. c.*, p. 49, fig. 15 (not very useful); from the southern states, for instance, Ch. C. Jones, Antiquities of the Southern Indians, 1873, pl. XVI, fig. 1; Moorehead, *l. c.*, p. 142; Chas. Rau, Smiths. Contrib., No. 287, p. 64, fig. 238 (Kentucky, Tennessee); from shellmounds of New England; Wyman, Am. Naturalist, I, pl. 14, fig. 5, and pl. 15, fig. 9 (both repeated in Abbott, *l. c.*, p. 213, figs. 199 and 202), from New York; Schoolcraft Archives of Aborig. Knowledge, 1860, II, pl. 49, fig. 3, with p. 90, from the Aleutian Islands, Chas. Rau, *l. c.*, fig. 236.

The absence of points indicates a somewhat different use to which such instruments were put. In addition to this feature there is very frequently a peculiar curve which, while it is the natural shape of the bone, must have been chosen purposely,—for instance, 1–8692, pl. 9, fig. 5, from IV, and 1–8829, text-fig. 26, from stratum VII*a*. The bone of front leg of a stag is the original form of the partly awl-shaped partly paper-cutter-like implement, 1–8579, text-fig. 27, from stratum II. A similar one from the southern part of the United States has been observed.[129]



Figs. 27 and 28. × ½. Bones probably used as awls. Fig. 29. × ½. Bone of "paper-cutter" type.

c. Flat Awl-like Implements.

These represent a large and important class of implements which occur in numbers in several of the lower strata (V and IX), although really only in fragments; cf. 1–8985, pl. 9, fig. 6, from stratum V. They are curved sideways, and well-pointed in spite of their otherwise flat character. The interior reticulate structure of the natural bone is retained on one side of the implement.

[129] Moorehead, *l. c.*, p. 142; comp. also Ch. Rau, Smiths. Contrib., No. 287, XXII, p. 64, fig. 237 (from Kentucky).

Fig. 28, 1–8541, from stratum II, has a peculiar shape; it is broad, in the form of a channel and pointed. One of the edges of the channel seems to be worn smooth through usage. The back end is broken off.

2. Needle-like Implements.

They differ from the awl-like implements in that they are intended not only to pierce an article but also to pass through it. In this class there are also secondary shapes.

a. Straight needles without perforation.

1–8895, pl. 9, fig. 8, found twenty-seven feet beneath the surface in stratum VIII, may be taken as the prevailing type. The needle is a thin, pointed instrument, oval in cross section, blunt at the back end, well finished throughout. To this class also belongs a number of fragments found in different strata up to the VIIIth.

b. Curved needles.

1–8901, pl. 9, fig. 9, from stratum VIII, represents this type. The needle is very slender and thin and of good workmanship. Unfortunately it is broken off at the smoth posterior end.[130]

c. Needles with "eyes."

We have also only one specimen of this type, 1–8735, pl. 9, fig. 10, from stratum V. It is straight, round in cross section and tapering at the perforated end.[131] The bluntness of the point must be the result of use.

d. Long crooked needles.

1–8831, pl. 9, fig. 7, a well preserved and seemingly perfect specimen, was found in stratum VII*a*, in the tunnel, from eleven to fourteen feet below the surface. It consists of a long, thin rib pointed at the stronger end, thereby exposing the canal within.[132]

[130] Comp. the objects found in a shellmound in New England, Am. Naturalist, 1; pl. 15, fig. 17; it, however, is broader.

[131] A similar needle from a mound in Ohio has been shown by C. L. Metz and by F. W. Putnam, Rep. of the Peabody Museum, 1880 to 1886, III, p. 452. The Point Barrow Eskimos use a similar one (J. Murdock, IXth Ann. Rep. of the Bur. of Ethnology, 1887-88, p. 318, fig. 325).

[132] It reminds one somewhat (in that it is curved and pointed) of an instrument designated, and that manifestly wrongly, by Moorehead as a hairpin (see Moorehead, *l. c.*, p. 271, fig. 410, under No. 4). Jeanne Carr tells of needles made usually of the strong wing bones of the hawk, used to keep the strands in place when the basket-weaver left his work. These were handed down from mother to daughter generation after generation and regarded as valuable possessions. (The Californian, 1892, No. 5, p. 603.)

Among those found there is also a needle of fish bone and likewise one made from the spine of a stingray.

3. Rough awl-like implements of the lower strata.

We have chosen to discuss a number of implements from the lower strata under this separate head. Although some of these were probably used as awls, yet along with others with which they form a small group they cannot easily be considered with the other implements of this class. Plate 7, which represents typical bone implements of the lower layers, shows the greater number of these peculiar shapes in figs. 1 to 10. Altogether about fourteen of these awl-like implements were found in stratum VIII, five in stratum IX and four in stratum X. When one considers that from layers IX and X, only small sections were explored, the relative number of these implements must excite some interest. The awl-like and needle-like objects of pl. 9, although but little worked, are yet characterized by a definite fundamental form, different from that shown in the objects represented in pl. 7, figs. 1 to 10.[133] They represent simply bone splinters of the most varied forms such as would be made by accident. To be sure, there were isolated bone splinters in other places in the excavation, probably used as implements, as would naturally occur in a shellmound. In all of these latter cases, however, the character of the objects was, owing to the form of the bones and to the accidental or typical intention of their use, completely different. The objects shown in figs. 1 to 10 of this plate are made of fragments of somewhat thick long bones. All of them have been much used and the upper ends are strongly rounded and worn. Their use was evidently intentional both with reference to their more general and their typical uses. They do not belong to a peculiar type of implements because it is evident from their form that they were used for many purposes.

Some, as figs. 6, 7, and 8, 1–8919, 1–8918 (VIII), 1–8979 (IX), have an awl-like pointed form and may accordingly have been used as such an implement. Others, as figs. 1, 3, 4, and 10, 1–8983 (VIII), 1–9069 (X), 1–9068 (X), 1–9072 (X), although in general awl-like, are blunter and can hardly have been put to

[133] The principal smaller forms figured from southern California by Putnam, *l. c.*, Pl. IX, figs. 16-17.

the same use as these forms just mentioned. Objects like 1–8980, pl. 7, fig. 5; 1–8996, pl. 7, fig. 9, and possibly also 1–8871, pl. 7, fig. 2, have such broad and blunt ends that for them characterization as "awl-like" would be entirely unsuitable and their use must be explained in some other way. The tie that holds them together is, therefore, in no way that of similar use but rather of analogous origin. They comprise a large number of implements having different uses. What is common to them is the similarity of the way in which they were obtained. Their use was determined by the chance form which they thereby received. There is before us then a class of the most primitive ethnological implements of which we have knowledge, in which, as in the oldest known implement of the human period, the natural form of the object determines the use, rather than the use the individual form.

4. Implements of the shape of paper-cutters.

It is natural that in so large a number of bone implements this shape also should be represented. Five belonging to two different types have already been discussed under the grave finds. Altogether the amount of material of this character obtained from the upper strata of the mound is remarkably small. Only a small number of fragments were found, of which only a fragment of the point, 1–8803, from stratum VIII is represented in fig. 29.

In the deeper strata the case was entirely different. There are from these layers no perfect implements, only fragments, but their number is in proportion to what one would expect, or even greater. Some of these show a variety of form and a degree of ornamentation which was hardly to be expected among the finds of the mound in general and least of all among the specimens obtained from the lower strata. Little as the well formed implements, which the fragments figured in pl. 7, figs. 11-17, represent, appear to resemble the rough awl-like implements on the same plate and which have been derived from the same strata, there is yet no doubt possible that the two classes of implements must have been used by the same people.

We have therefore the task, instead of denying the contrast, of suggesting some solution for it.

These paper-cutter like implements have a moderate width and a thickness of only one-thirty-second to one-sixteenth of an inch. They are well worked in all cases. The objects shown in fig. 12, 1–8989 (IX), fig. 14, 1–8987 (IX), fig. 15, 1–8920 (VIII), fig. 13, 1–8988 (IX), of plate 7 show artistic forms differing from the simpler types of implements. Perforation, which in the bone implements of the mound is very infrequent, is in these implements alone found four times on the lower end. The notch on the lower end of pl. 7, fig. 14, probably the remnant of a circular section, is very artistic and one notices also curved lines on the surface about it. These show the geometric accuracy with which this work was carried out. 1–8986, pl. 7, fig. 16, from stratum IX, is the only piece of bone among all those recovered from the mound which has been engraved with geometric figures.

Out of the strongly varying yet constantly artistic characters of these fragments we are justified in drawing the conclusion that a much greater variety of implements of this form was used by these people. The variations seem to have been influenced largely by personal taste.

1–8875, fig. 11, represents a small fine point of a well formed small paper-cutter-like implement.

1–8989, fig. 12, stratum IX, is a quadrate piece of bone cut out of a "paper-cutter" and was possibly used in play.

1–8988, fig. 13, stratum IX, is the lower end of a "paper-cutter" with parallel sides and obliquely truncated at the lower end with a remarkably perfect perforation.

1–8987, fig. 14, stratum IX, is the lower part of a thin "paper-cutter" with a semi-circular notch. The base shows broken surfaces next the notch.

1–8920, fig. 15, stratum VIII, the lower, triangular part of a "paper-cutter," which has been very broad and thin, has a small perforation.

1–8986, fig. 16, stratum IX, the middle fragment of a well-worked "paper-cutter" ornamented with geometric figures.

1–8984, fig. 17, stratum IX, is the oblong upper part of a very thin, well-worked "paper-cutter" with a perforation. The upper part is broken off.

At this place there should probably be mentioned also the

small bar of bone, 1–8975, fig. 18, stratum IX, as it also comes from this stratum. This is likewise an uncommon form of implement. It is small and well worked, although not of the paper-cutter type. It is oval in cross section and has a small paper-cutter-like lower end which shows that it was fastened to some other object. Its upper end is broken.

5. Pointed Implements.

In the middle strata of the mound there were found about eight pointed bones, of which the types are figured in pl. 9, figs. 11–16.

1–8869, pl. 9, fig. 11, stratum VII, is 2⅛ inches long, oval in cross section and having an inferiorly constricted neck. There is a small hook on the lower end of the broad side. A small fracture on the opposite side appears to indicate that there were originally two such hooks.

1–8868, fig. 12, stratum VIII, is two inches long. This specimen is in general similar to the one just mentioned. There is only one hook at the lower end. The side opposite is without a hook and is unbroken. Similar is 1–8738, from stratum V. An analogous object is figured by Moorehead, page 273, fig. 412, No. 3, from Stockton Channel.

1–8916, fig. 13, stratum VIII, 2 inches long, is similar to the last with the differences that the small broad, flat hook points toward the broad side, and that the pointed end has been smoothed by use. On this end there are also small traces of asphaltum which indicate that a cord had sometime been wound about it to fasten it to some other object.

1–8917, fig. 14, stratum VII*a* or VIII, 1⁷⁄₁₆ inches long with a rounded cross section, is slightly curved and gradually narrows towards the lower point. The convex side shows a slight flattening.

1–8870, fig. 15, stratum VII*a* or VIII, is 1½ inches long, but the lower end is incomplete. The cross section is oval to flat; it shows on the broad side a sloping groove.

1–8694, fig. 16, stratum IV, an implement 2³⁄₁₆ inches long, is typically knife-like in its form in so far as it has a broad blade-like part. It is sharp on one side, blunt on the other and rounded at the upper end. It is bent well backward. At the lower end it

runs out into a small neck-like portion which is extended in the same line with the back of the implement and is broadened at the base.

The objects already described and shown in figs. 11, 13, 14, 15, and 16 of plate 9 represent the principal types. Among these the knife-like object, fig. 16, is, judging from its shape, evidently to be separated from the others.[134] Numerous other knives of obsidian occur in addition to this one of bone.

Of the remaining, fig. 14 represents a typical arrow point made of bone such as are used in various parts of the world, *e.g.*, in South America. The convex, slightly flattened side was laid against the slightly truncated upper end of the shaft of the arrow and was fastened to it by numerous coils of cord. The figure of a similar arrow point from the Swiss Pile Dwellings is given in Ranke's work, Vol. II, pp. 5–19, fig. 11. This shows very well the manner of attachment.

The similarity of the remaining bone points, figs. 11, 13, 14, 15, is so significant that a similar use is to be ascribed to them. That they were used as fishhooks, which might be conjectured, there appears to be less evidence. It is worth considering that Mr. Meredith found on the breast of a single skeleton 51 objects of the form shown in pl. 9, fig. 14. In another case 28 such objects were found.[135] In the first case, with the skeleton in addition to these were found two long spear spoints with barbs such as are used on the northwest coast of America. A large number of objects from one grave and the association with other analogous objects supports very strongly the idea that the pointed bones were used for the points of arrows. The neck of these points was the portion about which the cord was wound and about this was laid a small quantity of asphaltum to hold the cord in place, while the hooks had the object of preventing the cord from sliding off from the neck. The form of the hooks varies but slightly. This suggests the prominent hooks at the base of the

[134] Compare knife-like "hide-scrapers" of bone used by the Eskimo of Behring Straits and figured by E. W. Nelson in the 18th Annual Report of the Bureau of Ethnology, 1896-97, Part I, pl. 50, figs. 3-6.

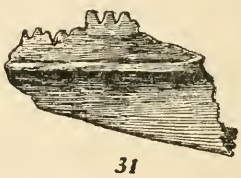
[135] In Moorehead, *l. c.*, p. 272. Two similar objects from South America are figured by F. W. Putnam, *l. c.*, pl. 11, figs. 10, 11, and are described (p. 227) as fishhooks.

arrow points of stone. In a certain way these arrow points may possibly be considered as a middle form between long bone points provided with barbs, such as were used by the Eskimo, and the Indian arrow points of stone. In this connection it is worth noting that Mr. Meredith finds them in association with such bone points (also with a lip-plug such as are used on the northwest coast of America). The form of the Indian stone arrow-heads might have been imitated in the North in other materials.

That the analogy with the more northerly races is not limited to the burial layers of the mound from which the pointed implements, pl. 9, figs. 11, 15, were found is indicated by the object, pl. 7, fig. 12, which was found in the cremation layer, No. 2.



30



31

Figs. 30 and 31. × ½. Notched bones perhaps used in net-making or weaving.

6. Saw-like notched bones.

The excavations furnish twelve objects of this type of implement, of which perhaps half were from stratum II. The remainder were found from the lower strata up to the eighth. Quite a number of the objects from stratum II were calcined, an evidence that they were deemed of value in life since they were burned with the dead.

The best preserved type of this implement, of which in most cases only small fragments were found, is shown in 1–8898, pl. 9, fig. 17, stratum VIII.

Nearly all of these objects have a stereotyped form, being made from the shoulder blade of some large mammal, probably the deer. One, however, seems to have been made from a bird bone (1–8900, fig. 30, stratum VIII). On the specimen shown in pl. 9, fig. 17, about half of the length is taken up by the rounded handle, using the ridge-like end of the bone for this purpose. The other end of the object is incomplete, but according to the

form in other specimens it was probably cut off squarely at the end. At any rate only a small piece of the implement is missing since the teeth cut into the thin convex margin of the bone are complete to the number of 15. The ridge-like edge runs next to the row of teeth, giving the implement greater firmness. The teeth vary considerably in different objects in size, in form, and in regularity (compare 1–8573, fig. 31, from stratum II). They also vary in degree of wear, which so far as observed is sometimes seen on the edge and sometimes in the spaces between the teeth. On one specimen the opposite edges of the bone are similarly toothed, although one side of the bone was quite thick. A smoothing or polishing of the object is never to be noticed, excepting on the under side.

Similar objects have frequently been found in California. Single fragments are figured by Moorehead.[136] As similar as these objects are to saws, it is probable that they were not used as such. The name "sachos" given to these implements by the Napa Indians, who possibly did not know their former use, is not to be taken as the slightest support for the idea that they were actual saws. In the first place it is hardly necessary to mention that the concept "saw" is missing among the Indians. The form of these objects and the general state of wear as already described shows that they were not and could not have been used as saws. It is remarkable enough that saw-like implements made of bone have a distribution much more extended than the Californian region. Since these occurrences are mostly local and entirely independent of each other, these implements must in their production have served certain practical aims. Why, however, saws made of bone should have such a wide distribution it is difficult to understand.

An analogous implement has been found in a shellmound in Massachusetts and figured by J. Wyman. He also in his description has shown that judging from the width of this implement it could not have been used as a saw.[138]

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[136] Moorehead, *l. c.*, p. 236, fig. 363.

[138] The stone points with saw-like teeth on the edge do not represent technically such an implement as a saw since the toothing is only a result of the method of reproduction.

Another saw-like toothed bone implement was found in the cave dwellings in Franconia (Bavaria), which were inhabited in the early neolithic period. This has been described by Ranke as probably used in weaving.[139]

An implement having almost identical form as this just described above was figured by J. Murdock. This object was obtained from the Pt. Barrow Eskimo and was made of the shoulder blade of a reindeer. He received it as a model of a saw said to have been used before the introduction of iron.

After having made inquiries for the primitive form of the implement, this specimen doubtless was made for him.[140] His paper also contains a figure of another saw-like implement, of about twice the size of the first, made of antler. There was with this a kind of shuttle and a form of weaver's sword with the statement that these three implements had been used in weaving feather girdles. In watching the process of making these belts he had, however, not seen any of these three implements.[141] In the opinion of the writer there is no reason to doubt materially the accuracy of the statements concerning the use of these implements by the Eskimo. It therefore contains the key to the understanding of all the remaining forms of this type of saw-like implements found in the northern region. And this explanation may be extended to the wrongly determined Californian bone saws. In our opinion the bone implement first figured by J. Murdock shows simply that the Eskimo remembered having had such an implement and that they gave to him the impression that it had been used in the way in which the investigator was inclined to think it ought to have been used. It appears that Ranke was on the right track when he supposed the Frankish bone implement to have been used in some processes of weaving. In like manner all of the Californian bone saws agree thoroughly with this supposed use.[142] In California many valuable feather girdles have been made, in the weaving of which these bone implements may

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[139] Am. Naturalist, 1868, Vol. I, pl. 15, fig. 15, 583.

[140] Der Mensch, II, p. 558-560.

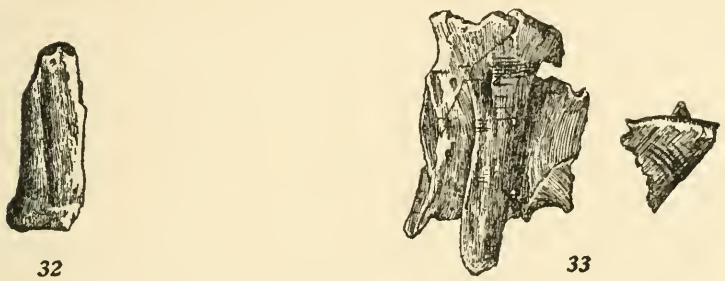
[141] Ninth Annual Report of the Bureau of Ethnology, 1887-88, p. 175, fig. 147.

[142] *l. c.*, p. 317, fig. 323.

have been used.[143] The exact mode of their use is not yet determined, but it is to be hoped, however, that even this may some time or other be discovered.

7. Various Implements and Objects of Bone.

It naturally occurs that in a shellmound in which so many implements of bone have been preserved there would be a number of bone objects the use of which can only be imperfectly determined. These implements are in part possibly only attempts to work bone, in part they are actually implements which had a use somewhat different from that of the other forms and a use for which the character of the material especially fitted them.



Figs. 32 and 33. × ½. Bone artifacts of unknown use.

Many fragments of bone show only a few cuts or marks as indications that they were worked. In one case, 1–8527, fig. 32, stratum IX, the marks which vary somewhat from those in the other strata may represent an implement of the paper-cutter type. The point is in this case calcined, as is also true of many other implements. This is evidently done intentionally, possibly in order to work the bone more easily. Other common bone fragments look as if they had occasionally been used as implements when they happened to have the right form, and that they were not intentionally worked into this shape. Still other bone fragments show knife-like incisions on the other edges, as, for ex-

[143] Recently a great deal has been written about the relation of widely separated peoples to each other. And this relationship has usually followed definite geographic lines. It is, however, worth while to notice the great similarity between the implements of eastern and western United States, and those of the caves of Switzerland and of the Arctic region. Many implements of similar type and use are to be found in these regions, implements which are not discovered in any other portion of the world.

ample, that shown in fig. 33, 1–8877, stratum VII*a*. They are probably not to be considered as marks of dog's teeth, as which these could also be determined, for they are generally very numerous in one place or else they show exceeding regularity as if made intentionally.

The shellmound dwellers did not fail to notice the peculiar character of the tubular bones, which when cut into sections are easily made into small receptacles, similar to the cane plant, which is used in a similar manner by the inhabitants of tropical regions (for instance by the ancient Peruvians). Many such small objects with differing proportions were found, two of which are shown in fig. 34, 1–8922, stratum VIII; and fig. 35, 1–9076, stratum X.

Implements of Antler.

For many kinds of implements antler is particularly valuable on account of its hardness. For this reason a number of implements of this character have been found in the shellmound; they are, however, not so numerous as those of bone. They are usually made of deer or elk antler.

1. Chisel-like Implements.

Of these there are two principal types.

a. Actual chisels.

About half of the objects of antler are to be considered as complete implements. These are shown in pl. 8, figs. 2*a* and 2*b*, 1–8892, stratum VIII; figs. 3*a* and 3*b*, 1–8821, from stratum VII*a*, represent the two subspecies of the same, *viz.*, broad and narrow chisels. The main difference between the two is simply one of size and proportion.

The broad chisels are represented by about ten objects, which belong to the middle and lower strata of the mound only, down to the Xth stratum. Whether this is accidental or caused by other reasons remains undecided. These objects are from four and one-half to five and one-half inches long, to one and three-fourths inches broad, and even as thick as one and one-quarter inches. Oval in cross section, they slightly diminish toward the lower end. Frequently they pass one to two inches above the lower end into the flat, knife-like, one-sided slope, ending in a semi-circular edge about one inch broad. The sloping surface as

well as the polished sides of the implement frequently have impressions due to actual use upon hard objects. In a similar manner, the straight surface is broken by the use of a hammer which was struck upon it.

The narrow chisels are represented only by one complete specimen (pl. 8, fig. 3) and two fragments of the knife-edge. The latter were found between strata VII*a* and IX. The complete chisel is only three and nine-sixteenths inches long; while it is one and three-sixteenths inches broad at the upper end, and but seven-sixteenths of an inch thick, it nevertheless diminishes toward the lower end to a breadth of three-eighths of an inch at the knife-edge. The slope of the one side toward the latter is by far shorter than that of the broad chisel, and yet the same indications of its use with a hammer can be found. The curvature of the cross section of this implement corresponds to the natural form of the antler from which it was made.

Such chisels[144] partly took the place of an axe in woodwork among the Indians, just as, for example, this was still the case among the Hupa during the eighties of the last century,[145] in the construction of houses. The Klamaths in Oregon still make use of such chisels. The better known implements of recent times possess only the natural surface of the original antler.

It is of interest to know that implements of exactly the same kind were found in the shellmounds of the Atlantic coast, *e.g.*, in Maine.[146]

b. Chisel-like Implements of varying forms.

Implement 1–8730, pl. 8, fig. 1, found in stratum V, has a length of nine and three-fourths inches and a breadth of one and seven-eighths and one and five-sixteenth inches. It will be seen that though of greater length and breadth it is flatter than the preceding. On account of its origin from a complete antler it is curved along its length, and slightly curved in on its concave side. At the lower end of the latter it is given a straight slant

[144] A little information on this point is brought together by the writer in Mitth. der Anthrop. Ges. Wien., 1886, Vol. 16.

[145] A similar one from San Joaquin county has been illustrated by Moorehead, *l. c.*, p. 271, fig. 410, No. 2. Cf. also F. W. Putnam, *l. c.*, p. 229, figs. 106-108, wedge-like implements from southern California.

[146] Cf. Mason, Smithson. Reports, 1886, I, pl. xviii, fig. 19, with 10, 208.

for three and a quarter inches in the diameter of the breadth. Its upper end shows the same signs of use with a hammer, while the slanting surface is greatly worn on the sides. This makes it probable that the use of this tool was in many respects different from the preceding. It was possibly used as a lever.

For this also a parallel exists in the form of an apparently identical implement from the shellmounds in Maine.[147] As regards form, certain implements of the bones of cattle found in the caves of French Switzerland are similar to this object. Rauch calls them "leather-cutters" (Lederschneidemesser).[148]

2. Implements of antlers with dull, rounded ends.

Three such objects have been found. One of them is seven and one-eighth inches long, diminishing, horn-like, toward the blunt point. It came from the middle stratum of the mound. It is represented in pl. 8, fig. 7. Another is a young branch of an antler, and the third is a mere fragment. The use of these objects, which were doubtless implements, cannot be conjectured.

3. Pointed Implements.

Only one fragmentary blade exists, about one inch long.

4. Straight, truncated Implements.

Two specimens of this kind came from stratum V of the mound. They are wanting in other parts of the mound. One of them is reproduced in pl. 8, fig. 4. It diminishes, horn-like, toward the lower end. Here it is truncated abruptly, having a breadth of five-eighths inches. Unfortunately the upper end is incomplete. The other implement, 1–8722, is absolutely identical with the one just described.

The collection contains also a fragmentary bone tool, 1–9066, which was found in stratum X. It may have corresponded to the peculiar implement, reproduced by J. Wyman,[149] pl. 14, fig. 3 (with the spiral cuts at the upper end), which was found in the shellmounds of Massachusetts.

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[147] Cf. J. Wyman, *l. c.*, pl. IV, figs. 2 and 2*a* with p. 583. Ch. A. Abbott, who represents the same implement, *l. c.*, p. 211, fig. 196, says Massachusetts probably by mistake.

[148] J. Wyman, *l. c.*, pl. XIV, fig. 1, with p. 582. Cf. also Ch. A. Abbott, *l. c.*, p. 211, fig. 195. The implement is unfortunately represented in both places sidewise in an unfavorable manner.

[149] *l. c.*, II, p. 556.

Implements of Tooth.

Only one object made of tooth was found, *viz.*, 1–8736, fig. 36, in stratum V. It is a bear's tooth perforated at the root, serving the purpose of ornament or amulet, and corresponds exactly to the typical illustration of the one from New Jersey;[150] here Abbott emphasizes the fact that such ornaments were the most common among the earlier and present-day Indians.



34



35



36

Figs. 34 and 35. × ½. Fragments of bones. Fig. 36. × ½. A bear-tooth ornament.

C. Implements made of shells.

The objects of this material mentioned among the grave-finds are supplemented by two implements, one of which came from the IInd, the other from the VIIIth stratum of the mound. Both are made of the haliotis shell, the material preferred for ornamental purposes by the Indians throughout the country. Recovered in different strata, they differ completely with respect to their form. Yet, owing to the scarcity of the finds we are not permitted to advance the opinion that the form of one was limited in its stratum to the complete exclusion of the other.

1–8632, fig. 37, from stratum II, is about as long as broad, but rounded off at the lower part, while the upper rim is cut off straight. The three-sixteenths inch wide perforations in one row on the upper rim served for the purpose of suspending.

[150] Cf. F. W. Putnam, *l. c.*, pl. XI, fig. 18.

1–9106, fig. 38, from stratum VIII, represents the broken edge of a larger ornamental plate which was originally triangular or of a quadrilateral shape. The edge is now trapezoidal. Two of the four sides still show the well-worked rims, ornamented with



37



38

Fig. 37. × ½. Fig. 38. × ⅖. Haliotis shell ornaments.

indentations, of the original ornamental plate. The two other sides are rough surfaces of fracture.[151]

[151] Ch. A. Abbott, *l. c.*, p. 406, fig. 388.

Issued June 15, 1907.

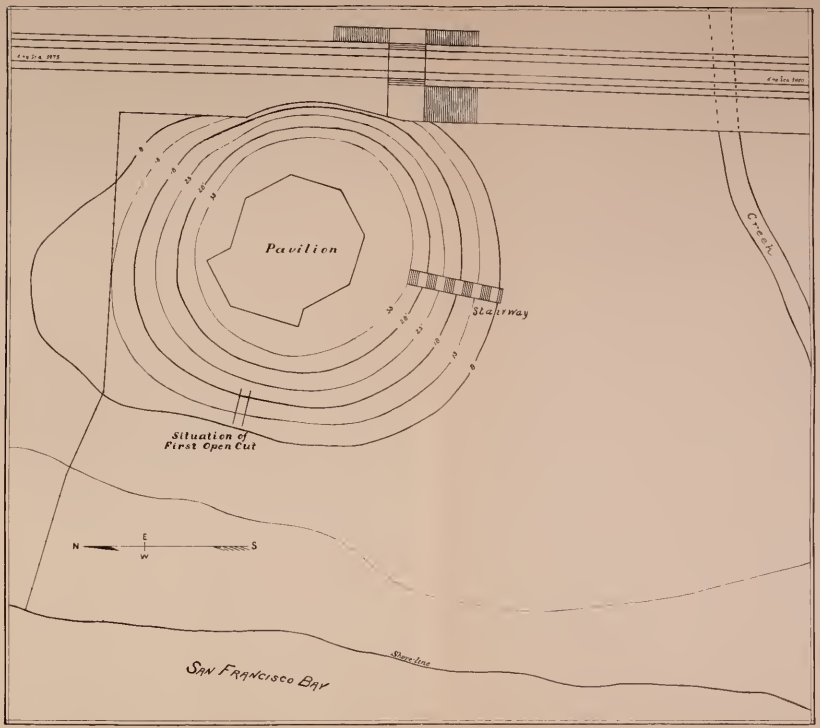
EXPLANATION OF PLATE 2.

Emeryville Shellmound seen from the Bay. The cut made in the side of the mound had been filled when the photograph was taken, but the site of the excavation is seen in the light area on the western slope.



EXPLANATION OF PLATE 3.

Topographic map of the Emeryville Shellmound. Contour intervals 5 feet. Scale: 1 inch = 60 feet.


Pavilion
Stairway
Situation of
First Open Cut
Creek
N
E
W
S
Shore line
SAN FRANCISCO BAY

EXPLANATION OF PLATE 4.

Fig. 1. Cross-section of the western foot of Emeryville Shellmound, showing the extent of the excavations. Scale: 1 inch = 19.4 feet.

1. Alluvial clay.

2. Thin gravel layer.

3. Basement clay, the stratum upon which the mound and the gravel layer rest.

Fig. 2. Cross-section through the principal excavated portion of the western foot of the Emeryville Shellmound, illustrating the stratification of the deposits. Scale: 1 inch = 6.46 feet.

I-X, Recognized strata of the mound.

A, B, C. Sections of the excavation designated in text.

Fig. 1

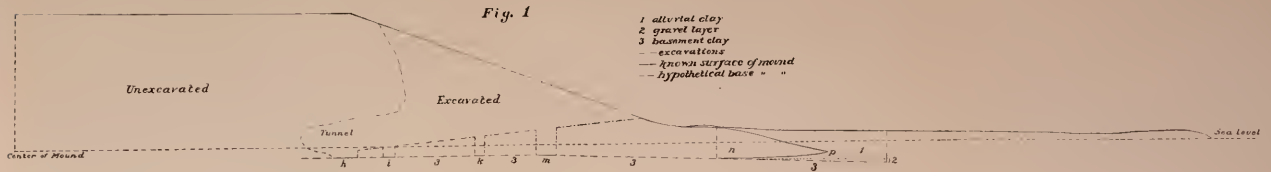
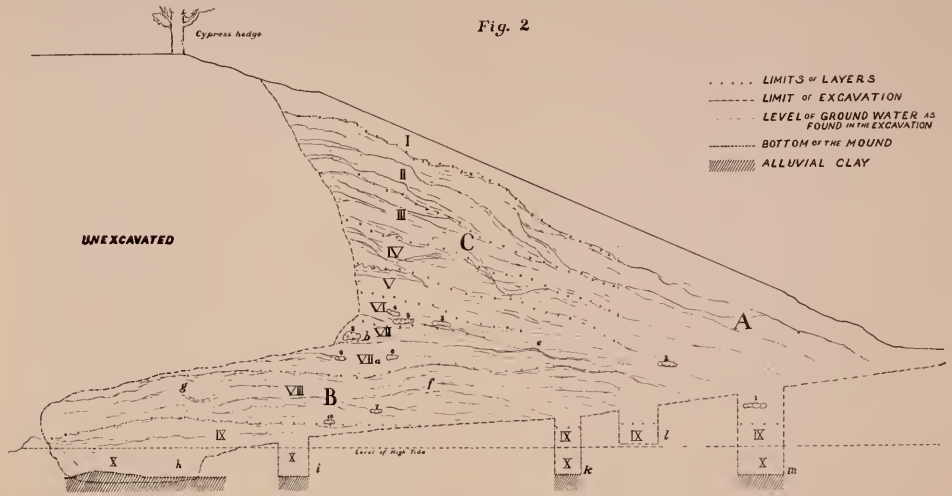

1 alluvial clay
2 gravel layer
3 basement clay
excavations
known surface of mound
hypothetical base " "
Unexcavated
Excavated
Tunnel
Center of Mound
Sea Level
h
i
j
k
l
m
n
p
q
1/2

Fig. 2


Cypress hedge
LIMITS OF LAYERS
LIMIT OF EXCAVATION
LEVEL OF GROUND WATER AS FOUND IN THE EXCAVATION
BOTTOM OF THE MOUND
ALLUVIAL CLAY
UNEXCAVATED
I
II
III
IV
V
VI
VII
VIIa
VIII
IX
X
A
B
C
Level of High Tide
a
b
c
d
e
f
g
h
i
k
l
m

EXPLANATION OF PLATE 5.

The open cut on the western side of the Emeryville Shellmound.



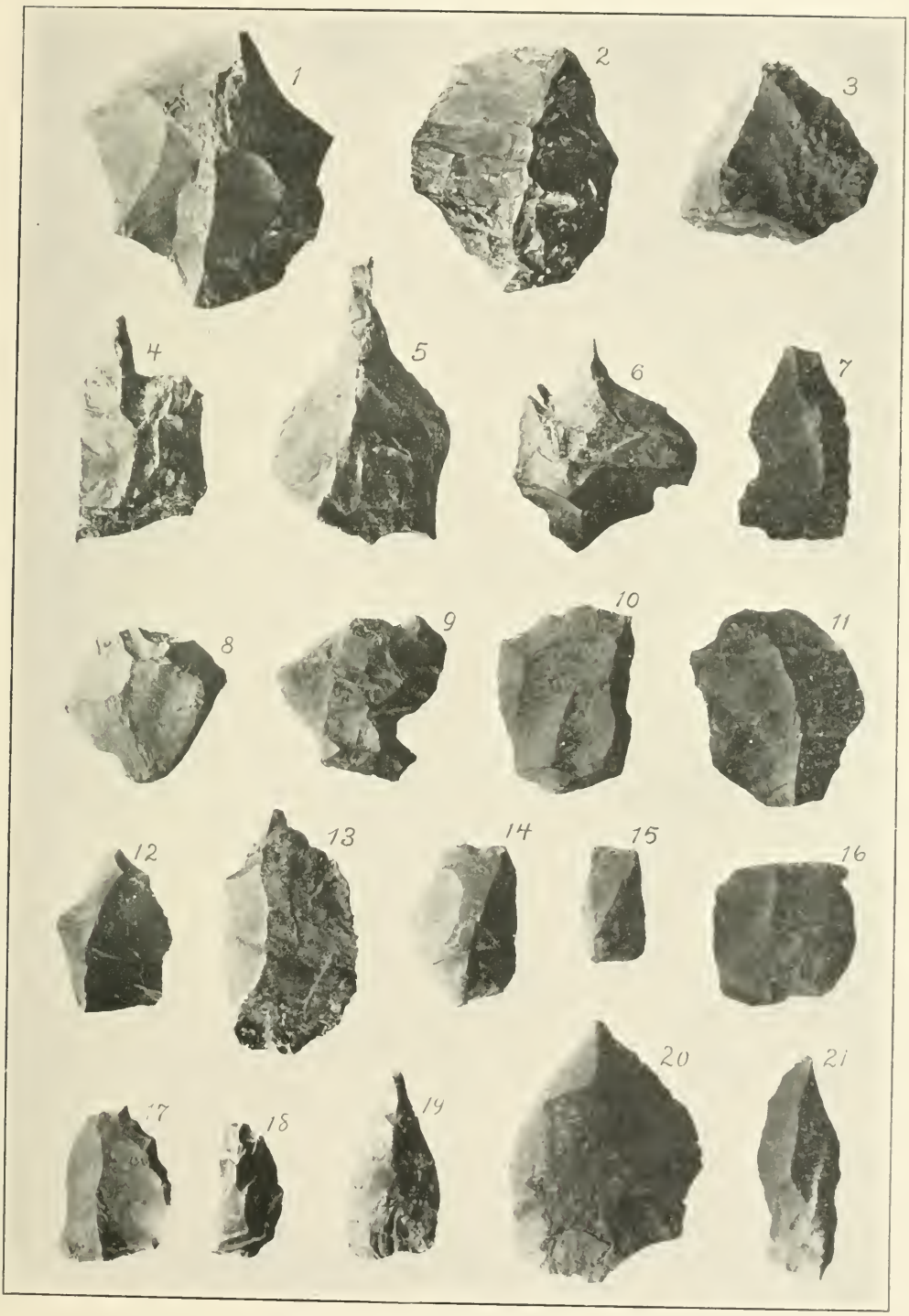
EXPLANATION OF PLATE 6.

Figs. 1-21. Flaked cherts principally from the lower layers of the mound. Some of these, as represented by figs. 4, 5, 6, 11, 19, and 20, are possibly finished implements. The others are perhaps in part rejects, but all were probably used to some extent. $\times$ 9/10.

Following are the accession numbers of the specimens, as catalogued in the museum of the Department of Anthropology.

Fig. 1 (1–9007)
Fig. 2 (1–9095)
Fig. 3 (1–8551)
Fig. 4 (1–9031)
Fig. 5 (1–9005)
Fig. 6 (1–8961)
Fig. 7 (1–9043)
Fig. 8 (1–9023)
Fig. 9 (1–9053)
Fig. 10 (1–9085)
Fig. 11 (1–8966)
Fig. 12 (1–9012)
Fig. 13 (1–9040)
Fig. 14 (1–8857)
Fig. 16 (1–?)
Fig. 17 (1–9093)
Fig. 18 (1–9012)
Fig. 19 (1–8815)
Fig. 20 (1–8929)
Fig. 21 (1–8756)

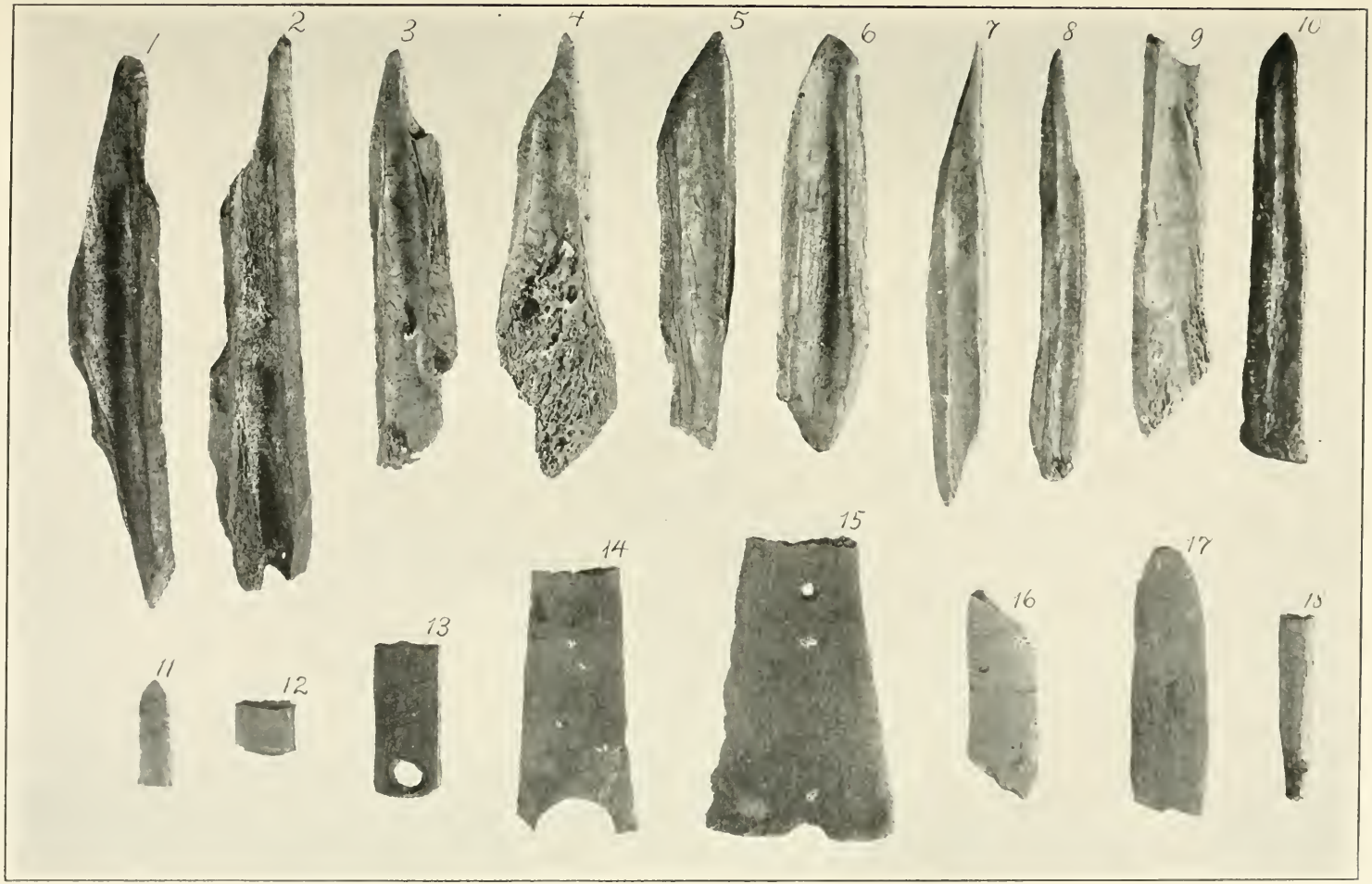
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EXPLANATION OF PLATE 7.

Rough bone implements and ornaments largely from the lower layers of the mound. × ⅔.

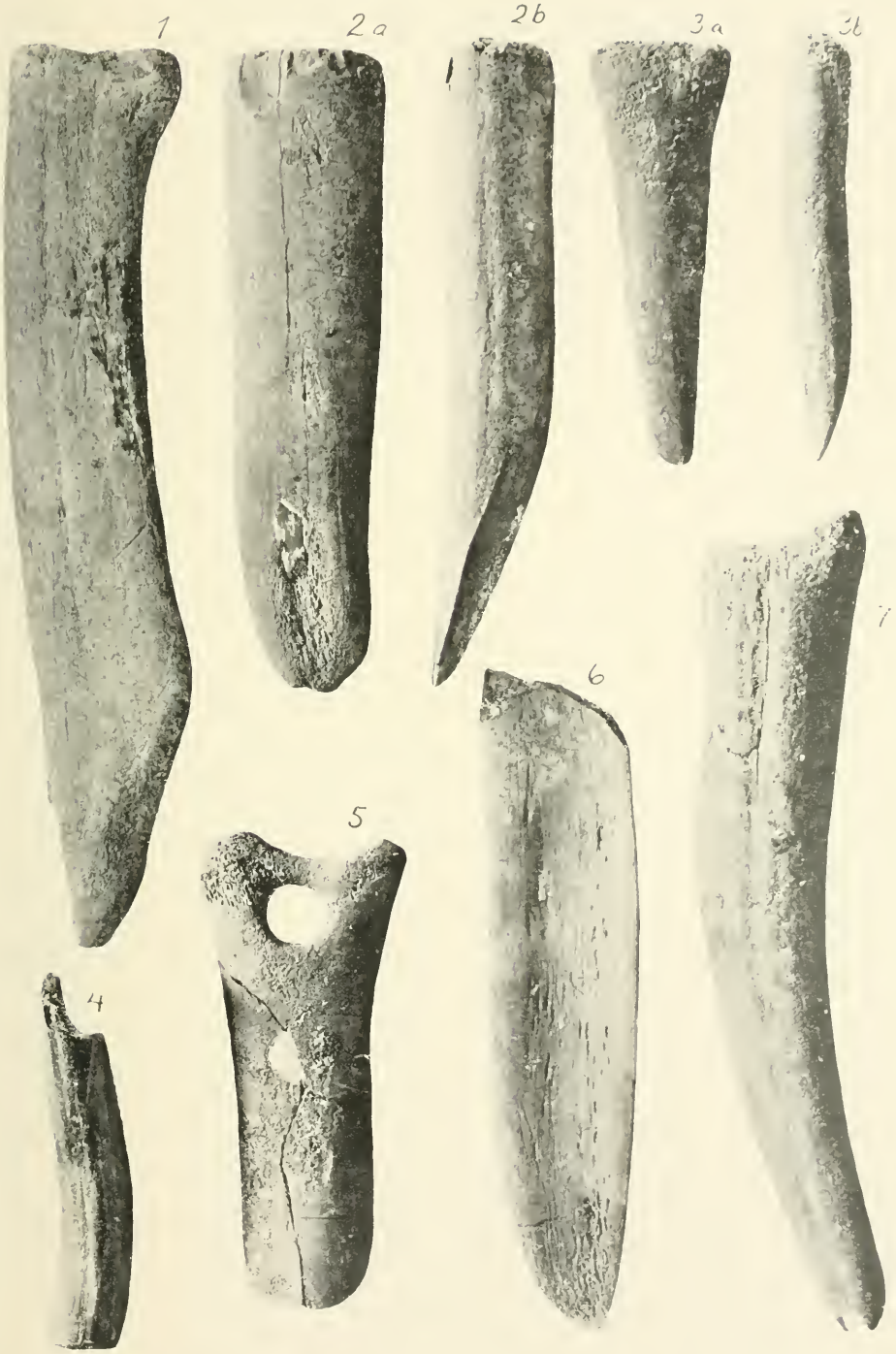
Fig. 1 (1–8983)
Fig. 2 (1–8871)
Fig. 3 (1–9067)
Fig. 4 (1–9068)
Fig. 5 (1–8980)
Fig. 6 (1–8919)
Fig. 7 (1–8918)
Fig. 8 (1–8979)
Fig. 9 (1–8996)
Fig. 10 (1–9072)
Fig. 11 (1–8875)
Fig. 12 (1–8989)
Fig. 13 (1–8988)
Fig. 14 (1–8987)
Fig. 15 (1–8920)
Fig. 16 (1–8986)
Fig. 17 (1–8984)
Fig. 18 (1–8975)


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EXPLANATION OF PLATE 8.

Implements of bone and antler from the Emeryville mound. Figures about one-half natural size.

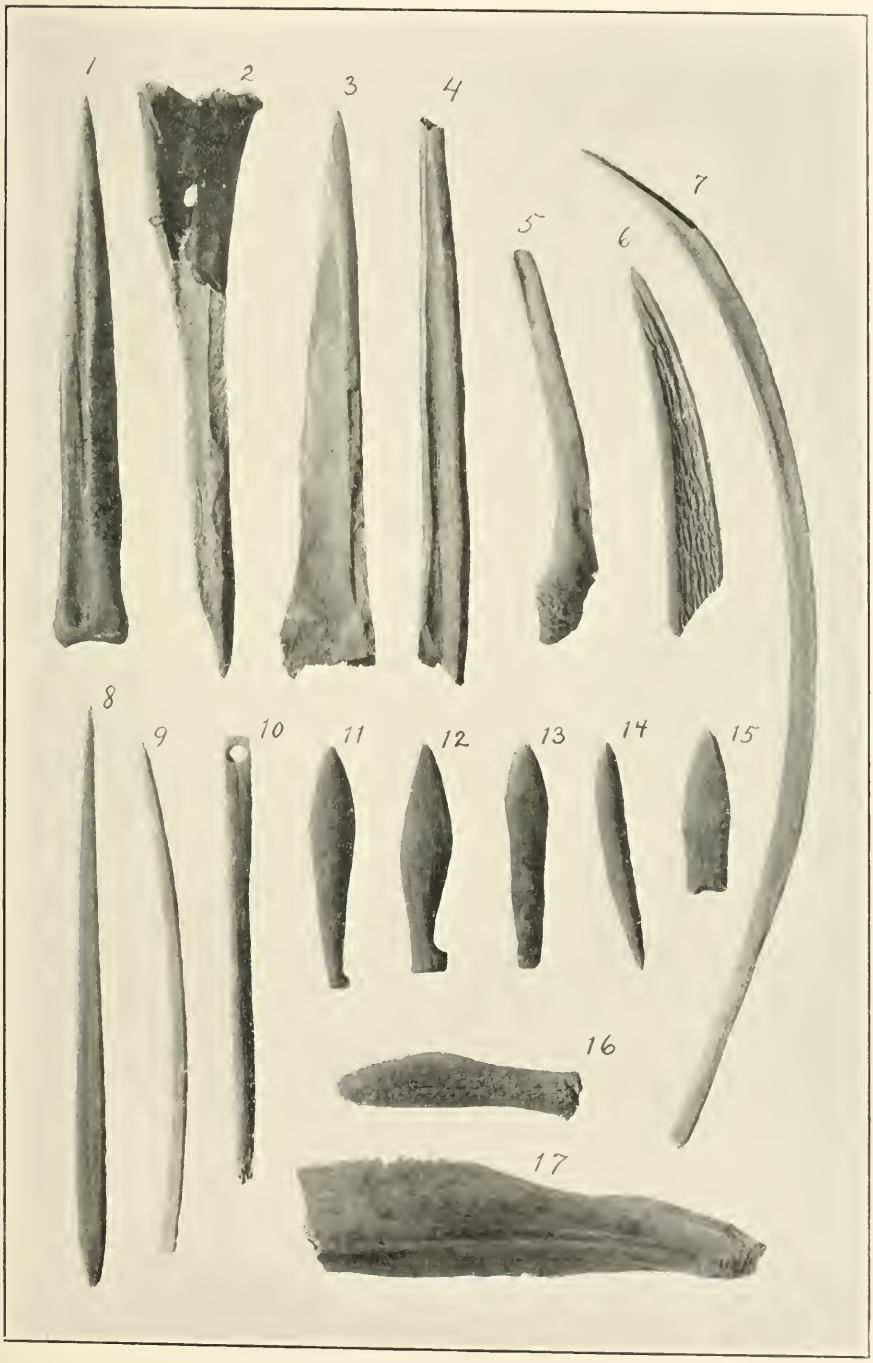
Fig. 1 (1–8730)
Figs. 2*a* and 2*b* (1–8892)
Figs. 3*a* and 3*b* (1–8821)
Fig. 4 (1–?)
Fig. 5 (1–8780)
Fig. 6 (1–8778)
Fig. 7 (1–8889)


1
2a
2b
3a
3b
4
5
6
7

EXPLANATION OF PLATE 9.

Bone implements from the Emeryville mound. $\times$ 6/10.

Fig. 1 (1–8522)
Fig. 2 (1–8686)
Fig. 3 (1–8897)
Fig. 4 (1–8972)
Fig. 5 (1–8692)
Fig. 6 (1–8985)
Fig. 7 (1–8831)
Fig. 8 (1–8895)
Fig. 9 (1–8901)
Fig. 10 (1–8735)
Fig. 11 (1–8869)
Fig. 12 (1–8868)
Fig. 13 (1–8916)
Fig. 14 (1–8917)
Fig. 15 (1–8870)
Fig. 16 (1–8694)
Fig. 17 (1–8898)


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EXPLANATION OF PLATE 10.

Stone implements principally from the upper layers of the mound. Figures about three-fifths natural size.

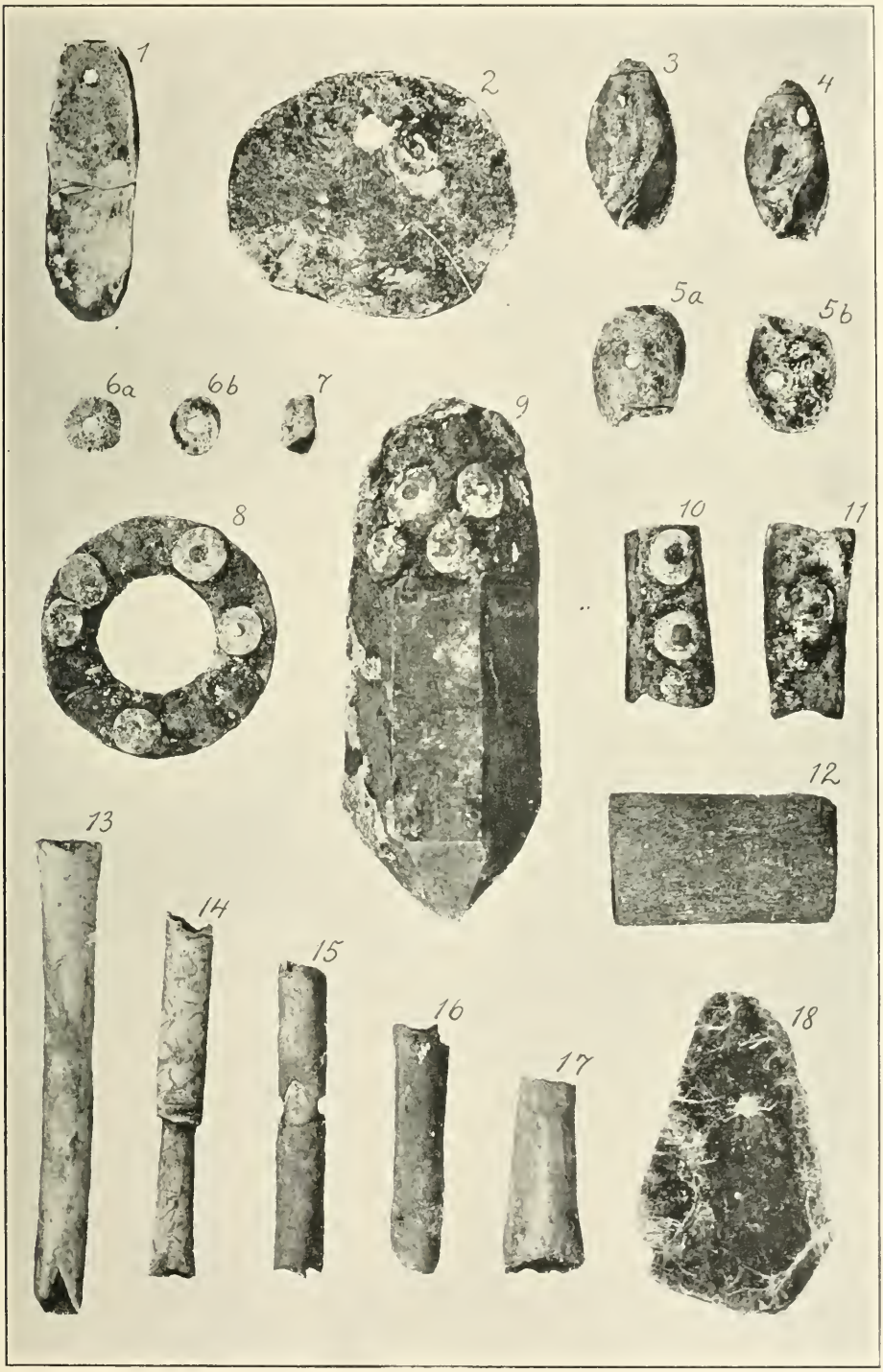
Fig. 1 (1–8613)
Fig. 2 (1–8611)
Fig. 3 (1–8615)
Fig. 4 (1–8718)
Fig. 5 (1–8614)
Fig. 6 (1–8618)
Fig. 7 (1–8719)
Fig. 8 (1–8616)
Fig. 9 (1–8925)
Fig. 10 (1–8610)
Fig. 11 (1–8633)
Fig. 12 (1–8536)
Fig. 13 (1–8676)
Fig. 14 (1–8883)
Fig. 15 (1–8926)
Fig. 16 (1–8634)


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14
15
16

EXPLANATION OF PLATE 11.

Ornaments principally from the upper and middle layers of the mound. Natural size.

Fig. 1 (1–8777)
Fig. 2 (1–8784)
Fig. 3 (1–8879)
Fig. 4 (1–8775)
Figs. 5*a* and 5*b* (1–?)
Figs. 6*a* and 6*b* (1–8788)
Fig. 7 (1–?)
Fig. 8 (1–8783)
Fig. 9 (1–8791)
Fig. 10 (1–?)
Fig. 11 (1–?)
Fig. 12 (1–8843)
Fig. 13 (1–8702)
Fig. 14 (7–8743)
Figs. 15, 16, and 17 (1–8776)
Fig. 18 (1–8766)

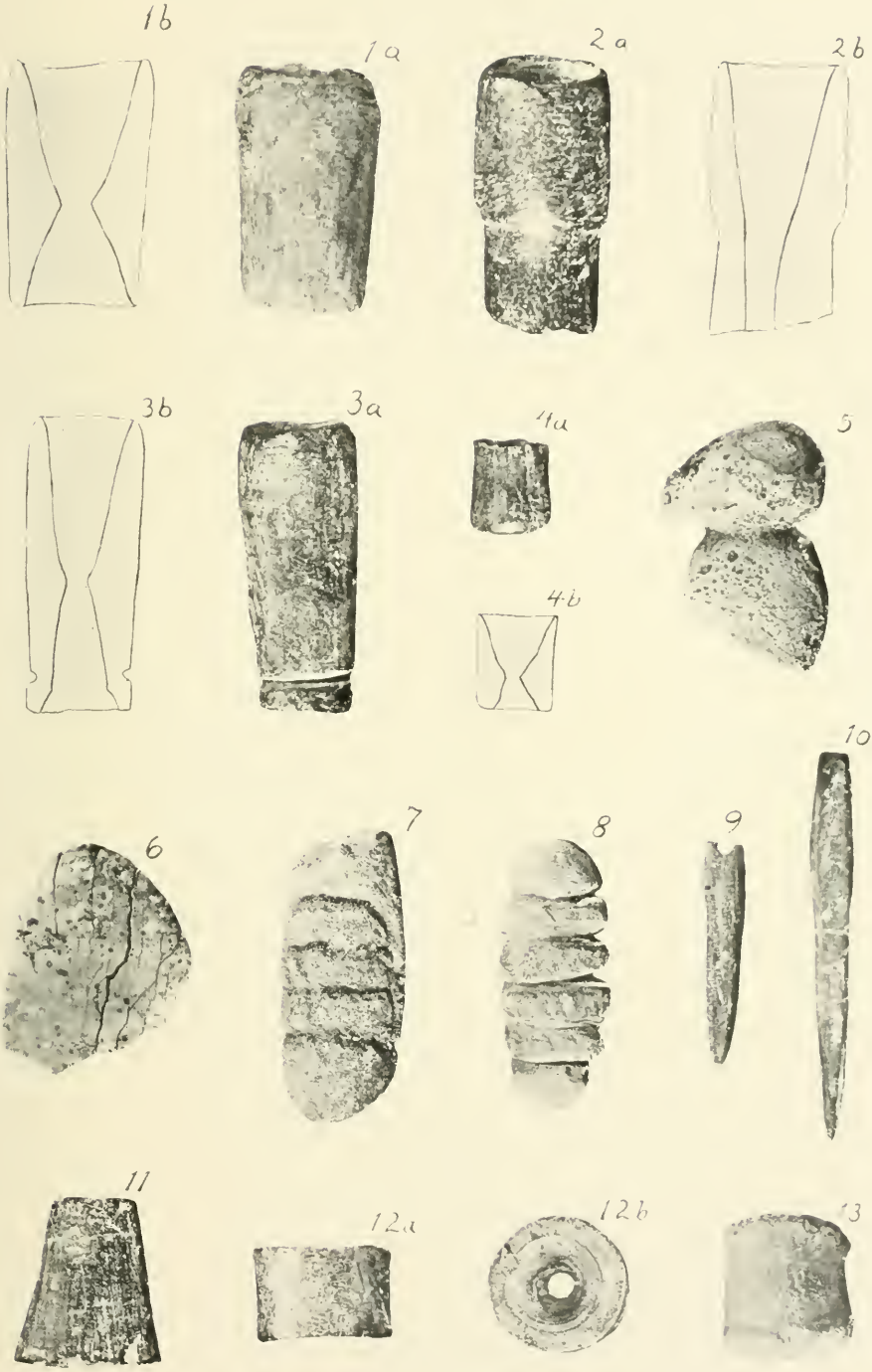

1
2
3
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5a
5b
6a
6b
7
8
9
10
11
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13
14
15
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17
18

EXPLANATION OF PLATE 12.

Various artifacts principally from the upper layers of the mound. Figures 1 to 4, × ¾; figures 5 to 13, × ⅔.

Figs. 1*a* and 1*b* (1–8624)
Figs. 2*a* and 2*b* (1–8622)
Figs. 3*a* and 3*b* (1–8623)
Figs. 4*a* and 4*b* (1–8626)
Fig. 5 (1–8850)
Fig. 6 (1–8631)
Fig. 7 (1–8535)
Fig. 8 (1–8630)
Fig. 9 (1–8711)
Fig. 10 (1–8608)
Fig. 11 (1–8620)
Figs. 12*a* and 12*b* (1–8671)
Fig. 13 (1–8628)

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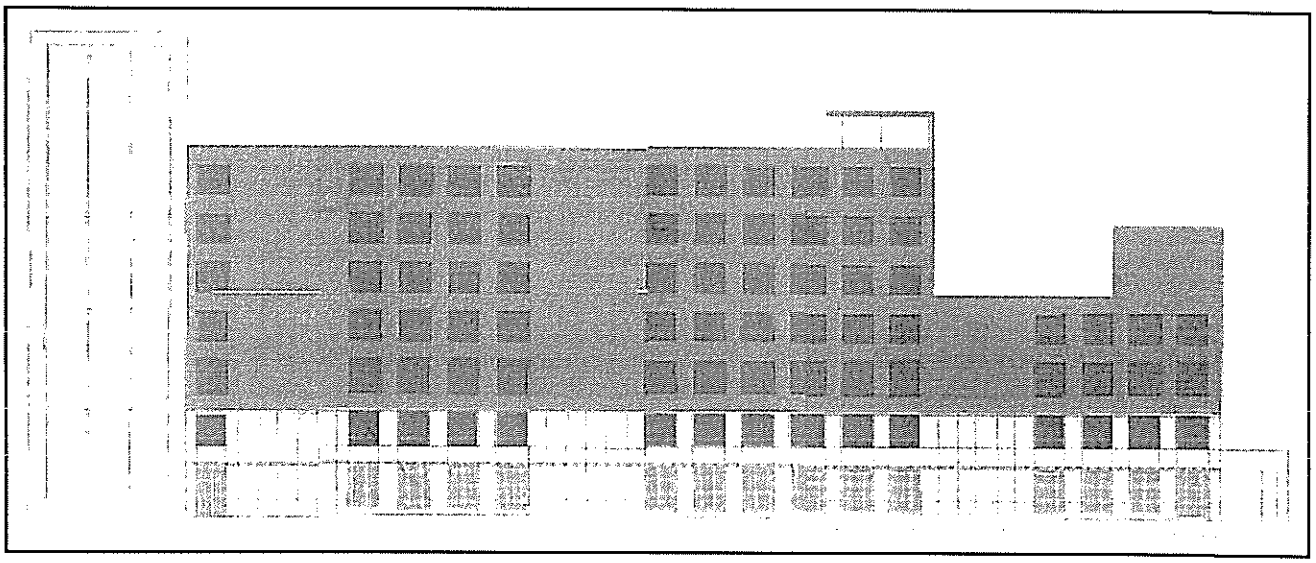
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S-25127

Report on the Archaeological Monitoring at the Chiron Campus Expansion: Building 12A Parking Structure, Emeryville, CA



Prepared For:

CHIRON CORPORATION
4560 Horton Street
Emeryville, CA 94608-2916

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Prepared by:
William Self Associates
Orinda, California

February 2002

Report on the Archaeological Monitoring at the Chiron Campus Expansion: Building 12A Parking Structure, Emeryville, CA

Prepared by:

Kimberley Popetz, Kyle Brown, Eric Strother,
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February 2002

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Appendix

Catalog of Artifacts

1.0 PROJECT LOCATION AND DESCRIPTION

The Chiron Campus Expansion Program involves the continued development of the Chiron Life Sciences Project in Emeryville, California with the addition of a multi-story parking structure. Construction began on the property during June 2001. The general location of the project is shown on the Oakland West, California USGS 7.5' topographic map and is located in Township 1 South, Range 4 West, MDBM (Figure 1). It is in a formerly industrial neighborhood ¾-mile east of the San Francisco Bay along Temescal Creek (Figure 2). The boundaries of the project area are the Southern Pacific Railroad tracks on the west and north, Horton Street on the east, and an existing Chiron Life Sciences building on the south (Figure 3).

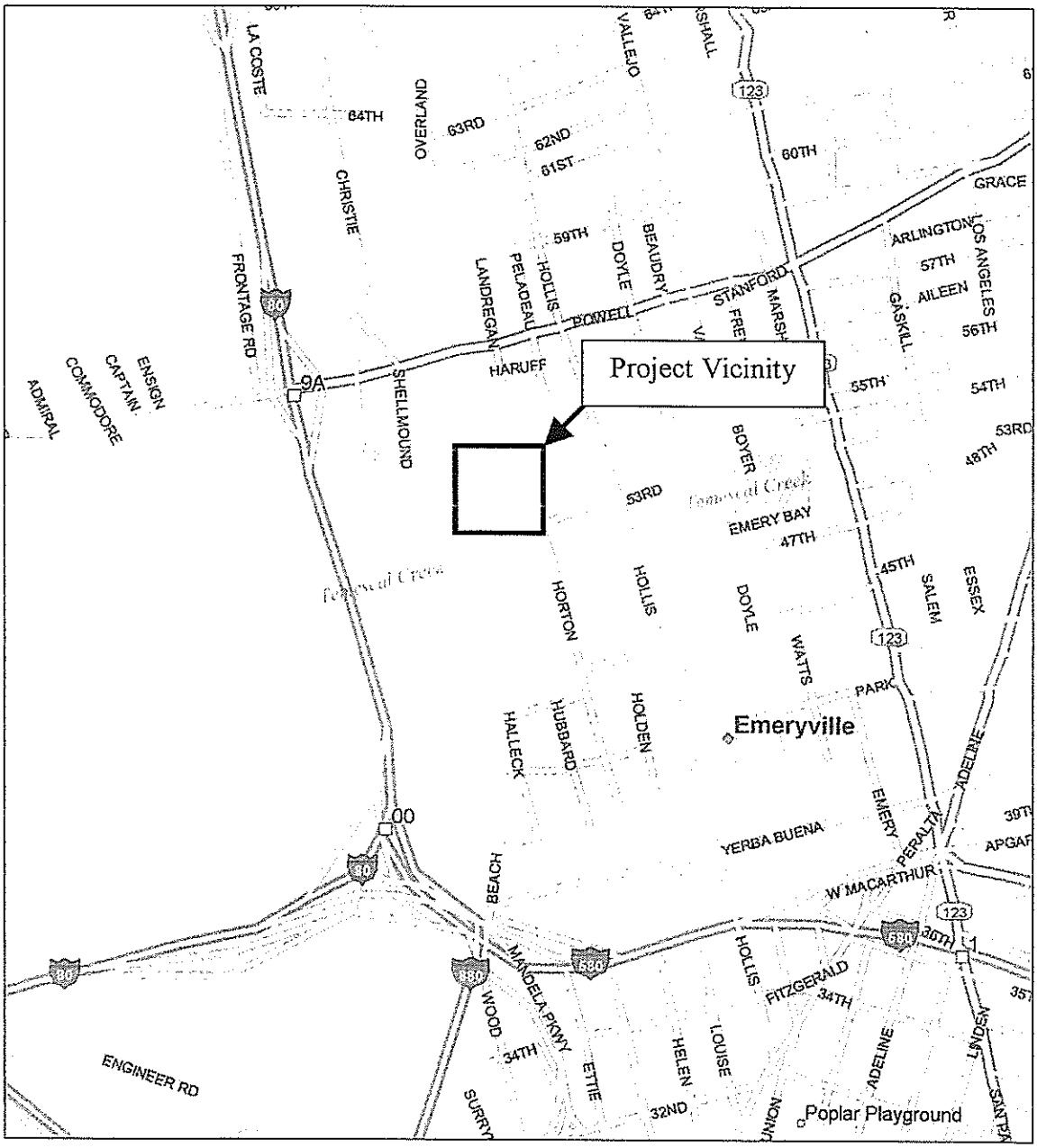
In compliance with the required mitigation measures outlined in the Archaeological Monitoring and Data Recovery Program (AMDRP) prepared for Chiron Corporation, archaeologists from William Self Associates (WSA) conducted monitoring during the earth moving portion of construction for the new parking facility.

2.0 NATURAL AND CULTURAL SETTING

Existing Environment

The Chiron Life Sciences Center is situated near the eastern shore of San Francisco Bay, the largest estuarine system in California. The project area, located near the southern city limits of Emeryville, comprises a flat, developed industrial area. Temescal Creek, which drains the Berkeley Hills to the east, has been channelized and flows in a subterranean conduit south of 53rd Street.

Annual precipitation in the Bay region varies from 20 to 40 inches with precipitation concentrated in the fall, winter, and spring months. This climate is much like that found in the Mediterranean: mild, rainy winters, and dry, warm summers. After the first rain at the end of October or early November, the vegetation becomes green and remains green, but not growing, until late February, when the grasses that cover the surrounding Berkeley Hills begin to grow rapidly. By early May, these have usually changed to dry golden-colored grasses, that remain that way until fall (Brown 1985). Due to the cooling effects of the local bay environment, temperatures in the project area are mild in the summer, usually averaging 55-65° (Moratto 1984:223). The cold water of the bay also creates frequent fog, and relative humidity remains high most of the time (Schoenherr 1992:627).

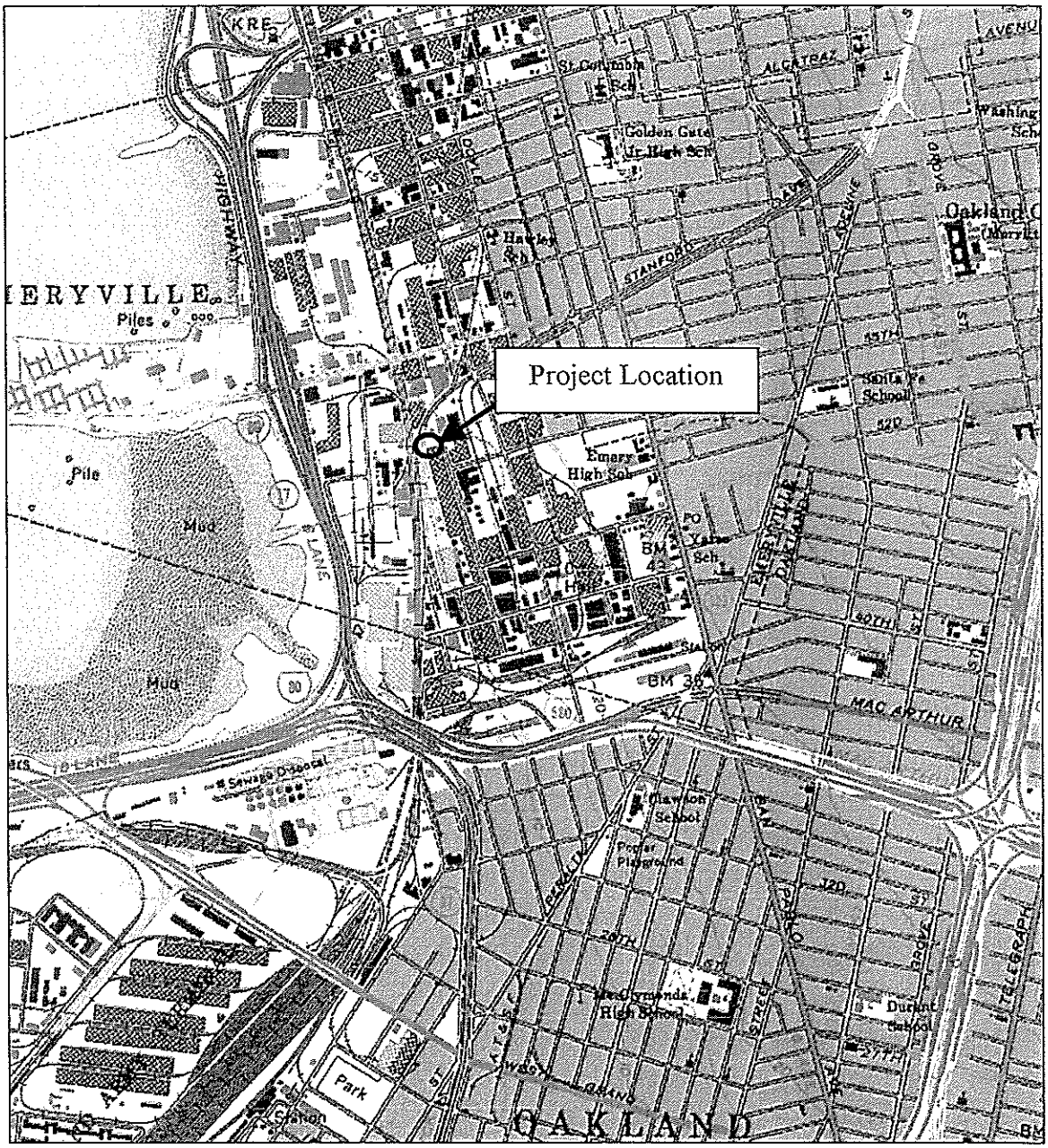


N

Project Vicinity Map

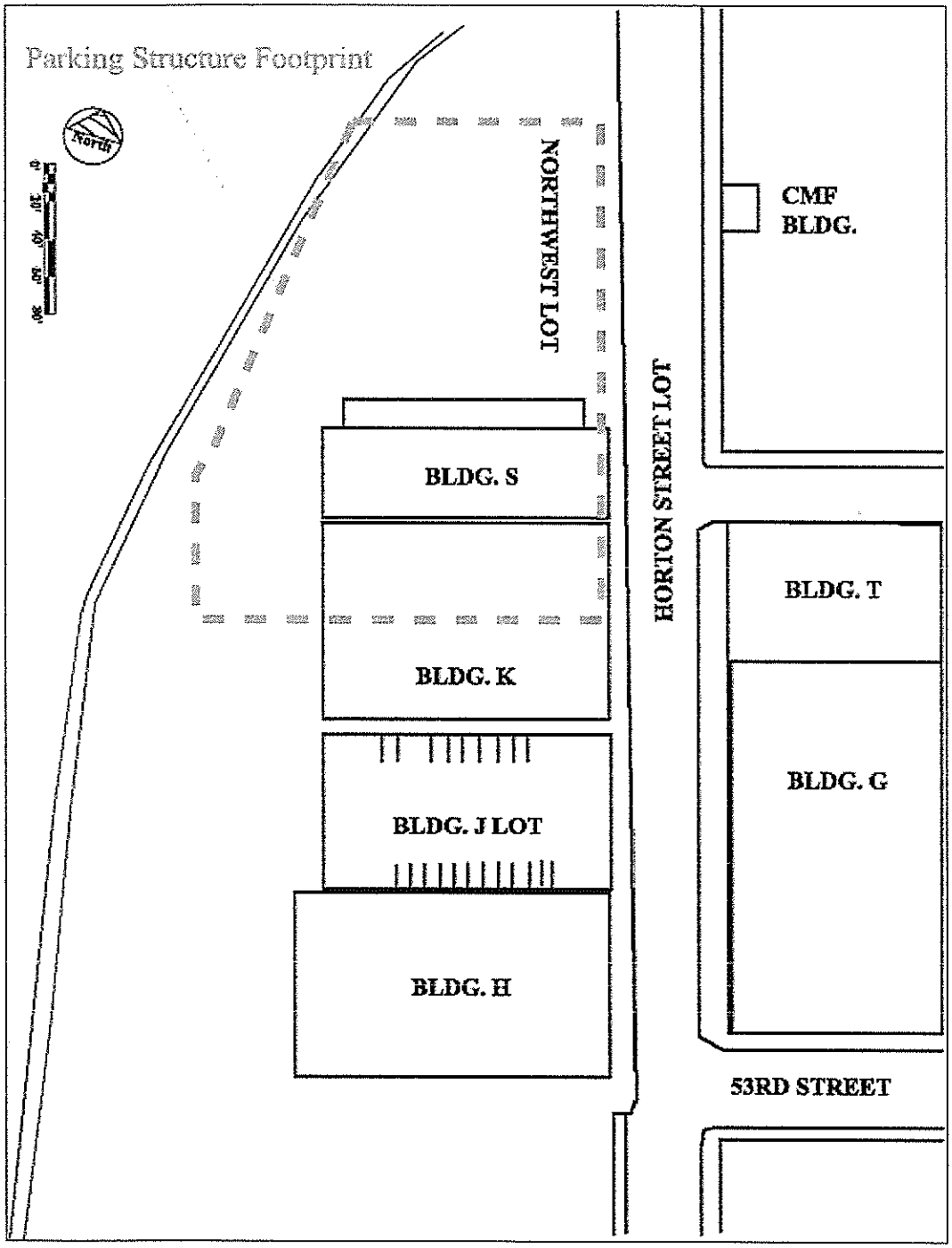
Scale 1inch: 2.5 miles

Figure 1
Chiron Campus Expansion
Emeryville, CA



Project Location Map
USGS 7.5' Oakland West (1959, PR 1980)
Scale 1:2,000

Figure 2
Chiron Campus Expansion
Emeryville, CA



Parking Structure Footprint

Figure 3
Chiron Campus Expansion
Emeryville, CA

Prehistory

In 1902, under the auspices of the University of California, Max Uhle excavated a portion of a large shellmound located in Emeryville, near the shoreline of San Francisco Bay. The Emeryville Shellmound (CA-ALA-309) was one of the largest in the bay region, covering an area approximately 100 x 300 meters, and was nearly 10 meters in height (Moratto 1984:228-229). It was used to define the Emeryville facies of the Augustine Pattern, 500 - 1500 A.D. (see below).

N. C. Nelson of the University of California at Berkeley conducted the first intensive archaeological survey of the San Francisco Bay region from 1906 to 1908. He was the first person to recognize that the Bay Area was a discrete archaeological entity. He maintained that the intensive use of shellfish, a subsistence strategy reflected in both coastal and bay shore middens, was an indication of a general economic unity in the prehistoric region (Moratto 1984). Nelson documented more than 100 shellmounds along the bay shore in Alameda and Contra Costa Counties, when the area was still ringed by salt marshes three to five miles wide (Nelson 1909: 316).

In 1911, Nelson supervised excavations at CA-SFR-7 (the Crocker mound) near Hunter's Point, a site later dated to 3000-1500 BP[1]. L.L. Loud identified archaeological components from this same period in Santa Clara County in 1911 while excavating at CA-SCL-1 (the Ponce, Mayfield, or Castro Mound site). R.J. Drake recognized them in San Mateo County in 1941-42 at CA-SMA-23 (Mills Estate) in San Bruno (Moratto 1984).

The work of Nelson and Loud in the Bay Area provided the impetus for investigation into the prehistory of Central California, which began in earnest in the 1920s. Stockton-area amateur archaeologists J.A. Barr and E.J. Dawson excavated a number of sites and made substantial collections in the area from 1893 to the 1930s. On the basis of artifact comparisons, Barr identified what he felt were two distinct cultural traditions. Dawson later refined his work into a series of "Early," "Middle," and "Late" sites (Ragir 1972; Schenck and Dawson 1929).

Professional or academic-sponsored archaeological investigations began in the 1930s when J. Lillard and W. Purves of Sacramento Junior College formed a field school, which conducted excavations throughout the Sacramento Delta area. By means of artifact and burial data they identified a three-phase sequence similar to Barr's and Dawson's, which they called "Early," "Intermediate," and "Recent" cultures (Lillard and Purves 1936). In 1954, Richard Beasley refined this system and extended it to include the region of San Francisco Bay. The result was referred to as the Central California Taxonomic System (CCTS) (Lillard, Heizer and Fenenga

[1] All BP (before present) dates are calculated from 1950 AD.

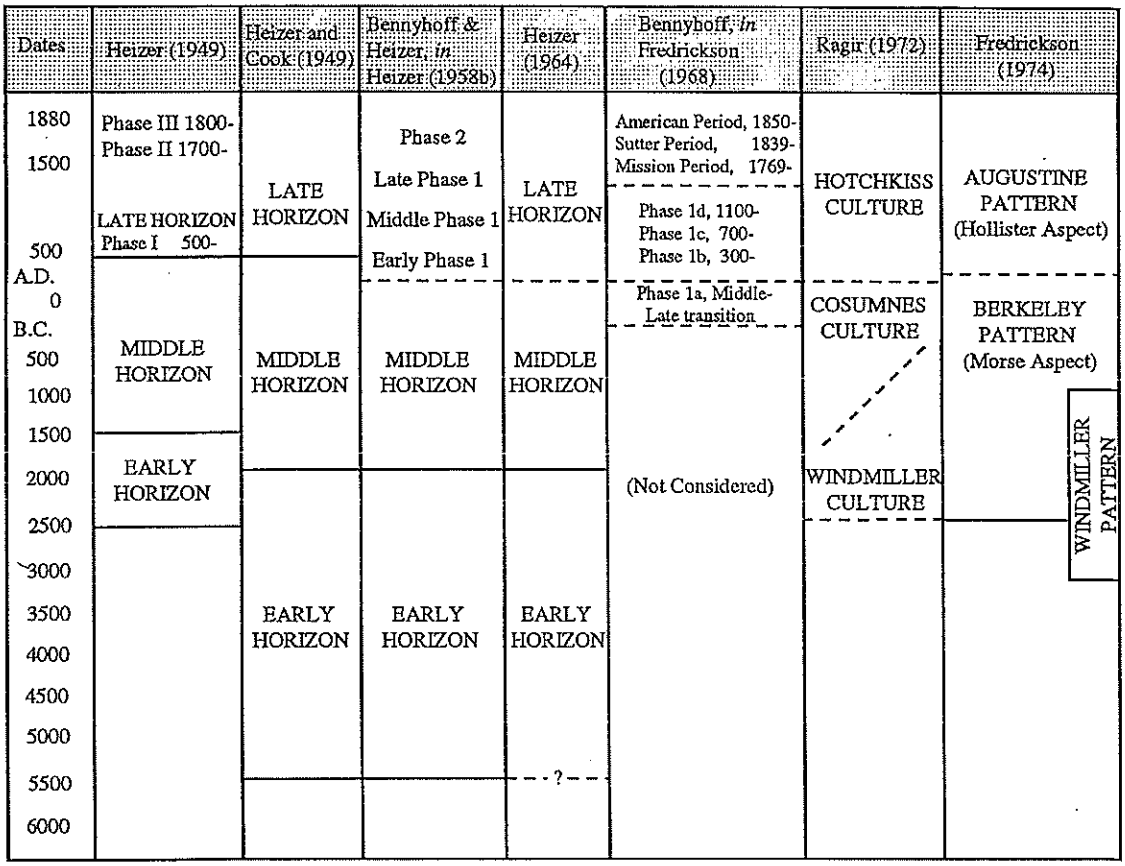
1939; Moratto1984). Subsequently the CCTS system was applied widely to site dating and taxonomy throughout Central California (Figure 4).

Much of the subsequent archaeological investigation in the Central Valley focused on a refinement of the CCTS through an analysis of environmental change, settlement and subsistence strategy, exchange, population movement, and related topics. These studies established sub-sequences for many regions of Central California. The best received of these studies has been Fredrickson's (1973) concept of cultural "patterns" (Moratto 1984:201-214). His idea was that, in spite of local variations, widespread cultural patterns are identifiable. He characterized patterns as

> adaptive mode[s] extending across one or more regions, characterized by particular technological skills and devices, particular economic modes, including participation in trade networks and practices surrounding wealth, and by particular mortuary and ceremonial practices (Fredrickson 1973:7-8).

The chronological sequence for the Central California region begins with the Windmiller Pattern, which possesses cultural elements belonging to both the Early and Middle Horizons. Sites from this period date from about 6950 to 3950 BP. Although earlier occupations no doubt existed, sites from the Paleo-Indian Period, dating from about 11950 to 7950 BP, are thought to be buried beneath Holocene alluvial deposits and are not well documented in this part of California (Ragir 1972). Some scholars have suggested that Windmiller Pattern sites are associated with an influx of people from outside of California, who introduced survival skills for life in river-wetlands (Moratto 1984:207).

Windmiller Pattern sites are often situated in riverine, marshland, or valley floor settings, as well as atop small knolls above prehistoric seasonal floodplains. Such an area provided a wide variety of plant and animal resources. Most Windmiller Pattern sites have contained burials with remains that are extended ventrally, oriented to the west, and that contain copious amounts of mortuary artifacts. These artifacts often include large projectile points and a variety of fishing paraphernalia – net weights, bone hooks, and spear points. The faunal remains indicate that the inhabitants hunted a range of large and small mammals. Stone mortars and grindstones for seed and nut processing are common finds. Other artifacts – such as charmstones, ochre, quartz crystals, *Olivella* and *Haliotis* shell beads – suggest a practice of ceremonialism and trade.



Source: Moratto 1984

San Francisco Bay Area
Cultural Chronology

Figure 4
Chiron Campus Expansion
Emeryville, CA

The subsequent Berkeley Pattern (previously included in the Middle Horizon culture) covers a period from about 3500 to 1500 BP in the San Francisco Bay region. At the beginning of the sequence this pattern shares some attributes with the Windmiller Pattern and with the Late Horizon period at the end. Berkeley Pattern sites are much more common and well documented, and therefore better understood, than Windmiller Pattern sites. These sites are scattered in more diverse environmental settings, but riverine settings are prevalent.

Deeply stratified midden deposits, which develop over generations of occupation, are common to Berkeley Pattern sites. These middens contain numerous milling and grinding stones for food preparation. Projectile points become progressively smaller and lighter over time, culminating in the introduction of the bow-and-arrow during the Late Horizon period. Slate pendants, steatite beads, stone tubes, ear ornaments, and burial techniques that utilize variable directional orientation, flexed body positioning, and a general reduction of mortuary goods are unique to Berkeley Pattern sites (Fredrickson 1973; Moratto 1984).

The Late Prehistoric Period (formerly the Late Horizon) ranges from about 950 to 150 BP. This period coincides with Fredrickson's Augustine Pattern, which is typified by intensive fishing, hunting, and gathering (especially acorns), a large population increase, expanded trade and exchange networks, increased ceremonial and social attributes, and the practice of cremation in addition to flexed burials. Certain artifacts are also distinctive of this pattern: bone awls used in basketry, small notched and serrated projectile points indicative of bow-and-arrow usage, occasional pottery, clay effigies, bone whistles, and stone pipes. The Augustine Pattern and the Late Prehistoric period are recognized as the apex of Native American cultural development in this part of California.

In 1951, prehistoric burials and artifacts were exposed by heavy equipment operators on the southwestern bank of San Francisquito Creek in Santa Clara County. Dubbed the University Village Site (CA-SMA-77), it was excavated in 1951 and 1952 by G.A. Gerow of Stanford University. The cultural pattern identified was a mixture of Windmiller Pattern traits with materials markedly dissimilar to other Early Horizon period sites. To explain this, Gerow argued for a cultural expression different from that found in the Central Valley, which had been used to define the Windmiller Pattern. Gerow suggested that an Early Bay Culture inhabited the area from 3400 to 2900 BP. It eventually merged with the culture of the Central Valley.

Evidence of even earlier occupation in the Bay Area came to light in 1970 during construction of the Bay Area Rapid Transit system (BART) when workers unearthed a skeleton in San Francisco's Civic Center. W.G. Henn and R.E. Schenk of San Francisco State University examined the skeleton and confirmed, through radiocarbon dating, that the skeletal remains dated to

approximately 5660 BP. Further confirmation for early occupation came from Sunnyvale when Bada and Helfman provided radiocarbon dates of about 4410 ±95 BP for charcoal found in association with a skeleton unearthed there.

In 1922, B. Seymour, a student at Stanford University, found a skull eroding out of the bank of San Francisquito Creek. It was located about six meters below the surface and was in primary context. Labeled Stanford Man I, it was dated in 1974 to 5080 ±70 BP (Berger 1974). B. Gerow discovered Stanford Man II, a flexed human skeleton, 1150 meters downstream from Stanford Man I in 1963. Radiocarbon dates for Stanford Man II were 4350 ±70 BP (Berger 1974).

Data recovered from these and other Bay Area sites indicate a widespread but sparsely populated culture of hunters and gatherers in the region as early as 5660 BP (Henn and Schenk 1970; Henn et al 1972). This culture was replaced around 3950 BP by one adapted to bay shore and marshland habitation. The Berkeley Pattern specifies this culture although there is considerable regional variation (Moratto 1984). Moratto suggests that this replacement culture corresponds to the spread of Utian (Miwok-Costanoan) people from eastern Contra Costa County. By 3400 BP, this group had settled the southern Bay Area. From here they spread northward to the peninsula, westward to the coast, and southward to the Santa Clara Valley. They would remain in these areas until historic times.

By 1920 BP, the Berkeley Pattern was developing into the Augustine Pattern, with its characteristic bow-and-arrow, tubular tobacco pipe, cremation, intensive acorn utilization, and complicated exchange systems. It was this emerging pattern that was destroyed by the Spanish mission system and subsequent historical developments (Moratto 1984; 283).

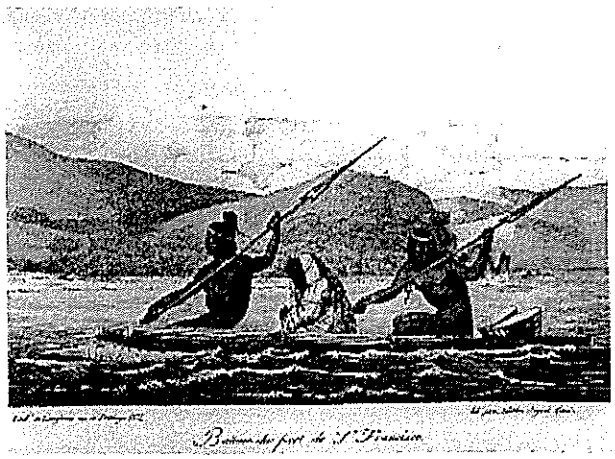
Ethnography

There is a considerable body of ethnographic literature on the Native American inhabitants of the project region. This section provides a brief summary of the ethnography of the area and is intended to provide a general background only. For a more extensive review of Ohlone ethnography, see Bocek (1986), Cambra (et al. 1996), Kroeber (1925), Levy (1978), Milliken (1983), and Shoup with Milliken and Brown (1995).

The project area lies within the region occupied by the Ohlone or Costanoan group of Native Americans at the time of historic contact with Europeans (Kroeber 1925: 462-473). Although the term Costanoan is derived from the Spanish word Costaños, or "coast people," its application as a means of identifying this population is based in linguistics. The Costanoans spoke a language now considered one of the major subdivisions of the Miwok- Costanoan, which belonged to the Utian

family within the Penutian language stock (Shipley 1978: 82-84). Costanoan actually designates a family of eight languages. Of these, Chochenyo or East Bay Costanoan was the language spoken by the estimated 2,000 people who occupied the " . . . east shore of San Francisco Bay between Richmond and Mission San Jose, and probably also in the Livermore Valley" (Levy 1978: 485).

Tribal groups occupying the area from the Pacific Coast to the Diablo Range, and from San Francisco to Point Sur spoke the other seven languages of the Costanoan family. Modern descendants of the Costanoan prefer to be known as Ohlone. The name Ohlone is derived from the Oljon group, which occupied the San Gregorio watershed in San Mateo County (Bocek 1986: 8). The two terms (Costanoan and Ohlone) are used interchangeably in much of the ethnographic literature.



Indians of the San Francisco Bay Area (Lithographic plate by Louis Choris [1822])

On the basis of linguistic evidence, it has been suggested that the ancestors of the Ohlone arrived in the San Francisco Bay area about 500 A.D., having moved south and west from the Sacramento-San Joaquin Delta region. The ancestral Ohlone displaced speakers of a Hokan language and were probably the producers of the artifact assemblages that constitute the Augustine Pattern described above (Levy 1978:486).

Although linguistically linked as a family, the eight Costanoan languages actually comprised a continuum in which neighboring groups could probably understand each other. However, beyond neighborhood boundaries, each group's language was unrecognizable to the other. Each of the eight language groups was subdivided into smaller village complexes or tribal groups. The groups were independent political entities, each occupying specific territories defined by physiographic features. Each group controlled access to the natural resources of their territories, which also included one or more permanent villages and numerous smaller campsites used as needed during a seasonal round of resource exploitation.

Leadership was provided by a chief, who inherited the position patrilineally and who could be either a man or woman. The chief and a council of elders served mainly as community advisers. Specific responsibility for feeding visitors, providing for the impoverished and directing ceremonies, hunting, fishing, and gathering activities fell to the chief. Only in times of warfare was the chief's role as absolute leader recognized by group members (Levy 1978:487).

Extended families lived in domed structures thatched with tule, grass, wild alfalfa, or ferns (Levy 1978: 492). Semi-subterranean sweathouses were built into pits excavated in stream banks and covered with a structure against the bank. The tule raft, propelled by double-bladed paddles similar to those that were used in the Santa Barbara Island region, were used to navigate across San Francisco Bay (Kroeber 1925: 468).

Mussels were an important staple in the Ohlone diet as were acorns of the coast live oak, valley oak, tanbark oak and California black oak. Seeds and berries, roots and grasses, as well as the meat of deer, elk, grizzly, rabbit, and squirrel formed the Ohlone diet. Careful management of the land through controlled burning served to insure a plentiful and reliable source of all these foods (Levy 1978: 491).

The Chochenyo usually cremated a corpse immediately upon death but, if there were no relatives to gather wood for the funeral pyre, interment occurred. Mortuary goods comprised most of the personal belongings of the deceased (Levy 1978: 490).

The arrival of the Spanish in the San Francisco Bay Area in 1775 led to a rapid and major reduction in native California populations. Diseases, declining birth rates, and the effects of the mission system served to largely eradicate the aboriginal life ways (which are currently experiencing resurgence among Ohlone descendants). Brought into the missions, the surviving Ohlone, along with former neighboring groups of Esselen, Yokuts, and Miwok were transformed from hunters and gatherers into agricultural laborers (Levy 1978; Shoup with Milliken and Brown 1995). With abandonment of the mission system and the Mexican takeover in the 1840s, numerous ranchos were established. Generally, the few Indians who remained were then forced, by necessity, to work on the ranchos.

Today, descendents of the Ohlone live throughout the Bay Area. Several Ohlone groups (Muwekma, Amah) have banded together to seek Federal recognition. Many Ohlone, both as individuals and as groups, are active in preserving and reviving elements of their traditional culture, such as dance, basketry, and song, and are active participants in the monitoring and excavation of archaeological sites.

Regional History

The historic period in the eastern San Francisco Bay region begins with the Fages-Crespi expedition of 1770. The Fages party explored the eastern shore of San Francisco Bay, eventually reaching the location of modern Fremont, where they traded with the local Costanoans. Members of the

expedition eventually sighted the entrance to San Francisco Bay from the Oakland Hills. In 1772, a second Fages expedition traveled from Monterey through what is now Milpitas, San Lorenzo, Oakland, and Berkeley, finally reaching Pinole on March 28, 1772 (Cook 1957:131). From there they traveled through Rodeo and Crockett to Martinez, made a brief foray into the delta region of the Central Valley, and then camped somewhere near Pittsburg or Antioch. On 31 March, the Fages party began the return journey to Monterey. They traveled to Walnut Creek, turned south, and then made their way to Danville, where they spent the night. On 1 April they passed through San Ramon, Dublin, and Pleasanton, finally arriving back in the area of Milpitas on the following day.

In 1776, the Anza-Font expedition traveled through the same area and also traded with residents of native villages encountered along the way. The significant impact of the European presence on the local California natives, however, was not felt until the Spanish missions were established in the region.

In 1775, Captain Juan Manuel Ayala's expedition studied the San Francisco Bay and ventured up the Sacramento and San Joaquin Rivers in search of a suitable mission site. The first mission in the region was established the following year with the completion of Mission San Francisco de Asis (Mission Dolores) in San Francisco. Mission Santa Clara de Asis followed in 1777, and Mission San Jose in 1797. The ensuing Mission era lasted for the next 46 years and proved to be the downfall of the native inhabitants of the region, who were brought to the missions as conscripts for labor under the pretense of "Christianization." The missions became the loci of native "missionization," which brought disease, subjugation, and ultimately decimation, to the native Californian groups. It is reported that by 1810, the traditional Costanoan lifestyle ceased to exist (Levy 1978:486). Diseases introduced by the early expeditions and missionaries, and the contagions associated with the forced communal life at the missions, killed a large number of local peoples, exemplified by a mass burial of 18 individuals adjacent to the Hotchkiss Mound site near Oakley (Heizer 1954). On an expedition through the Central Valley in 1832-1833, Ewing Young observed:

> *In the Fall of 1832...the banks of the Sacramento River, in its whole course through the valley, were studded with Indian villages.... On our return, late in the summer of 1833, we found the valleys depopulated. From the head of the Sacramento to the great bend and slough of the San Joaquin, we did not see more than six or eight Indians; while large numbers of their skulls and dead bodies were to be seen under almost every shade-tree near water, where the uninhabited and deserted villages had been converted into graveyards....* (Cook 1955:318).

Cook (1943) estimates that by 1832, the Costanoan population had been reduced from a high of over 10,000 in 1770 to less than 2000.

In 1820, Sergeant Luis Maria Peralta received a grant of 10 square leagues of land in the East Bay in recognition of his long, faithful military service in California. Peralta named his grant Rancho San Antonio. It comprised the land that lay from the water's edge to the crest of the Oakland hills between San Leandro Creek in the south and El Cerrito Creek in the north (Hendry and Bowman 1940:585). The entire Emeryville area was encompassed in Peralta's holdings.

In 1842, Peralta formally divided his holdings among his four sons. Vicente Peralta received the area between Lake Merritt and the southern border of Berkeley. On the north bank of Temescal Creek, in the vicinity of the intersection of Telegraph Avenue, 55th Street, and Highway 24, he built his home, a chapel, corrals, storerooms, and other buildings (Bowman 1951: 225-226; Hendry and Bowman 1940: 589-591; Judd 1984:2) (Figure 5). Corrals were also situated along the lower course of Temescal Creek and two structures stood at its mouth. Hides and tallow from the Peralta cattle herds were processed at the mouth of the creek and then shipped to San Francisco.

Following the U.S. takeover of Alta California from Mexico in 1846, Rancho lands began to be divided up and generally overrun by the Anglo immigration to the area coincident with the land boom following the Gold Rush of 1849. By the beginning of 1850, Vicente Peralta had lost nearly $100,000 in rustled cattle, and squatters were usurping his land (Davis 1967:252). Rancho San Antonio suffered the fate of most Mexican land grants in northern California, with squatters taking quasi-legal title to lands, and the courts denying title to the original grantees. By 1870, most of the Peralta grant was divided; what remained in title to the Peralta family was but a fraction of the original grant (Hendry and Bowman 1940:585) (Figure 6).

Although early maps show scattered residences and structures in the Emeryville area as early as the 1850s, significant development didn't occur in the area until Edward Wiard purchased a 115 acre tract of land from Joseph Emery (after whom Emeryville is named) for $7000 in 1859. Wiard's property was located west of San Pablo Avenue, north of Park Avenue, and south of Stanford Avenue. In the late 1860s, Wiard built the Oakland Trotting Park on the eastern portion of his tract. The one-mile track, 2000 feet long and 900 feet wide, was completed in 1871 (Hausler 1994: 5). Temescal Creek flowed through the center of the track and the racetrack itself crossed the creek on bridges (Figure 7).

The track complex included a two-story hotel, stables, and grandstand. The tack rooms and jockey club were located between what are now 45th and 53rd Streets. The track attracted a number of commercial establishments to the area, including saloons, hotels, restaurants, and bordellos.

Harness racing was the track's primary feature for its first twenty-five years. In 1873, the first California Derby was held at the Trotting Park, featuring thoroughbred races between the harness racing heats (Hausler 1994:6).

In 1874, Wiard's property was bisected by the tracks of the Northern Railway that connected Oakland with Martinez. Two years later, Wiard leased the land west of the tracks to Captain L. Seibe, who developed Shell Mound Park, the famous resort and picnic area on top of the largest Emeryville shellmound.

In the 1880s, Wiard fell on hard times, eventually lost the track, and died a broken man in 1885. San Francisco judge James Mee assumed ownership of the track in 1886, maintaining its operation until his death in 1894. In May of that year, Thomas H. Williams, president of the California Jockey Club, leased the property from Mee's estate. Williams rebuilt the track and its infrastructure, replacing the stables, paddocks, barns, jockey club, and other buildings. He replaced the grandstand with one resembling a large Japanese pagoda, insuring that it was connected to the nearby train depot with a covered walkway. The track itself was redesigned and relayed:

> Underlying the track is nine inches of rock, which acts as a subdrain. Above this is a dressing of twelve inches of soil. In making the base of the course, some twenty thousand yards of broken rock were required. . .(*Oakland Enquirer*: 10/23/1896 in Hausler 1994)

Renamed the New California Jockey Club, the track flourished for another fifteen years. To protect their investment in the track, which was situated on unincorporated land, Williams and his investors promoted the incorporation of Emeryville into a town. In December 1896, local voters approved incorporation and the town of Emeryville was established (Hausler 1994:11).

The track flourished into the twentieth century, serving as a magnet for commercial development in the surrounding neighborhoods. In 1906 it also provided a haven for thousands of people displaced by the 1906 San Francisco earthquake and fire.

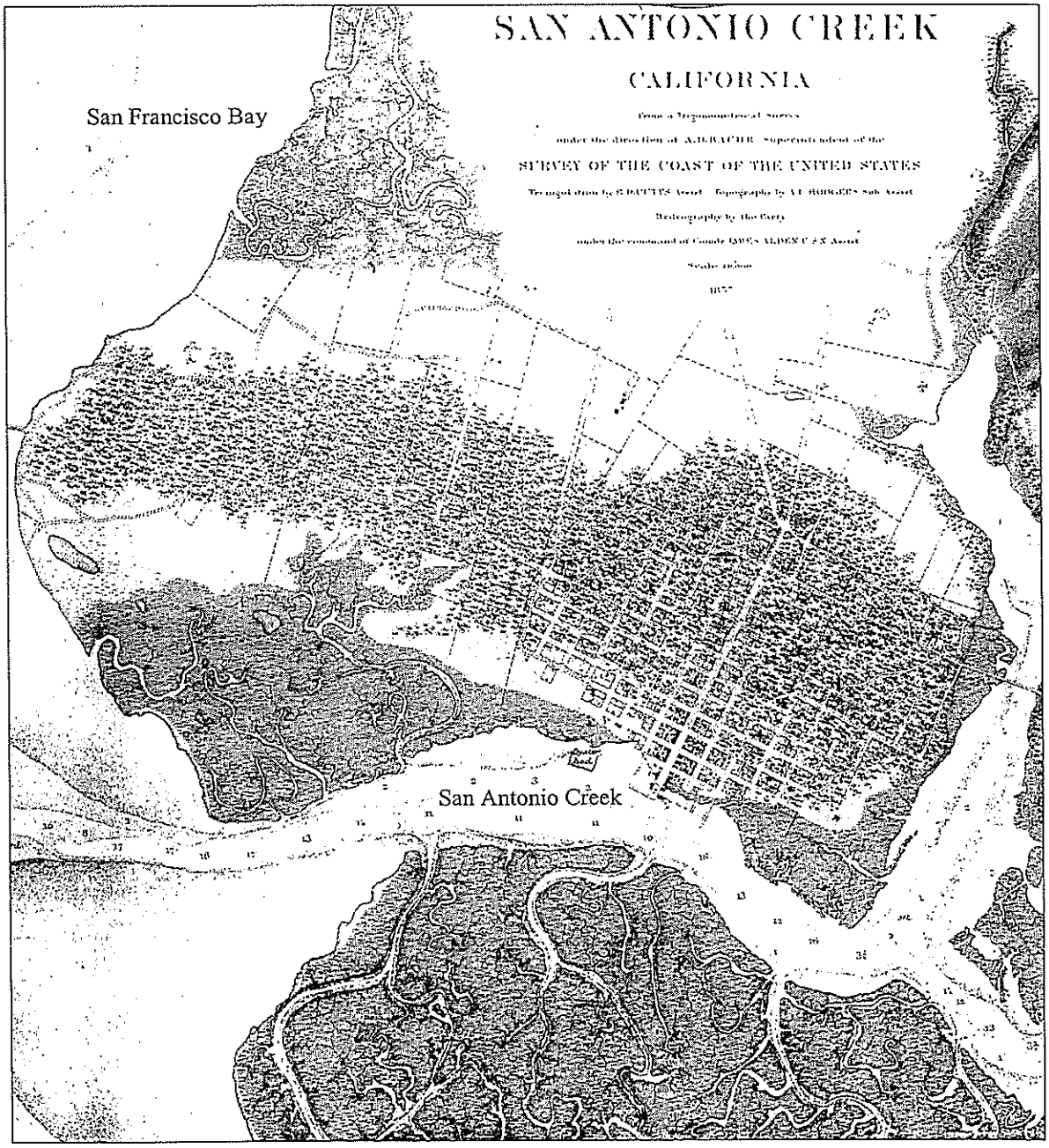
By 1910, the political climate embodied in the Progressive movement was such that the state legislature passed the Walker-Young anti-gambling law, which made racetrack betting illegal. The bill took effect in February 1911 and the last race on the track was held on February 15th (Hausler 1994:13).

Barnstorming pilots subsequently used the track facilities and in 1912 the California Jockey Club was the site of the Third International Aviation Meet. Two years later, the track was the site of the famed race between Lincoln Beachey, piloting a Curtiss Biplane, and renowned racecar driver

Barney Oldfield, behind the wheel of a Simplex racer. Oldfield won the race by a scant twenty feet (Hausler 1994:14).

In 1915, the Mee's estate announced the property was to be subdivided into factory sites and demolition of the track and its infrastructure began in the fall of that year. On December 15, 1915, the portion of the grandstand not yet dismantled and the remaining outbuildings of the track caught fire and burned to the ground (San Francisco Chronicle, Dec. 16, 1915).

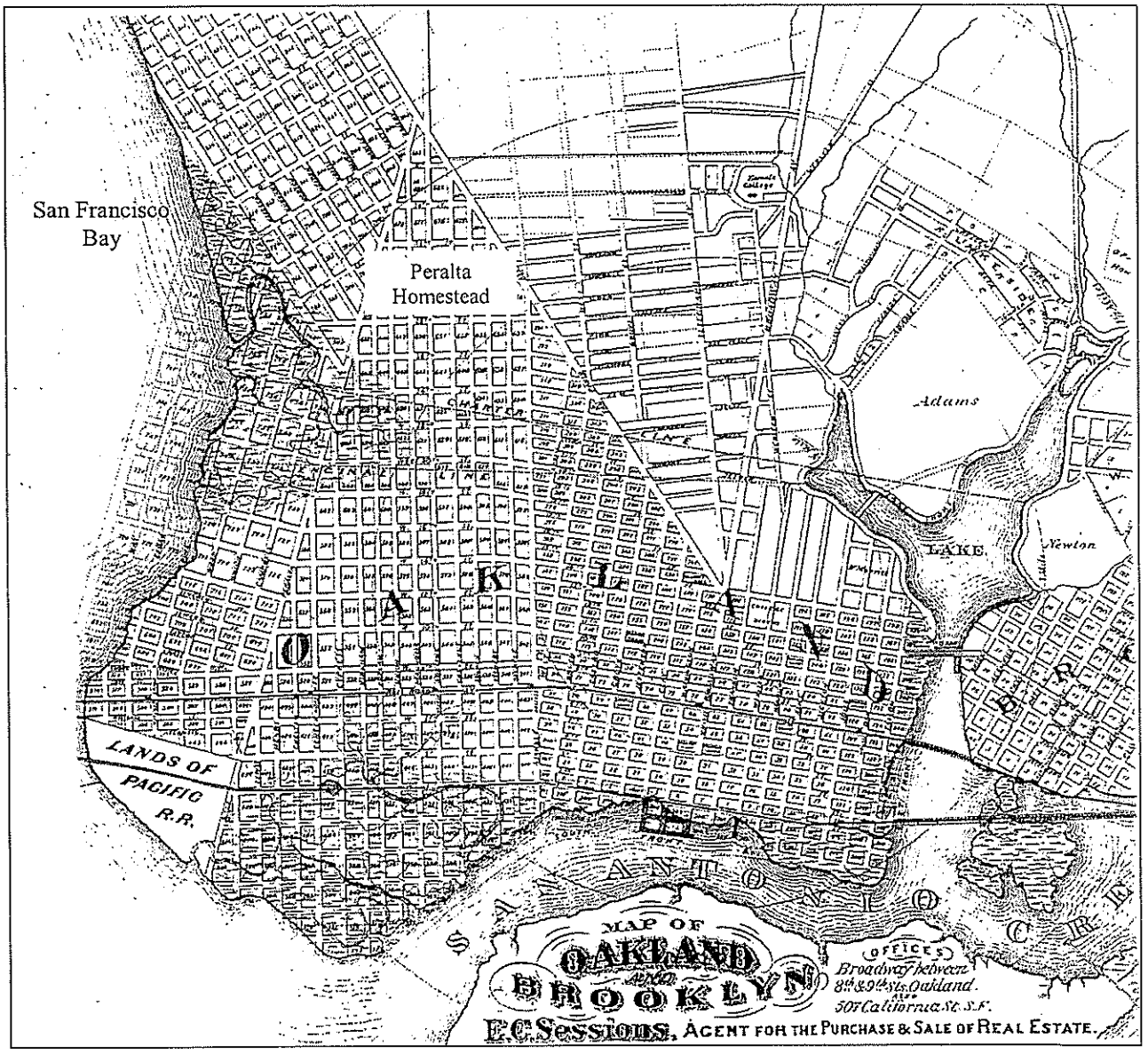
Development of the property proceeded and in the 1920s PG& E built two plants on the west side of Hollis Street, the Watkins Company established a brick factory at what was once the south end of the track, and Western Electric built a factory on the former north end of the track, a structure that now houses a portion of the Chiron Life Sciences Center (Hausler 1994:14). Over the next two decades, several other industrial enterprises established operations on the former grounds of the racetrack. Pacific Telephone and Telegraph, and the Shell Development Company both built offices and warehouses on the northern end of former track grounds. The Thorsen Tools Company, an electrical contractor, and an asbestos products company also had commercial enterprises in that immediate area.



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1857 Map
Survey of the Coast of the United States

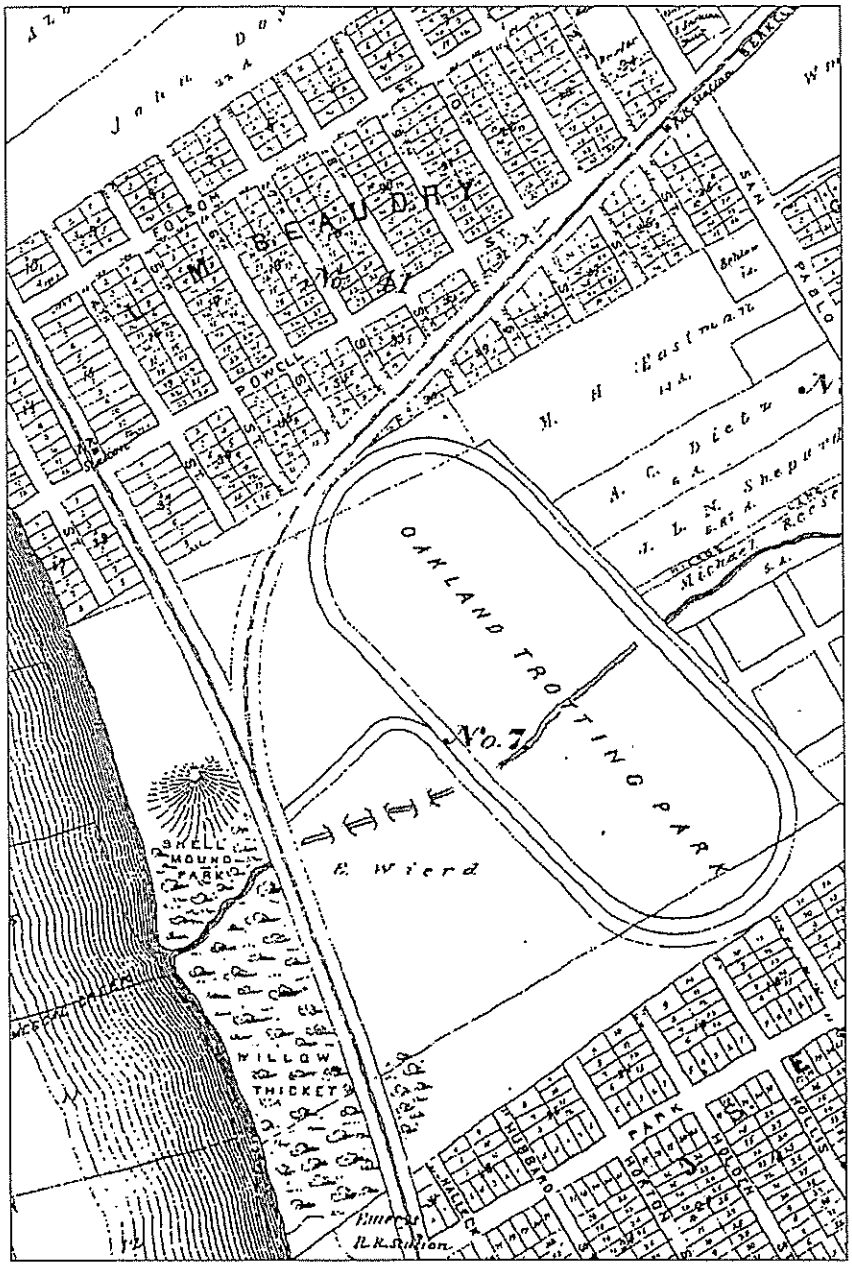
Figure 5
Chiron Campus Expansion
Emeryville, CA



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1869 Map of Oakland and Brooklyn

Figure 6
Chiron Campus Expansion
Emeryville, CA



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Oakland Trotting Park

Source: Historical Atlas of Alameda County, by Thompson and West *In* Hausler 1994

Figure 7
Chiron Campus Expansion
Emeryville, CA

Handbook of North American Indians

WILLIAM C. STURTEVANT
General Editor

VOLUME 8

California

ROBERT F. HEIZER
Volume Editor



SMITHSONIAN INSTITUTION
WASHINGTON
1978

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For sale by the Superintendent of Documents,
U.S. Government Printing Office, Washington, D.C. 20402.
Stock Number: 047-000-00347-4

Library of Congress Cataloging in Publication Data

Handbook of North American Indians.
Bibliography: pp. 721-768
Includes index.
CONTENTS:
v. 8. California.
1. Indians of North America. 2. Eskimos.
I. Sturtevant, William C.

E77.H25 970'.004'97 77-17162

Native Languages of California

WILLIAM F. SHIPLEY

Presumably, at one time it was common for a great many highly divergent languages to be spoken within a modest geographical area. Such a situation still obtains in various parts of the world—in the Caucasus, in West Africa, in New Guinea, in the mountains and gorges at the convergence of Upper Burma, Thailand, and southwestern China. Another such tangle of languages, perhaps in some ways the most complex of all, was found in the California culture area until the European conquest, which began just two centuries ago. Over the mountains, valleys, and deserts of the area were spread no fewer than 64—and perhaps as many as 80—mutually unintelligible tongues, further differentiated into an unknowably large number of dialects. Miraculously, something more than two dozen of these languages have survived through the middle of the twentieth century—as terminal cases, it is true, and spoken only by a few elderly persons. These languages have provided the modern researcher with a glimpse, however faded, of a marvelous linguistic diversity with its origins lying millennia in the past.

The orderliness of Darwinian theorists inspired nineteenth-century linguists to reach certain conclusions about the mechanisms of diachronic or historical change in languages. Thus a detailed study of the historical development of the Indo-European family of languages, the principal pastime of nineteenth-century linguists, led to the formulation of clear-cut tenets with regard to the dynamisms of linguistic change. The maturation of this understanding about language was much abetted by the nature of the data from which such understanding was derived. Not only are there dozens of modern Indo-European languages to which anyone may have massive access, but also there are extensive records of older languages—Sanskrit, Greek, Hittite, Latin—sometimes going back as far as 3,500 years. The analysis of this ocean of material provided insights of vast importance to the study of language: that, for example, sound-change in language is regular, recurrent, and predictable and that apparent exceptions are always due to special circumstances about which individual statements may be made, given sufficient information. One of the most important types of special circumstance is that in which words have been borrowed by one language from another. Such words, of course, do not reflect the historical development of the borrowing language prior to the time of their adoption.

It is only in the light of these principles that the situation with regard to the languages of California can really be understood. A basic system of recurrent sound correspondences is the only known certain diagnostic for validating a genetic relationship among any group of languages. Such a validation is possible in California for small families of languages; in fact, it has been done for Miwokan (Broadbent and Callaghan 1960), Yokutsan (Golla 1964), Palaihnihan (Olmsted 1964), Pomoan (McLendon 1973; Moshinsky 1974), Maiduan (Ultan 1964), and Yuman (Langdon 1968, 1975; Wares 1968). Those California languages belonging to the three relevant exterior stocks—Algic (Algonquian-Wiyot-Yurok), Na-Dene, and Uto-Aztecan—have been genetically identified in the very process of discovering their exterior relationships, a simple and obvious task in the case of the Uto-Aztecan and Athapaskan languages but much more difficult in the case of Wiyot and Yurok (Sapir 1913, 1915, 1915a; Michelson 1914, 1915; Haas 1958).

An example from the Miwokan languages will make the nature of this validation clear (Broadbent and Callaghan 1960; Callaghan 1970).

	'heart'	*'swim'*	*'fly' (verb)*	*'eye'*
Southern Sierra Miwok	*wihki*	*ʔipih*	*hile·t*	*hinti*
Central Sierra Miwok	*wiṣki*	*ʔipiṣ*	*ṣile·t*	*ṣinti*
Plains Miwok	*wáski*	*ʔəpə́h*	*silé·t*	——
Bodega Miwok	*wúṣki*	*ʔupúh*	——	*ṣút*

It will be noted that wherever Southern Sierra Miwok has an *h*, Central Sierra Miwok has an *ṣ*. This recurrent correspondence, along with the various obvious identities (*i* to *i*, for instance), validates the genetic relationship between the Southern and Central Sierra languages. Matching this *h* : *ṣ* correspondence, Plains Miwok has *s* in the words for 'fly' and 'heart' but *h* in the word for 'swim'. A parallel pattern with *ṣ* and *h* obtains in Bodega Miwok. These *h* variants in Plains and Bodega Miwok are due to the occurrence of the sound in final position. The correspondence, then, is *h* in Southern Sierra Miwok, *ṣ* in Central Sierra Miwok, *h* finally and otherwise *s* in

Plains Miwok, and *h* finally and otherwise *ṣ* in Bodega Miwok. The genetic relationship of these four languages is certified by the marshaling of such evidence in as much detail as possible.

For the two great language stocks—Hokan and Penutian—that have been proposed as subsuming a majority of the California languages, there is as yet no demonstrable evidence of the type presented for Miwokan. There are many provocative resemblant forms among the languages, particularly among the Penutian ones, as well as certain general grammatical features that may be labeled Penutian or Hokan. In short, the terms Penutian stock and Hokan stock are names for unverified hypotheses. It is likely that both theories will eventually be validated, probably with minor, possibly with major alterations and rearrangements.

Various factors complicate the situation. One of the major difficulties has to do with linguistic diffusion, the borrowing of language material—speech sounds, words, grammatical constructions—by one language from another. The freedom and ease with which most of the California languages borrowed terms from Spanish is a case in point (Shipley 1962). Hundreds of Spanish words, linked with diffused elements of Spanish culture, invaded the aboriginal tongues in the nineteenth century, very probably representing an old continuing tradition of linguistic borrowing. Bilingualism and multilingualism were common among the California Indians, undoubtedly accompanied, over the centuries, by a steady process of acculturation and exchange of linguistic material in all directions. Many animal, bird, and plant names are widespread, crisscrossing all known boundaries between linguistic families. Some of these, like words for 'goose', 'crane', and 'frog' are scattered over the whole continent. Indeed, the word for 'bluejay'—Karok *ka·y* 'sound of a bluejay', Maidu *ƙáy,* Nisenan *čayit,* Wappo *čay,* Chukchansi Yokuts *čayčay,* Barbareño Chumash *cay*—is reflected even by Latin *gaius* and English *jay.* To say that these words are onomatopoetic is simply to name the phenomenon without explaining it. The fact that some linguistic diffusion is global, some continental, and some areal is directly involved with the problem of elucidating prehistory in California as well as elsewhere.

Quite apart from the correspondence of sounds as an attestation of genetic connections among languages, there is the equally important but much more complex matter of grammatical evidence for the historical relationship of one language to another. Such evidence may be inflectional or derivational (such as the noun cases in Latin, Greek, Sanskrit, German, and Russian, which reflect the common Indo-European origin of these languages) or syntactic, (that is, having to do with the structures of sentences). Inflexional and derivational elements have been explored to some extent for the California languages. The validating criteria involved in syntactic comparisons are, as yet, very poorly characterized. The difficulties come in separating the genetic similarities between two grammars from those that are due to chance or sporadic diffusion. For example, English is, in some ways, grammatically closer to Chinese (by chance) than it is to German (to which it is closely related genetically).

In order to make a realistic assessment of what can be known about interrelationships among the languages of California, the complications and difficulties described above must be kept clearly in view. All sorts of things are very possible: that Esselen, for example, is not Hokan but Penutian, or that it is neither Hokan nor Penutian but the single remnant of a language family that has long since vanished.

With all these caveats in mind, what deductions can be made from the distribution of the California languages, based on the current views regarding their provenience?

The oldest language group still more or less in situ in California would seem to be Hokan. Perhaps these languages were spoken over most of the area, very likely along with speech families of which no trace remains. They were then disrupted by the incursion of Penutian, which, spreading through the great central valley, forced Hokan to the periphery. A later Uto-Aztecan thrust in

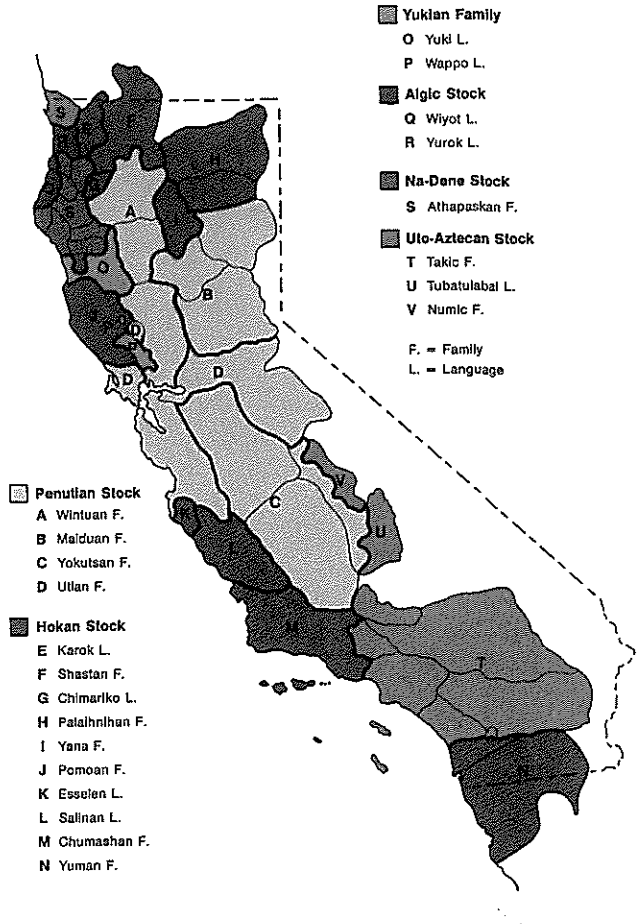


Fig. 1. Language stocks and families of the California culture area.

southern California may have pushed the Yuman languages still farther away from their Hokan congeners.

Somewhat earlier than this, the ancient forms of Yurok and Wiyot speech were brought into the northwest, though not necessarily at the same time. The common ancestral form from which Wiyot, Yurok, and Proto-Algonquian sprang was certainly never spoken in California, so that ancient Yurok and ancient Wiyot must have been separate languages while they were still somewhere to the east or north.

The latest arrivals were probably the Athapaskans, whose ancestors may have drifted down the rivers and coast from Oregon.

The Yukians present the greatest uncertainty. If, as Elmendorf (1963, 1964) suggests, they are related to Siouan, then the circumstance of their presence in California parallels that of Wiyot and Yurok. This is based on the assumption that Wappo is Yukian, for Wappo and Northern Yukian are very remotely related. Such speculation is very tenuous without further research. It is even conceivable that Yukian speech is older in California than Hokan.

In the delineation that follows, languages, language families, and language stocks are organized provisionally, based on the current consensus of researchers. Estimates of numbers of speakers in the various groups are based largely on Kroeber (1925; see also "Historical Demography," this vol.).

Penutian Stock

The Penutian stock was first identified and named by Dixon and Kroeber (1913, 1919). Further attempts to elucidate and define Penutian have been made by many scholars over the years (Sapir 1921-1923, 1921b, 1929; Shafer 1947, 1952; Hymes 1957a, 1964, 1964a; Pitkin and Shipley 1958; Shipley 1957, 1966; Broadbent and Pitkin 1964; Callaghan 1967). The name is a compound of the word for 'two' in Maiduan (Proto-Maiduan **pé·ne*) and Costanoan (Proto-Costanoan **uṭxi*).

The relationship among the Penutian languages is a very old one. Validation of the group as a "true" linguistic stock has been difficult to achieve, though evidence adduced by Hymes (1964) and Shipley (1966) would seem to be conservative and reliable enough to carry conviction. The situation has been complicated by the efforts of various scholars to add languages and language groups outside California to the inventory of Penutian tongues (Sapir 1929a; Freeland 1931; J.A. Mason 1940; F. Johnson 1940; Sapir and Swadesh 1953; Swadesh 1954, 1956; Hymes 1957a, 1964, 1964a; Newman 1964, Shipley 1966, 1969, 1970). It would be irresponsible to say that California Penutian has been established as a genetic group in the sense that Indo-European is so established. However, there seems to be little doubt that further research will eventually certify the relationship. Reviews of the history of Penutian research have been published by Callaghan (1958) and Shipley (1973).

The characteristics of the protolanguage from which the Penutian languages are descended may be adumbrated to some extent. The sound system was of moderate complexity with two series of voiceless stops (plain and aspirated), probably a labiovelar k^w, perhaps no more than the two spirants *s* and *h*, and very likely the sonorants *m, n, r, l, w* and *y*. Most of the languages are not so simple as this (though the Utian group is actually simpler), but the evidence points to a diffused origin for the glottalized consonants so commonly found, while the proliferation of spirants and affricates in Wintuan, Yokutsan, and Costanoan may be due to defunct systems of consonantal symbolism. There were five vowels: *i, u, e, o, a*. The typical stem-morpheme shape proposed long ago by Sapir (1921-1923) has been borne out by subsequent research. In its modern version, the formula may be stated as a disyllabic stem with a single initial and single medial consonant, with or without a final consonant: CVCV(C). As Sapir pointed out, the vowels in the two syllables are often the same.

Certain aspects of the grammar of Proto-Penutian are fairly clear. There was probably a rather complex system of postfixed case markers on nouns and pronouns. The pronoun system was particularly elaborate, with markers not only for case but also for singular, dual, and plural numbers. In addition to subject, object, and possessive cases, the nouns and pronouns were almost certainly marked for the locative and instrumental.

Verbs were marked with suffixes denoting various aspects, modes, and tenses but probably not for person. It is possible that there were instrumental prefixes, though the evidence for this is unreliable. Prefixing in general was minimal or lacking.

There were four families in the Penutian stock: Wintuan, Maiduan, Yokutsan, and Utian. All these names are derived from terms meaning 'person' or 'human being' except Utian, which is based on the Miwok-Costanoan word for 'two'.

Wintuan Family

The three languages in the Wintuan family are Wintu, Nomlaki, and Patwin. Wintu and Nomlaki are quite similar; Patwin is clearly more remote. Harvey Pitkin (personal communication 1962) has suggested that many of the resemblances between Patwin and Wintu may be the result of diffusion and that the genetic relationship is, perhaps, more distant than a superficial inspection of the data would indicate. Kroeber (1925:883) estimated the number of Wintuan speakers at 12,000 in preinvasion times, of which probably at least half were speakers of Patwin.

These Wintuan languages, particularly Wintu, are much more complex phonologically than Proto-Penu-

tian. There were four series of stops: plain, aspirated, glottalized, and voiced; in addition, Wintu had several extra spirants as well as a two-way velar contrast between fronted and backed stops and spirants (*k* and *q* as well as *x* and *x̣*). This last feature may very well have been in Proto-Penutian though no other California Penutian language retains it.

Wintu was the northernmost language of the family, with nine known dialects (Pitkin 1963): McCloud River, Trinity County, Shasta County, Upper Sacramento, Bald Hill, Hayfork, Keswick, Stillwater, and French Gulch.

Closely related to Wintu is Nomlaki (*nom* 'west', *laki* 'speech'?), spoken just to the south in the upper end of the Sacramento Valley. Nomlaki is the least known of the Wintuan languages and probably had no more than 1,000 or so speakers, with at least two dialects and perhaps as many as six.

The area of Patwin speech extended southward to the delta of the Sacramento–San Joaquin river system. There were perhaps 6,000 speakers of Patwin, with many dialects, some of which are known: Hill, River, Cache Creek, Lake, Tebti, Dahcinci, and Suisun. The Patwin (*patwin* 'person') played a dominant cultural role in Central California. Many Patwin words were diffused into the neighboring languages.

Maiduan Family

The Maiduan languages exhibit three phonological innovations of particular interest when compared with the postulated system for Proto-Penutian: there is a glottalized stop series; there are two voiced imploded stops, *b* and *d*; and there is a sixth vowel, the high central unrounded *i̇*. Konkow and Nisenan have yet a seventh vowel, a mid-central unrounded *ə*. The origins of these two extra vowels are obscure. The high vowel is found in some Miwokan and Yokutsan languages as well as in Maiduan, specifically in those languages that are contiguous to or near the Uto-Aztecan languages to the east and south of the Sierra Nevada, all of which have such a vowel. Silverstein (1970) has shown that *i̇* may very well have developed from *u* under the influence of a neighboring *y*.

Maiduan stems tend to be monosyllabic. The Proto-Penutian stem type CVCV(C) has often been reduced by the loss of the medial consonant or of the second syllable.

There are three languages in the family: Maidu (Northeastern Maidu, Mountain Maidu), Konkow (Concow, Northwestern Maidu), and Nisenan (Southern Maidu). Although they share a large inventory of near-identical stem morphemes, they are quite different from one another grammatically and are not mutually intelligible. Phonological and lexical reconstructions have been made (Shipley 1961; Ultan 1964). According to Kroeber (1925:883) there were some 9,000 speakers in aboriginal times, Nisenan being probably the largest group.

Maidu was spoken entirely in the high mountains to the east and south of Mount Lassen. There is little reliable evidence for dialect differentiation though it seems reasonable to assume that there were different dialects originally in the four major areas of Maidu settlement: Susanville, Big Meadows, Indian Valley, and American Valley. Grammars, texts, and a dictionary of the language are available (Dixon 1911, 1912; Shipley 1963, 1964).

Southwest of the Maidu, along the Feather River and its tributaries and in the adjacent Sacramento Valley, were the Konkows, who spoke a large number of dialects: Otaki, Metsupda, Nemsu, and Eskewi near Chico; Pulga, Feather Falls, Challenge, and others near Oroville and in the Feather River Canyon; and doubtless other dialects in the region around the Marysville Buttes.

Nisenan was also spoken in various dialects. Those that can be identified are: Valley Nisenan, Oregon House, Auburn, Clipper Gap, Nevada City, Colfax, and Placerville. Although no Nisenan grammar has been written there is a partial description in manuscript of the Auburn (Uldall 1940) and Clipper Gap (R. Smith 1964) dialects. A dictionary and collection of texts are available for Auburn Nisenan (Uldall and Shipley 1966).

Yokutsan Family

The Yokutsan-speaking people, some 18,000 in number (Kroeber 1925:883), occupied the San Joaquin valley from the delta to Tehachapi, including the contiguous foothills of the Sierra and the Coast Range. There were 40 to 50 small tribes in this area, each with a distinctive dialect (Kroeber 1925:474), a state of affairs unlike any other in California. Kroeber (1963) classified these dialects into 12 groups belonging to two divisions; his arrangement was based on lexical material collected for 21 of the dialects.

These facts make it very difficult to say how many Yokutsan languages there were—indeed, the very notion of language becomes blurred in such a context. Linguists have called two forms of speech two languages if they are mutually unintelligible. This is an extremely unreliable practice if only for the reason that the term "mutually unintelligible" cannot be defined. Probably any Yokutsan dialect was intelligible to the speakers of immediately neighboring dialects with only some minor adjustments; on the other hand, speakers of two widely divergent dialects were almost certainly incapable of understanding each other. Perhaps there were two Yokutsan languages (corresponding to the two divisions) or 12 (corresponding to the 12 groups). It is not possible to decide nor is it important to attempt to do so, given the circumstances.

Yokutsan is much more complex phonologically than Proto-Penutian. No only is there a series of glottalized voiceless stops as in Maiduan and Wintuan, but there is also a set of glottalized continuants: *m̓, n̓, ŋ̓, w̓, y̓,* and *l̓*. There are extra stops and spirants in the palatal area,

perhaps, as elsewhere, the result of old consonant symbolism.

Yokutsan has a very involved system of alternating verb and noun stem shapes, specifically with regard to vowel changes and vowel loss in certain grammatically definable situations. This has been described by Newman (1944, 1946) within the framework of his general description of the Yokutsan languages and has been partially restated by Kuroda (1967) and others (see references in Hockett 1973 and Pullum 1973).

There are three extensive treatments of Yokuts dialects. Yawdanchi and Yawelmani were described by Kroeber (1907). Several dialects, principally Yawelmani, were described by Newman (1944), who also did a later sketch of Yawelmani alone (1946). Of special interest is an annotated reconstitution of a grammatical sketch of the long-extinct Nopchinchi dialect, written in the early nineteenth century by Father Arroyo de la Cuesta (Beeler 1971).

Utian Family

The Utian languages fall into two clearly defined subgroups: Miwokan and Costanoan. Though there is considerable grammatical diversity among these languages, they share certain clear-cut phonological characteristics that set them off sharply from the other Penutian languages. All of them (except Lake Miwok) have but a single series of stops—a situation even simpler than that postulated for Proto-Penutian. Functional distinctions based on glottalization and aspiration are entirely absent. There is some proliferation of palatal stops and spirants as in Yokutsan. There is an underlying basic five-vowel system, though the eastern Miwok languages have a functional sixth high-mid vowel (Plains Miwok had a seventh, like Maiduan Nisenan), undoubtedly due to the innovation discussed in connection with Maiduan. Some of the Costanoan languages have a stem-morpheme structure that invariably matches Sapir's (1921-1923) formulation: CVCV(C) with the two vowels frequently identical.

There are 15 languages in Utian, seven Miwokan and eight Costanoan. Significant lexical and phonological reconstructions have been done for Miwokan (Broadbent and Callaghan 1960; Callaghan 1972), for Proto-Miwok and Mutsun (Callaghan 1962), and for Costanoan (Levy 1970a).

The Miwokan languages were spoken in a (probably) continuous belt across central California, from Marin County on the west to the southern Sierra Nevada on the southeast.

Lake Miwok territory, just to the southeast of Clear Lake, was geographically separated from the other Miwokan languages; Lake Miwok was also unique in the possession of a complex phonological system with four stop series—plain, aspirated, glottalized, and voiced—presumably borrowed either from Pomo or, more likely, from Patwin (Callaghan 1964, 1965).

Closely related to Lake Miwok, but with a regular, simple, Miwokan-type sound system, was Coast Miwok, probably with two dialects: Bodega and Marin (Callaghan 1970).

Across the Carquinez Strait the long-extinct Saclan was spoken. This language, about which very little is known, was only recently identified as Miwokan (Beeler 1955, 1959).

Farther to the east, in the valley area around Stockton, was Plains Miwok.

Still farther east, from north to south in the Sierra, were three closely related languages: Northern, Central, and Southern Sierra Miwok. The southernmost of these is the most fully described (Broadbent 1964), though some material is also available on the central language (Freeland 1951; Freeland and Broadbent 1960).

The Costanoan languages were spoken around most of San Francisco Bay and southward along the coast to Point Sur, south of Carmel. From what is known of them, they appear to have been much more like one another than were their Miwokan congeners, though a good deal of variability is found in some details of their grammars. Levy (1970a) identified and named the eight languages for which there is evidence: Karkin, Chochenyo (East Bay), Tamyen (Santa Clara), Ramaytush (San Francisco), Awaswas (Santa Cruz), Mutsun (San Juan Bautista and the Pajaro River drainage), Rumsen (Carmel and the lower Salinas River), and Chalon (Soledad, farther up the Salinas River). The classification of the Northern Costanoan languages was carried out by Beeler (1961).

Although the most important nineteenth-century word lists for Costanoan were assembled and published by Heizer (1952, 1955), none of the material collected by Harrington (1921-1938) has appeared in print. Harrington's data on Chochenyo, Mutsun, and Rumsen are extensive and phonetically accurate.

Relations outside California

Within two years of the full-scale display of the evidence for California Penutian (Dixon and Kroeber 1919), Sapir (1921b) proposed a much-expanded inventory of Penutian languages. In its later "classical" form (Sapir 1929), this expansion became the Penutian superstock, an amalgam containing many Oregon languages, Tsimshian on the British Columbia coast, and Mixe-Zoque and Huave in southern Mexico. Although Sapir's proposal was couched in conservative and tentative terms, his Penutian theory has dominated the thoughts and researches of interested scholars ever since, in spite of the fact that no conclusive or definitive evidence for most of the proposed linguistic relationships outside California has ever been brought forward. This is not to say that the Penutian hypothesis of Sapir is wrong; careful research will prob-

ably eventually bear it out in the main. The point is that it is a hypothesis.

Various other candidates have been proposed for membership in the Penutian stock over the years. The two that remain viable are Mayan (F. Johnson 1940; J.A. Mason 1940; Swadesh 1956) and Zuni (Swadesh 1956; Newman 1964).

In this connection Klamath-Modoc deserves special mention. Some of the speakers of Klamath-Modoc lived in what is now northern California. Strong lexical evidence has been adduced to show that Klamath-Modoc is related to Nez Perce and other Sahaptian languages of northern Oregon, Idaho, and southern Washington (Aoki 1963). It has also been shown with reasonable certainty, again on the basis of lexical evidence, that Klamath-Modoc is genetically related to the California Penutian languages (Shipley 1966). Thus, it seems safe to infer that the Sahaptian languages are also Penutian.

Hokan Stock

The Hokan stock was identified and named by Dixon and Kroeber (1913); however, the classical characterization of the stock was made by Sapir (1917). The word Hokan is based, as is Penutian, on the word for 'two', presumably from Atsugewi *hoqi.*

Cross-family studies within Hokan have been made for Northern Hokan (Bright 1954), Eastern Pomo and Yana (McLendon 1964), Palaihnihan and Shasta (Olmsted 1956–1959), Shasta and Karok (Silver 1964), and Washo and Karok (Jacobsen 1958). Haas (1964), though ostensibly concerned with Yana-Karok cognates, presents a large amount of data on the other Hokan languages as well as on other California languages outside the Hokan stock as it is presently defined.

A comparison of the Hokan situation with the Penutian one brings to light a dramatic contrast. The interrelationships of the Hokan languages lie much deeper in time, a fact paralleled by their geographical discontinuity. They are dispersed like a broken chain around the margins of the compact California Penutian heartland.

Langdon (1974:87) has outlined the consensus as to the probable nature of the Hokan protolanguage:

> Proto-Hokan probably had a rather simple sound system, with very little trace of the more marked categories exhibited by many of the attested languages. Contrasts involving plain *versus* aspirated and perhaps even glottalized consonants may well turn out to be accountable as independent developments; voiceless sonorants are already accounted for as innovations in Pomo and Yuman, and Washo. Vowels may not have been more than three with a probable length contrast—Proto Yuman has such a system. In the few available good cognate sets, the persisting elements appear to be essentially conservative. The great diversity of the daughter languages, it seems, must be accounted for by repeated processes of loss of vowels leading to subsequent loss and change of consonants (particularly in the laryngeal area), with resulting lexical items where little remains that is truly comparable. Typical Hokan morphemes must have been short (monosyllabic).

Many of the morphemes found in the attested Hokan languages would seem to be the result of what Silver (1975) has called "morphemization," that is, a historical process whereby old compounds blend into single morphemes with the passing of time. English has a few morphemes of this type: boatswain, knowledge, blackguard, forecastle. Only the archaic spelling reveals the fact that these words were not always single morphemes. Haas (1954, 1963) has marshaled evidence for a general shortening of various words in the modern Hokan languages by comparison with longer ancient forms that themselves may have been strings of two or more morphemes. Even more provocative is her postulation of possible lexical intersections between Hokan and Penutian, specifically with the terms for 'ear' and 'navel' (Haas 1964).

The California Hokan languages and language families are: Karok, Shastan, Chimariko, Palaihnihan, Yana, Pomoan, Esselen, Salinan, Chumashan, and Yuman. Sapir (1925) placed Karok, Shastan, Chimariko, Palaihnihan, Yana, and Pomoan in a separate Northern Hokan subgroup. Subsequent investigations have not validated this subgrouping on the basis of the linguistic evidence.

Karok Language

The Karok language *(káruk* 'a considerable way upriver') was described by Bright (1957). The speakers of Karok, estimated at between 1,500 and 2,000 in aboriginal times, lived along a stretch of the Klamath River in northwestern California. The language is not closely or obviously related to any other; its presumed Hokan affiliations are distant. There was no known dialect differentiation.

Shastan Family

Shastan, a family of four languages, originally had some 2,500 speakers. The languages were: Shasta, New River Shasta, Okwanuchu, and Konomihu. Shasta proper was spoken in at least four dialects: Oregon Shasta, extending up to the Rogue River in southern Oregon, Scott Valley Shasta, Shasta Valley Shasta, and Klamath River Shasta. The dialect situation with the other Shastan languages is not known; they occupied small territories to the south and are all extinct. Shasta has been described by Silver (1966).

Chimariko Language

Chimariko was spoken by only a few hundred people along a 20-mile stretch of the Trinity River, just south of the New River Shasta. Although the language has long been extinct, there is some published material in Dixon (1910a) as well as various manuscript resources including

an extensive collection of linguistic data by Harrington (1921-1928).

Palaihnihan Family

Southeast of the Shasta in northeastern California were the speakers of Palaihnihan (from a Klamath word for the Achumawi). There were two languages in the family: Achumawi, spoken in several closely related dialects by the nine bands along the Pit River, and Atsugewi or Hat Creek, with two dialects, Atsuge (also called Hat Creek) and Apwaruge (Dixie Valley). These two languages were very distantly related, though they were apparently closer to each other than to any other Hokan language (Olmsted 1964). There were probably about 3,000 speakers in aboriginal times, the majority being Achumawi. There are descriptive materials available on both Achumawi (Angulo 1926a; Angulo and Freeland 1931; Olmsted 1966; Uldall 1935) and Atsugewi (Garth 1944; Kroeber 1958a; Olmsted 1958, 1961; Talmy 1972, 1975).

Yana Family

East of the Wintu and west of the Atsugewi and the Maidu were the Yana (*yaana* 'person') numbering altogether some 1,500 speakers. There were two languages, Yana with three dialects (Northern, Central, and Southern) and a separate language, Yahi (*yaaxi* 'person') (Sapir and Swadesh 1960). Yana has long been extinct; the famous Ishi was the last speaker of Yahi (T. Kroeber 1961). Although no full-scale grammar of Yana has been written, there is considerable descriptive material (Sapir 1909, 1910, 1918, 1922, 1923, 1929a; Sapir and Swadesh 1960; Nevin 1975).

Pomoan Family

There were seven languages in the Pomoan family (*pomo* 'person, people'), with a total of some 8,000 aboriginal speakers. The Pomoans lived between the Sacramento Valley and the ocean, largely in what is now Sonoma County. Since there were no aboriginal names for the languages, they have been given directional designations: Northeastern, Eastern, Southeastern, Northern, Central, Southern, and Southwestern. Southwestern Pomo has come to be called Kashaya, a name that is probably derived from a stem meaning 'agile, nimble' (Oswalt 1961, 1964).

The Pomoan languages are phonologically among the most complex of the Hokan stock. A great deal of comparative work has been done on the relationships among them. Among early classifications are those of Barrett (1908) and Kroeber (1925). Halpern (1964) improved the grouping on the basis of a survey made in 1939-1940; Oswalt (1964a) made a careful count of shared cognates and proposed some revisions (see "Pomo: Introduction," fig. 1, this vol.). By far the most imposing document on Proto-Pomo is McLendon's (1973) monograph in which she carried out an extensive phonological and lexical reconstruction. Note must be taken of Oswalt's (1964b) binary comparison of Kashaya and Central Pomo as a forerunner of McLendon's work.

There are descriptive materials, some of them extensive, on four of the languages: Eastern (Angulo 1927; Kroeber 1911; McLendon 1975, 1969), Southeastern (Moshinsky 1975), Kashaya (Oswalt 1958, 1961, 1964; Worth 1960), and Northern (Vihman 1975).

Esselen Language

Esselen is very little known. The language was spoken by a few hundred people on the upper reaches of the Carmel River and on the coast around Big Sur. It was classified as Hokan on the basis of a few lexical resemblances. Only word lists are available (Heizer 1952; Kroeber 1904a).

Salinan Language

The Salinan language was spoken by some 2,000 persons in at least two dialects: Migueleño and Antoniaño, named for the two Spanish missions that were established in their territory. There may have been a third dialect along the coast, which Kroeber (1925:546) refers to as Playano; of this form of Salinan speech there are no records whatever. The language is extinct. Aside from some word lists (Heizer 1952), there are two descriptive documents (Kroeber 1904a; J.A. Mason 1918). The Salinans occupied the middle and upper Salinas Valley and the Coast Ranges to the west almost as far south as the town of San Luis Obispo.

Chumashan Family

According to Beeler (1975), the Chumashan family consisted of at least six languages, which may be subgrouped into three dialect areas: a central group consisting of the languages once used around the missions at Ventura (including Emigdiano), Santa Barbara (including Castac, formerly thought to be Uto-Aztecan but shown by Beeler (1972; Beeler and Klar 1974) to have been Barbareño as spoken by certain Indians displaced in mission times), Santa Ynez, and La Purísima; the speech on the islands of San Miguel, Santa Rosa, and Santa Cruz; and the language of San Luis Obispo. These languages are all extinct. There were possibly 10,000 speakers of Chumashan in aboriginal times. In addition to nineteenth-century word lists assembled by Heizer (1952, 1955), further descriptive information is available (Beeler 1975; Applegate 1975; Harrington 1974).

Yuman Family

The Yuman family of languages is the most peripheral geographically. Most of the Yuman languages are or were spoken outside California, in Arizona and Baja California. Although the relationship among these languages is clear and has been extensively studied by many

workers, an authoritative classification has not yet been determined. Two classifications are to be noted: that of Kroeber (1943) and the much later one of Joel (1964). The latter study is based on a much larger and more accurate body of data than the former. The only Yuman language in the California culture was Diegueño (Langdon 1970), of which there are at least three dialects, all still spoken, Ipai ('Iipay), Kumeyaay, and Tipai (Tiipay).

Relations outside California

Early versions of the Hokan hypothesis (Kroeber 1915; Sapir 1917) proposed the inclusion of groups partly or entirely outside the California area: Washo, in the Great Basin; Yuman; Seri, in Sonora; and Chontal (Tequistlatec), in southern Oaxaca. Then the languages of northeastern Mexico and southern Texas that Swanton (1915) had classed together as Coahuiltecan were added to the Hokan roster (Sapir 1920). Sapir's (1921b, 1929:140–141) even more inclusive Hokan-Siouan superstock has been abandoned, and other, even more incredible, proposals, including the postulation of Hokan congeners in South America, have largely been considered unsubstantiated. Even Hokan-Coahuiltecan remains far from being established as a genetic reality.

Yukian Family

The small, isolated Yukian family of languages had four members: Yuki, Coast Yuki, and Huchnom in Mendocino County and Wappo, a considerable distance to the south in Lake and Napa counties. The three northern languages were very similar; indeed, they may have been little more than dialects of a single language. In 1975 there was one known surviving speaker of the northern group, which may have had about 2,000 speakers aboriginally. Wappo (from Spanish *guapo* 'handsome') is very different in grammar and lexicon from the northern languages. Either the genetic connection is a remote one or it may be that Wappo is not a Yukian language at all but owes what Yuki-like features it has to the effects of ancient contact and diffusion. There were some 1,000 Wappos originally, with four dialects, one of which was spoken by a small group on the southern end of Clear Lake, geographically separated from the other Wappos. Descriptive material is available on Yuki (Kroeber 1911), Wappo (Radin 1929; Sawyer 1965), and on Yukian generally (Barrett 1908).

Various proposals have been made suggesting links between Yukian and other language groups: Penutian (Radin 1919; Shipley 1957), Hokan (Sapir 1921b, 1929; Swadesh 1954; Gursky 1965), Siouan (Sapir 1921b, 1929; Elmendorf 1963), and Yuchi (Sapir 1921b, 1929; Elmendorf 1964). Of all these, Elmendorf's evidence for a distant Yukian-Siouan-Yuchi affiliation seems the most credible.

Peripheral Stocks

All the other languages that were spoken in aboriginal California have been clearly identified as belonging to larger linguistic stocks with most of their member languages in other parts of North America. These exterior stocks are Algic, Na-Dene, and Uto-Aztecan.

Algic

Algic is represented by two languages, Wiyot and Yurok, both of which were spoken in Northwestern California. These two languages are very distantly (though certainly) related to each other; they are about equally distantly related to the Algonquian languages in the eastern and central parts of the continent (Teeter 1964a; Haas 1966; Hamp 1970). Thus Algonquian, Yurok, and Wiyot are the three equally remote members of a very old family of languages that has been called Algonquian-Wiyot-Yurok, Algon-Ritwan (Haas 1967), or simply Algic (I. Goddard 1963; Teeter 1965:225).

Wiyot was spoken by no more than 1,000 people who lived around Humboldt Bay and the mouth of the Eel River and in the immediate hinterland. The language was described by Kroeber (1911:384–431), by Reichard (1925), and by Teeter (1964a). The language is now extinct.

Yurok was spoken on the coast to the north of the Wiyot by a much larger group, perhaps 2,500 persons, around the mouth of the Klamath River, with territory extending upriver as far as the confluence of the Klamath and the Trinity, some 30 miles. The name Yurok is from the Karok word *yúruk* 'a considerable distance down the river'. There is a brief grammatical description by Kroeber (1911:414–426) and a much fuller one by Robins (1958).

Na-Dene

The Na-Dene languages of California all belong to the Athapaskan family, which contains most of the languages in the Na-Dene stock. The four California Athapaskan languages were Tolowa, Hupa-Chilula-Whilkut, Mattole, and Wailaki-Nongatl-Lassik-Sinkyone-Cahto (Hoijer 1960).

Tolowa (from Yurok *tolowel*) was spoken by perhaps 1,000 people in the extreme northwestern corner of California, with some territory in Oregon. No descriptive material is available on Tolowa except for a study of the phonology (J.O. Bright 1964).

The other Athapaskan languages, separated from Tolowa by Yurok territory, were spoken over a continuous area from Hupa in the north to Cahto in the south, the latter being just to the north of Yukian. There were three languages involved; two of these had varying dialects associated with distinctive political groups.

There may have been some 2,000 speakers of Hupa-Chilula-Whilkut. The Hupa dialect was described by Goddard (1905) and by Golla (1964, 1970; "Sketch of Hupa, an Athapaskan Language," vol. 17). The Chilula and the Whilkut have long been extinct.

Mattole, spoken by a few hundred people on the coast south of the Wiyot, is also extinct. There is a description by Li (1930). The Bear River dialect differed slightly.

There are no remaining speakers of any of the dialects of the third language. There were an estimated 1,000 speakers of the Nongatl-Lassik-Sinkyone group, perhaps 1,000 speakers of Wailaki, and no more than 500 speakers of Cahto. There are a grammar of Cahto (Goddard 1912) and a collection of Wailaki texts (Goddard 1921-1923).

Uto-Aztecan

The third exterior stock, Uto-Aztecan, is represented in the California culture area by a number of languages, mainly in the south. These are grouped into three branches: Takic, Tubatulabal, and Numic. The first two branches are entirely within California, while Numic is an extensive family spreading over most of the Great Basin and even including Comanche on the southern Plains (Lamb 1964; Langacker 1970; Seiler 1965, 1967).

There were six Takic languages, two along the coast—Gabrielino-Fernandeño in Los Angeles County and Luiseño-Juaneño to the south—and four in the interior desert—Serrano, Kitanemuk, Cahuilla, and Cupeño. In addition, there was a language spoken on San Nicolas Island (Kroeber 1907b:153) and the Tataviam language of the upper Santa Clara valley, which are so poorly known as to be impossible to classify.

Virtually nothing is known of the Gabrielino-Fernandeño language. There may have been as many as 5,000 speakers, with several dialects, in the San Fernando Valley and the great Los Angeles basin to the south as well as on Catalina Island. The names come from the missions of San Gabriel and San Fernando.

Luiseño-Juaneño, also with some 5,000 speakers in precontact times, has been studied by several workers. Descriptive materials (Kroeber and Grace 1960; Malécot 1963-1964), and a dictionary (Bright 1968) are available. A teaching grammar of Luiseño by Hyde (1971) has also been written. The names are from the missions of San Luis Rey and San Juan Capistrano.

The largest of the inland language groups was Serran (K.C. Hill 1967; Bright 1975) with more than 3,000 speakers including the Serrano and Kitanemuk languages, plus the Vanyume, who undoubtedly spoke at least a distinctive dialect. The language name Serrano has often been applied to the entire Serran group.

Between the Serrano and the Ipai-Tipai were the Cahuilla with more than 2,000 speakers. There were three dialects: Desert, Mountain, and Pass (Seiler 1970). Some information on the phonology (Seiler 1957; Bright 1965) is available, as well as a small amount of grammatical material (Seiler 1958).

The Cupeño lived inland from the Luiseño and north of the Kumeyaay. They were among the smallest distinct groups in California with about 500 people living in two villages, *kúpa,* from which they get their name, and *wilákalpa.* There is a grammar of the language (Hill and Nolasquez 1973) and a historical study (Bright and Hill 1967).

Tubatulabal is classified as an isolated language within Uto-Aztecan. There were possibly some 1,000 speakers, living in the upper Kern River valley at the southern end of the Sierra Nevada. A description of the language (C.F. Voegelin 1935, 1935a) and a short dictionary (C.F. Voegelin 1958) have been published. The distinctiveness of Tubatulabal speech points to its being an older idiom in California than the other Uto-Aztecan languages. The term Tubatulabal is from one of the Numic languages, meaning 'pine-nut eaters'.

The Numic languages were spoken over a vast fan-shaped area of the intermountain west. The name for this family is adapted from *nimi, nïimmi, niwi,* the words for 'person' in the various languages (Lamb 1958). Only one of these languages was spoken within the California culture area: Mono, of which there were two main groups, speaking several dialects. The Eastern Mono along the eastern side of the Sierra Nevada, notably in the Owens Valley, were culturally in the Great Basin, while the Western Mono or Monache on the western side of the Sierra crest were in the California culture area. All together, there may have been as many as 4,000 speakers, with the larger number in the eastern group. There is a description of Monache by Lamb (1958a).

Summary

The following classification is somewhat informally arranged in that different orderings and subgroupings are used in explicating different language families. The real situation, even as postulated, was more complex than any systematic presentation can characterize without distortion and simplism. The details as given here are based on the most reliable sources available; nevertheless, there are unavoidable shortcomings. The dialect listings are highly variable in reliability. In many cases the omission of dialect information is simply the result of ignorance; in other cases, such as Chimariko and Esselen, there probably really was no dialect differentiation. The designation of languages is probably more reliable, though there are problems. Most important, the various classifications themselves are subject to revision or rejection as future research may dictate. Only those portions of a family or stock that were spoken in the California culture area (fig. 1) are included in this outline.

1. Penutian Stock.
  Wintuan family.
    Wintu language. Dialects: McCloud River, Trinity County, Shasta County, Upper Sacramento, Bald Hill, Hayfork, Keswick, Stillwater, French Gulch.
    Nomlaki language. Dialects: Hill, Valley.
    Patwin language. Dialects: Hill, River, Cache Creek, Lake, Tebti, Dahcinci, Napa, Suisun.
  Maiduan family.
    Maidu language. Dialects: Susanville, Big Meadows, Indian Valley, American Valley.
    Konkow language. Dialects: Otaki, Metsupda, Nemsu, Eskewi, Pulga, Cherokee, Feather Falls, Challenge, Bidwell Bar.
    Nisenan language. Dialects: Valley, Oregon House, Auburn, Clipper Gap, Nevada City, Colfax, Placerville.
  Yokutsan family (Kroeber 1963:237).
    Foothill division.
      Buena Vista group: Tulamni, Hometwoli, Chuxoxi.
      Poso Creek group: Palewyami, Kumachisi.
      Tule-Kaweah group: Yawdanchi, Wikchamni, Gawia, Bokninwad, Yokod.
      Kings River group: Chukaymina, Ayticha, Choynimni, Entimbich(?) Toyhicha.
      Intermediate between Northern Valley Group D and Kings River Foothill group; living in hills: Gashowu.
    Valley division.
      Northern Valley groups.
        Group A, far north on lowest San Joaquin: Chulamni, Lakisamni.
        Group B, on San Joaquin below Fresno River: Chawchila, Hewchi, Nopchinchi.
        Group C, on upstream plains along San Joaquin: Pitkachi, Wakichi, Hoyima.
        Group D, actually living in San Joaquin foothills: Chukchansi, Kechayi, Dumna, Dalinchi, Toltichi (?).
      Southern Valley groups.
        Group A, on Kings River and Tulare Lake: Wechihit, Nutúnutu, Chunut, Wowol, Apyachi, Tachi.
        Group B, on lower Kaweah to Kern rivers: Wo'lasi, Choynok, Yawelmani, Wimilchi, Telamni, Koyeti.
  Utian family.
    Miwokan subfamily.
      Western division.
        Lake Miwok language.
        Coast Miwok language. Dialects: Bodega, Marin.
      Eastern division.
        Saclan language.
        Plains Miwok language.
        Sierra Miwok group.
          Northern Sierra Miwok language.
          Central Sierra Miwok language. Dialects: West Central, East Central.
          Southern Sierra Miwok language. Dialects: Merced-Yosemite, Mariposa-Chowchilla.
    Costanoan subfamily.
      Northern division.
        Karkin language (a separate division according to Beeler 1961).
        Chochenyo language.
        Tamyen language.
        Ramaytush language.
        Awaswas language.
        Chalon language.
      Southern division.
        Mutsun language.
        Rumsen language.
2. Hokan Stock.
  Karok language.
  Shastan family.
    Shasta language. Dialects: Oregon, Scott Valley, Shasta Valley, Klamath River.
    New River Shasta language.
    Okwanuchu language.
    Konomihu language.
  Chimariko language.
  Palaihnihan family.
    Achumawi language. Dialects: Hammawi, Qosalektawi, Hewisedawi, Astariwawi, Atwamsini, Ajumawi, Ilmawi, Itsatawi, Madesiwi.
    Atsugewi language. Dialects: Atsuge, Apwaruge.
  Yana family.
    Yana language. Dialects: Northern, Central, Southern.
    Yahi language.
  Pomoan family.
    Northeastern Pomo language.
    Eastern Pomo language.
    Southeastern Pomo language.
    Western branch.
      Northern Pomo language.
      Southern group.
        Central Pomo language.

Southern Pomo language.
Kashaya language.
Esselen language.
Salinan language. Dialects: Migueleño, Antoniaño.
Chumashan family.
Central group.
Ventureño-Emigdiano language.
Barbareño language.
Ynezeño language.
Purisimeño language.
Island Chumash language.
Obispeño language.
Yuman family.
Diegueño language. Dialects: Ipai (Northern), Kumeyaay (Southern), Tipai (Mexican).
3. Yukian family.
Yuki language. Dialects: Yuki proper, Coast Yuki, Huchnom.
Wappo language. Dialects: Clear Lake, Western, Northern, Central, Southern.
4. Algic Stock.
Wiyot language.
Yurok language.
5. Na-Dene Stock.
Athapaskan family.
Tolowa language.
Hupa language. Dialects: Hupa, Chilula, Whilkut.
Mattole language. Dialects: Mattole, Bear River.
Wailaki language. Dialects: Nongatl, Lassik, Sinkyone, Wailaki, Cahto.
6. Uto-Aztecan Stock.
Takic family.
Cupan group.
Gabrielino-Fernandeño language. Dialects: Gabrielino, Fernandeño, and others.
Luiseño-Juaneño language. Dialects: Luiseño, Juaneño.
Cahuilla language. Dialects: Desert, Mountain, Pass.
Cupeño language.
Serran group.
Serrano language. Dialects: Serrano, Vanyume.
Kitanemuk language.
Tubatulabal language.
Numic family.
Western group.
Mono (Monache).