ASSESSMENT OF SUBSURFACE CONTAMINANTS

MARKETPLACE PROPERTY

Emeryville, California

Prepared for

Equity Financial and Management Company
10 South LaSalle Street, Suite 690
Chicago, Illinois 60603

May 1982

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May 1, 1982 FINAL REPORT

Project: 15093A

Equity Financial and Management Company
10 South LaSalle Street, Suite 690
Chicago, Illinois 60603

Attention: Mr. Sanford Shkolnik

Gentlemen:

ASSESSMENT OF SUBSURFACE CONTAMINANTS
MARKETPLACE PROPERTY
Emeryville, California

The enclosed report presents results of a study to assess subsurface contaminants at the Marketplace property located in Emeryville, California. This report and the study described herein were done for Equity Financial and Management Company by Woodward-Clyde Consultants in accordance with our Agreement for Consulting Services of July 22, 1981. This final report supercedes previous draft versions.

The purposes of this study are to investigate whether hazardous waste materials are present in soils or groundwater below the Marketplace property, and to develop sufficient information and documentation to permit the California Department of Health Services (DOHS) and the California Regional Water Quality Control Board (RWQCB) to provide their opinions concerning whether substantial subsurface contaminants exist which should be regarded as hazardous considering present use and possible future development of the property. The main motivation for this study is concern expressed by City of Emeryville officials because hazardous contaminants have been found at other sites located close to the Marketplace property.

This study was performed in close coordination and cooperation with DOHS and RWQCB, beginning with development of the assessment plan and continuing through reviews of two draft versions of this report. This final report addresses comments received from DOHS in its December 8, 1981 and December 29, 1981 letters to you, and comments received from RWQCB in its January 15, 1982 letter to you, based upon their reviews of the draft reports.

Our overall conclusion is that the soils of the site do not appear to contain contaminants including purgeable organics, organochlorinated pesticides or polychlorinated biphenyls at concentrations which would be categorized as hazardous, but that the soils do contain several heavy metals at concentrations exceeding the Total Threshold Limit Concentration which California uses to define a hazardous waste. However, fill soils which contain these metals are presently sealed from the surface environment, and presence of these metals should not unduly restrict future development on the property, provided that appropriate care and precautionary measures are observed during planning and subsurface exploration for, and during construction of any such future developments.

Similarly, chemical analysis results for groundwater samples show that groundwater below the site does not contain contaminants including heavy metals or purgeable organics at concentrations in excess of applicable drinking water and fish toxicity standards. Metals detected in fill at the site appear to be firmly adsorbed by the fill soils, and because the site surface is sealed with pavement and structures, the potential for infiltration of surface water is very low. It is judged that the potential for significant leaching of metal contaminants to groundwater at the site or to San Francisco Bay is, therefore, very low.

Both DOHS and RWQCB have expressed concurrence regarding the elements, performance and overall conclusions of this study, and these agencies are preparing letters to you providing their evaluations and any criteria which they may deem necessary regarding future development at the site.

It is a pleasure to be of service to Equity Financial and Management Company on this project. We would appreciate the opportunity to be of further geotechnical/environmental engineering service to you if future development of the Marketplace property is planned.

Sincerely yours,

Lawrence R. Houps

Lawrence R. Houps
Project Manager

Richard Woodward

Richard J. Woodward, III
Vice President

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Enclosure

cc: Mr. Lowell Miller, DOHS
Mr. Robert Samaniego, RWQCB
Mr. John Anderson, Emeryville Redevelopment Agency

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ASSESSMENT OF SUBSURFACE CONTAMINANTS

MARKETPLACE PROPERTY

Emeryville, California

This report presents results of a subsurface contaminant assessment study performed for the Marketplace property, located in Emeryville, California. Included herein are descriptions and results of the field and laboratory investigations conducted during this study, together with evaluations of results and assessments regarding subsurface contaminants at the site. This assessment was performed for Equity Financial and Management Company of Chicago, Illinois, by Woodward-Clyde Consultants of San Francisco, California under terms of an agreement between these firms.

PURPOSE OF STUDY

The Marketplace is a development of restaurants, shops and offices housed in buildings previously used for other purposes. The Marketplace site is located in an area of Emeryville which has been heavily industrialized since about 1900. Recent investigations of nearby sites, conducted by regulatory agencies and private consultants, have shown that past industrial practices of material handling, storage and waste disposal in this area have, in some instances, resulted in contamination of soil and groundwater.

Contaminant assessment studies which are of particular concern to the Marketplace site are currently being conducted at two sites located just east of the Marketplace site. These studies have documented the presence of polychlorinated biphenyls (PCB) in soils at concentrations which may be categorized as hazardous at locations about 200 to 300 feet east of the Marketplace propertyline on Westinghouse Corporation and ITT Grinnell Corporation properties. Other recent studies have documented the presence of heavy metal contaminants at sites in the vicinity of the Marketplace.

These contaminant assessment studies for nearby sites do not indicate that similar contaminants exist at the Marketplace. However, considering the proximity of some of these sites to the Marketplace, and also considering that the Marketplace property was occupied by heavy industry during the period from about 1900 until the mid-1960's, concerns have been expressed by City and State officials regarding the possibility that similar contaminants may exist at the Marketplace.

The purposes of this contaminant assessment study are to investigate whether potentially hazardous waste materials may exist at the Marketplace property and to develop sufficient information and documentation to permit the California Department of Health Services (DOHS) and the California Regional Water Quality Control Board (RWQCB) to provide their opinions concerning whether there are substantial subsurface contaminants which should be regarded as hazardous considering the present use and possible future development of the property. This study has been made in close coordination and cooperation with and full disclosure to representatives of DOHS and RWQCB. This coordination began with development of the assessment plan and continued through review of this report.

METHOD OF STUDY

The method of study is summarized in this section. Details of study methods and results are presented subsequently in this report and the enclosed appendices.

- <u>Site Reconnaissance</u>: The Marketplace property was inspected in detail for signs of surface contamination or of surface conditions which may suggest an increased likelihood of contamination.

- <u>Literature Review</u>: Pertinent sources of information were researched to investigate the historical development of the Marketplace property. Particular attention was directed towards information regarding the history of land-filling at the site, and of the previous industries at the site and the types of waste materials which might be associated with these industries. Sources of information included file data of DOHS, City of Emeryville (COE) and Woodward-Clyde Consultants (WCC); historical U.S. Coast and Geodetic Survey and U.S. Army Corps of Engineers topographic maps and charts covering the period from 1856 to 1947; aerial photographs covering the period 1947 to 1975; site plans and building-layout plans for the previous industries at the site; interviews with former employees of the previous industries at the site and with present and former officials of COE; and a review of design grading plans for the site in its present condition, including an interview with the contractor who performed the site grading.

- Field Investigation: Exploratory soil borings were drilled at 15 locations on the site to investigate the subsurface fill, native soil and groundwater conditions at the site, and to provide soil samples for use in laboratory chemical analysis testing. Groundwater monitoring wells were installed at 4 selected boring locations to provide groundwater table data and to permit monitoring and sampling of the site groundwater for laboratory chemical analysis testing.

- Laboratory Testing: Laboratory chemical analyses were performed on 24 subsurface soil samples and on 2 surface samples to provide data on types and concentrations of contaminants in soils at the site. Samples of groundwater from the 4 monitoring wells were also obtained and analyzed.

- Information Assessment: The information resulting from the study was evaluated, and assessments have been made regarding presence, concentrations and significance of contaminants in soils and groundwater at the site.

SITE DESCRIPTION

The location and configuration of the Marketplace property are shown in Figure 1. The site has plan dimensions of about 450 feet by 1400 feet, and an area of about 13.6 acres. The site is bounded on the south side by the elevated segment of Powell Street and the Shellmound Street curve; on the north side by the Nielsen Freight Lines property; on the west side by several industrial-commercial and office buildings; and on the east side by a 100-foot wide Southern Pacific Railroad

(SPRR) line corridor. The Westinghouse Electric Corporation and ITT Grinnell Corporation properties are located adjacent to the east side of this railroad corridor, as indicated in Figure 1.

Existing structures at the site are shown in Figure 1. These include the two main Marketplace commercial and restaurant buildings located at the northwest-central area of the site; a small wooden office building located at the south end of the site adjacent to Shellmound Street; and an abandoned 19-foot high concrete tank structure located at the southeast corner of the site. Most of the remainder of the site is paved with asphalt concrete. These structures were built as part of the previous industries at the site. The two main Marketplace buildings were constructed in stages during the period from 1917 to 1936; these buildings were renovated as part of the present Marketplace development which occurred during the period from 1968 to 1975. The construction dates of the small wooden office building and the concrete tank structure were not determined. However, based on review of available aerial photographs, it appears that the wooden building is either a renovated portion of a larger building which was constructed prior to 1947 or a new building constructed in 1974-1975 at the same location as the previous building. The concrete tank was apparently constructed sometime during the period from 1953 to 1959. The only other readily observable remnant of the previous industries at the site is a railroad spur-line located at the south end of the site, as shown in Figure 1.

A "Grading and Drainage" plan is on file with COE for the present Marketplace Development ("Emeryville Market", Sheet 1B, George S. Nolte and Associates, October, 1973, Rev. 11/20/73). The degree of conformance between this plan and the as-constructed site grading, is not known. However, the plan indicates that it was intended to grade the existing parking lot with a high, or "crown" axis, through the approximate north-south trending centerline of the parking lot, such that drainage would be directed to storm drains along the east and west sides of the site. Based on this plan, site grades would range from about Elevation* 11 to 12 feet at the north end of the parking lot to about Elevation 8 feet at the south end.

Subsequent to completion of the Marketplace parking lot construction in 1975, a number of localized, apparently "upwelled" areas or "bulges" have appeared in the parking lot pavement. Approximate locations of the most prominant of these pavement bulges are shown in Figure 1. In addition, a black tarry substance is present at the pavement surface at some locations and it appears that this substance has exuded through the pavement. Locations of the largest of these tar areas are also shown in Figure 1. This tarry substance does not occur at locations of observed pavement bulges, and the two features do not appear to be directly associated with each other.

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*All elevations given in this report refer to the recently-adopted COE Datum, which corresponds approximately to a level at about -0.4 feet Mean Sea Level at the Berkeley Tide Station. Elevations shown in the cited grading plan are based on the former COE Datum, which corresponds approximately to a level near Mean Higher High Water.

ON-SITE AND OFF-SITE FEATURES OF CONCERN

The current business activities at the site are judged not to be the kind that generate hazardous waste. The probable sources of hazardous waste, therefore, would be materials on-site prior to completion of paving in 1975 and off-site materials transported to the site. In order to judge locations where samples for chemical analysis should be obtained, features of concern were identified.

On-site features of concern include the previously described pavement bulges and the exuded tarry substance together with features that a site history study of the previous industrial use would reveal. An example of a feature of concern revealed by the site history study is a large area near the northeast corner of the site which appears darkened in site aerial photographs taken through 1959, but prior to 1969. Other on-site features of concern include the abandoned concrete tank structure located at the southeast corner of the site, and the possible presence of buried subsurface industrial storage tanks, as discussed later in this report.

The prime off-site feature of concern is the documented presence of PCB contaminated soils on the Westinghouse and ITT Grinnell properties immediately east of the SPRR corridor that forms the east site boundary. There are four main possible mechanisms which could transport these contaminants to the site: activities of man, wind currents, surface water runoff, and groundwater. Nothing was revealed by observational data or site history study that suggests manual transport. The probability of significant airborne transport is very low because of the tendency of PCB to adsorb to soils, oils and greases. Surface grading and swales on the

SPRR corridor significantly limit the probability of surface water transport of contaminants onto the site. Groundwater flow is a possible transport mechanism. Groundwater flow apparently occurs in a southwesterly direction from these properties and towards the Marketplace site.

There are three areas between contaminated soil on the Westinghouse property and the site which deserve attention. One of these is the low, wet and marshy area ("cattail area" in Figure 1) on Westinghouse property; the second is a concrete-walled catchment basin area which encloses several tanks on the Westinghouse property; and the third is a small wooden "culvert-type" structure which passes beneath the intervening railroad tracks, possibly from Westinghouse property, opening at the drainage swale on the west side of the tracks, and which has an appearance suggestive of an abandoned outfall structure (see Figure 1). Boring and sampling locations were selected taking into account these features of concern.

SITE HISTORY

Historical Bay Shoreline

The site is located in an area of Emeryville which was formerly a tideland and marshland bordering San Francisco Bay. Figure 2 is a geologic-topographic map showing the historical (1856) bay shoreline and the Marketplace site. This, and similar maps, show that the historical "ordinary" high water shoreline crossed the west-central area of the Marketplace property, approximately as shown in Figure 1. The area to the west of this line was a tidal flat, while the area to the east of this line, and extending to about the location of Peladeau Street, was marshland which was occasionally inundated during periods of extremely high tide. The oval shaped area shown near the center of the Marketplace property in Figure 1 was apparently a low area which may have been inundated most of the time.

Site Filling and Previous Industries

The history of landfilling at the Marketplace site and in the area west of the Marketplace is closely tied to the development and activities of the Paraffine Company (1884-1920), Pabco (1920-1957) and Fireboard Corporation (1957-1968) at the site. A chronology of developmental events of significance to the Marketplace property is contained in the enclosed Appendix C, and a summary of these industries and of landfilling at the site is provided in this section.

The Emeryville area was open, undeveloped land in the mid-1800's. By about 1900 to 1910, the entire Emeryville area east of the SPRR had been essentially fully developed with streets and structures. Much of this development occurred as residents and businesses relocated from San Francisco to the East Bay following the San Francisco earthquake of 1906. Historical maps and charts show little, if any, observable changes in the location of the Bay shoreline in the vicinity of the Marketplace property during this period, and it appears that landfilling during this period was confined to the on-shore marshland area east of the historical bay shoreline shown in Figures 1 and 2.

Development at the Marketplace property began in about 1884 when the Paraffin Company was formed by several chemists and opened for business in a small office located at the extreme northeast corner of the site. Little information is readily available concerning the early operations of the Paraffin Company during the period from 1884 to about 1900. However, it appears that these early operations may have been directed primarily towards research and development of bituminous and petroleum based products, and possibly some small-scale asphalt and kerosene refining, with only limited product manufacturing, if any. Also, it appears that only limited landfilling, if any, would have been done at the site during this period.

However, beginning in about 1902, the Paraffin Company began preparations for manufacture of roofing felt, roofing paper, roofing shingles and refined asphalt for use in lineoleum and asphalt-based paints. Several small buildings were constructed at the northeast corner of the site during the period 1902-1905, and several larger buildings were constructed in this northeast area and in the on-shore, east-central and southeast areas of the site during the period 1906-1908. By about 1910, therefore, it appears that manufacturing of at least some of the products named above was being done at the site. Considering the widespread locations across the site of the structures which had been constructed by 1910, it appears that much, or most, of the on-shore marshland area of the Marketplace site had been filled by that year, or soon thereafter.

Figure 3 is a site plan which shows the locations of previous structures at the site, together with their dates of construction and the industrial uses of the buildings. Superimposed on this figure is the historical bay shoreline shown in Figure 1, together with the approximate location of the landfilled shoreline as it existed by 1925. Examination of this figure shows that construction of new buildings continued progressively at the site as the Paraffin Company expanded, and that most of the Marketplace site area was covered with buildings by about 1930. This figure indicates that construction of the first structures in the "off-shore" area of the site commenced in 1917; this date correlates well with the approximate 1925 shoreline shown, and suggests that much or most of the fill in the area between the original bay shoreline and the 1925 shoreline had probably been placed by about 1917.

The only area of the site which remained to be filled subsequent to 1925 is a small area located at the southwest corner of the site as shown in Figures 1 and 3. Historical maps indicate that this area had been filled by 1931.

In 1920, the Paraffin Company became Pabco. Products associated with the Pabco industry at the Marketplace site include the products manufactured previously by the Paraffin Company, as well as paint and possibly some creosote. However, Figure 3 indicates the construction dates for the Paint Manufacturing Building (Building No. 34) and the Paint Traffic Building (Building No. 21) to be 1929 and 1936, respectively, suggesting that paint manufacture was not a significant aspect of the Pabco industry at the site prior to 1929.

Recent Site History

In 1957, Pabco was purchased by the Fibreboard Corporation. Products manufactured by Fibreboard at the Marketplace site were apparently the same as those manufactured by Pabco: roofing materials, paint and some industrial asphalts.

Beginning about 1964, Fibreboard began to divest its industries at the Marketplace property and at the areas west of the Marketplace. The site plan upon which Figure 3 is based was prepared in 1965. By 1965 the asphalt and kerosene refining equipment, which was located at the northeast corner of the site and which accounted for the darkened appearance of this area in aerial photographs described previously in this report, had been dismantled. By 1969, only the existing Marketplace buildings (Building Nos. 21, 33, 34, 64 and 64A in Figure 3), and several adjacent buildings remained. These remaining adjacent buildings were demolished in about 1973-74, and by 1975 site grading and construction of the existing Marketplace parking lot had been completed.

Roofing Paper and Paint Manufacture

Figure 3 shows that nearly all of the previous industrial structures at the Marketplace site were used for manufacture of roofing materials. Only the existing easterly Marketplace building (Bldg. Nos. 21, 33 and 34 in Figure 3) was used for manufacture of paint. Appendix C provides general information concerning raw materials and processes used in the manufacture of paper and paint. Additional information concerning specific processes at the Marketplace site was obtained by studying Figure 3 and by interviewing several present and previous employees of Fibreboard Corporation.

Roofing Products - The basic raw materials used in the manufacture of roofing products at the site included waste paper, wood flour, and some waste rags and wood chips, used in making roofing felt; liquid asphalt, used to saturate the felt in making roofing paper; and crushed slate stone, used as surfacing in roofing shingles. The roofing felt was manufactured in the southeasterly area of the site (Bldg. Nos. 4, 4A, 5, 10, 10A, 12 and 170 in Figure 3). Bailed waste paper was processed in the hydro-pulper building (Bldg. No. 170) and wood flour was added. The resulting mixture was then processed into felt material in the felt mill (Bldg. No. 10).

Crude asphalt, similar to paving grade asphalt, was obtained from Union Oil Company and refined by a simple distillation process in the refinery area at the northeast corner of the site. The volatile fraction obtained during refining was pumped to the powerhouse (Bldg. Nos. 9 and 9A) and used as fuel. The resulting refined asphalt was then pumped to the roofing building (Bldg. No. 15) where the roofing felt material was asphalt-saturated. Crushed slate, processed in Bldg. No. 83, was then added as a surface cover in manufacture of roofing shingles.

It appears that few chemical additives, if any, would have been used routinely in the manufacture of roofing products at the site. Some caustics, such as caustic soda or caustic lime, may have been used in the hydro-pulping process. Bleaching solutions and dyes which are commonly used in paper manufacture would probably not have been routinely used in production of felt material at the site.

<u>Paint</u> - Paint manufacture at the site apparently commenced soon after construction of the paint manufacturing building (Bldg. Nos. 33 and 34) in 1929. Products included typical oil based paints and enamels. All paint ingredients were obtained from off-site sources, and the paint operation at the site consisted entirely of mixing and packaging done in the paint manufacturing building.

Paint mediums included mainly linseed oil (see linseed tank at northeast corner of site in Figure 3) and some synthetic resin varnishes for enamels. The primary medium solvent was apparently mineral spirits, although lesser amounts of other solvents including ethyl alcohol, xylene and toluene were also used.

A variety of paint pigments were used. A former Fibreboard Operations Manager for paint manufacturing at the site recalled during an interview that commonly used pigments included titanium oxide, red and white lead, zinc oxide, zinc chromate, magnesium silicate, barium sulfate, and others.

Discussion

Several observations regarding the landfill at the Marketplace site are suggested by the available information concerning the historical development of the site.

Because it appears that most of the landfill in the on-shore marshland area of the site was placed from about 1902 to 1910, during the period when the initial Paraffin Company production buildings were being constructed, it is considered unlikely that this fill would have contained large quantities of waste materials from Paraffin Company operations. Also, the site cross-sections shown in Figure 3 indicate that most of the buildings in the southern half of this on-shore area had 5 to 10 foot deep basements (this basement area is outlined in Figure 3), suggesting that either fill had not been placed in much of this southern area prior to the times these buildings were constructed, or that much of the fill which had been placed would have been removed to construct the basements.

Fill placed in the off-shore area of the site could have contained waste materials associated with the Paraffin Company operations (see pp. 10-11 of this report). However, it appears unlikely that fill placed at the site, including the off-shore area extending to about the 1925 shoreline, would have contained substantial amounts of wastes associated with paint manufacturing; as discussed in p. 11 of this report, paint manufacturing does not appear to have been a significant aspect of the site industries until about 1929. If paint-associated wastes are present in the fill at the site, they would more likely have entered the fill as a result of localized surface or subsurface deposition or leakage subsequent to placement of the fill.

Additional fill was placed at the site during excavation and grading for the existing Marketplace parking lot which was completed in 1975. Aerial photographs taken during the period from about 1969 to 1973 show that much of the "basement area" outlined in Figure 3 was a low and frequently wet area during this period; apparently most of these basements were not backfilled during demolition of the previous structures. Examination of aerial photographs taken in 1971 and 1973 indicates that surface runoff from both the north area of the site and from the shallow drainage gulley located adjacent to the west side of the SPRR tracks drained into this low basement area. Based on an interview with the grading contractor who prepared the site during the parking lot construction, it appears that this area was wet and soft during construction, with Bay Mud exposed at many locations.

The grading contractor indicated that a considerable amount of rubble consisting of brick, concrete, wood and old foundations was encountered at the site during grading for the parking lot. Most of these materials were apparently debris resulting from d$\overset{e}{\text{o}}$molition of structures at the site. These materials as well as foundations and basement slabs were apparently left in place during grading unless they directly interfered with the site grading operations. The site was apparently then filled and graded for the parking lot using available nearby sources for import fill materials; the contractor indicated that these import materials were generally clayey soils which were free of debris. No records were found to indicate that any engineering inspection or compaction testing was performed during this earthwork.

Subsurface Storage Tanks

Figure 3 shows that 4 groups of subsurface storage tanks, labelled Groups A, B, C and D, existed at the northern end of the site. Based on information obtained during the interview with the former Fibreboard Operations Manager for paint manufacturing at the site, it appears that the Group A tanks contained crude asphalt and the Group B, C and D tanks contained solvents used in paint manufacture.

During the interview with the grading contractor who constructed the Marketplace parking lot, the contractor recalled that some subsurface reinforced concrete tanks which contained asphaltic material were encountered in excavations made during the parking lot construction. The contractor recalled that efforts were made to remove the asphaltic material. He did not mention encountering any tanks which contained solvent, and he apparently did not recall with certainty whether the subsurface tanks were left in place and filled, or demolished and removed.

Because possible presence of these subsurface tanks is important to the purposes of this study, a supplementary field investigation was conducted to determine whether tanks exist at the locations shown in Figure 3. Details and conclusions of that investigation are discussed in pages 25 through 27 of this report.

EXPLORATORY SOIL BORINGS

Subsurface exploration at the Marketplace site was done in two phases. The initial phase, described below, was planned in cooperation with DOHS and included drilling and sampling of 11 exploratory soil borings and installation of 3 groundwater monitoring wells. A laboratory chemical analysis testing program was then conducted using a total of 24 soil samples and 2 samples of the surface tarry substance which exists at several locations of the Marketplace parking lot.

Subsequently, when Figure 3 became available and the possible presence of subsurface tanks at the site was known, a supplementary subsurface exploration program was conducted specifically to provide definitive information concerning these tanks. This supplementary program included exploratory trenching and borings in the tank areas. Details and results are provided in the next section of this report.

Concurrent with the supplementary tank investigation program at the site, RWQCB requested that a fourth groundwater monitoring well be installed in the vicinity of tank groups and that groundwater samples from the 4 monitoring wells be tested for contaminants. This work was done and results are reported herein.

Field Procedures

Prior to commencement of work, written agreement was reached with DOHS on procedures to be employed. The procedures agreed upon include: locations of borings; depths of borings; method of advancing borings; sampling equipment and methods; techniques to mitigate cross-contamination including sampler decontamination methods; protocol for dividing and controlling samples among DOHS, chemistry laboratory, temporary archive, and field examination; and analytical chemistry tests and test methods. During the work modification to these procedures were agreed upon and then made including: offset boring locations when subsurface obstructions were encountered; different sampling methods and equipment used to improve sample recovery; and changed chemistry laboratory testing sequence to respond to requests to parties indirectly related to the work.

Exploratory soil borings were drilled at 11 locations on site to investigate subsurface conditions and to obtain soil samples for laboratory chemical analysis testing. The borings were drilled during the period July 29 through August 6, 1981. Boring locations are shown in Figures 1 and 3. These locations were established in Figures 1 and 3 based on transit and steel tape survey measurements made of each boring location with respect to the existing 1- and 5-story Marketplace building. The surveying was done by the firm of George S. Nolte and Associates of Walnut Creek, California, working under subcontract to WCC.

The boring locations were selected to investigate the site features of concern discussed in pp. 7 and 8 of this report. The features are judged to have a high probability of occurrence of contaminated materials, if present at all.

Examination of Figure 1 indicates that the boring locations chosen also provide a reasonably representative distribution over the site area. Boring No. 1 was located adjacent to the abandoned concrete tank structure at the southeast corner of the site; Boring Nos. 2 and 6 were located in the vicinity of the wooden culvert-type structure; Boring Nos. 3 and 4 were located near the east property line in the vicinity of the "cattail" area of Westinghouse; Boring No. 5 was located at the northeast corner of the site in the area of the previous asphalt and kerosene refining equipment which appeared darkened in aerial photographs; Boring Nos. 6, 8, 9 and 10 were located in areas of pavement bulges, as shown in Figure 1; and Boring No. 11 was located in an area of exuded tar at the northwest corner of the site. Figure 3 shows that Boring Nos. 2, 6 and 7 were located in the previously low, wet basement area described in pp. 15 and 16 of this report.

The borings were drilled using rotary-wash drilling techniques to depths in the range 9 to 16 feet. For most of the borings, supplementary borings were also drilled at locations within several feet horizontally of the primary location; this was done to avoid subsurface obstructions such as concrete slabs or foundatons, to provide open holes for groundwater level measurements and to provide supplemental soil samples. Each boring was continuously logged by WCC engineers. Careful attention to detail was observed regarding cleanliness during drilling and sampling, to avoid contamination of soil samples obtained from borings. Logs of the borings were prepared, and these logs are provided in Appendix A.

Supplemental soil and groundwater information for the site is available from a previous geotechnical study conducted for the existing Sherman-Williams Company warehouse, located adjacent to the southwest corner of the site (WCC Project No. S12376, report to Lathrop Construction Company, dated July 14, 1971). Locations of exploratory soil borings from that study are shown in Figure 1, and logs of borings are included in Appendix A.

Sampling Methods

Four types of sampling were done during this work. The primary type of sampler was the 2 1/2-inch modified California sampler. At some locations when there was poor sample recovery, a 2-inch modified California sampler or an Osterberg or Shelby tube sampler was used either at the next lower sampling depth or at the same sampling depth in an adjacent borehole. At a few locations, samples were obtained from the blades of augers. Surface samples of tarry material were manually obtained.

The modified California sampler consists of cutting shoe, an approximately 2-foot long split-barrel into which four 6-inch-long brass tubes are placed, and a butt which threads onto the barrel at one end and drill rod at the other. Details of 2 1/2-inch and 2-inch modified California samplers are given in Appendix A. The sampler, attached to drill rod, is lowered into the borehole previously advanced by rotary-wash techniques, is driven into the soil by the impact of a 140-lb weight falling 30 inches and striking an anvil attached to the drill rod. After retrieving the samples, the soil-filled brass tubes were removed, capped immediately, marked for identification and refrigerated. When full sample recovery was obtained (that is, when sample was present in all 4 tubes of the sampler), soil in the top tube (the No. 1" tube, as described in Appendix A) was extruded at the borehole, examined and classified. This soil was then placed in a jar, sealed, marked for identification and refrigerated. After the sampler was decontaminated and washed, brass tubes were inserted for the next sampling interval.

The Osterberg sampler consists of a 3-inch-ID, 30-inch-long Shelby tube (thin walled and seamless), a piston, and a special adapter which threads onto drill rod. The Shelby tube attached to the adapter is inserted in the borehole by the drill rods to the sampling depth with the piston advanced to the cutting edge end. Using hydraulic pressure applied through the drill rods, the adapter forces the Shelby tube downward into the soil while allowing the piston to remain at a constant depth. When extracting the sampler, vacuums tend to develop through fluids on the piston usually resulting in high sample recovery. A detail of this sampler is given in Appendix A. After the piston and adapter were removed, the Shelby tube was immediately sealed, marked for identification, and refrigerated.

On a few occasions, samples were obtained from auger blades. When the borehole was advanced to a level just above the sampling depth the augers were rotated at high speed to remove cuttings. The auger was then raised without rotation and soil was removed from the auger blades and placed in jars which were sealed, marked for identification and refrigerated. This sampling method is not preferred because it increases the opportunity of cross-contamination of soils from lower and higher depths when compared to the modified California sampler, the Shelby tube, or Osterberg samplers.

Soil samples were obtained at closely-spaced intervals in the boreholes using these sampler types and methods. Care was taken to avoid loss of volatiles by sealing and refrigerating each sample immediately upon recovery of the sample, and all samples were distributed, transported and sorted in strict accordance with the chain-of-custody protocol agreed upon before the sampling began. A total of 59 samples were recovered, together with 2 samples of the exuded tarry material obtained from just below the pavement at the locations shown in Figure 1. Enclosed Table 1 provides a complete inventory of these samples, and corresponding descriptions of materials contained in the samples are given in the boring logs.

Decontamination Procedure

Brass tubes for the modified California samplers were prepared in WCC's Oakland laboratory by washing with hexane, rinsing with distilled water and sealing the tubes in plastic bags for transport to the site. All steel Shelby tubes used with the Osterberg and Shelby tube samplers were coated with a standard corrosion/resistant compound. The compound consists of a polyester/epoxy mix plus hardening agent. The compound is manufactured by the Fuller-O'Brien Corproation of South San Francisco, and its ingredients are proprietary. The compound is approved by the United States Department of Agriculture for use on cookware. The coated Shelby tubes were transported to the site and stored on-site in sealed cardboard boxes as received from the tube manufacturer.

After obtaining a sample in the borehole, the sampler was pulled from the hole, rinsed with water over a 55-gallon catch-drum to remove materials adhering to the sides and then dismantled to obtain the sample tubes. Sample tubes were immediately capped at both ends with Teflon-lined plastic caps, sealed with tape to prevent loss of volatiles, and marked for identification as described in the previous section of this report. The tubes were then rinsed in water, wiped dry and placed in an on-site refrigerated container. The sampler was then washed with water and with hexane, respectively, and reassembled with clean tubes for the next sampling. Samples stored in the refrigerated container were transported to the chemical analysis laboratory at the end of each working day.

Bentonite drilling fluid was used in the boreholes with the rotary drilling method. The bentonite product used was "Speed Gel", manufactured by Hill Brothers Chemical Company of San Jose. This product is commonly used in water well drilling and its typical chemical constituents are summarized in a technical bulletin from Hill Brothers, enclosed in Figure A-a, Appendix A.

Two techniques were used to fill completed boreholes. For rotary drilled holes, cement was added to drilling fluid and pumped to within 1 to 2 feet of the ground surface. All excess drilling fluid was then pumped into 55 gallon storage drums, as was the rinse water used in cleaning the lines of the drilling rig. The fluid pump on the drilling rig was dismantled and cleaned after completion of each borehole filling to prevent buildup of material inside the pump. For auger drilled holes, soil obtained from the borehole during drilling was recompacted in the borehole to within 1 to 2 feet of the ground surface. All soil remaining after filling the borehole was stored in 55 gallon drums. In both rotary and auger boreholes, the final filling the the upper 1 to 2 feet below pavement surface was done with concrete to provide a smooth and firm surface finish.

Before moving to the next borehole location, the drill rods, augers and drilling rig were steam-cleaned to remove any adhering materials. All cleaning solvents, rags and excess soil from boreholes were placed in 55 gallon drums.

Protective clothing worn by personnel at the site included rubber boots, plastic work suits and waterproof gloves. All personnel were supplied with dust masks and respirators. At the completion of the drilling program, all protective clothing was stored in 55 gallon drums which were then removed from the site and stored along with borehole waste materials at WCC's Oakland office laboratory, pending appropriate disposal based upon testing program results. All rubber hoses used on the drill rig to pump drilling fluids were removed and stored pending the outcome of the testing program.

Groundwater Level Measurements

Measurements of groundwater level were made at each boring location at the time of drilling. These measurements are shown in the boring logs. In addition, standpipe piezometer groundwater monitoring wells were installed in Boring Nos. 4, 5, 10 and 12 to permit future groundwater monitoring. A description and detail of piezometer installation is given in Appendix B. Surface elevations at the boring locations were surveyed by George S. Nolte and Associates to permit accurate determinations of groundwater elevations. The results of groundwater elevation determinations obtained from the monitoring wells on 3 occasions during the 5 month period August, 1981 to January, 1982, are summarized in the enclosed Table 3.

Additional information regarding the exploratory soil boring and sampling program and monitoring well installation at the site are provided in Appendices A and B.

SUBSURFACE TANK INVESTIGATION

When Figure 3 became available and the possiblity that subsurface tanks may exist at the Marketplace site was known, DOHS requested that conclusive information be obtained regarding presence and contents of the tanks.

To accomplish this, present and former officials of the City of Emeryville, present and former employees of Fibreboard Corporation and the grading contractor who constructed the existing Marketplace parking lot were interviewed. These interviews provided information concerning the previous contents of the tanks, discussed in page 16 of this report, and the interview results tended to indicate that the tanks would have been properly disposed of during grading for the existing Marketplace development. However, persons interviewed were not able to provide conclusive verification regarding final disposition of the tanks. Two methods of relatively inexpensive subsurface geophysical exploration (conductivity and magnetometer surveys) were also applied in the tank areas, but the results obtained were judged not to provide conclusive verification concerning the tanks.

To provide conclusive verification, backhoe excavations were made in the areas of Tank Groups A, B and C, and soil borings were made in the area of Tank Group D. The backhoe excavations were made by Klaas Construction Company, Antioch, and the borings were made using truck-mounted auger equipment by AAA Drilling Company, Haward, both working under subcontract to, and under the continuous on-site observation of WCC engineers. The backhoe excavations were also inspected by Mr. Lowell Miller of DOHS and by Mr. Robert Samaniego of RWQCB.

All backhoe excavations were made to depths in the range of 7 to 10 feet. The excavations at Tank Groups A and B completely covered the areas of these groups as shown in Figure 3, while the excavation at Group C covered the area shown for the northernmost 4 of the 6 tanks in Group C; the area of the remaining 2 tanks in Group C was not excavated because this would have required demolition and replacement of a concrete patio slab, which was judged to be unnecessary.

The backhoe excavation at Group A encountered numerous large and heavy pieces of reinforced concrete rubble embedded in soil, which may be remnants of demolished subsurface tank structures at that location. Although weak petroleum-type odors were noted in soils obtained from the excavation, there was no visual evidence of contaminant presence. No tank structures or concrete rubble were encountered in the excavations made in the Tank Group B and C areas, although weak petroleum-type odors were also noted at both of these locations.

Tank Group D is located in a concrete patio area. Considering the results obtained at the Group A, B and C areas, it was judged that several soil borings drilled at the precise locations of tanks in this group, as shown in Figure 3, should provide sufficient verification regarding tank presence in Group D. Three soil borings (Boring Nos. 13, 14 and 15) were drilled to depths of 10, 4.6 and 8 feet, respectively. Logs of these borings are presented in Appendix A. Although subsurface concrete slabs, concrete rubble and weak petroleum-type odors were encountered in each of these borings, no voids or other indications of presence of unfilled subsurface tanks were observed in the borings.

Based on these results, it is concluded that subsurface tanks are not present in the Tank Group A, B and C areas shown in Figure 3, and that tanks are unlikely to be present in the Group D area; if some abandoned tank structures do remain in the Group D area, the soil borings drilled into tank locations in this area indicate that the tanks have been emptied of contents and backfilled with clay soils.

Materials obtained from the backhoe excavations in the Tank Group A, B and C areas, excluding concrete rubble from the Group A area, were placed and compacted as backfill material in the excavations under the observation of WCC engineers. Curbs, gutters and pavement which were removed by these excavations were then restored. Materials obtained from boreholes in the Group D area were used to backfill the boreholes. The upper 1 foot at each borehole was sealed with concrete.

SOIL AND GROUNDWATER CONDITIONS

The fill at the Marketplace site is underlain by native soils consisting of a thin layer of soft, organic silty clay (Recent Bay Mud) over much of the site area, followed by predominantly stiff to very stiff silty, sandy and gravelly clays with interbedded layers of medium dense to dense clayey to non-plastic gravels and sands.

Fill

The fill at the Marketplace site is typically about 4 to 6 feet thick, but locally deeper in areas of previous subsurface structures, including basements.

The composition of the fill material varies from boring to boring. The predominant fill soil types encountered in the majority of borings were clayey to non-plastic, medium dense gravels, sands and gravel-sand mixtures. In several borings, dominant fill material was medium stiff to stiff, sandy and gravelly clay. In each boring, the upper 8 to 12 inches of material consisted of about 2 inches of asphalt concrete pavement underlain by an aggregate base material.

Except for Boring No. 1, debris was encountered in the fill in each boring. The debris consisted mainly of concrete, brick and wood with minor glass, metal and pieces of asphaltic material. Amounts ranged from trace quantities in some borings to primarily rubble in Boring Nos. 2, 3 and 13. Based on discussion given in p. 16 of this report, it appears that much of this debris is the result of demolition of the previous site structures.

A petroleum-type odor was observed in the fill in 7 of the borings. This odor was typically observed in the lower portion of the fill, and it was often associated with a black discoloration in the soil. In 5 of these 7 borings, the petroleum odor was also present in the upper several feet of the underlying native soil.

Boring No. 11 was drilled at the northwest corner of the site at a location where tarry substance is present on the pavement surface. Approximately 2 feet of black tar was encountered commencing several inches below the pavement surface at the boring. It appears that the pavement section was constructed upon tar at this location.

Except for debris, petroleum odor and this tar, no other foreign materials or odors were observed in the fill in any of the borings. No tar paper or paint was observed in any of the borings; however, approximately 3 feet of tarpaper but no paint was observed in the previous Boring No. 5 at the adjacent Sherman-Williams Company site (see Figure A16, Appendix A). This site is located on the bay side of the approximate 1925 shoreline, and the presence of tar paper in fill there correlates well with discussion of filling in the off-shore area of the site given in p. 15 of this report.

Native Soils

A thin layer of Bay Mud, generally 2 to 3 feet thick, was encountered beneath the fill in 7 of the 15 borings. The distribution of these boring locations and the depths at which Bay Mud was encountered suggest that the Bay Mud may have been partially or completely excavated at many locations of the site during construction of previous structures, particularly in the "basement area" shown in Figure 3. The adjacent Sherman-Williams Company site is underlain by about 7 feet of Bay Mud.

The underlying layers of predominantly stiff clays with minor interbedded layers of dense clayey to granular gravels and sands are part of a deep soil deposit in the site vicinity. These clays are overconsolidated and typically have low values of coefficient of permeability compared to overlying fill soils and Bay Mud.

Groundwater

The groundwater surface presently underlies the site at varying depths in the range of about 2-1/2 to 5-1/2 feet below the existing site grades, ranging from about Elevation 7 to 9 at the northeast corner of the site to about Elevation 5 at monitoring well No. 10 (see Table 3). Groundwater levels recorded at the Sherman-Williams Company site in the 1971 borings were about Elevation 3. Based on the data shown in

Table 3, groundwater flow is in a southwesterly direction across the site, and the seasonal variation in groundwater level at the site appears to be about 2 feet.

LABORATORY CHEMICAL ANALYSES OF SOIL SAMPLES

Twenty-four of the 59 soil samples recovered from the soil borings plus 2 samples of exuded tarry substance obtained from just below pavement surface were selected for chemical analyses. The selected samples are identified in Table 1 and at the corresponding sample depths in boring logs.

Sample Selection Procedures and Testing

The selection of samples for chemistry laboratory testing was made jointly and with full agreement between DOHS and WCC personnel. Previous contaminant studies in the near site vicinity had revealed that soil samples with visual or olfactory evidence of contamination (petroleum or petroleum odors) almost always contained several trace metal contaminants of concern and that soil samples without petroleum or its odors almost never contained these contaminants. The selection criteria required that at least one sample from the upper 5 feet of each boring be tested and that every sample with visual or olfactory evidence of contamination (there were 12 such samples) be tested, even if this required substituting specimens which were directed by protocol to DOHS or to temporary archive. In addition, at least one specimen was tested from a depth below and as near as possible to each of these.

The laboratory testing program was established in cooperation with DOHS personnel. The testing was done by Brown and Caldwell (B&C), Emeryville, under contract to WCC. Each sample was analyzed for purgeable organics (aromatics and halocarbons) and for Total Identifiable Chlorinated Hydrocarbons (TICH), including organochlorine pesticides and PCB. The 12 samples which had been selected for testing based on visual or olfactory evidence of possible contamination were analyzed for 8 heavy metals: arsenic, cadmium, chromium (total and hexavalent), cobalt, copper, lead, nickel and zinc. Based on results for these initial 12 samples, the remaining 14 samples were then tested for chromium (total and hexavalent), copper, lead, nickel and zinc, and an additional test for cadmium in one of the 14 samples.

Analysis Results

Completed results of the laboratory chemical analyses are provided in Appendix D, and a summary is provided next.

Based on the results of gas chromatograph-photoionization detector analyses for volatile aromatics, it is estimated that none of the compounds which appear in the United States Environmental Protection Agency's (US EPA) list of compounds for volatile aromatic chromatograms were present at concentrations exceeding 0.1 parts per million (ppm, air dry wet basis) in 25 of the 26 samples tested. One sample (Boring No. 5, Sample No. 3) showed peaks corresponding to an estimated maximum concentration of less than 0.5 ppm.

Based on the results of gas chromatograph-halide specific detector analyses for volatile halocarbons, it is estimated that none of the compounds which appear in the USEPA's list of compounds for halocarbon chromatograms were present at concentrations exceeding 0.09 ppm.

The only organochlorine pesticide detected in the TICH analyses on the 26 samples tested was chlordane in 2 samples (Boring No. 2, Sample Nos. 1 and 2), with concentrations of

0.49 ppm and 0.99 ppm, respectively. The Total Threshold Limit Concentration (TTLC) for chlordane, as given in the California Assessment Manual for Hazardous Wastes, is 3 ppm; the chlordane concentrations detected in these 2 samples would, therefore, not be considered hazardous.

Polychlorinated biphenyls (PCB) were detected in 5 of the 26 samples tested. The detected concentrations are summarized in Table 2; these concentrations are all well below the proposed TTLC for PCB given in the California Assessment Manual for Hazardous Wastes (CAM).

Several metals were detected at concentrations exceeding TTLC values in 10 of the 26 samples tested. These samples and the detected metals concentrations in excess of the TTLC are summarized in Table 2. These data show that copper, lead or zinc were present at concentrations exceeding the TTLC in 10 of the 26 samples tested, while cadmium, chromium (trivalent) or nickel were present in excess of the TTLC in only 2 of the 26 samples.

GROUNDWATER SAMPLING AND LABORATORY CHEMICAL ANALYSES

A groundwater sampling and laboratory chemical analyses testing program was performed for the Marketplace site in January, 1982, in response to requests of RWQCB. The groundwater sampling protocol and selection of specific tests to be made for groundwater samples were determined in cooperation with RWQCB.

Groundwater Sampling

Groundwater samples were obtained from the 4 monitoring wells on January 20, 1982. Details regarding preparation of the wells for sampling and sampling methodology are presented in

Appendix B. The sampling was observed at the site by RWQCB personnel.

Groundwater Testing

The laboratory groundwater testing program included analyses for dissolved metals in groundwater samples obtained from each of the 4 monitoring wells and tests for purgeable organics in the groundwater sample obtained from Well No. 4, located in the vicinity of subsurface Tank Groups B, C and D as shown in Figure 3. The testing was performed by Brown and Caldwell, Emeryville, under subcontract to WCC.

Dissolved metals were analyzed using the standard sample filtration/atomic absorption method. Metals analyzed were the same 8 which had been analyzed previously for soil samples: arsenic, cadmium, chromium (total), cobalt, copper, lead, nickel and zinc. Purgeable organics were analyzed using standard gas chromotograph/mass spectroscopy (US EPA Method 624). Additional analyses for PCB content in the 4 groundwater samples were conducted by RWQCB. These PCB analysis results are on file with RWQCB and are not reported herein.

Analysis Results

Analysis results are summarized in Appendix E. These results show that the 8 dissolved metals were typically not detected in the 4 groundwater samples analyzed, and that in the few cases where metals were detected, the reported concentrations are well below US EPA drinking water standards.

Six identifiable compounds were detected in the purgeable organics analysis conducted for the groundwater sample from monitoring well No. 4. Of these 6 compounds, 4 were detected at concentrations which are judged to be negligible (1 to 3 ppb) for the respective compounds.

Two compounds, tetrahydrofuron and methylethyl keytone, were detected at concentrations of 0.34 ppm and 0.23 ppm, respectively. As discussed in the toxicity assessment for these compounds contained in Appendix E, these reported concentrations are judged to be very low and should not constitute a hazard.

DISCUSSION OF STUDY RESULTS

The primary objective of this study was to investigate the possible presence and concentrations of hazardous wastes at the Marketplace site; therefore, both selection of locations for exploratory soil borings and groundwater monitoring wells and selection of soil samples for laboratory chemical analyses were purposely and conservatively biased: soil borings and monitoring wells were placed at the most suspect locations of the site, and the most suspect soil samples were chemically analyzed. The results of laboratory chemical analyses performed on soil samples obtained from the borings indicate that for the range of possible contaminants investigated, only several heavy metals were found at concentrations which would be categorized as hazardous by definition, per CAM. No contaminants were detected at concentrations which would be categorized as hazardous in laboratory chemical analyses performed on groundwater samples.

Heavy Metals in Soil Samples

These metals included copper, lead and zinc, and some cadmium, chromium and nickel. If presence of these metals in soils beneath the site is a result of previous industries at the site, the discussion provided in the "Site History" section of this report suggests that their presence would most likely be associated with the on-site refining of petroleum and asphaltic materials; petroleum-type odors or tarry materials were observed in or near many of the soil samples having relatively high concentrations of these heavy metals. Though it appears less likely, it is possible that some of these metals could also be associated with pigments used in the previous paint manufacturing industry at the site.

PCB

No evidence was found during this study to directly link presence of PCB found in 5 of the 26 soil samples which were chemically analyzed to either the previous on-site industries or to possible transport from the adjacent Westinghouse or ITT Grinnell properties. Very low levels of PCB were found in soil samples obtained from Boring Nos. 4 and 5 which were drilled near the east property line of the Marketplace site at locations nearest to the areas of contamination on Westinghouse and ITT Grinnell properties. However, of the 5 samples which contained PCB, the highest concentrations of PCB were detected in 2 soil samples obtained from Boring No. 8, which was drilled at a location approximately 160 feet west of the east Marketplace property line; even these higher concentrations were well below levels which would be categorized as hazardous.

An analysis of the potential for migration of PCB by groundwater from contaminated areas on Westinghouse and ITT Grinnell properties has been conducted for COE by Dr. David Keith Todd, Consulting Engineer; a copy of Dr. Todd's report to COE, dated August 10, 1981, is contained in Appendix F. WCC concurs with Dr. Todd's conclusion that because of the low solubility of PCB in water and its strong tendency to be adsorbed by soil particles, the potential for migration of PCB by groundwater at concentrations greater than the part-per-billion range from contaminated areas at Westinghouse and ITT Grinnell properties is very low. Such migration by groundwater could possibly account for the trace concentrations of PCB detected in soil samples from Boring Nos. 4, 5 and 7, but it appears very unlikely that it could account for the higher concentrations of PCB detected in soil samples from Boring No. 8.

No evidence was found during this study to suggest that PCB may have been used in the manufacturing and refining process associated with the previous industries at the Marketplace site. The results of this study instead suggest that the relative higher concentrations of PCB detected in soil samples from Boring No. 8 indicate a localized condition in the fill in the vicinity of Boring No. 8. This localized deposition could have occurred in many ways. For example, careful examination of Figure 3 shows that numerous high-voltage transformers were present at the site during the previous industries; leakage of PCB from those transformers may have occurred, or some of the transformers may even have been buried in the fill during demolition of the previous structures.

Groundwater

Based on the laboratory chemical analysis results for groundwater samples, it appears that the several heavy metals which were detected at concentrations exceeding the TTLC in samples of the site fill materials do not occur in the site groundwater at concentrations above either current drinking water standards or current fish toxicity criteria for outfall water into the Bay. Also, the several purgeable organics compounds which were detected in the groundwater samples were determined to be at concentrations well below those which may be categorized as hazardous. These results indicate that heavy metals in fill at the Marketplace site are being firmly held by the fill soils, and that the potential for any leaching of these metals to groundwater or to the Bay is very low.

Surface Tarry Substance and Pavement Bulges

As discussed in p. 6 of this report, the presence of pavement "bulges" and an exuded tarry substance at the pavement surface in the areas shown in Figure 1 are separate, unrelated phenomena.

Reasons for the exuded tarry substance at several locations of the parking lot were not determined with certainty. Based on information obtained during this study, it appears that the tarry substance is asphalt which was used in the on-site manufacture of roofing paper. The "tar area" shown in Figure 1 near the northeast corner of the existing Marketplace building occurs near the "paper saturating building" (Building No. 15 in Figure 3) of the previous industries at the site. Also, Figure 3 shows that a number of large surface storage tanks, as well as the Group A subsurface tanks, contained asphalt prior to their demolition and removal. Based on this information, together with the results of Boring No. 11 which was drilled in one of these tarry areas and information obtained during an interview with the contractor who graded the Marketplace parking lot, it appears that the surface tar may be the result of placing new fill or pavement section directly above roofing asphalt which had spilled or ponded in limited areas of the site prior to or during grading for the existing parking lot. Chemical analyses of samples of the asphaltic substance performed during this study and analyses of other samples of the substance performed previously by DOHS confirm that it contains some heavy metals (lead and zinc) at concentrations in excess of the TTLC, as would be expected for many bituminous and petroleum-based products.

Some attention was given during this study to investigating the likely cause of the bulges in the Marketplace parking lot. Boring Nos. 6 and 6A were drilled on and just off one of these bulges, respectively, located in the previous "basement area" in the southeast area of the parking lot, to investigate whether localized differences in subsurface soil conditions may account for the bulges. The logs of these borings (Figure Nos. A-6 and A-6a in Appendix A) show that a larger thickness of soft silty clay occurs below a depth of about 4.5 feet in Boring No. 6A compared to Boring No. 6.

This greater thickness of soft soil together with indications from the grading contractor that excavation and fill placement was not subject to strict engineering controls during grading for the existing Marketplace parking lot, suggests that the bulges may result from differential settlement which has occurred in the fill and in the upper several feet of the underlying soft native soils, subsequent to completion of the parking lot.

Extensive heavy truck traffic in the parking lot since its completion in 1975 would intensify the tendency for occurrence of these differential settlements. The pavement section of the parking lot does not appear to have been designed to support heavy vehicles, and such use could produce localized shear failures in the fill.

The information concerning the bulges obtained during this study indicates that the pavement bulges are not the result of any type of "upwelling" phenomenon, but that they are instead related to the engineering strength and compressibility properties of the underlying soils. Also, chemical analysis results for soil samples obtained from soil borings in bulge areas show that the bulges have no special significance regarding the purpose of this study.

ASSESSMENT CONCLUSIONS

The following conclusions are derived from results of the subsurface contaminants assessment study for the Marketplace property, as presented in the preceding pages of this report:

- The soils of the site do not appear to contain contaminants including purgeable organics (volatile aromatics and volatile halocarbons), organochlorinated pesticides, or polychlorinated biphenyls (PCB) at concentrations which would be categorized as hazardous or extremely hazardous by definition of the California Assessment Manual for Hazardous Wastes (CAM).

- Groundwater beneath the site does not contain heavy metals or purgeable organics at concentrations which would be categorized has hazardous, per drinking water and fish toxicity criteria for water. Metals detected in fill at the site appear to be firmly adsorbed by the fill soils, and the presently sealed condition of the site surface virtually eliminates the potential for infiltration of rainwater. It is judged that the potential for significant leaching of metal contaminants to groundwater beneath the site or to the Bay is, therefore, very low.

- It does not appear that PCBs have migrated from the nearby Westinghouse Corporation and ITT Grinnell Corporation properties at concentrations greater than the part-per-billion range, if at all; this is documented by both observational and theoretical results presented herein.

- Several heavy metals do exist at concentrations exceeding the TTLC in soils on the site and in the tarry material which apparently has exuded to the pavement surface at some locations of the site. These metals include copper, lead and zinc, and some cadmium, chromium and nickel. The data obtained during this study indicate that where these metals occur in soils at concentrations exceeding the TTLC, they appear to be confined to the in-place fill soils. The presence of these metals in the fill may be related to the previous industries at the site.

What about
tarry substance - where might
the heavy metals go.
Surface H2O contamination

- No evidence was found during investigation of the site history to suggest that contaminant types other than those types for which laboratory chemical analyses were conducted may exist at the Marketplace property.

- The pavement bulges and the tarry substance which has exuded to the pavement surface at some locations of the site are features which are not related to each other. The pavement bulges have no significance with respect to contaminants at the site. The tarry substance contains heavy metals (lead and zinc) at concentrations exceeding the TTLC.

- The previous subsurface tanks shown as Tank Groups A, B and C in Figure 3 were demolished or removed during development of the Marketplace. Tanks shown in the Group D area were apparently demolished or removed, or filled with soil.

- The entire assessment program was designed and carried out in a manner intended to increase the probability of encountering and identifying contaminants of concern, consistant with experience and knowledge of DOHS, RWQCB and WCC personnel assigned to the work. Therefore, it is judged that there is a low probability of significant occurrence of these contaminants at other site locations in concentrations exceeding what is reported herein.

Discussion

The presence of some heavy metals at concentrations exceeding the TTLC in the fill soils beneath the Marketplace property should be assessed considering the present use of the property and possible future development of the property. In the present Marketplace development, virtually the entire site is sealed with an 8- to 12-inch thick pavement section and the existing Marketplace buildings. It is therefore very unlikely that these metals would be exposed to surface environment at the site as presently developed.

Human exposure to these metals could occur during excavations or grading performed for future development of the site or by ingesting plantings grown in metals-contaminated fill. However, presence of these metals in the subsurface fill should not unduly restrict future development, provided that appropriate care and precautionary measures are observed during planning and performing any such earthwork, including appropriate disposal of any fill materials which may be removed from the site.

TABLES

MARKETPLACE CONTAMINANT ASSESSMENT

TABLE 1

SOIL SAMPLE INVENTORY

ASSESSMENT OF SUBSURFACE CONTAMINANTS

Soil Boring Number	Soil Sample Number	Sample Type	Specimen Tube Number	Sample Depth Interval (feet)	Distribution
1	1	Tube	4	2.5 - 3	DOHS
			3	2 - 2.5	B&C
	2	Tube	2*	4 - 4.5	B&C (only tube)
1A	1	Tube	4	8.5 - 9	DOHS
			3	8 - 8.5	B&C
			2	7.5 - 8	WCC
			1	7 - 7.5	WCC (jar)
2	1	Tube	4	2.5 - 3	DOHS
			3**	2 - 2.5	B&C
			2	1.5 - 2	WCC
			1	1 - 1.5	WCC (jar)
	2	Tube	4	5 - 5.5	DOHS
			3*	4.5 - 5	B&C
	3	Tube	4	6 - 6.5	WCC
	4	Tube	4	8.5 - 9	DOHS
			3	8 - 8.5	B&C
	5	Tube	4	10.5 - 11	DOHS
			3	10 - 10.5	WCC
3	1	Tube	4**	2.5 - 3	DOHS
			3	2 - 2.5	B&C
			2	1.5 - 2	WCC
	2	Jar	A	3.5 - 5.5	B&C (Auger Sample)
			B	3.5 - 5.5	DOHS (Auger Sample)
				4.5	WCC (Auger Sample)
				4.5	WCC (Auger Sample)
	3	Tube	4	7 - 7.5	DOHS
			3*	6.5 - 7	B&C
			2	6 - 6.5	WCC
			1	5.5 - 6	WCC (jar)
	4	Tube	4	9.5 - 10	DOHS
3A	1	Tube	4	5 - 5.5	DOHS
			3	4.5 - 5	B&C
			2	4 - 4.5	WCC
	2	Tube	4	9.5 - 10	DOHS
			3	9 - 9.5	B&C
			2	8.5 - 9	WCC
3D	2	Shelby Tube	4	7.2 - 7.7	DOHS
			3**	6.7 - 7.2	B&C
			2	6.2 - 6.7	WCC
			1	5.7 - 6.2	WCC

TABLE 1 (Continued)

SOIL SAMPLE INVENTORY

Soil Boring Number	Soil Sample Number	Sample Type	Specimen Tube Number	Sample Depth Interval (feet)	Distribution
4	1	Tube	4	1.5 - 2	DOHS
			3	1 - 1.5	B&C
			2	0.5 - 1	WCC
4A	1	Tube	4	2.5 - 3	DOHS
			3	2 - 2.5	B&C
	1	Jar		3 - 2	WCC (Cutting Shoe Sample)
4C	1	Tube	4**	4.5 - 5	DOHS
			3	4 - 4.5	B&C
			2	3.5 - 4	WCC
			1	3 - 3.5	WCC (jar)
	2	Tube	4	7 - 7.5	DOHS
			3	6.5 - 7	B&C
			2	6 - 6.5	WCC
			1	5.5 - 6	WCC (jar)
	3	Tube	4	9.5 - 10	DOHS
			3*	9 - 9.5	B&C
			2	8.5 - 9	WCC
			1	8 - 8.5	WCC (jar)
	4	Tube	4	12 - 12.5	DOHS
			3	11.5 - 12	B&C
			2	11 - 11.5	WCC
			1	10.5 - 11	WCC (jar)
4D	1	Shelby Tube	4	4.3 - 4.8	DOHS
			3	3.8 - 4.3	B&C
			2	3.3 - 3.8	WCC
			1	2.8 - 3.3	WCC
	2	Tube	4	6.5 - 7	DOHS
			3	6 - 6.5	B&C
			2	5.5 - 6	WCC
5	1	Tube	4	2.5 - 3	DOHS
			3*	2 - 2.5	B&C
			2	1.5 - 2	WCC
	2	Jar	A	3.5 - 5.5	B&C (Auger Sample)
			B	3.5 - 5.5	DOHS (Auger Sample)
			C	3.5 - 5.5	WCC (Auger Sample)
	3	Tube	4	7.5 - 8	DOHS
			3*	7 - 7.5	B&C
			2	6.5 - 7	WCC
			1	6 - 6.5	WCC (jar)
	4	Jar	A	8.5 - 10	B&C (Auger Sample)
			B	8.5 - 10	DOHS (Auger Sample)
			C	8.5 - 10	WCC (Auger Sample

TABLE 1 (Continued)

SOIL SAMPLE INVENTORY

Soil Boring Number	Soil Sample Number	Sample Type	Specimen Tube Number	Sample Depth Interval (feet)	Distribution
5	5	Tube	4	13.5 - 14	DOHS
			3	13 - 13.5	B&C
			2	12.5 - 13	WCC
			1	12 - 12.5	WCC (jar)
5A	1	Shelby Tube	4	5.5 - 6	DOHS
			3**	5 - 5.5	B&C
	2	Shelby Tube	4	8 - 8.5	DOHS
			3	7.3 - 8	B&C
			2	6.2 - 7.3	WCC
			1	6.2 - 6.7	WCC
6	1	Tube	4	3 - 3.5	DOHS
			3*	2.5 - 3	B&C
			2	2 - 2.5	WCC
	2	Tube	4	5.5 - 6	DOHS
			3	5 - 5.5	B&C
			2	4.5 - 5	WCC
			1	4 - 4.5	WCC (jar)
	3	Tube	4	8 - 8.5	DOHS
			3	7.5 - 8	B&C
			2	7 - 7.5	WCC
			1	6.5 - 7	WCC (jar)
	4	Tube	4	10.5 - 11	DOHS
			3	10 - 10.5	B&C
			2	9.5 - 10	WCC
6A	1	Tube	4	2.5 - 3	DOHS
			3	2 - 2.5	B&C
			2	1.5 - 2	WCC
7	1	Tube	4	2.5 - 3	DOHS
			3*	2 - 2.5	B&C
			2	1.5 - 2	WCC
			1	1 - 1.5	WCC (jar)
	2	Tube	4	3.5 - 4	DOHS
	3	Tube	4	7 - 7.5	DOHS
			3	6.5 - 7	B&C
			2	6 - 6.5	WCC
			1	5.5 - 6	WCC (jar)
	4	Tube	4	9.5 - 10	DOHS
			3	9 - 9.5	B&C
			2	8.5 - 9	WCC
			1	8 - 8.5	WCC (jar)

TABLE 1 (Continued)

SOIL SAMPLE INVENTORY

Soil Boring Number	Soil Sample Number	Sample Type	Specimen Tube Number	Sample Depth Interval (feet)	Distribution
8	1	Tube	4**	2.5 - 3	DOHS
			3	2 - 2.5	B&C
	2	Tube	4	5 - 5.5	DOHS
			3*	4.5 - 5	B&C
			2	4 - 4.5	DOHS
	3	Tube	4	7.5 - 8	DOHS
			3	7 - 7.5	WCC
9	1	Tube	4	2.5 - 3	DOHS
	2	Tube	4	5 - 5.5	DOHS
			3**	4.5 - 5	B&C
			2	4 - 4.5	WCC
	3	Tube	4	7.5 - 8	DOHS
			3**	7 - 7.5	B&C
	4	Tube	4	10 - 10.5	DOHS
			3*	9.5 - 10	B&C
			2	9 - 9.5	WCC
10	1	Jar	A	0.5 - 2.5	B&C (Auger Sample)
		Jar	B	0.5 - 2.5	DOHS (Auger Sample)
	2	Tube	4**	3.5 - 4	DOHS
			3	3 - 3.5	B&C
	3	Tube	4	6 - 6.5	DOHS
			3**	5.5 - 6	B&C
			2	5 - 5.5	WCC
			1	4.5 - 5	WCC (jar)
10C	1	Jar	A	4 - 6	B&C (Auger Sample)
			B	4 - 6	DOHS (Auger Sample)
			C	4 - 6	WCC (Auger Sample)
10D	1	Tube	4	7.5 - 8	DOHS
	2	Shelby Tube	4	10 - 10.7	DOHS
			3	9.3 - 10	B&C
			2	8.7 - 9.3	WCC
			1	8 - 8.7	WCC
	4	Shelby Tube	4	15.5 - 16	DOHS
			3*	15 - 15.5	B&C
			2	14.5 - 15	WCC
			1	14 - 14.5	WCC

TABLE 1 (Continued)

SOIL SAMPLE INVENTORY

Soil Boring Number	Soil Sample Number	Sample Type	Specimen Tube Number	Sample Depth Interval (feet)	Distrubution
11	1	Tube	4	1.5 - 2	DOHS
			3**	1 - 1.5	B&C
		Jar	A	2 - 2.2	WCC
	2	Tube	4**	4 - 4.5	DOHS
			3	3.5 - 4	B&C
	3	Jar	A	5 - 7'	WCC (Auger Sample)
	4	Shelby Tube	4	9 - 9.7	DOHS
			3*	8.3 - 9	B&C
			2	7.7 - 8.3	WCC
			1	7 - 7.7	WCC
	5	Shelby Tube	A	10 - 11	B&C

Surface Tar Sample - Near Boring 8*	B&C
Surface Tar Sample - Near Boring 11*	B&C

---

*, **Sample specimen selected for laboratory chemical analyses; specimens for which all analyses were conducted on expedited basis are indicated by double asterisks.

TABLE 2

SELECTED LABORATORY CHEMICAL ANALYSIS RESULTS

ASSESSMENT OF SUBSURFACE CONTAMINANTS

MARKETPLACE PROPERTY

Detected Concentrations of PCB

Boring No./ Sample No.	Approximate Depth (feet)	Detected Concentration of PCB (ppm, wet weight)
4C/1	4.0-5.0	Aroclor 1260: 0.34
5/3	7.0-8.0	Aroclor 1260: 0.12
7/1	2.0-3.0	Aroclor 1260: 0.19
8/1	2.0-3.0	Aroclor 1242: 29.0 Aroclor 1260: 4.0
		Total: 33.0
8/2	4.5-5.5	Aroclor 1242: 9.6 Aroclor 1260: 1.3
		Total: 10.9 ✓

Pressey & Jeanne

Fireman's Fund — dry weight ✓ [illegible], ppm.

Detected Metals Concentrations in Excess of the TTLC

Steve Wilber

Boring No./ Sample No.	Approximate Depth (feet)	Metal		Detected Concentration (ppm, wet weight)	
2/1	2.0-3.0	Copper	2500	370	
		Lead	1000	340	
		Zinc	5000	350	
2/2	4.5-5.5	Copper	2500	1,600	
		Lead	1000	370	1000
		Zinc	5000	800	
4C/1	4.0-5.0	Copper	2500	340	
		Lead	1000	280	
		Zinc	5000	430	

dry weight

TABLE 2 (Continued)

SELECTED LABORATORY CHEMICAL ANALYSIS RESULTS

ASSESSMENT OF SUBSURFACE CONTAMINANTS

MARKETPLACE PROPERTY

Boring No./ Sample No.	Approximate Depth (feet)	Metal		Detected Concentration (ppm, wet weight)
6/1	2.5-3.5	Chromium (III)	~~2500~~ 2500	880
		Copper	~~50~~ 2500	230
		Lead	1000	110
		Zinc	5000	550
7/1	2.0-3.0	Lead	1000	52
8/1	2.0-3.0	Cadmium	500	11
		Chromium (III)	2500	1,000
		Copper	2500	1,100
		Lead	1000	880
		Zinc	5000	2,300
8/2	4.5-5.5	Lead	1000	55
10/1	3.0-4.0	Copper	2500	1,000
		Lead	1000	740
		Nickel	2000	240
		Zinc	5000	1,900
Surface tar near Boring No. 8	---	Lead	1000	50
Surface tar near Boring No. 11	---	Lead	1000	300
		Zinc	5000	290

TABLE 3

GROUNDWATER LEVEL READINGS IN ON-SITE MONITORING WELLS

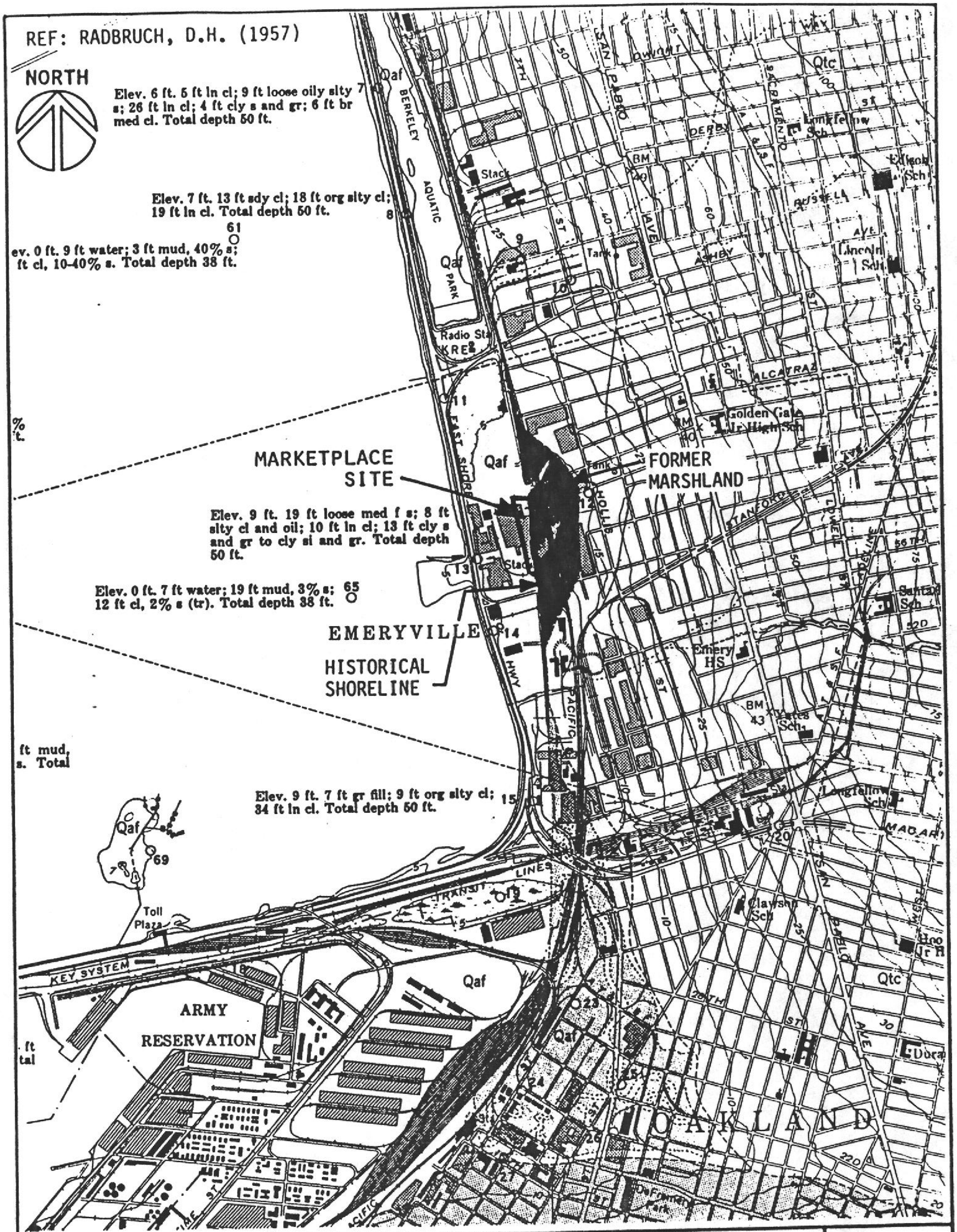
	Groundwater Depth/Elevation* (feet)		
Well No.	Aug. 7, 1981	Sept. 10, 1981	Jan. 18, 1982
4	4.3/6.2	4.4/6.1	2.5/8.0
5	4.7/7.5	4.9/7.3	2.5/9.6
10	1.8/5.8	3.0/4.6	2.5/5.1
12	---	---	4.3/6.0

---

*City of Emeryville Datum

FIGURES

MARKETPLACE CONTAMINANT ASSESSMENT



Project No. 15093A Woodward-Clyde Consultants	GEOLOGIC/TOPOGRAPHIC CONDITIONS IN SITE VICINITY MARKETPLACE CONTAMINANT ASSESSMENT	Figure 2

APPENDIX A

EXPLORATORY SOIL BORINGS AND SOIL SAMPLING

APPENDIX A

EXPLORATORY SOIL BORINGS AND SOIL SAMPLING

Fifteen soil borings were drilled during the subsurface exploration and soil sampling program at the Marketplace site. Locations of the borings are shown in Figures 1 and 3 of this report, and logs of the borings are enclosed as Figures A-1 through A-15, respectively, of this appendix.

Boring Nos. 1 through 11

Boring Nos. 1 through 11 were primary soil borings which were drilled to investigate subsurface soil and groundwater conditions and to provide representative soil samples to be used in the laboratory chemical analysis testing program for assessment of soil contaminants at the site. These borings were drilled during the period July 29 through August 6, 1981, by Pitcher Drilling Company of Palo Alto, California, working under subcontract to Woodward-Clyde Consultants.

Depths of the borings ranged from 9 to 16 feet. Most borings were drilled using the rotary-wash drilling method with bentonite drilling fluid. Nominal chemical composition of the bentonite used is summarized in a technical bulletin by the product manufacturer, enclosed herein as Figure A-a. Borings were generally advanced by augering to groundwater level, located at depths of 3 to 5 feet below ground surface, with rotary-wash drilling below groundwater. For some shallow borings which had negligible groundwater inflow and no evidence of soil fall-in from the borehole walls, the borings were continued to full depth using continuous flight auger equipment.

All boring locations, depths, drilling and sampling methods, decontamination procedures and chain-of-custody protocol for soil samples were in strict accordance with agreements reached with the California Department of Health Services. All boring locations and surface elevations were established by surveying done by the firm of George S. Nolte and Associates of Walnut Creek, California, working under subcontract to Woodward-Clyde Consultants. All borings were drilled and sampled with continuous on-site supervision of Woodward-Clyde Consultants engineers. Mr. Lowell Miller of the California Department of Health Services was present on-site to observe field procedures for most borings.

Each boring was logged by Woodward-Clyde Consultants engineers. Soil cuttings and soil samples obtained from the borings were examined and classified continuously during drilling in accordance with the Unified Soil Classification System, summarized herein as Figure A-b. Groundwater level measurements were obtained at each boring location during drilling.

Most soil samples were obtained from the borings using a 2 1/2-inch (inside diameter) modified California drive sampler containing brass liners. A detail sketch of this sampler is shown in Figure A-c. Where occasional sampling difficulties were encountered in loose sands or soft clays, a 2-inch (inside diameter) modified California drive sampler (Figure A-d) or 2 7/8-inch (inside diameter) thin-walled Shelby tubes, used with a Shelby Tube Sampler (Figure A-e) or a piston-equipped Osterberg Sampler (Figure A-f), were employed to improve sample recovery. Descriptions of the use of these samplers and of the sample handling and distribution protocol observed for this project are provided under "Sampling Methods" in the main text of this report.

Drafted logs of the soil borings are given in Figures A-1 through A-11. A legend to the boring logs is provided in Figure A-g. Locations of soil samples and types of samplers used in the borings are shown in the logs at the corresponding sample depths.

Methods used to backfill completed boreholes are discussed under "Decontamination Procedures" in the main text of this report. All waste soils and drilling fluid obtained from the borings were placed in sealed 55-gallon drums which were then transported to Woodward-Clyde Consultants Oakland laboratory for temporary storage and appropriate disposal pending completion of the laboratory testing program.

Boring Nos. 12 through 15

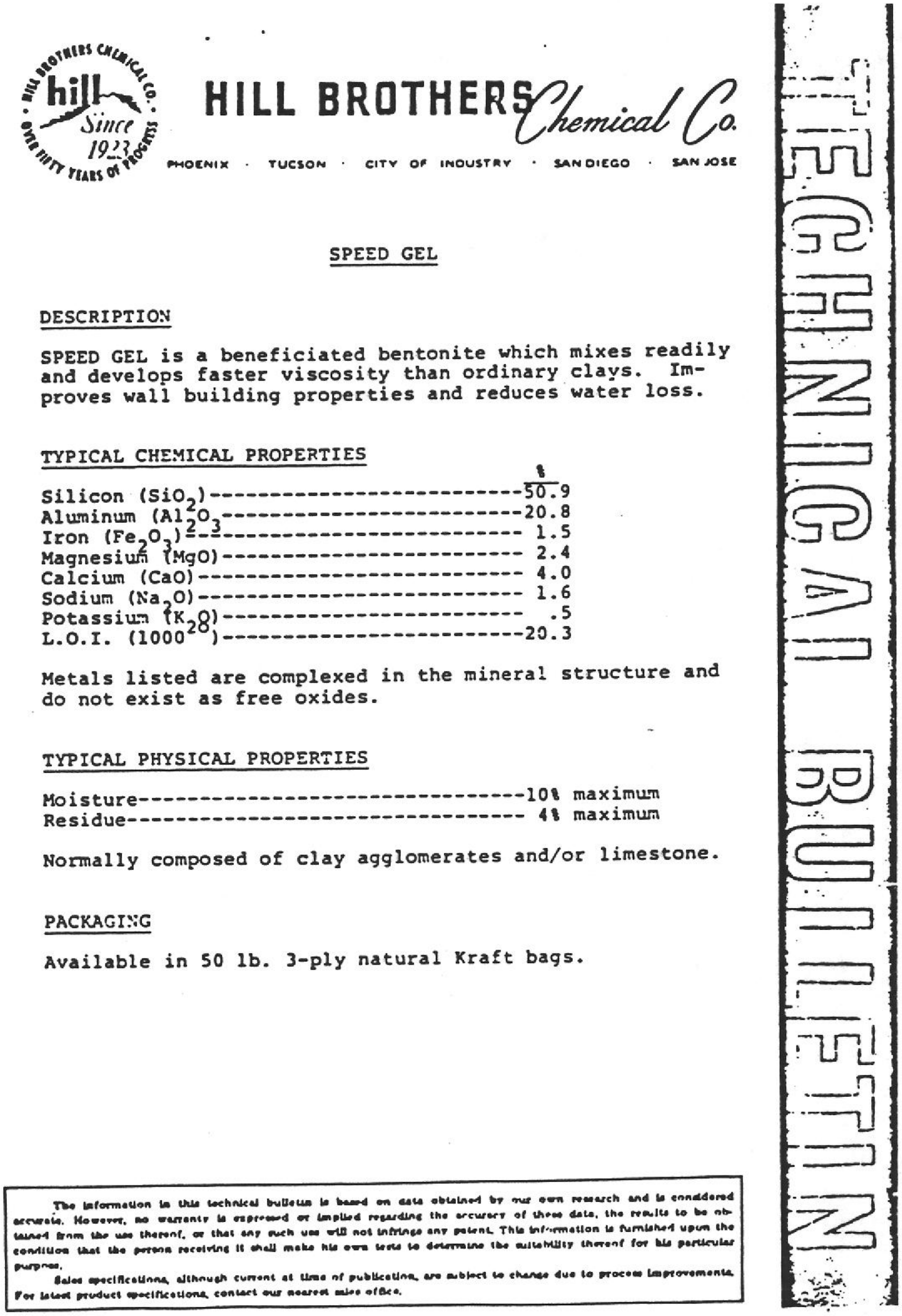
Boring Nos. 12 through 15 were drilled subsequent to the initial subsurface exploration and laboratory soil testing programs to provide supplementary information regarding possible abandoned, buried storage tanks at the site, as discussed under "Subsurface Tank Investigation" in the main text of this report.

Specifically, Boring No. 12 was drilled and developed to serve as a groundwater monitoring well located down groundwater gradient from Tank Areas B, C and D, as shown in Figures 1 and 3 of this report. Installation of this well was requested by the California Regional Water Quality Control Board in its January 15, 1982 letter to Equity Financial and Management Company. This boring was drilled on January 14, 1982 by AAA Drilling Company of Hayward, California, working under subcontract to Woodward-Clyde Consultants, and under the on-site supervision of Woodward-Clyde Consultants engineers. The boring was drilled using truck-mounted 6-inch-diameter continuous flight auger equipment. The boring was observed and logged during drilling by Woodward-Clyde Consultants engineers, and a log of the boring is presented in Figure A-12. Additional information regarding piezometer installation and groundwater sampling protocol is presented in Appendix B.

Boring Nos. 13, 14 and 15 were drilled in Tank Area D as part of the supplementary field investigation conducted to determine whether buried tanks are present at the locations shown in Figures 1 and 3, as requested by the California Department of Health Services in its December 29, 1981 letter to Equity Financial and Management Company. The borings were drilled on February 5, 1982 by AAA Drilling Company, under subcontract to Woodward-Clyde Consultants. The borings were drilled to depths of 10, 4-1/2 and 8 feet, respectively, using truck-mounted 6-inch-diameter continuous flight auger equipment. The borings were supervised, observed and logged at the site by Woodward-Clyde Consultants engineers.

Very difficult drilling conditions were encountered in all 3 borings due to presence of thick, reinforced concrete slabs and concrete rubble fill. Boring Nos. 13 and 15 were continued to depths which were judged to be sufficient to provide the desired information concerning buried tanks. However, Boring No. 14 was abandoned at a depth of 4-1/2 feet where an obstacle, which may have been a buried pipe or conduit, was encountered.

Soil samples were obtained from the auger blades and placed immediately in glass jars. The jars were stored on-site in refrigerated containers, and then transported at the end of the day to Woodward-Clyde Consultants' Oakland laboratory for refrigerated storage. Logs of the borings are presented in Figures A-13, A-14 and A-15. Soil sample lcoations are shown in the logs at the corresponding sample depths.



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TECHNICAL BULLETIN

SPEED GEL

DESCRIPTION

SPEED GEL is a beneficiated bentonite which mixes readily and develops faster viscosity than ordinary clays. Improves wall building properties and reduces water loss.

TYPICAL CHEMICAL PROPERTIES

	%
Silicon (SiO_2)	50.9
Aluminum (Al_2O_3	20.8
Iron (Fe_2O_3)	1.5
Magnesium (MgO)	2.4
Calcium (CaO)	4.0
Sodium (Na_2O)	1.6
Potassium (K_2O)	.5
L.O.I. (1000°)	20.3

Metals listed are complexed in the mineral structure and do not exist as free oxides.

TYPICAL PHYSICAL PROPERTIES

Moisture	10% maximum
Residue	4% maximum

Normally composed of clay agglomerates and/or limestone.

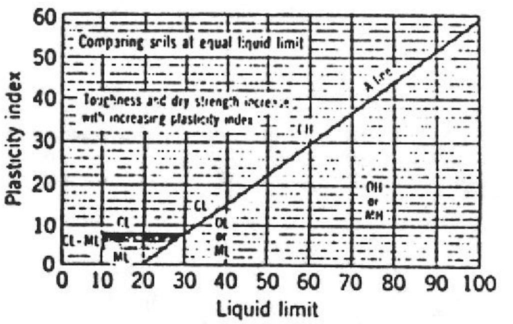
PACKAGING

Available in 50 lb. 3-ply natural Kraft bags.

Project No. 15093A **Woodward-Clyde Consultants**	NOMINAL COMPOSITION, "SPEED GEL" BENTONITE MARKETPLACE CONTAMINANT ASSESSMENT	Figure A-a

Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights)					Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria			
Coarse-grained soils More than half of material is *larger* than No. 200 sieve size[b] (The No. 200 sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than No. 7 sieve size	(For visual classification, the ¼ in. size may be used as equivalent to the No. 7 sieve size)	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)	Use grain size curve in identifying the fractions as given under field identification	Determine percentages of gravel and sand from grain size curve Depending on percentage of fines (fraction smaller than *No.* 200 sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP* More than 12% *GM, GC, SM, SC* 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
				Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines				Not meeting all gradation requirements for *GW*	
			Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures				Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
				Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures				Atterberg limits above "A" line, with *PI* greater than 7	
	Sands More than half of coarse fraction is smaller than No. 7 sieve size		Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines				$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
				Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines				Not meeting all gradation requirements for *SW*	
			Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures				Atterberg limits below "A" line or *PI* less than 5	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
				Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures				Atterberg limits below "A" line with *PI* greater than 7	

Identification Procedures on Fraction Smaller than No. 40 Sieve Size					Group Symbols[a]	Typical Names	Information Required for Describing Soils
		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)			
Fine-grained soils More than half of material is *smaller* than No. 200 sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

From Wagner, 1957.

[a] *Boundary classifications*. Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW-GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus No. 40 sieve size particles, approximately $\frac{1}{64}$ in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking):

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics):

After removing particles larger than No. 40 sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit):

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eight inch in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Woodward-Clyde Consultants

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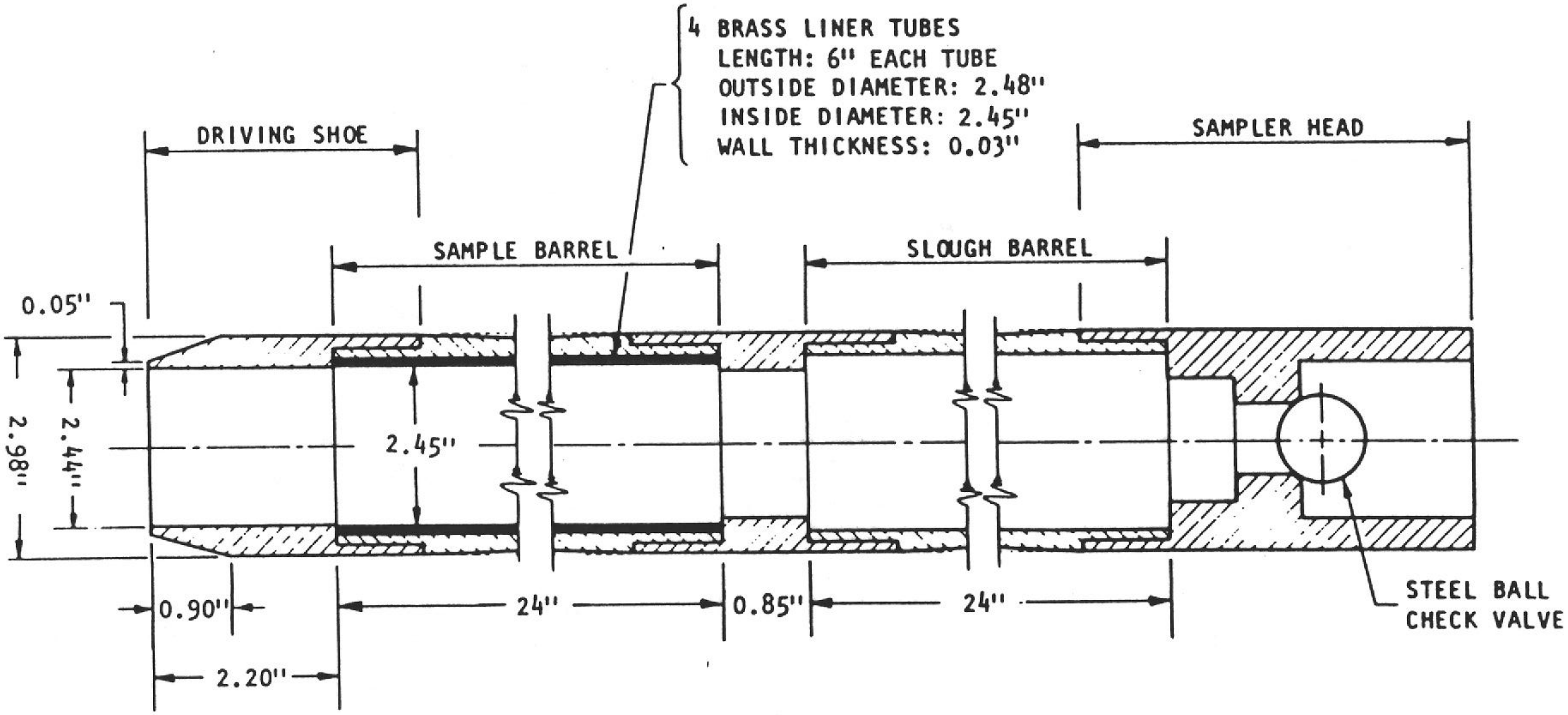
UNIFIED SOIL CLASSIFICATION SYSTEM
MARKETPLACE CONTAMINANT ASSESSMENT

Figure A-b

SKETCH NOT TO SCALE



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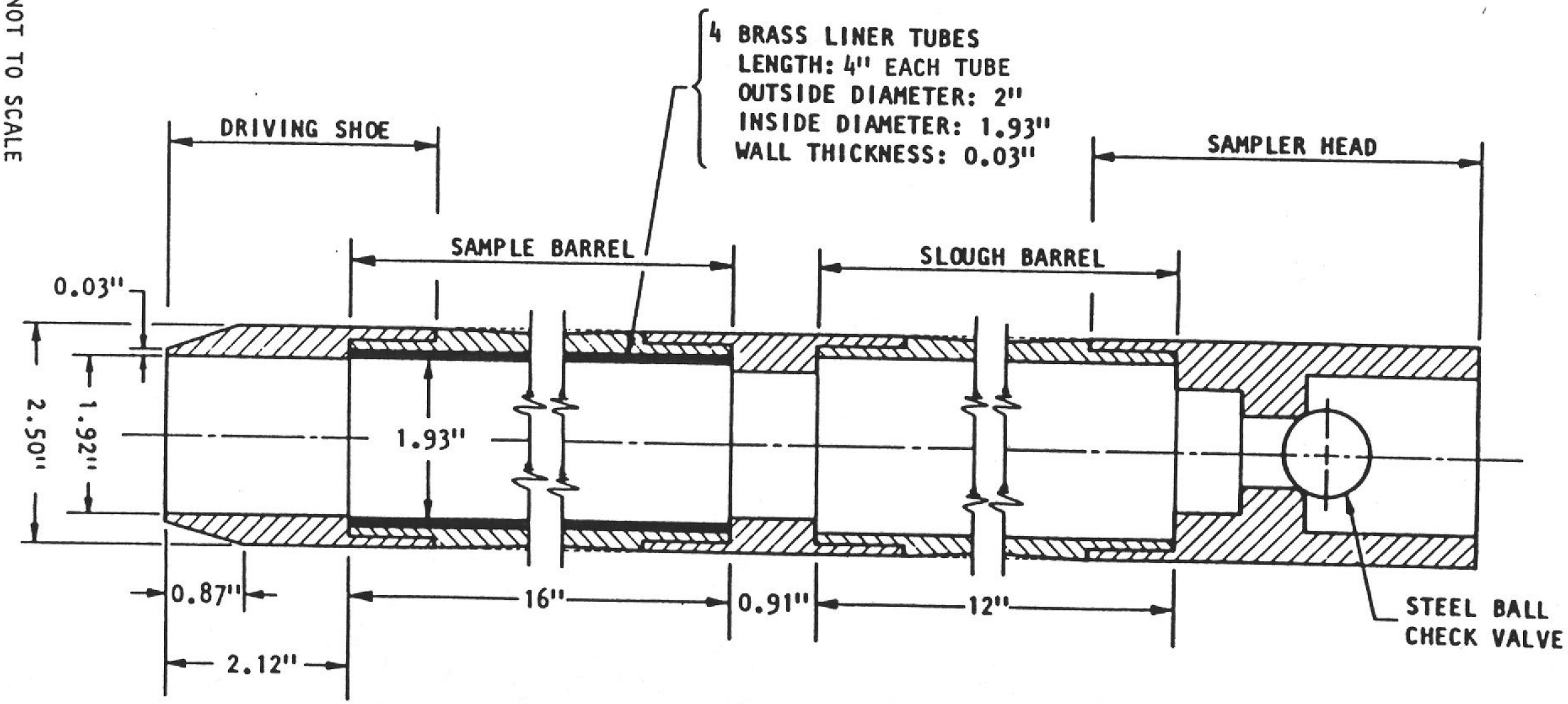
Project No. 15093A

2½" MODIFIED CALIFORNIA SAMPLER ASSEMBLY

MARKETPLACE CONTAMINANT ASSESSMENT

Figure A-c

SKETCH NOT TO SCALE



NOTE:

SAMPLE BARREL AND SLOUGH BARREL ARE MACHINED TO 2.45" O.D.

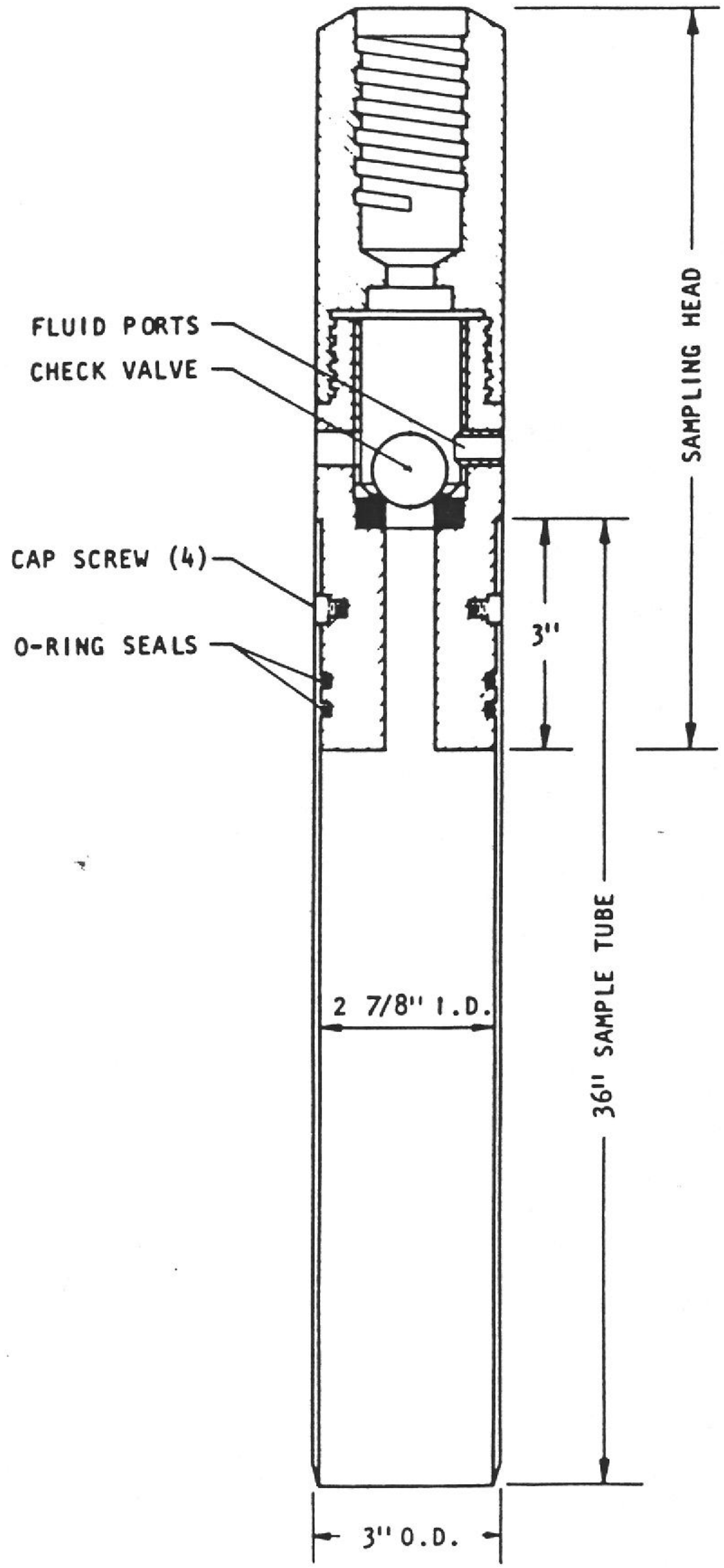
Woodward-Clyde Consultants

Project No. 15093A

2" MODIFIED CALIFORNIA SAMPLER ASSEMBLY

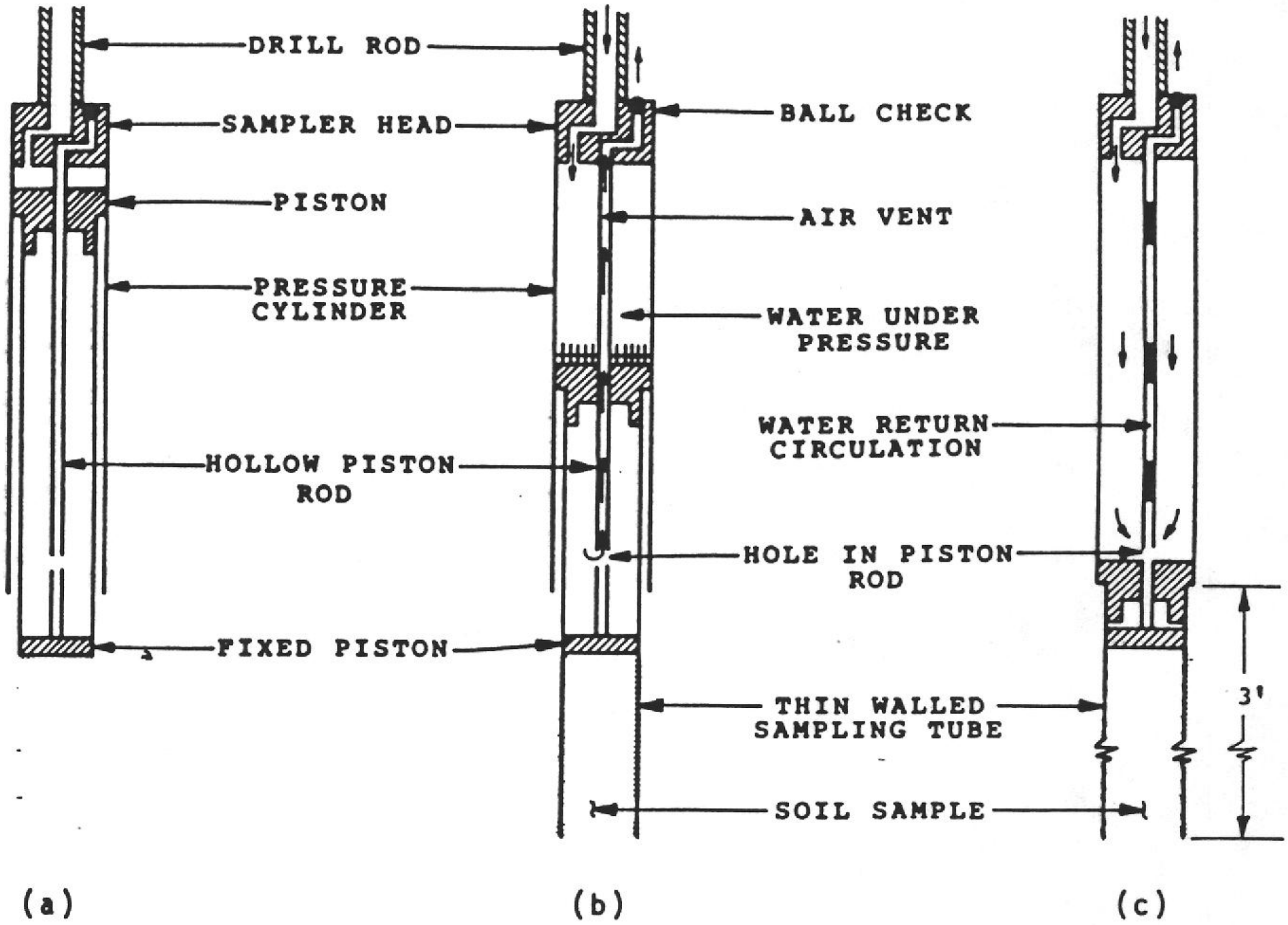
MARKETPLACE CONTAMINANT ASSESSMENT

Figure A-d



SKETCH NOT TO SCALE

Project No. 15093A **Woodward-Clyde Consultants**	SHELBY TUBE SAMPLER ASSEMBLY MARKETPLACE CONTAMINANT ASSESSMENT	Figure A-e



(a) SAMPLER BEING LOWERED INTO DRILL HOLE;
(b) WATER PRESSURE BEING APPLIED THROUGH DRILL ROD;
(c) PISTON HAS REACHED FULL STROKE.

SAMPLER OVERALL DIAMETER	SAMPLER TUBE SIZE			
	NOMINAL	O.D.	I.D.	LENGTH
3-3/4"	3"	3"	2-7/8"	36"

SKETCH NOT TO SCALE

Project No. 15093A
Woodward-Clyde Consultants

OSTERBERG PISTON SAMPLER
MARKETPLACE CONTAMINANT ASSESSMENT

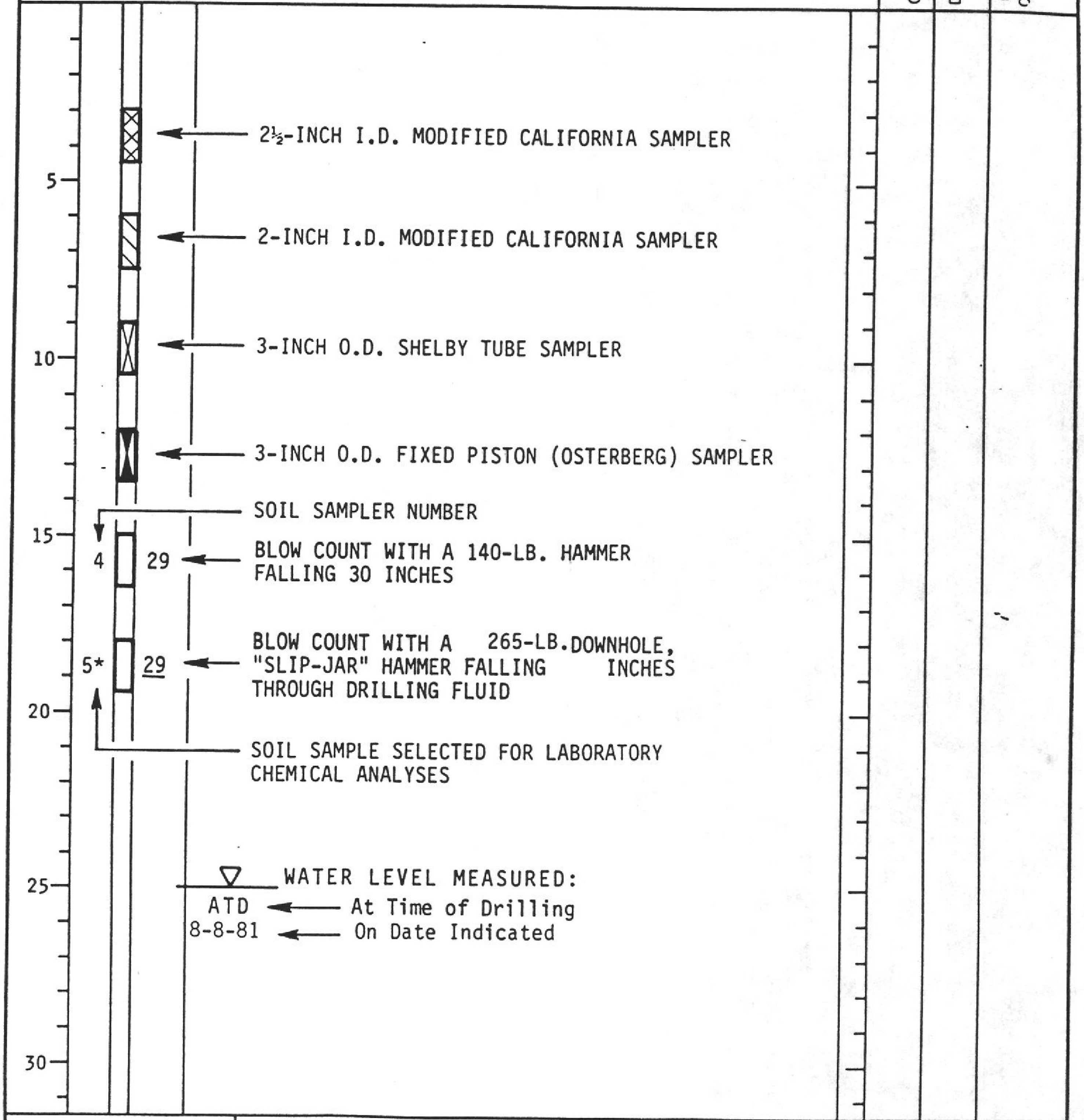
Figure A-f

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

BORING LOG LEGEND SHEET

Date Drilled: ______
Type of Boring: ______
Hammer Weight: ______
Remarks: ______

Depth, Ft | Samples | Blows/Ft | DESCRIPTION | LABORATORY TESTS: Moisture Content, % | Dry Density, pcf | Unconfined Compressive Strength, psf



2½-INCH I.D. MODIFIED CALIFORNIA SAMPLER

2-INCH I.D. MODIFIED CALIFORNIA SAMPLER

3-INCH O.D. SHELBY TUBE SAMPLER

3-INCH O.D. FIXED PISTON (OSTERBERG) SAMPLER

SOIL SAMPLER NUMBER

BLOW COUNT WITH A 140-LB. HAMMER FALLING 30 INCHES

BLOW COUNT WITH A 265-LB. DOWNHOLE, "SLIP-JAR" HAMMER FALLING INCHES THROUGH DRILLING FLUID

SOIL SAMPLE SELECTED FOR LABORATORY CHEMICAL ANALYSES

WATER LEVEL MEASURED:
ATD ← At Time of Drilling
8-8-81 ← On Date Indicated

Proj. No. 15093A

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Figure A-9

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 1

Date Drilled: Auger/Rotary
Type of Boring: July 30, 1981
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS		
				Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation: 8.64' City of Emeryville Datum			
			2" Asphalt GRAVELLY SANDY CLAY; AGGREGATE BASE MATERIAL			
	1	25	FILL			
			SILTY CLAY (CH) Medium stiff to stiff, damp, dark brown, Bay Mud			
	2*	30	SILTY CLAY (CL-CH) Medium stiff to stiff, moist, green-gray			
5						
			BOTTOM OF HOLE @ 5½'			
10						
15						

Proj. No. 15093A

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Figure A-1

Project: MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 1A

Date Drilled: August 5, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation: 8.73' City of Emeryville Datum			
			2" Asphalt 10" SANDY GRAVELLY CLAY; AGGREGATE BASE MATERIAL			
			SANDY CLAY FILL : Damp, with rocks FILL			
			SILTY CLAY (CH) Stiff, dark brown, with organics, fibers, roots; Bay Mud			
			SILTY CLAY (CL-CH) Stiff, moist, green-gray, with root fibers, trace dark gray and brown			
5			Becomes stiff to very stiff, wet, gray and light brown mottled, trace fine gravel			
	1 ▨	11				
			▽ 8-6-81			
10			BOTTOM OF HOLE @ 9'			
15						

Proj. No. 15093A

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Figure A-1a

Project: MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 2

Date Drilled: August 3, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation: 8.78' City of Emeryville Datum			
			2" Asphalt 10" GRAVELLY CLAY; AGGREGATE BASE MATERIAL			
	1*	41	RUBBLE FILL Concrete, brick fragments, gravel to 1" Ø in sand Asphalt piece			
	2*	48	SILTY CLAY FILL Medium stiff to stiff, dark green, with wood pieces, gravel			
5	3	28/2"	SAND / SANDSTONE FILL Dense, black / hard, green, with rubble, gravel to 1" Ø Wood			
	4	38	FILL			
			SILTY CLAY (CL): Stiff to very stiff, light brown, with some green-gray mottling, with trace fine gravel Becomes stiffer			
10	5	92	SANDY CLAY (CL): Very stiff, light brown, orange brown and gray mottled, with some gravel			
			BOTTOM OF HOLE @ 11'			
15						

Proj. No. 15093A

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Figure A-2

Project: MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 2A,B,C

Date Drilled: August 3, 1981

Type of Boring: Auger

Hammer Weight: ---

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 6" GRAVELLY CLAY; AGGREGATE BASE MATERIAL			
			SANDY GRAVELLY CLAY FILL Medium stiff, moist, gray-green, with brick, concrete and wood			
			▽ Water level for Boring No. 2C 8-4-81			
5			Concrete slab or foundation			
			BOTTOM OF HOLE @ 5½'			
10						
15						

Proj. No. 15093A

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Figure A-1a,b,c

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 3

Date Drilled: July 29, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Surface Elevation: 10.65'City of Emeryville Datum

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			2" Asphalt CLAYEY GRAVELLY SAND; AGGREGATE BASE MATERIAL Medium dense, moist, brown			
			SAND FILL : With concrete chunks			
	1*	40	SILTY CLAY FILL : Medium stiff, light brown to brown			
			← With brick fragments RUBBLE FILL Brick pieces, sand, clay, dark brown, mixed with organic silty clay, petroleum odor FILL ↑			
5	2	10	SILTY CLAY (CL): Medium stiff to stiff, green-gray mottled light brown ↓ Becomes sandy and gravelly			
	3*	27				
	4	12				
10			BOTTOM OF HOLE @ 10'			
15						

Proj. No. 15093A

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Figure A-3

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 3A

Date Drilled: July 30, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.
Remarks:
(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content, %	LABORATORY TESTS: Dry Density, pcf	LABORATORY TESTS: Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 8" CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			RUBBLE FILL Bricks, concrete, in brown sandy clay matrix ← (½" iron railing, 12" long)			
5	1	11	▽ ATD SILTY CLAY (CH) Medium stiff, moist, dark brown; Bay Mud With concrete chunks With petroleum odor @ 6'-6½'			
10	2	33	GRAVELLY CLAY to CLAYEY SAND & GRAVEL (CL/GC) Dense, blue green, fine gravel With less clay			
			BOTTOM OF HOLE @ 10'			
15						

Proj. No. 15093A

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Figure A-3a

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 3B

Date Drilled: August 6, 1981
Type of Boring: Auger/Rotary
Hammer Weight: ---
Remarks:
(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS		
				Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 6" GRAVELLY SANDY CLAY; AGGREGATE BASE MATERIAL			
			SILTY SAND FILL Medium dense, damp, gray, with wood, firebrick, bricks obstruction - concrete			
			BOTTOM OF HOLE @ 3'			
5						
10						
15						

Proj. No. 15093A

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Figure A-3b

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 3C

Date Drilled: August 6, 1981
Type of Boring: Auger/Rotary
Hammer Weight: ---

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content,%	 Dry Density, pcf	 Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt			
			8" GRAVELLY SANDY CLAY; AGGREGATE BASE MATERIAL			
			CLAYEY SAND FILL: Loose to medium dense, moist, brown, with brick, wood, concrete			
			With concrete piece			
			With petroleum odor			
			BOTTOM OF HOLE @ 2½'			
5						
10						
15						

Proj. No. 15093A

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Figure A-3c

Project: MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 3D

Date Drilled: August 6, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS		
				Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 6" GRAVELLY SANDY CLAY; AGGREGATE BASE MATERIAL			
			SANDY CLAY FILL (CL) Medium stiff, moist, brown and dark brown, with brick fragments FILL			
	1	7	SILTY CLAY (CH) Medium stiff, moist, dark brown, with organics; Bay Mud			
5			SILTY CLAY (CL) Soft to medium stiff, green-gray and black With petroleum odor; Bay Mud			
	2*		SILTY CLAY (CL) Medium stiff to stiff, green-gray, with trace gravel			
			BOTTOM OF HOLE @ 7'-8"			
10						
15						

Proj. No. 15093A

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Figure A-3d

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 4

Date Drilled: August 4, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content, %	LABORATORY TESTS: Dry Density, pcf	LABORATORY TESTS: Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
	1 ☒	77	FINE SAND FILL (SP-SM): Medium dense, brown, with some brick fragments and gravel			
			CLAYEY SAND FILL (SC) Medium dense, brown and green, with brick fragments and large pieces of wood (3"), petroleum odor w/ black-stained sandy clay @ 2'			
			BOTTOM OF HOLE @ 2½' Concrete obstruction			
5						
10						
15						

Proj. No. 15093A

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Figure A-4

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 4A

Date Drilled: August 4, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS		
				Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 8" CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			CLAYEY SAND FILL (SC) Medium dense, moist, brown, with concrete and brick fragments			
	1 ☒	24/6"	Tar, concrete obstruction With concrete slab and brick rubble			
			BOTTOM OF HOLE @ 3½'			
5						
10						
15						

Proj. No. 15093A

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Figure A-4a

Project: MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 4B

Date Drilled: August 4, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.
Remarks:
(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS		
				Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 8" CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			SAND FILL (SM) Medium dense, damp, brown, with brick fragments } Wood piling, with tar obstruction			
			BOTTOM OF HOLE @ 3½'			
5						
10						
15						

Proj. No. 15093A

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Figure A-4b

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 4C

Date Drilled: August 4, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks: Piezometer installed

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS		
				Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation: 10.45' City of Emeryville Datum			
			2" Asphalt 8" CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			SAND FILL (SP) Medium dense, damp, brown, with brick			
			SILTY FINE SAND FILL (SM) Medium dense to dense, moist, green-gray ▽ 1-18-82			
	1*	25	8-7-81 ▽ 9-10-81 ▽			
5			SAND FILL (SP) Dense, black, petroleum odor Becomes clayey FILL ↑			
	2	30	SILTY CLAY (CL-CH) Stiff, moist, light brown Grades to green-gray, with trace brown			
			Grades to blue-gray, with trace brown, becomes sandy			
	3*	15				
10						
			SILTY CLAY (CL) Stiff, moist, brown			
	4	17	CLAYEY SANDY GRAVEL (GC) Dense, wet, brown			
			BOTTOM OF HOLE @ 12½'			
15						

Proj. No. 15093A

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Figure A-4c

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 4D

Date Drilled: August 6, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	LABORATORY TESTS Dry Density, pcf	LABORATORY TESTS Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 6" CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			SAND FILL Loose to medium dense, damp, brown, with brick fragments and powder			
			FINE SILTY SAND (SM/ML) Medium dense, moist, green, with some gravel			
	1	P	Grades to sand and gravel			
5			Approx. 2" of black, sandy clay, with petroleum odor FILL			
	2	7	SILTY CLAY (CL): Medium stiff to stiff, moist, green, with some gravel			
			SILTY CLAY (CL): Stiff, light brown-gray			
			BOTTOM OF HOLE @ 7'			
10						
15						

Proj. No. 15093A

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Figure A-4d

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 5

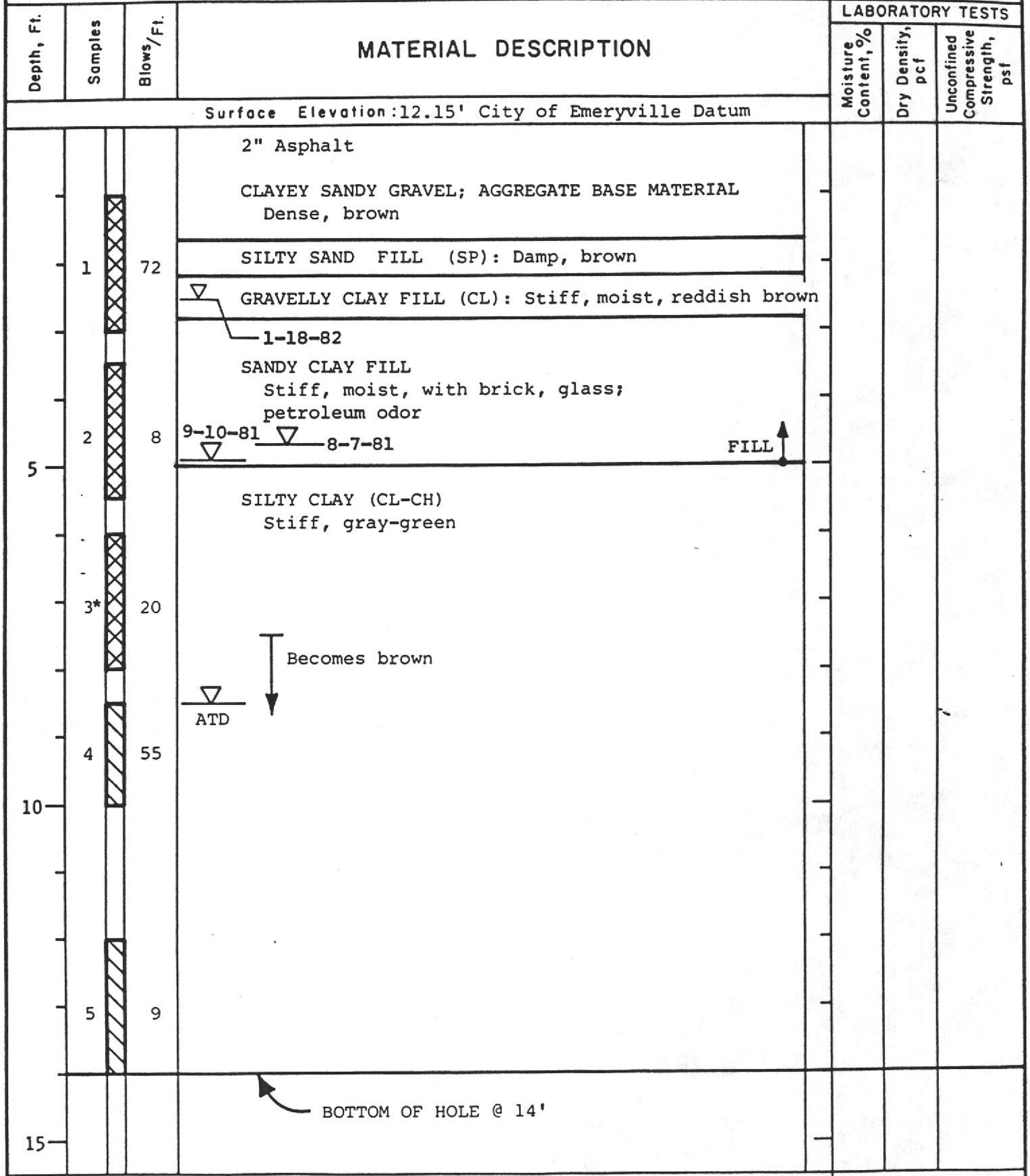
Date Drilled: July 30, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks: Piezometer installed; water surface appeared oily

(See Legend Sheet for sampler types and hammer weights)

Surface Elevation: 12.15' City of Emeryville Datum

Samples	Blows/Ft.
1	72
2	8
3*	20
4	55
5	9



2" Asphalt

CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL
Dense, brown

SILTY SAND FILL (SP): Damp, brown

GRAVELLY CLAY FILL (CL): Stiff, moist, reddish brown

SANDY CLAY FILL
Stiff, moist, with brick, glass; petroleum odor

SILTY CLAY (CL-CH)
Stiff, gray-green

Becomes brown

BOTTOM OF HOLE @ 14'

Proj. No. 15093A

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Figure A-5

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 5A

Date Drilled: August 3, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content,%	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			2" Asphalt CLAYEY SAND FILL With brick fragments With slight petroleum odor FILL			
5	1*	P	SILTY CLAY Soft to medium stiff, black, with heavier petroleum odor; Bay Mud			
	2	P	SILTY CLAY (CL) Medium stiff, gray to blue-gray, with some gravel			
10			BOTTOM OF HOLE @ 8'-10"			
15						

Proj. No. 15093A

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Figure A-5a

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 6

Date Drilled: July 30, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks: **Water appears perched over sandy clay layer (see Boring No. 6A)

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	 Dry Density, pcf	 Unconfined Compressive Strength, psf
			Surface Elevation: 9.89' City of Emeryville Datum			
			2" Asphalt 10" CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL Moist, brown			
	1*	54	CLAYEY SAND AND GRAVEL FILL Light brown ▽** ATD			
			SANDY CLAY Very stiff, moist, orange-brown, with some gravel to 1" Ø FILL ↑			
5	2	11	SILTY CLAY (CH) Medium stiff, dark brown; Bay Mud			
	3	11	GRAVELLY CLAY / CLAYEY GRAVEL (CL/GC) Medium stiff/dense, blue-green to blue-gray Grades to gravel (GP) Grades to sand (SP) Medium dense, light brown-gray			
10	4	38	Grades to sand and gravel with some clay, dense			
			BOTTOM OF HOLE @ 11'			
15						

Proj. No. 15093A

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Figure A-6

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 6A

Date Drilled: August 5, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content, %	LABORATORY TESTS: Dry Density, pcf	LABORATORY TESTS: Unconfined Compressive Strength, psf
			Surface Elevation: 9.40' City of Emeryville Datum			
			2" Asphalt 10" CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			SANDY GRAVELLY CLAY (CL): Medium stiff to stiff, brown			
			FINE SAND (SP): Medium dense, moist, green			
	1	38	GRAVELLY CLAY FILL Medium stiff to stiff, moist, green with trace brown, brick fragments			
			8-6-81 ▽ CLAYEY SAND (SC) Dense, dark brown, with some gravel FILL ↑			
5	2	30	SILTY CLAY (CH): Medium stiff to stiff, dark brown, with organics and some sand; Bay Mud			
			SILTY CLAY Soft to medium stiff, green, brown and gray, with some gravel			
	3	5	SANDY GRAVELLY CLAY (CL) Soft to medium stiff, green			
			BOTTOM OF HOLE @ 8'			
10						
15						

Proj. No. 15093A

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Figure A-6a

Project: MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 7

Date Drilled: July 29, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Surface Elevation: 10.70' City of Emeryville Datum

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			2" Asphalt			
			CLAYEY GRAVELLY SAND; AGGREGATE BASE MATERIAL Dense, dry, brown			
	1*	33	SILTY SAND (SP/SM) Dense, moist, light gray and brown Grades to gray, with some wood fragments, brick fragments and some clay, concrete chunks to 3/4" Ø			
	2	11/6"	Becomes more clayey (Rubble Fill)			
5			ATD ▽ FILL ↑			
	3		SILTY CLAY (CH) Soft to medium stiff, dark brown, with organics; Bay Mud			
			SILTY CLAY (CL) Medium stiff, blue-gray, with trace shells			
	4	25	Grades to gravelly clay with some sand inclusions			
10			BOTTOM OF HOLE @ 10'			
15						

Proj. No. 15093A

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Figure A-7

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 8

Date Drilled: July 31, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Surface Elevation: 9.49' City of Emeryville Datum

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			2" Asphalt CLAYEY SANDY GRAVEL; AGGREGATE BASE MATERIAL			
	1*	27	CLAYEY GRAVEL (FILL) ATD Dense, moist, light brown, to 1" Ø With piece of hard tar approx. 1" Ø FILL			
	2*	6	SILTY CLAY (CL): Medium stiff, gray and brown mottled; Bay Mud			
5			SILTY CLAY (CL) Stiff, light brown and dark brown mottled, with some fine gravel			
	3	34	SILTY CLAY (CL) Very stiff, orange-brown, with some fine gravel			
	4	56	CLAYEY GRAVEL Very dense, brown gravel, orange-brown clay			
10						
	5	42				
			BOTTOM OF HOLE @ 11½'			
15						

Proj. No. 15093A

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Figure A-8

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 9

Date Drilled: August 5, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.
Remarks:
(See Legend Sheet for sampler types and hammer weights)

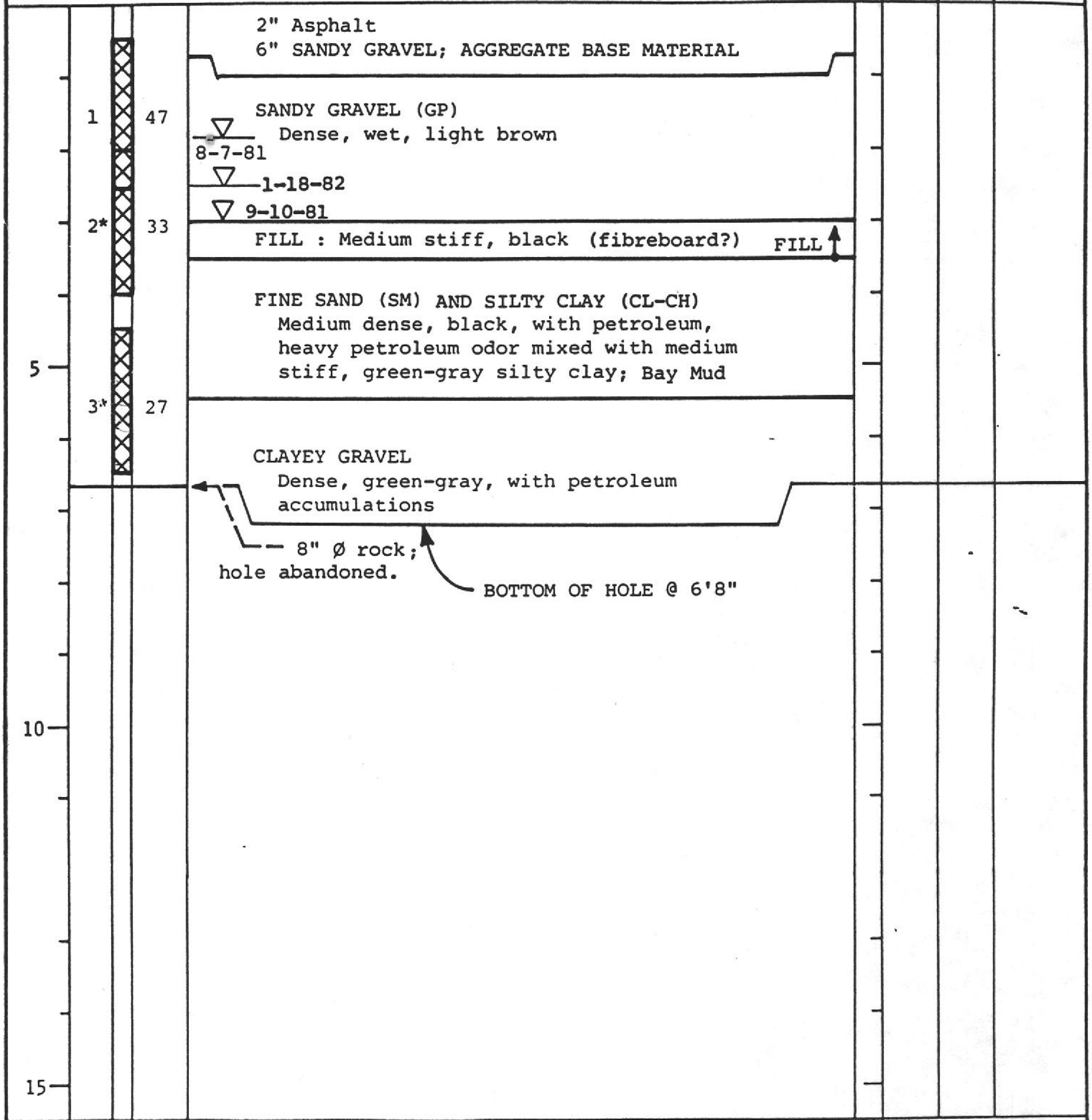
Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation: 10.32' City of Emeryville Datum			
			2" Asphalt 8" SANDY GRAVEL; AGGREGATE BASE MATERIAL Damp, brown			
	1	33	SANDY GRAVEL FILL (GP) ▽ ATD Medium dense, wet, with piece sheet metal, gravel to 4" Ø			
	2*	6	CLAYEY GRAVEL FILL (GC): Loose to medium dense, dark green-gray, with kerosene odor FILL ↑			
5			SILTY CLAY (CL) Medium stiff, green-gray, with occasional light brown mottling, petroleum odor — Becomes stiffer, with no petroleum odor			
	3*	25	With trace fine gravel — With slight petroleum odor			
	4*	20	SANDY CLAY (CL): Stiff, green, with some gravel			
10			SILTY CLAY Light brown and gray mottled, with trace gravel			
			BOTTOM OF HOLE @ 10½'			
15						

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 10

Date Drilled: August 4, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.
Remarks: Piezometer installed @ 12'
(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation: 7.56' City of Emeryville Datum			
	1	47				
	2*	33				
	3*	27				



2" Asphalt
6" SANDY GRAVEL; AGGREGATE BASE MATERIAL

SANDY GRAVEL (GP)
Dense, wet, light brown

FILL : Medium stiff, black (fibreboard?)

FINE SAND (SM) AND SILTY CLAY (CL-CH)
Medium dense, black, with petroleum, heavy petroleum odor mixed with medium stiff, green-gray silty clay; Bay Mud

CLAYEY GRAVEL
Dense, green-gray, with petroleum accumulations

8" Ø rock; hole abandoned.

BOTTOM OF HOLE @ 6'8"

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-10

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 10A

Date Drilled: August 5, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS: Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 8" SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			SANDY GRAVELLY CLAY FILL Medium stiff, moist Becomes wet			
			SILTY CLAY (CL) Medium stiff, green-gray mixed with black			
			FILL : Medium stiff, black, with organic pieces, may be fibreboard or insulation			
5			BOTTOM OF HOLE @ 4½' (obstruction)			
10						
15						

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-10a

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 10B

Date Drilled: August 5, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS		
				Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 8" SANDY GRAVEL; AGGREGATE BASE MATERIAL			
			MIXED SAND GRAVEL AND CLAY FILL Medium dense, wet, brown and green-gray			
			FILL : Medium stiff, black, organic, possible old fibreboard			
			SILTY CLAY : Medium stiff, green-gray with black, with sand lenses, shells, slight ammonia odor			
5			BOTTOM OF HOLE @ 3½' (obstruction)			
10						
15						

Proj. No. 15093A

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Figure A-10b

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 10C

Date Drilled: July 30, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			2" Asphalt 8"GRAVELLY SANDY CLAY; AGGREGATE BASE MATERIAL			
			GRAVEL Medium dense, wet, purplish brown, rocks to 6" Ø, piece of metal, piece of slag, with some clay FILL			
5	1	13	SILTY CLAY Soft to medium stiff, green-gray with some black, shells, ammonia odor; Bay Mud Becomes gravelly, with petroleum accumulations, no ammonia odor			
	2	48	GRAVEL (GP) Dense, green, with shells, fine gravel to 3/8" Ø			
10	3	P	SILTY CLAY (CL-CH) Soft to medium stiff, green-gray mottled with gray			
			BOTTOM OF HOLE 10½'			
15						

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-10c

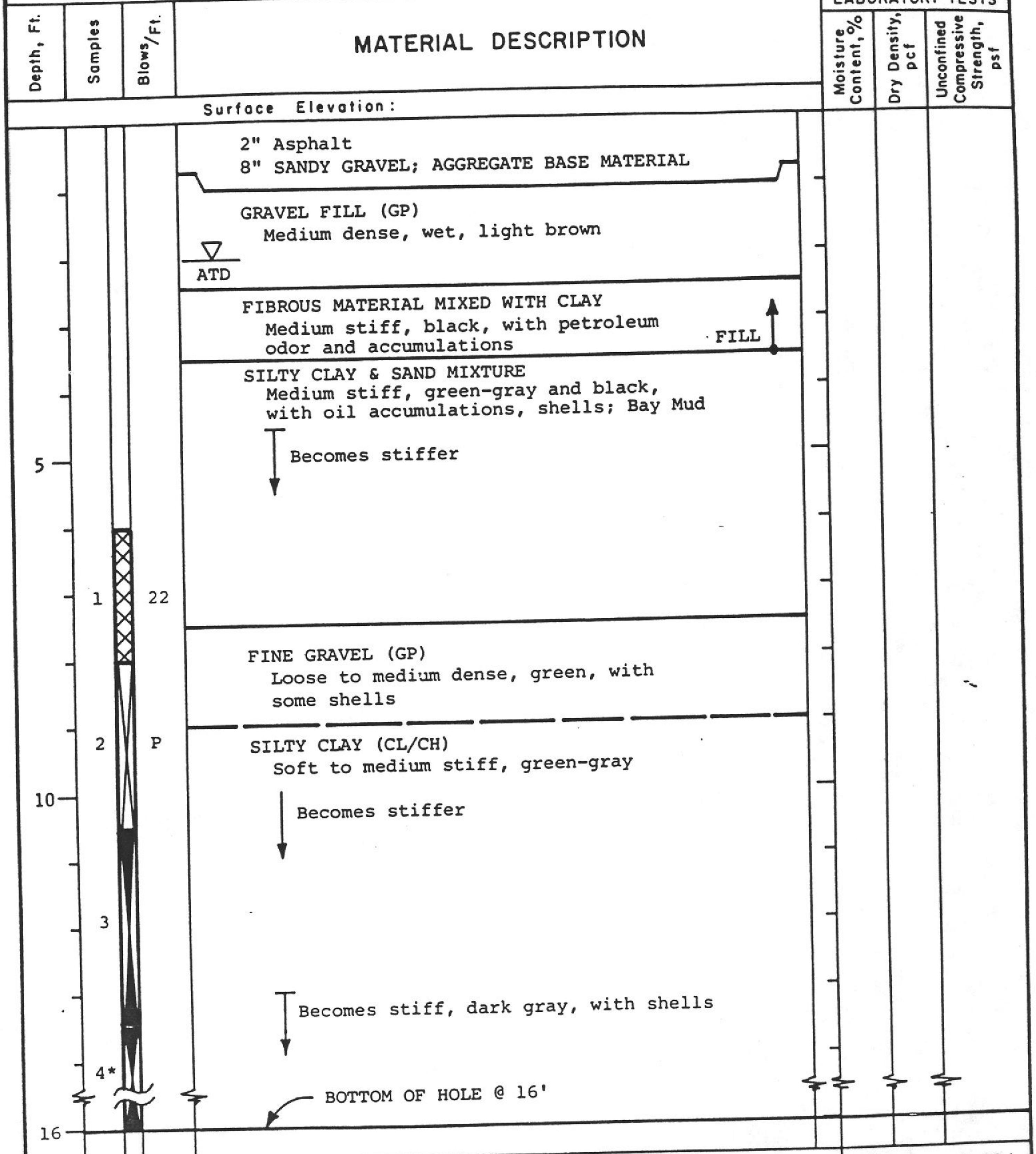
Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 10D

Date Drilled: August 6, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)



Depth, Ft.	Samples	Blows/Ft.
	1	22
	2	P
	3	
	4*	

2" Asphalt
8" SANDY GRAVEL; AGGREGATE BASE MATERIAL

GRAVEL FILL (GP)
Medium dense, wet, light brown

FIBROUS MATERIAL MIXED WITH CLAY
Medium stiff, black, with petroleum odor and accumulations

SILTY CLAY & SAND MIXTURE
Medium stiff, green-gray and black, with oil accumulations, shells; Bay Mud

Becomes stiffer

FINE GRAVEL (GP)
Loose to medium dense, green, with some shells

SILTY CLAY (CL/CH)
Soft to medium stiff, green-gray

Becomes stiffer

Becomes stiff, dark gray, with shells

BOTTOM OF HOLE @ 16'

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-10d

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 11

Date Drilled: August 5, 1981
Type of Boring: Auger/Rotary
Hammer Weight: 140 lbs.

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Surface Elevation: 9.38' City of Emeryville Datum

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			2" Asphalt 2" GRAVELLY CLAY: Medium stiff, damp, green			
	1*	71	TAR Medium stiff to stiff, black			
	2*	15	SANDY CLAY FILL Medium stiff, moist, green-gray, with trace shells, mixed with wood, tar residue No wood, tar			
5	3	11	FINE SAND (SP): Loose to medium dense, wet, green-gray, with trace fine gravel; fill? Becomes very silty, no gravel, green, loose			
	4*	P				
10	5	P	Refusal of shelby			
			BOTTOM OF HOLE @ 11'-2"			
15						

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-11

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

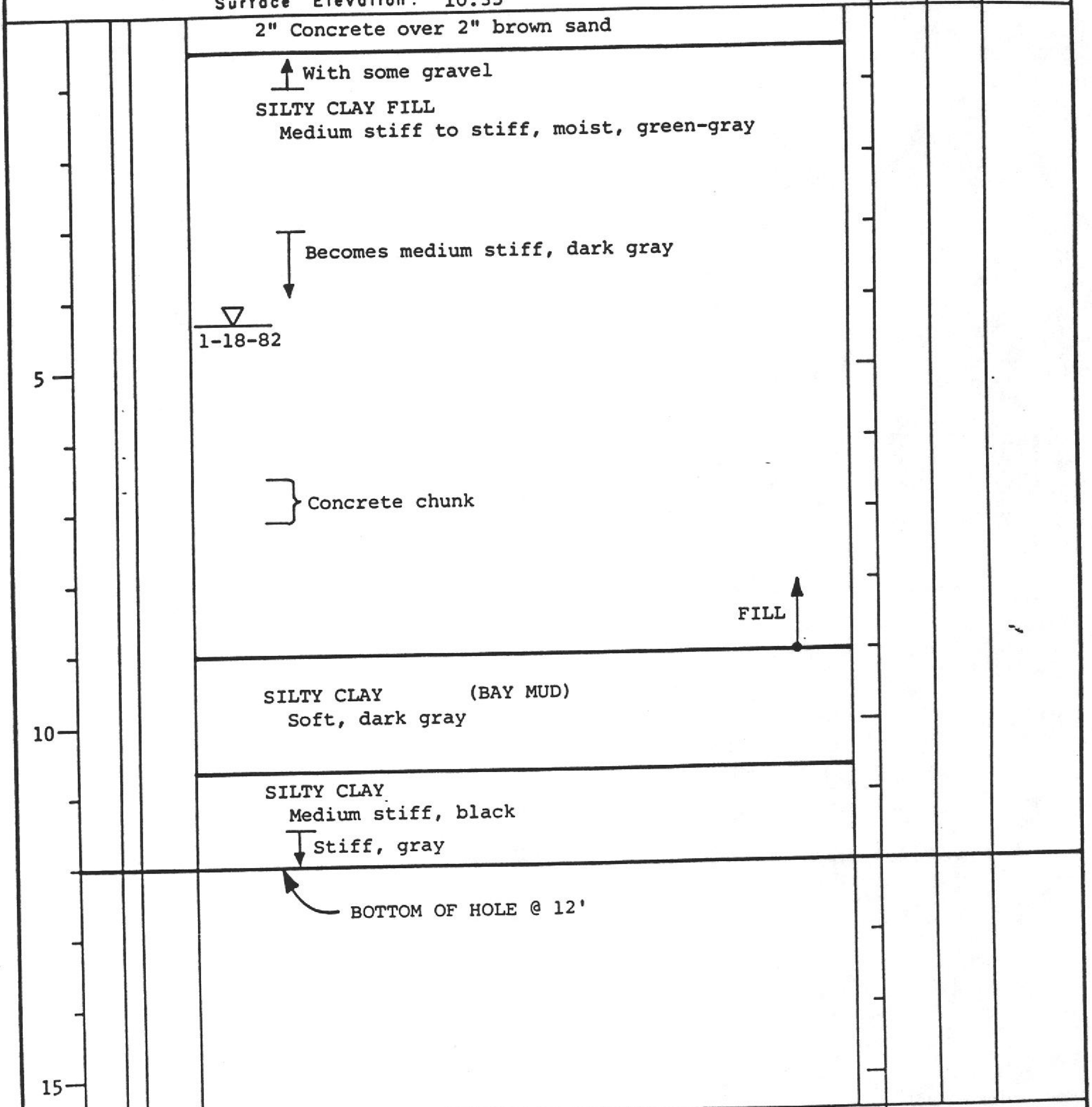
Log of Boring No. 12

Date Drilled: January 14, 1982
Type of Boring: 6" Auger
Hammer Weight: ---

Remarks: Piezometer Installed

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation: 10.35			



2" Concrete over 2" brown sand

With some gravel

SILTY CLAY FILL
Medium stiff to stiff, moist, green-gray

Becomes medium stiff, dark gray

1-18-82

Concrete chunk

FILL

SILTY CLAY (BAY MUD)
Soft, dark gray

SILTY CLAY
Medium stiff, black

Stiff, gray

BOTTOM OF HOLE @ 12'

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-12

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 13

Date Drilled: February 5, 1982
Type of Boring: 6" Auger
Hammer Weight: ---

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			4" Concrete Slab			
			SILTY CLAY : Stiff, moist, dark gray			
			4" Concrete Slab over 2" dark gray Clay			
			ATD ▽ 6" Concrete Slab over 2" dark gray Clay			
			12" Concrete (Rubble?)			
	☐	2 JAR SAMPLES	CONCRETE RUBBLE Mixed with brown-gray Sandy Clay; trace petroleum odor			
5			GRAVELLY CLAY FILL FILL ↑			
			SANDY CLAY (FILL?) Medium stiff, dark green-gray, petroleum odor			
	☐	2 JAR SAMPLES	SILTY CLAY Stiff, green-gray, petroleum odor			
10			BOTTOM OF HOLE @ 10'			
15						

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-13

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 14

Date Drilled: February 5, 1982
Type of Boring: 6" Auger
Hammer Weight: ---

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	Dry Density, pcf	Unconfined Compressive Strength, psf
			Surface Elevation:			
			4" Concrete Slab			
			SANDY CLAY FILL Stiff, moist to wet, with gravel and brick fragments			
		▽ ATD				
		2 JAR SAMPLES	With piece of wood and brick, petroleum odor			
5			AUGER REFUSAL, possible underground pipe, boring abandoned			
10						
15						

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-14

Project MARKETPLACE CONTAMINANT ASSESSMENT
Emeryville, California

Log of Boring No. 15

Date Drilled: February 5, 1982
Type of Boring: 6" Auger
Hammer Weight: ---

Remarks:
(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Blows/Ft.	MATERIAL DESCRIPTION	LABORATORY TESTS Moisture Content, %	 Dry Density, pcf	 Unconfined Compressive Strength, psf
			Surface Elevation:			
			4" Concrete Slab			
			SILTY CLAY FILL: Medium stiff, dark gray ← Dark green Clayey Sand lens Becomes stiff, with slight petroleum odor ▽ ATD			
			6" Concrete Slab			
	☐	2 JAR SAMPLES	SILTY CLAY FILL Medium stiff, dark gray, trace petroleum odor			
5			CONCRETE RUBBLE With dark gray clay			
			SILTY CLAY FILL Soft, dark gray			
			CONCRETE RUBBLE FILL			
			BROKEN AUGER, boring abandoned			
10						
15						

Proj. No. 15093A

Woodward-Clyde Consultants

Figure A-15

LOGS OF PREVIOUS EXPLORATORY SOIL BORINGS

(Woodward-Clyde Consultants
Project No. S12376,
Report dated July 14, 1971)

Project:
LATHROP-SHELLMOUND TILT-UP WAREHOUSE

Log of Boring No. 1

Date Drilled: 6-16-71
Hammer Weight: 140 LBS.
Type of Boring: 6" AUGER
Remarks:

Depth, Ft.	Samples	Blows/Ft.	DESCRIPTION	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength, psf
			Surface Elevation			
			1/2" ASPHALT			
			CLAYEY GRAVEL: DENSE, MOIST, GREEN-BLUE, BASE COURSE MATERIAL			
			BRICK & CONCRETE FILL			
	1 ▨	10	SILTY SAND: MEDIUM DENSE, DAMP, GRAY-BROWN, WITH BRICK (FILL)	NO RECOVERY		
5			BAY MUD SOFT, VERY MOIST, BLACK, ORGANIC SILTY CLAY WITH WOOD CHIPS, OIL-IMPREGNATED ▽ WATER AT TIME OF DRILLING			
	2 ☒	1/24" 2½" SAMPLER	(BAY MUD)	118	37	340
10	3 ☒	24 2½" SAMPLER	SANDY GRAVEL DENSE, GREEN TO MEDIUM BROWN	19	110	600
15						
	4 ▨	15	SANDY CLAY STIFF, BROWN	21	108	1220
20						
25	5 ▨	76	SILTY CLAY STIFF, BROWN, WITH THIN LENSES OF SAND AND BROWN GRAVEL	23	104	5280
30	6 ▨	14	SILTY CLAY STIFF, GRAY-BROWN	30	93	1080
			SILTY CLAY: STIFF, BROWN			
	7 ▨	22	SILTY SAND: MEDIUM DENSE, GRAY	[illegible]	[illegible]	[illegible]
			CLAYEY SILT: DENSE, BLUE BOTTOM OF HOLE @ 34.5'			

Job No. S-12376

WOODWARD-LUNDGREN & ASSOCIATES

Figure A-16

Project:
LATHROP-SHELLMOUND TILT-UP WAREHOUSE

Log of Boring No. 2

Date Drilled: 6-16-71
Type of Boring: 6" AUGER
Hammer Weight:
Remarks:

Depth, Ft	Samples	Blows/Ft.	DESCRIPTION	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength, psf
			Surface Elevation			
			CLAYEY GRAVEL DENSE, DAMP, GREENISH-BROWN, BASE ROCK MOIST, DARK BROWN (FILL)			
5			BAY MUD SOFT TO MEDIUM STIFF, MOIST, BLACK ORGANIC SILTY CLAY WATER AT TIME OF DRILLING (BAY MUD)			
10 15			GRAVELLY CLAY STIFF, BROWN			
			SANDY CLAY STIFF, GRAY-BROWN, WITH GRAVEL			
20			SILTY CLAY STIFF, GRAY-BROWN, WITH SAND			
25 30			BOTTOM OF HOLE @ 23'			

Job No. S-12376 **WOODWARD-LUNDGREN & ASSOCIATES** Figure A-17

Project:
LATHROP-SHELLMOUND TILT-UP WAREHOUSE

Log of Boring No. 3

Date Drilled: 6-16-71
Type of Boring: 6" AUGER
Hammer Weight:
Remarks:

Depth, Ft.	Samples	Blows/Ft.	DESCRIPTION	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength, psf
			Surface Elevation			
			SANDY GRAVEL: DENSE, MOIST, BROWN			
			CLAYEY SAND			
			CLAYEY GRAVEL: DENSE, MOIST, GREENISH-BROWN, (BASE COURSE MATERIAL)			
			(FILL) CLAYEY GRAVEL: MEDIUM DENSE, MOIST, REDDISH-BROWN * ▽			
5			BAY MUD SOFT, BLACK, ORGANIC SANDY SILTY CLAY (BAY MUD)			
10			VERY SANDY CLAY STIFF, BROWN			
15			SANDY CLAY STIFF, BROWN			
20			SANDY SILTY CLAY STIFF, REDDISH-BROWN			
			SANDY CLAY STIFF, BROWN, WITH GRAVEL			
			BOTTOM OF HOLE @ 23'			
25						
			*WATER AT TIME OF DRILLING			
30						

Job No. S-12376

WOODWARD-LUNDGREN & ASSOCIATES

Figure A-18

Project:
LATHROP-SHELLMOUND TILT-UP WAREHOUSE

Log of Boring No. 4

Date Drilled: 6-16-71
Hammer Weight: 140 LBS.
Type of Boring: 6" AUGER
Remarks:

Depth, Ft	Samples	Blows/Ft.	DESCRIPTION	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength, psf
			Surface Elevation			
			CLAYEY GRAVEL DENSE, RUST-BROWN, BASE ROCK			
			SILTY CLAY MEDIUM STIFF, BLACK, WITH TRACES OF GRAVEL (FILL)			
5			BAY MUD SOFT, ORGANIC SILTY CLAY WATER AT TIME OF DRILLING (BAY MUD)			
10 15 20			VERY SANDY CLAY STIFF, BROWN, WITH SAND LENSES LESS SANDY			
	1	73	SILTY SAND DENSE, BROWN	18	112	730
25	2	27	SANDY CLAY STIFF, BROWN GRAVEL LENSE	19	109	1300
30			BOTTOM OF HOLE @ 29.5'			

Job No. S-12376

WOODWARD-LUNDGREN & ASSOCIATES

Figure A-19

Project:
LATHROP-SHELLMOUND TILT-UP WAREHOUSE

Log of Boring No. 5

Date Drilled: 6-16-71
Type of Boring: 6" AUGER
Hammer Weight:
Remarks:

Depth, Ft.	Samples	Blows/Ft.	DESCRIPTION	Moisture Content, %	Dry Density pcf	Unconfined Compressive Strength, psf
			Surface Elevation			
			10" CONCRETE SLAB			
			CLAYEY SAND & ROCK FRAGMENTS MEDIUM DENSE, BLUE-GREEN, BASE ROCK			
			SAND: LOOSE, MOIST, PINK, WITH BRICK CHIPS			
			CLAYEY SAND: LOOSE, MOIST, BLACK			
5			TARPAPER BLACK, MOIST, TARPAPER MIXED WITH MUD ↑ (FILL) * ▽			
			BAY MUD SOFT, BLUE-GRAY, SILTY CLAY ↑ (BAY MUD)			
10			VERY SANDY CLAY STIFF, BLUE-GREEN, TRACES OF GRAVEL			
15			SANDY CLAY STIFF, BROWN, WITH GRAVEL ↓ LESS GRAVELLY			
20						
			SANDY CLAY STIFF, BROWN			
			BOTTOM OF HOLE @ 23'			
25						
			*WATER AT TIME OF DRILLING			
30						

Job No. 3- [illegible]

WOODWARD-LUNDGREN & ASSOCIATES

Figure A- 20

APPENDIX B

MONITORING WELLS AND GROUNDWATER SAMPLING

APPENDIX B

MONITORING WELLS AND GROUNDWATER SAMPLING

Well Installation

Standpipe piezometers were installed in Boring Nos. 4, 5, 10 and 12 to permit monitoring of groundwater levels and to obtain groundwater samples for laboratory water quality chemical analyses. The piezometer locations are shown in Figure 1 and details of a typical piezometer installation are shown in Figure B-1. Piezometer Nos. 4, 5 and 10 were installed on July 30 and August 4, 1981 during the exploratory soil boring program at the site. Piezometer No. 12 was subsequently installed on January 14, 1982, as requested by Mr. Robert Samaniego of the California Regional Water Quality Control Board (RWQCB) in a letter dated January 15, 1982.

The four piezometer boreholes were drilled using truck-mounted 6-inch diameter continuous flight auger equipment. The borings were drilled to a nominal depth of 12 feet, and each boring penetrated through fill materials and from 3 to 9 feet into the underlying native clayey soils. Details of the subsurface soil conditions in the piezometer borings are provided in the logs of Boring Nos. 4, 5, 10 and 12, respectively.

The piezometer boreholes were cleaned by lowering and raising the augers several times to be sure that soil cuttings and any fall-in were removed. Groundwater inflow to the boreholes was slow, giving ample time for careful visual inspections of the boreholes for cleanliness.

Pipe used for piezometers was 2-inch (inside diameter) PVC, capped at the bottom and hot-wire slotted from the bottom of the pipe to a depth 3 feet below ground surface, as shown in the typical sketch. The piezometer pipe was lowered to the bottom of the borehole, centered and backfilled to a depth of 2 feet below ground surface with coarse sand. To protect the piezometer, a 12-inch diameter concrete utility box was installed in the borehole with the top of the box at ground surface. The upper 2 feet of the borehole was then filled with concrete to a level just below the top of the piezometer pipe, as shown in the typical sketch. For security, the top of each piezometer pipe was sealed with a locking cap.

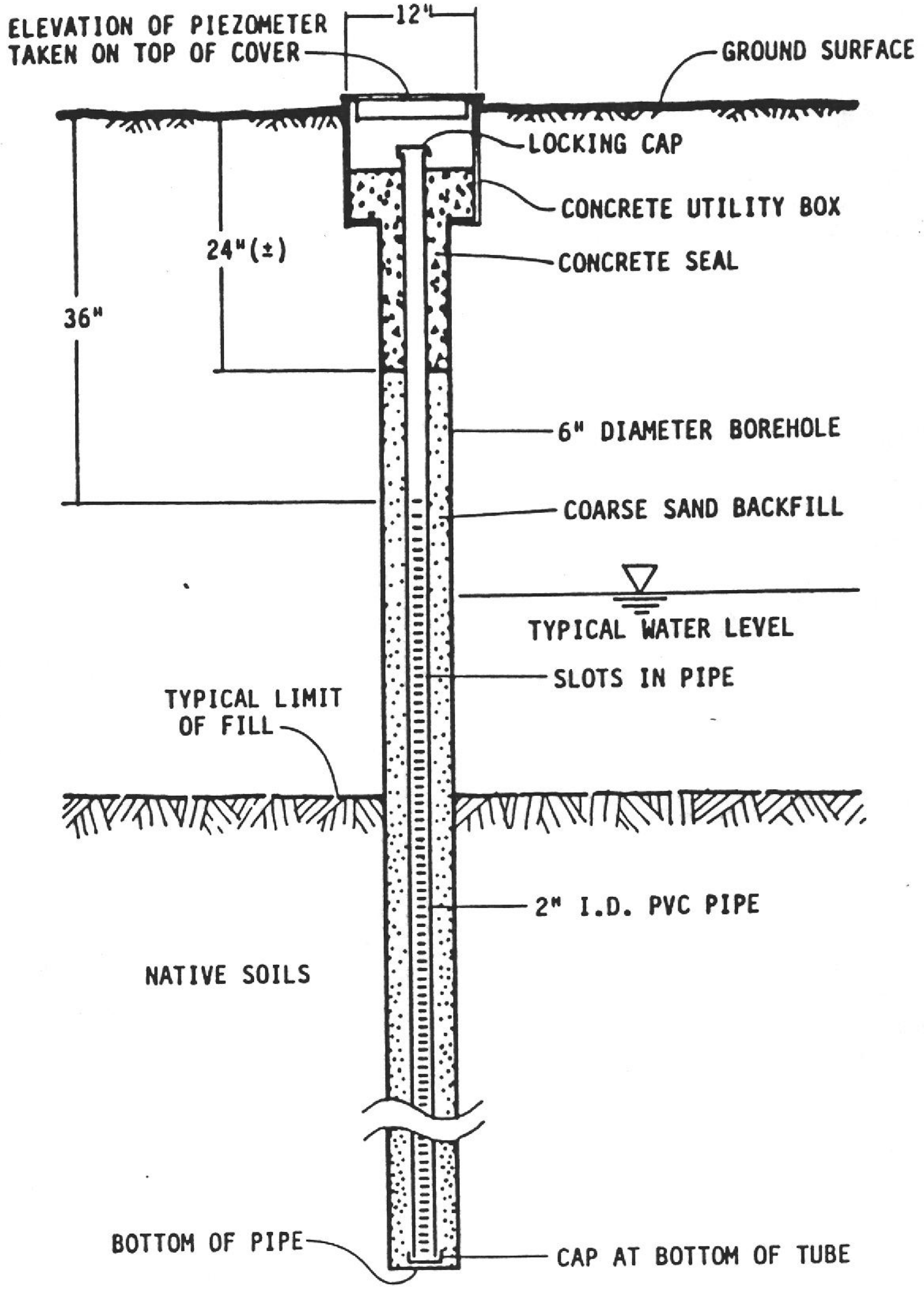
Surface elevations at boring and piezometer locations were surveyed by the firm of George S. Nolte and Associates, Walnut Creek. For piezometers, the reported elevations were taken on the top of the utility box cover as shown in the typical sketch.

Groundwater Sampling

Groundwater samples for laboratory chemical analyses were obtained from the 4 monitoring wells on January 20, 1982. The sampling was performed by Brown and Caldwell's Environmental Sciences Division, Emeryville, under subcontract to Woodward-Clyde Consultants (WCC). The sampling methodology was observed at the site by Mr. Robert Johnston of WCC and by Mr. Robert Samaniego of RWQCB. The specific laboratory tests which were performed on groundwater samples were determined in cooperation with Mr. Samaniego.

Each well was flushed 2 days before sampling by pumping all groundwater from the well, allowing the well to recharge, and then repeating the pumping a second time.

Groundwater samples were obtained using both a stainless steel bailer for samples to be analyzed for purgable organics and a peristaltic pump with Tygon tubing for samples to be analyzed for heavy metals. To avoid cross-contamination of samples among wells, 4 clean bailers and 4 lengths of Tygon tubing were used, one each per well. Samples to be analyzed for purgable organics were stored in standard water-quality septum vials and samples to be analyzed for heavy metals were stored in 1 liter polyethelene bottles. All samples were placed immediately in an on-site refrigerated container and then transported to Brown and Caldwell's Emeryville laboratory on the day of sampling.



Project No. 15093A **Woodward-Clyde Consultants**	TYPICAL MONITORING WELL INSTALLATION MARKETPLACE CONTAMINANT ASSESSMENT	Figure B-1

APPENDIX C

CHRONOLOGICAL SUMMARY OF MARKETPLACE SITE HISTORY AND PREVIOUS INDUSTRIES

APPENDIX C

CHRONOLOGICAL SUMMARY OF MARKETPLACE SITE HISTORY AND PRÉVIOUS INDUSTRIES

Site Chronology

- <u>Pre-to-Late 1800's</u>: Historical unfilled San Francisco Bay shoreline crossed Marketplace site approximately as shown in Figures 1, 2 and 3. Area east from shoreline to about location of present Peladeau Street was marshland. Area to east of present Peladeau Street was open farmland/ranchland.

- <u>1884 - 1902</u>: Paraffin Company formed in small office located at extreme northeast corner of Marketplace site in 1884. Early operations apparently directed primarily towards research and development of bituminous/petroleum based products. Possibly some small-scale on-site asphalt and kerosene refining, but only limited product manufacturing, if any. Little, if any, landfilling in area west of present Peladeau Street.

- <u>1900 - 1910</u>: Emeryville area east of Marketplace property essentially fully developed with streets and structures. Much or perhaps most of marshland area east of historical Bay shoreline filled and occupied by Paraffin Company structures by 1910. Early Paraffin Company product manufacture apparently included asphalt-impregnated roofing materials and some asphalt refining. Chronology of plant building construction at Marketplace site shown in Figure 3.

- <u>1920</u>: Paraffin Company became Pabco.

- <u>1925</u>: "Off-shore" area of Bay at Marketplace site had been filled to approximate westerly limits shown in Figures 1 and 3. Construction of new plant buildings as noted in Figure 3. Most of landfill in area between historical Bay shoreline and 1925 shoreline had been placed by about 1917.

- <u>1929</u>: Pabco producing previous Paraffin Company products and preparing for manufacture of paint. Marketplace site essentially covered with Pabco structures. Plant expansion continues progressively westward.

- <u>1934</u>: Earth embankment for initial Eastshore Freeway placed. Much of area immediately west of 1925 Marketplace shoreline and freeway embankment filled and occupied by Pabco structures.

- o <u>1935 - 1937</u>: Inundated area just north of presently existing Marketplace buildings filled (area bounded approximately by existing 64th and 63rd Streets, SPRR corridor and Eastshore Freeway).

- o <u>1947 - 1962</u>: Marketplace site appears essentially as shown in Figure 3. Northeast corner of site in area of asphalt refining equipment appears "darkened" in aerial photographs taken in years 1947, 1949, 1953 and 1959.

- o <u>1957</u>: Pabco purchased by Fibreboard Corporation. Product manufacturing at Marketplace site same as during Pabco period. Manufacture of building insulation materials began in area west of Marketplace.

- o <u>1962</u>: Demolition of several industrial buildings at Marketplace site began.

- o <u>1964</u>: Fibreboard began to divest its industries at Emeryville location. Parcel plan developed for properties, including Marketplace.

- o <u>1965</u>: Existing Christie Avenue and Powell Street Overpass planned and designed. Asphalt refining equipment at northeast corner of Marketplace site dismantled and removed.

- o <u>1968</u>: Consolidated Equities Company, et. al., purchased existing Marketplace site from Fibreboard and began development of Emeryville Marketplace.

- o <u>1969</u>: Most of previous Paraffin Company and Pabco buildings at Marketplace site had been demolished and removed. Only existing Marketplace buildings (Building Nos. 21, 33, 34, 64 and 64A in Figure 3) and several adjacent buildings remained.

- o <u>1973</u>: Consolidated Equities, et. al., sold Marketplace property to Emeryville Market Limited Partnership.

- o <u>1973 - 1975</u>: Emeryville Marketplace developed. Remaining Pabco structures in existing Marketplace parking lot area removed and parking lot graded and paved. Building Nos. 21, 33, 34, 64 and 64A (see Figure 3) renovated and Marketplace developed to existing restaurant/shop complex.

- o <u>July, 1980</u>: Commencement of this site assessment study.

Paper and Paint Manufacture

The following discussions are excerpted from Encyclopedia Britannica and are enclosed to provide general background information concerning typical raw materials and processing methods associated with manufacture of paper and paint. Descriptions of the previous asphalt-impregnated roofing paper and paint industries at the Marketplace site are presented under "Site History" in the main text of this report. Additional details concerning specific aspects of these industries at the Marketplace site may be obtained from officials of Fibreboard Corporation, San Francisco.

MANUFACTURE

PAPERMAKING MATERIALS

Introduction.—The first manufactured paper was made in China about the dawn of the Christian era, from bamboo and rags; and rags continued to be the almost universal source of papermaking fibre until the middle of the 19th century (see *Early History* above). Other fibres, such as straw and other grasses and the inner bark of Japan's mitsumata (paper mulberry), came into use. Except for certain special papers (*e.g.*, asbestos paper) nearly all papers are made of cellulosic (vegetable) fibres. Some wool fibre is useful in papers to be tar-saturated for roofing felt, but other noncellulose and converted cellulose fibres, such as rayon and Celanese, are not acceptable to paper mills.

Nature's most prolific source of cellulose is the forest, though trees differ in the value of their fibre for making paper. The fibre of flax (linen), cotton, jute, sisal, manila hemp, etc., comes to the paper industry as a secondary product, after serving a purpose as cloth, clothing, sacking, rope, etc. Agricultural wastes—straw, corn stalks, bagasse (sugar-cane waste), bamboo and some other grasses—are used for making certain grades; some of these are utilized to great amounts. Finally, one of the most important sources of papermaking material is the recovery of fibre from old papers, bags and boxes.

Until comparatively recently, few people could read and write, and the demand for paper was consequently small. Worn-out clothing, which was largely linen, provided sufficient raw material. As literacy increased, and particularly after Johann Gutenberg's invention of printing with movable type about 1450, the demand for paper grew and the art of papermaking spread throughout Europe and to America. As a result of this and the invention of mechanical pulpers or beaters, (see *Manufacturing Processes* below) supplies of rags became inadequate, and other fibres, such as esparto grass and straw, came into extensive use. A great upsurge in paper consumption followed the invention of the papermaking machine in 1799, and during the next half century a serious raw-material famine developed. During that time, several processes for obtaining papermaking fibre from wood were invented. Pulpwood became the most important source of papermaking fibre and of cellulose for many chemical conversion products. The latter use requires a specially purified grade of chemical wood pulp.

The world's forest areas (according to J. C. Weaver and F. E. Lukerman, *World Resource Statistics* [Minneapolis, 1953]) are divided as follows: North America, 21%; South America, 20%; Europe, 3%; U.S.S.R., 18%; Asia 13.5%; Africa, 23.5%; and Oceania, 1%. The best species for papermaking, and particularly the conifers, are predominantly in the north temperate zone. Some of the hardwoods were used from the first, and the development of the so-called semichemical process made many more species acceptable for pulping. This consequently increased the usable wood supply. The greatest enemy of the paper industry is fire in the forest, for which human carelessness is the principal cause. Fire, insects and disease destroy more wood than is usefully consumed.

A discussion of papermaking materials involves not only their source and characteristics, but also the methods by which the fibre is recovered and made available. The logical as well as the historical approach is to consider first the treatment of rags.

Rags.—The motion of the workman's arm and mallet as he macerated wet rags for the first primitive sheet of paper established the mechanical principle of a stamping machine in which stamps in a row were successively lifted and dropped by the action of pins set spirally on a shaft turned by a waterwheel or other power. This crude machinery was supplanted about 1750 in the Netherlands by the beater. The National Association of Waste Material Dealers in the United States established standard specifications for 27 grades of rags.

Rags arrive at the paper mill in bales weighing from 400 to 1,000 lb. (*see* Table I). The first three grades are used in some writing papers, which are then classified as 25%, 50%, 75% or 100% rag content, the other part being chemical wood pulp. Jute is used for strong wrapping and tag papers, hemp for sandpaper and electrical insulation paper, and roofing rags are used in felts (paper to be tarred for roofing and shingles).

TABLE I.—*Typical Yield From an Average Pack of 1,000 lb. of Mixed Rags*

Papermaking rags		Other types of rags	
Grade	Pounds	Grade	Pounds
No. 1 whites	25	Soft woollens	20
No. 2 whites	50	Hard woollens	125
Whites and blues	225	Mixed linseys (½ wool, ½ cotton)	20
Jute bagging	125	Wiping rags	60
Roofing stock	250	Quilts and white batting	85
		Rubbish	15
Total	675	Total	325

Source: J. N. Stephenson (ed.), *Pulp and Paper Manufacture*, vol. 2 (New York, 1951).

Rags require a preliminary treatment to prepare them for the high grades of paper for which they are now exclusively used. They are opened up and cleaned of loose dirt and dust in a boxlike thrasher, in which a drum with pins on its surface whips them against a beam. Next they are sorted into kinds and colours. Pockets are emptied, buttons etc. removed, heavy seams ripped and large rags cut. Rags containing rubber or synthetic fibre cause trouble and are often difficult to detect. The rags are chopped into small pieces and then given a second dusting before they are fed to the rag boiler. Bits of iron are removed by a magnetic roll on the sorting conveyor.

Rags usually contain substances that interfere with further processing, such as starch, mineral loading, dirt and grease, some natural waxes and resinous materials, and colours difficult to bleach. To soften the rags, remove foreign matter and render the colour bleachable, they are treated with an alkaline cooking liquor in a kier or a rotary boiler for from 6 to 15 hours at a pressure of 20 to 40 lb. per square inch. A detergent or wetting agent may be used to assist this process. The cooking liquor may be a solution of caustic soda, caustic lime or a mixture of soda ash (sodium carbonate) and lime. New rags require less drastic treatment than old, dirty rags. There are several variations of the cooking operation.

The rag boilers used in North American mills are usually cylinders or globes rotating about horizontal axes. Rags are charged through manholes in the boilers and spread out. Steam is introduced through one of the bearing trunnions. When the cooking operation is complete, the free liquor is drawn off and the boiler is rotated slowly with the manholes open to dump the rags. Hooks are used to remove the rags.

The kier is a stationary cooker with a perforated bottom. The cooking liquor is sprayed in at the top and percolates through the rags, passing through the perforated bottom to a reheater and is again introduced at the top of the kier. This equipment is common in the textile industry and is used to some extent in paper mills, particularly in England and continental Europe.

To rid the rags of chemicals and dissolved substances or attached materials, they are washed in a machine that removes such waste and, at the same time, ravels the fabric into threads. This washer is a tub with round ends and straight sides, with a centre partition the length of the sides. It is usually about 24 × 12 ft. and 3½ to 4 ft. deep. A large roll having thin bars set in the periphery is located in one channel. These just clear a group of similar bars in the bottom of the channel under the roll, which is rotated on its shaft. In the other channel there is a rotating, screen-covered dipper which extracts dirty water from the rags at the same rate as fresh water is added. By lowering the roll so that the two sets of bars nearly touch, the rags are ravelled. When the washing is complete, the fresh water is shut off and the dipper run for a time to thicken the stock, now called half stuff. Then a bleaching solution (calcium hypochlorite) or chlorine gas is introduced and thoroughly mixed with it, after which the contents of the washer are dumped into a draining chamber with a perforated bottom. There the water drains away and the bleaching is completed, leaving the snow-white rag stock to be taken as needed for the next operation—beating (described below, under *Manufacturing Processes*).

Jute rags are given a similar treatment but do not bleach to a good white.

Straw is cooked with lime, lime and soda ash, or caustic soda in spherical rotary digesters. The contents are dumped on a draining floor and conveyed to the paper-mill beaters as required, where the necessary washing is done.

Esparto grass is an important papermaking material in England and continental Europe. It is usually cooked in digesters similar to kiers and is bleached when used in high-grade writing and printing papers.

Wastepapers constitute not only a major source of papermaking material, but at the same time contribute to the conservation of forests. The Waste Paper institute, a division of the U.S. National Association of Waste Material Dealers, Inc., in 1949 adopted standards for 24 grades of wastepaper. Close specifications were set for prohibitive materials and total outthrows.

Sources of waste paper include cuttings and shavings from conversion and printing plants, repacked books and magazines and mixed papers. Wastepapers are principally book and writing paper of bleached chemical pulp; newsprint paper; kraft bags and wrapping paper; corrugated board and boxboard cuttings.

The treatment of wastepaper depends on its character and the grade of product to be made. If it is to be used in coarse products like roofing paper or boxboard, only a sorting out of useless and harmful material is required. Modern pulping machinery will then prepare the material for the paper machine.

For conversion of printed papers to pulp again suitable for manufacturing printing paper, a process akin to that used for rags is required.

The first process for removing ink is ascribed to Matthias Koops, who obtained English patents in 1800. Henry E. Rogers, in 1849, was the first to use a de-inking system in the United States. (Lyman Horace Weeks, *History of Paper Manufacture in the United States 1690–1916* [New York, 1916].) Several methods and types of equipment are used, the fundamentals of which are similar. Mechanical, heating and chemical action are required; the printed paper is broken up and fiberized by agitation in water containing suitable chemicals. Ink is a pigment in a vehicle such as boiled linseed oil. Such oil is attacked (saponified) by an alkali which loosens the pigment which then can be washed out of the fibre suspension. Some of the special heat-set inks and synthetic adhesives present greater difficulty.

A type of washer commonly used consists of a series of screen-covered cylinders rotating in the dilute suspension of fibre. Water drains through the screen, carrying off some of the ink. The mat of fibre left on the screen is removed and diluted and the process repeated two or three times. Application of suction inside the cylinder increases its efficiency and capacity.

Wood Pulp.—Human ingenuity has always found sources of supply for specific human needs. The problem presented by scarcity of rags together with increasing demand for paper was solved, about the middle of the 19th century, by the invention of several processes for the manufacture of papermaking pulps from wood. In the century after the first chemical pulp was made, the production of wood pulps increased to the figures shown in Table II.

TABLE II.—*Production of Wood Pulps, 1953*
(In short tons)

Area	Production	Area	Production
United States	17,537,291	Other Europe "non-Communist"*	2,015,000
Canada	9,612,256	Union of South Africa†	42,446
Latin America*	321,179	Japan	1,661,877
Sweden	3,539,640	Australia and New Zealand	163,191
Finland	2,125,633		
Norway	1,185,845	Total	36,710,311
Germany (western)	1,203,040		

*Estimated. †1951.
Source: United States Pulp Producers Association, *Wood Pulp Statistics, 1953* (New York, 1953).

For 1937 the wood-pulp production in what became Communist countries was: U.S.S.R., 924.000 tons; Baltic states, 215.000 tons; Poland, 191.000 tons; Czechoslovakia, 379.000 tons; Hungary and Rumania, 69.000 tons; Yugoslavia, 37.000 tons. The total production of Germany was 2.676.000 tons.

Classification.—Wood pulps may be classified first into two general groups—mechanical and chemical. Mechanical pulp, generally called groundwood, is not further divided except as fine, coarse or bleached; or by end use as book, news-grade, wallboard or screenings. Chemical pulps are classed by type as: unbleached sulphite (strong and news-grade); bleached sulphite (dissolving and paper-grade); bleached and unbleached sulphate (kraft); and soda. "Dissolving and special alpha" applies to both bleached sulphite and sulphate pulps used primarily for such nonpaper products as rayon, cellophane, plastics, explosives, etc. "Semichemical" is a term applied to a process of cooking followed by mechanical treatment, whereby yields of more than 60% are obtained.

Wood Procurement and Preparation.—Nearly all the world's pulp mills are located in the temperate zones because the woods most used for pulping are the conifers (softwood trees) that grow in those regions. Threatened depletion of northern softwoods, along with improvement of pulping processes, has encouraged the establishment of pulp and paper mills in the southern United States, Australia, New Zealand and Africa. Spruce, balsam fir and hemlock are considered the best woods for sulphite and mechanical pulping; several varieties of pine provide the bulk of wood for sulphate (kraft) pulp; while hardwoods are largely used for groundwood, sulphate, soda and semichemical pulping. The principal European pulpwoods are Norway spruce, Scotch fir, poplar and aspen. Wood is transported from the forest by floating (driving) down rivers; towing across lakes or on salt water; or haulage by freight cars, trucks or sleighs. One cord (128 cu.ft.) of piled wood, or about 90 to 95 cu.ft. of solid wood, will produce an average of one ton of groundwood pulp or half a ton of unbleached chemical pulp. Some wood is cleaned of bark in the woods by shaving or peeling before the sap dries, or by portable barkers. Most wood is barked as four-foot bolts at the mill by tumbling and rubbing in huge drums, with showers flushing off the loosened bark through openings in the drum. The wet bark may be drained, pressed and burned, which disposes of a waste and may supply some steam. Some mechanical barkers take logs eight feet long, while longer logs, especially big ones on the west coast of the United States and Canada, are barked by high-pressure hydraulic jets.

In cold climates, mills that receive their wood by water in the summer must store sufficient supplies for operation during winter months. Part of the clean wood from the barkers is therefore piled by mechanical stackers. It is brought into the mill by cable conveyors as required and in some cases dumped into a pond where any ice is allowed to melt.

Groundwood (Mechanical) Pulp.—Spruce, balsam and hemlock are the woods considered best suited to pulping by this process, although some pine species and poplar are used to a considerable extent. The principle of groundwood manufacture is very simple, but the efficient production of uniformly good pulp requires careful attention. The fibres in wood lie parallel to the length of the tree. When a stick is pressed lengthwise against a roughened (dressed) grindstone revolving at a peripheral speed of about 3,500 ft. per minute for natural sandstone, or about 5.000 ft. per minute for artificial stones, the fibres are torn from the wood and rubbed to a certain degree of fineness. The character of the pulp depends on the quality of the wood, the pressure against the stone, the temperature of grinding and the pattern made on the stone by dressing it with a special tool. This pattern may be straight grooves either around or across the stone; a combination of the two, making pyramids; or spirals of varying slope and coarseness. The stones also may have different sizes and degrees of hardness and sharpness of grit.

Natural pulpstones are 27 to 36 in. wide by 54 in. or more in diameter. Artificial stones are 27 to 54 in. wide and 54 to 72 in. in diameter. Standard lengths of wood ground are 24, 32, 48 and 50 in. Smaller grinders are fed by hand and may have two, three or four pockets.

The continuous type has a tall chamber above the stone and the wood is drawn down against it by the movement of spikes on conveyor chains. Another (ring-type) grinder has a huge ring with teeth on the inner side, set off-centre so that the stone nearly touches it. Into the narrow angle so formed, the wood is pinched by the movement of ring (slowly) and stone (faster) in the same direction, and the stone grinds off the fibre.

Under the stone is the pit into which the pulp falls, being washed from the stone by a shower. From there the thin pulp flows over a coarse screen that removes slivers and other unground bits of wood. The screened stock then passes through finer screens to obtain pulp suitable for papermaking. In order to save storage-tank space and pumping equipment, the pulp is thickened. This is done simply by submerging a rotating cylinder covered with wire screening in a vat, continuously fed by the thin pulp. Water flows through the screen and out of the ends of the cylinder, leaving a mat of groundwood on the surface. The pulp is squirted or scraped off. It is about 5% dry fibre and may flow to a storage tank, or be removed from the wire by contact with an endless felt and wound on a roll in a thick layer. When thick enough, the layer is cut loose and folded into a bundle, or lap, containing about 30% by weight of dry fibre. In this form groundwood is conveniently stored and shipped.

Chemical Pulps.—As mentioned above, there are two major chemical processes for preparing papermaking fibre from wood, the sulphite and sulphate (kraft) processes. Sulphite pulping is an acid process and the sulphate is alkaline. Other processes are the soda and the semichemical. All have a common operation—chipping. The chipper is a vertical steel disk with 4 to 12 radial slots in which knives are set. A chute or spout feeds the bolts of pulpwood endwise and at an angle of about 40° against the rapidly revolving knives. Thin slabs of wood are shaved off which break up into chips from ½ to 1½ in. long, depending on the type of cooking action to follow. Pieces that are too big are separated by screening and put through a rechipper.

Another feature shared by the various chemical processes is the vertical digester in which the wood is cooked. It has a conical bottom section, cylindrical centre section and domed top. Chips are fed in through a throat at the top which can be tightly closed with a cover plate. At the bottom is a fitting which provides inlets for the cooking liquor and steam, and an outlet for discharge of the cooked wood chips. Some digesters are kept at the proper cooking temperature by continuous introduction of steam. In others, the cooking liquor is drawn off through strainers that hold back the chips, passed through a reheating chamber and fed back into the top of the digester. This system gives faster and more uniform cooking.

Purpose and Principles of Cooking Processes.—The approximate composition for European spruce wood is: cellulose, 50%; lignin, 30%; carbohydrates, 16%; protein, 0.7%; resins and fats, 3.3%. Canadian woods have somewhat more cellulose and less resins and fats. Wood is a nonuniform material. The purpose of cooking is to separate the cellulose fibres from the noncellulosic material. The natural resistance of cellulose to attack by most chemicals is a fortunate characteristic. Lignin, which serves to bind the fibres together, is quite reactive and can be dissolved. While the hemicelluloses (carbohydrates) are nonfibrous. they may be retained in the pulp to some extent as they increase the yield of pulp and are useful in some grades of paper and board.

The soda process is the oldest, dating from the discovery of H. Burgess and C. Watt in England in 1851 that birch shavings could be pulped by boiling in alkali. Burgess came to the U.S. and set up a mill in 1854 where he cooked poplar with sodium hydroxide. The sulphite process is ascribed to B. C. Tilghman in the U.S. in 1867. C. D. Ekman in Sweden in 1874. Alexander Mitscherlich in Germany, and E. Ritter and C. Kellner in Austria. They cooked with sulphites and bisulphites and were plagued by the problem of acid corrosion of their equipment. A modified soda process was discovered in Norway in 1879 by C. F. Dahl. who made a strong brown pulp to which the name "kraft" was given. Toward the middle of the 20th century the so-called semichemical process, using chiefly a neutral sulphite cook, came into favour, marking a century of progress in wood-pulp manufacture.

Sulphite Process.—Cooking liquor for sulphite pulping begins with the burning of sulphur to form sulphur dioxide under conditions controlled to minimize formation of sulphur trioxide, which is troublesome. The dioxide is cooled rapidly and then bubbled through lime water or passed upward through a tower filled with limestone (calcium carbonate) over which water is showered. The result in either case is a solution of calcium bisulphite with an excess of sulphur dioxide as sulphurous acid. Sodium hydroxide. sodium carbonate, magnesium oxide and ammonia may also be used in specially designed systems. The important feature of acid making is the amount and proportion of combined (the sulphur dioxide as calcium bisulphite) and free sulphur dioxide as sulphurous acid. This raw acid is fortified with sulphur dioxide relieved from the digester during cooking. The liquor used for cooking contains about 1% of sulphur dioxide in combination and 3.5% to 4.5% free sulphur dioxide, a total of 4.5% to 5.5% sulphur dioxide. The corrosive action of this liquor requires that the steel digester is lined with acidproof brick and cement; or acid-resisting metals must be used.

When the digester has been filled with chips and liquor, admitted simultaneously, the cover is bolted on and steam is added to bring the pressure to 75 to 90 lb. per square inch and maintain a cooking temperature of 136° to 150° C. (245° to 270° F.). Cooking time varies from seven to ten hours depending on whether the pulp is to be a strong. unbleached grade or high quality, bleached and purified for fine white papers, rayon and other conversion products of cellulose.

The chemical reactions occurring in the digester are quite complex and the subject of constant research. Fundamentally, however, the action of the bisulphite and free sulphur dioxide is to render soluble the encrusting matter, mainly by forming soluble lignin-sulphonates and by hydrolyzing gums, etc. When the digester is blown (emptied), the softened chips emerge at high velocity and break up against a firm target. Most of the waste liquor drains through the perforated bottom of the blow pit, and more is removed from the pulp by high-pressure hosing. The disposal of such wastes is a problem that is receiving serious studies by industry and governments.

The waste liquor, containing about 50% of the original wood, may be utilized in various ways. Some is evaporated and the residue burned to generate steam; some is recovered as a binder for roads or foundry cores; some is neutralized. and the sugars fermented to form potable and commercial alcohols. Using the alcohols as raw material. many other organic chemicals are produced. Waste liquor also became an important source of vanillin used for flavouring and as a base for other chemicals.

Soda and Sulphate (Kraft) Processes.—These processes differ essentially from the sulphite process in that the cooking liquor is alkaline and thus has less corrosive action on iron and steel. and digesters are not lined. The active substance in the alkaline cooking liquors is sodium hydroxide (NaOH) formed by causticizing a solution of soda ash or sodium carbonate (Na_2CO_3) with lime (CaO). In the soda process a small amount of sulphide is sometimes present. about 5% of the chemical charge. In the sulphate process the solution of sodium hydroxide usually contains 20% to 30% sulphide (reduced from Na_2SO_4 make-up). Recovery of the sodium is an important factor in the economy of alkaline processes.

The pines and hardwoods are readily cooked by alkaline liquors. The resins of pines. which cause trouble in the sulphite process. are converted to soluble soaps in the soda and sulphate processes and are washed out. When the digester is filled. the liquor may be put in with the chips or after the digester is partly filled. Direct steaming is used on some digesters. but the majority have liquor circulation systems with indirect heating. Operation of soda and sulphate digesters is much the same. The cooking time is much shorter than for sulphite. It takes one and one-half to two hours to reach the maximum temperature of 340° to 350° F.. which would be held for about one hour for a hard stock for paperboard. For bleachable stock the maximum temperature would be maintained for one and one-half to three hours. The pulp is blown from the digester into a steel tank with conical bottom and agitator. This brown stock is brought to a uniform consistency and screened in a knotter as it passes to the washers. which are similar to those used on sulphite pulp. The rosin soap formed (particularly when cooking pinewood) produces foam on the black liquor washed out of the pulp; so a foam tank is used to remove foam before the liquor goes to the evaporators. There the liquor is thickened to a point where it contains about 50% solids. and these represent the lignin and other substances that made up about 50% of the original wood. This black. sticky mixture can be pumped while hot. It is fortified with chemical to replace losses and is sprayed into a special furnace where it burns and generates steam. The ash that forms contains most of the sodium in the original cooking liquor. In the soda process sodium carbonate remains; in the sulphate process. sodium sulphate is the makeup chemical and is reduced to sodium sulphide in the furnace. The presence of this sulphide in the cooking liquor modifies the effect of cooking and produces the stronger kraft pulp of the sulphate process.

In the recovery process (reuse of liquor) the smelt or molten black ash from the furnace is run into a dissolving tank where the smelt is dissolved in water to form green liquor. The green liquor is then causticized with lime to change the sodium carbonate to sodium hydroxide. producing white liquor containing the hydroxide and sulphide. After settling. the white liquor is available for a succeeding cooking operation. The reaction is $Na_2CO_3 + CaO + H_2O = 2\ NaOH + CaCO_3$ (sodium carbonate plus lime plus water equals sodium hydroxide plus calcium carbonate). The calcium carbonate that has settled out of the white liquor is fed to a lime kiln (about 8 ft. in diameter and 300 ft. long) where it is burned to drive off carbon dioxide, leaving lime for another turn in the causticizing operation.

Screening and Bleaching.—The washed pulp contains some large fibres and incompletely cooked bundles that must be removed by screening to produce a stock of uniform quality. Screens are of two general types. The flat screen is a box about 15 in. high, with a bottom of metal plates having slots from .006 to .014 in. wide. These grade the fibres passing through and retain material not acceptable for the grade of pulp required. A chamber below the screen plates has a flexible bottom that is given a pulsating movement to help draw fibres through the screen slots by suction.

In the rotary type screen, the plates form a cylinder that revolves very slowly and the thin pulp suspension is fed either to the inside or outside of the cylinder. Either the screen is vibrated or the pulp is agitated to cause the fibres of correct size to pass through the slots.

Besides screens, several types of separators act by centrifugal force created by whirling the suspension of fibres.

A large proportion of wood pulp is converted in the same mill into paper or paperboard. In such a case the thin suspension passing the screens at a consistency of .3% to .5% is thickened, as described above, to a consistency of 3% to 6% and held temporarily in storage chests fitted with agitators. Pulp to be stored for some time, or to be shipped, may be made into wet laps containing 30% to 45% dry fibre on wet machines (as described above, under *Groundwood Pulp*). Bleached pulp is usually dried, cut into sheets and baled. A pulp drying machine consists of a vat for pulp in which rotates a large wire-covered cylinder, like a vacuum thickener. The layer of pulp is passed through one or two presses that squeeze out more water and then through a drying chamber, in which the sheet travels back and forth several times. The water content can be reduced to about 10% or 15%.

Bleached Cellulose.—This is required for the higher grades of printing, writing and specialty papers and for chemical conversion in the manufacture of artificial silk, explosives and other derivatives. Bleaching not only whitens pulp but refines it by removing substances that may be useless or harmful if used for the manufacture of some products. The objective is a pulp with maximum content of alpha-cellulose—the portion most resistant to ordinary atmospheric conditions but reactable to special chemical reagents. For the latter purpose it is called dissolving pulp. Other grades of bleached pulp, for which the treatment is less severe, contain varying precentages of beta- and gamma-cellulose, the more reactive but nonfibrous forms of cellulose. The bleaching also removes, as its primary purpose, residues of lignin, colouring matter and lower carbohydrates.

The process of bleaching wood pulp involves the chlorination of lignin to form a soluble compound, and the oxidation by chlorine compounds of other substances, rendering them colourless. When the composition of a substance is chemically changed, the chances are about 20 to 1 that the result will be white or colourless.

According to F. Kraft (*Pulp and Paper Manufacture*, vol. 1), sulphite pulps can usually be satisfactorily bleached in three stages (with intermediate washings): (1) chlorination, (2) alkali extraction and (3) hypochlorite (brightening) treatment. To bleach sulphate pulps, at least five stages are necessary: (1) chlorination, (2) alkali extraction, (3) high-density hypochlorite treatment, (4) alkali extraction, (5) final hypochlorite; but two additional stages are recommended: (6) second chlorination and (7) alkali extraction. A final addition of sulphurous acid is made to stabilize brightness and destroy residual active chlorine which can, especially at high temperature, cause formation of oxycellulose, a substance having no fibrous structure or strength.

Nonfibrous Materials.—Materials other than fibres and the process materials mentioned above are required in making paper. These include: colours—synthetic dyestuffs, natural vegetable colouring matters, and mineral pigments; sizing—rosin, glue and synthetic resins; chemicals—alum, ferrous sulphate, casein, lime, limestone, salt, sodium sulphate, sulphur, chlorine, sodium carbonate, etc; and fillers and coating materials—clay, talc, gypsum, chalk, titanium, zinc pigments, etc.

MANUFACTURING PROCESSES

Introduction.—The manufacture of pulp from wood and other fibrous raw materials, along with the manufacture of paper from these pulps, has become one of the world's most important manufacturing industries. By the mid-1950s it ranked first in Canada and high in the United States, Finland, England, Germany, Sweden and other countries with high rates of paper consumption, and wherever extensive forests provided a basis for these articles of international commerce. In 1953 the United States led the world in consumption of paper with 325 lb. per capita.

Great changes in methods of manufacture have come with the invention of machinery and the discovery of improved processes, yet the fundamental principles persisted through the centuries of papermaking, and the primitive methods of the early days are still in use in some countries. In brief the manufacture of paper involves: (1) procurement of raw material; (2) preparation of fibres to give a uniformly distributed suspension in water; (3) formation of a sheet of interlacing, or felted, fibres on a surface of material through which superfluous water drains off; (4) removal by pressing and evaporation of further moisture to the point of equilibrium with the atmosphere; (5) giving such smoothness of surface as may be required.

Procurement of Raw Material.—This procedure necessarily varies with the type of mill and its location. Many mills are self-contained, particularly those making paper from rags, jute, manila rope, flax, straw, esparto grass and waste papers. Similarly self-contained are those producing their own wood pulp for newsprint, kraft wrapping and container board, and insulating board. Most mills buy all or a portion of their fibre requirements, for economic or technical reasons. Thus, a writing-paper mill may process its rag stock and buy the grades of chemical pulp required for the qualities of paper produced; or a mill using wood pulp may not have sufficient pulp of its own and will have to purchase the balance required.

Preparation of Stock.—In no industry is it likely that preparation of the material is more important than in the manufacture of paper. It is necessary to start with raw materials as nature makes them. No tree is exactly like another, nor is any tree uniform throughout, yet the cellulose fibre from the pulp mill meets severe specifications for the several grades. Regardless of the care taken by the supplier of the raw material to the paper mill the papermaker has a difficult task in preparing and blending the fibre and other materials so that they will form a sheet of paper with the qualities required. This is obvious when one compares such different products as tissue, writing and wrapping paper, board, newsprint, wallboard, paper shingles, magazine paper, etc.

The basic operation is to work the proper fibres into such a condition that they will form a suitably felted sheet (mat of fibres) on the paper machine. In the case of newsprint, the groundwood and sulphite fibres have received considerable screening treatment in the adjacent pulp mill and are fairly uniform as to size of fibre and density of suspension. These pulps, therefore, need very little, if any, refining (described below) and require only thinning to a standard and constant concentration (consistency), mixing in correct proportions (approximately 85% groundwood and 15% unbleached sulphite pulp), adding automatically by meter certain amounts of blue and red dyestuffs to improve the approach to whiteness and perhaps other materials to give a special quality. The mixture (now called stuff) is held in a storage chest to be pumped as required to the paper machine. Most other papers require more extensive preliminary treatment. The preparation of rag-content papers requires the maximum processing and will illustrate the various operations and equipment.

Let us first consider the material. In the first place the length of wood fibres from conifers (softwood) is 3.5 to 5.5 mm. (about ⅛ to ¼ in.) and that of broadleaf (hardwood), about 1 mm. (1/25 in.). In each case the fibres are about 100 times as long as they are wide. Each fibre is a tiny tube, with thin tips. Many are broken in making groundwood pulp, and some are cut in making chips for chemical pulp. Other vegetable fibres are much longer: cotton fibres may be an inch or more long, with a diameter of about .02 in.

Beating.—Papermaking may be considered as beginning in the beater room. The mixture of fibre and other materials added to the beaters is known as the furnish. Each kind and grade of paper has its own particular furnish.

The beater is a machine fundamentally the same as the washer but more carefully designed and built. The roll is much heavier and is capable of being set very accurately with respect to the bed plate, since the progressive adjustment of the roll position is the key to good beating. Each end of the roll shaft rests on a lever, the free ends of both being raised or lowered simultaneously by gearing; thus minute adjustment is possible and, because of the smallness of the fibres, necessary. A beater may hold from

300 to 3,000 lb. of stock, a common size being about 24 ft. long, 12 ft. wide, with ends of semicircular shape, and about 3½ ft. deep. A centre partition provides a continuous channel. The essential part is the combination of roll, bed plate and backfall. The roll will have a radius approximately equal to the depth of the beater, and almost the full width of the channel in which it turns. Bars of steel about ¼ in. × 3 in. and as long as the roll width are set radially so as to project about half their width from the roll and are held by wedge strips of wood. Set in the floor of the beater, under the roll, is a box of similar bars, called the bed plate. Behind the roll the floor is given a hump (called the backfall) over which the stock is thrown by the rotation of the roll.

With the roll set to clear the bed plate comfortably, the beater is partly filled with water and the washed and bleached rags (called half stuff) are added gradually. The turning roll draws in the lumps of half stuff, which break up and are thrown over the backfall to circulate around the tub. Sufficient water is added to give a consistency of about 5% when all the fibre is in. Since few papers are now made of 100% rag fibre, the rag half stuff is beaten first and the wood pulp or waste paper stock added in due course. The majority of paper grades produced today contain 100% wood pulp.

As the beating proceeds, the revolving roll is gradually lowered until it is riding full weight on the fibres between it and the bed plate. This action splits and mashes the fibres, creating hairlike fibrils and causing them to absorb water and acquire a sliminess. These beaten fibres will then drain more slowly on the paper-machine wire and bond together more readily as more water is removed and the wet web is pressed. After drying, the paper made from such stuff will be exceptionally strong. Much of the beating action results from the rubbing of fibre on fibre. Long fibres will, of course, be cut to some extent; the lower the consistency and the more rapid the roll lowering the more the cutting, an operation which is completed in the refiner. During the beating, other materials are added: (1) The paper is made water resistant by sizing; *i.e.*, a rosin soap is well mixed with the fibre, and an alum solution is added to break up the soap and make the rosin stick to the fibre. (2) Dyestuffs are added to give the shade desired or improve the whiteness, and the alum helps to set the colour. (3) a filler, such as clay or chalk, may be added to give some special property to the paper. The result of all this preparation is called full stuff or just stuff and is emptied into the beater chest. Other types of beaters have been developed, but all have the same principle and function.

Refining.—The next operation is refining, the purpose of which is to brush out knots or clusters of fibre and to cut the fibres to a more uniform length. Some further conditioning may occur to give an increase in the area of fibre surface, which is a factor in making fibres adhere one to the other. It is important that the stuff entering the refiner is regulated to a correct and uniform consistency. This is accomplished automatically by an instrument which controls the amount of water added as the stuff is pumped from the beater chest. Refiners also operate on the principle of one set of bars or knives passing another set, but at a more accurately controlled distance and at higher speeds. The two distinct types are: (1) a conical plug with bars on the surface revolving in a shell with corresponding bars on the inner surface; (2) two disks, of which one or both rotate, and which are grooved with sharp-edged ridges. In the first type the plug is accurately centred in the shell and the machine is given a preliminary run with a slurry of sand to grind the bars to a perfect fit. In operation the plug is pushed in or drawn out by a special gearing (which may be automatically controlled) to regulate the degree of rubbing and cutting of the fibre. The stuff is fed in at the small end at a constant rate and emerges at the large end of the machine. It flows from there to the machine chest, of which there are two if the paper machine makes a variety of grades or colours, since it takes time to prepare for the switch-over when the first run is finished. Such changes may involve a thorough wash-up of chest and paper machine.

Paper Machines.—The paper machine is one of the most massive and at the same time most delicately adjusted pieces of mechanical equipment found in any industry. While machines for some high or special grades may be small enough to fit into a double bowling alley, a modern newsprint machine would occupy the area of a city street a block long. The speed of one machine might be 100 ft. per minute, while others run at more than 2,000 ft. per minute. The thickness of the paper varies from a delicate cobweblike film to heavy wrapping papers and building boards. To operate such a machine hour by hour and day by day with a minimum of breaks requires the highest engineering skill in design and manufacture, steadiness and perfect adjustment of the speed of several separate but interlocked parts, the careful preparation of the stuff and the intelligent operation of the machine by men of experience, using the best available instruments and control apparatus.

The stuff supplied to the paper machine will have been fully prepared for grades of paper containing other than wood pulps and for those grades of wood-pulp papers requiring beating or similar conditioning treatment, or the admixture of special materials. Such stuff can be pumped directly from the machine stuff chest to the paper-machine screens. When the stuff is a mixture of pulps in slush form (*e.g.*, newsprint is a mixture of groundwood and sulphite pulp), these pulps are each brought to a definite consistency and mechanically metered in fixed proportions into a mixing apparatus, which also automatically adds colour, alum and sometimes other materials. From the proportioning and mixing machine, the stuff is conditioned in a refiner en route to the machine chest, where repulped broke (trimmings and other spoiled paper from the machine) is added.

Stuff from the chest is pumped to a consistency regulator so that the volume and consequently the weight of stuff fed to the machine can be accurately controlled, so that the paper will have a constant weight and thickness. The regulated stuff gets a final screening and then flows to the head box. This acts like a reservoir behind a dam. The weight of stuff forces the stuff out through a narrow opening—the slice—onto a travelling endless wire screen; the speed of stuff is kept even with that of the wire by controlling the depth in the head box. The slice must be perfectly horizontal with a uniform opening in order to produce a level sheet of uniform thickness.

The wire part, or Fourdrinier, is essentially the same machine that was invented by Louis Robert in France in 1799. Robert sold his patent to Leger Didot, who took it in 1800 to England, where his brother-in-law John Gamble was granted a patent in 1801 for a machine improved with the help of Bryan Donkin. The first machine was started at Frogmore and another at Two Waters in 1804. Henry and Sealy Fourdrinier acquired all patent rights and further improved the machine which became known as the Fourdrinier.

An endless bronze wire screen passes around a breast roll at the feed end and a driving, couch, roll at the other. The wire returns over wire-carrying rolls, a stretch roll and a guide roll. The top run of the wire carrying the wet pulp suspension is supported by flat table rolls and flat suction boxes. A light wire-covered dandy roll rides on the wire between suction boxes. The driving roll may have a felt-covered top roll to press water out of the freshly formed paper or have one or two interior suction boxes (vacuum couch) with a rubber-covered presser roll to level the surface of the paper. As the stream of stuff, containing from 0.2% to 1.5% fibre, shoots out from the slice, the river of paper stock flows along with the wire and is confined for a short distance by rubber deckle strips just touching the wire on either side. While travelling this distance, much water drains through the wire while the fibres felt together to form the sheet of paper. Now the table rolls and suction boxes continue to draw out more water and the dandy roll smooths the surface. If a watermark is required, a pattern is formed of wire sewed on the dandy; it makes an impression in the soft mat that remains denser than the rest of the sheet. Next comes the couch press or vacuum couch roll which extracts enough water to bring the dry content of the paper to from 15% to 18%. The water that has been taken out by draining and suction is used for diluting the stuff by the consistency regulator, for showers and other uses, except when it is too strongly coloured.

The sheet as made on the wire has uneven edges and is somewhat wider than required at the reel when the natural shrinkage in drying has taken place. Furthermore, this shrinkage in width varies with the composition and condition of the stuff. So a narrow strip is cut off each side of the paper by two jets of water (squirts) directed at the wire. A third jet slides in a tube that extends across the machine; it is used for cutting the narrow lead strip (tail) that is first carried along to lead the paper through the machine. When this strip has progressed a sufficient distance, the squirt is slowly pushed across the wire and presently the full width of the sheet has been transferred to the next part of the machine. The same procedure is followed in passing the weak wet paper to each succeeding part. This passing of the tail is still done by hand on slow-running machines but becomes very difficult as the speed increases to about 500 ft. per minute. The operation is now effectively performed at speeds up to 2,000 ft. per minute or more by compressed air blasts between the wire and the presses, by a twin-rope carrier through the dryers and with air blasts again at the calender and reel. Some machines are provided with an endless felt which presses against the wire to pick off the paper and carry it through the first press. With thin tissues and some light wrapping papers, this pickup felt presses the wet sheet directly onto a drying cylinder. This is the Yankee machine that gives paper a one-side glaze.

Removal of Further Moisture.—As mentioned above, the paper leaves the wire with an average dry fibre content of about 18%; *i.e.*, for each pound of paper, the sheet at this point contains about 4½ lb. of water. Mechanical pressing can reduce this ratio to about 1 lb. of paper to 2 lb. of water, and further drying must be done by evaporation, which may cost 12 times as much as pressing. There may be one, two or three presses between the wire and the dryers. A press consists of a bottom roll with a resilient rubber covering, driven by an electric motor. Above it is a top roll of granite or noncorrodible metal; its effective weight may be increased by weights and levers or by air or hydraulic pressure on its bearings. The paper is carried on the felt between the rolls, and water is squeezed out and runs through the felt and down off the bottom roll. Removal of this water is facilitated, and the efficiency of the press is increased, by making the bottom roll of a perforated shell with an interior suction box like that in the vacuum couch. The sheet goes to the dryers with 30% to 38% dry material and 62% to 70% water, depending on the grade of paper and condition of the felt and the machine. The paper is now strong enough to carry its own weight and for the tail to be slipped between the carrier ropes and whisked from the last press to the dryers.

Cylinder machines are used for making some thin papers and most paper boards, building papers, insulation boards and for drying chemical wood pulp. The sheet-forming part is described here because the drying and finishing parts are essentially the same for both paper and board. An important feature of the cylinder machine is that different kinds of stock may be used when there are two or more layers—top liner, filler and bottom liner. Some boards, of course, are made by pasting several sheets together. For a multicylinder machine there are several vats in which wire-covered cylinders rotate and perform as described above under *Papermaking Materials*. The stuff is prepared separately for the first, last and intermediate vats—chemical pulp, white or coloured, for liners and usually wastepaper for the filler. The top liner is formed on the first cylinder and taken off by the underfelt, which travels backward, picking up one or more layers of filler stock and a bottom liner if there is to be one from other vats.

These layers are pressed together by the couch roll on each cylinder and form a solid sheet, which is carried forward, overhead, to the presses. There the paper meets another felt and is carried between the two felts through several baby presses to set the sheet, then on the lower felt through a primary press and on a second lower felt through the main presses. Considerable additional pressure is applied to the presses, which are mechanically similar to those on a Fourdrinier paper machine. For thin papers, the presses are few, if any.

The first patent for a cylinder-type machine was granted in the United States to Charles Kingsey and one was granted to John Dickinson in England in 1809. The first paper machine in the United States and the first cylinder-type machine anywhere was installed by Thomas Gilpin at Wilmington, Del., in 1817.

The dryer section of the paper machine is a set of hollow steam-heated cylinders by which the paper is dried from a moisture content of about 65% to 5%–8%. Front and back frames carry the bearings which are set so that the top dryers come down part way between the lower ones. Heavy cotton or cotton-and-asbestos felts run over both top and bottom rows and are held tight against the dryers by felt-carrying and stretch rolls. The purpose is to keep the paper flat and to prevent air from forming an insulating layer between paper and dryer shell. No felt is required for most paper boards. The rear journal (axle) of each roll has a double-barrelled fitting which provides an inlet for steam and outlet for the water formed when the steam condenses in giving up heat to dry the paper. The moisture evaporated from the paper—about two pounds of water for each pound of paper—is drawn off by fans through an economizer which heats fresh air for carrying off more moisture. The hotter the air, the more moisture it can absorb.

Calenders.—The smooth finish is produced by passing the paper through a stack of highly polished rolls. The bottom roll of a big machine will weigh more than 30 tons; the tremendous weight of the eight or nine others can be further increased by levers or pressure cylinders. Scrapers keep the rolls clean, assist in threading the paper and prevent paper from winding around a roll in case of a break in the paper web. Some board machines have two or even three calender stacks. An extra-high finish is sometimes attained by dampening the paper surface before it enters the calenders, and surface colouring can be done by adding a dyestuff to water which is applied from a reservoir attached to the stack.

The paper is wound full width on a reel, using a steel core. Quick and skilful work is required to transfer the paper at high speed from a full reel to an empty core. The large jumbo rolls are then slit into widths required by the printer or other user and rewound into rolls of specified diameter, from nine-inch counter rolls of wrapping paper to five-foot rolls of straw board. When the paper is to be used in sheet form, the slitter may be combined with a cutter and piling attachment.

Some paper is unavoidably spoiled, but it is not wasted. The wet broke from the wire is mixed with white water draining through the wire and is used to dilute the stuff at the screens. The more solid broke at the presses and the dry broke from the dryers, calenders, winder and slitter must be repulped in a beater or pulper. It is stored in a chest and added in proper proportion to the machine sheet. In the case of machines making coloured papers, the broke is either dewatered and stored as wet laps or crumbs, or the dry broke from the machine room and finishing room is baled and stored dry.

The papermaking machine requires large amounts of power and steam. On many machines a steam engine or turbine provides the power, and the exhaust steam from it is used in the dryers, where the temperature is regulated by adding necessary quantities of live steam. Other machines are driven by electric motors, either one big motor driving a main shaft to which the several parts of the machine are connected or a separate motor for each part. Like persons walking in file, who must neither hurry nor lag, so each part of the paper machine must be in step. The analogy differs, however, in that the pace changes; the paper stretches in the "draw" between the wire and the first press, so that the surface speed of the latter must be increased slightly. Like adjustment must be made, but less noticeably, from one press to the next and from the last press to the dryers. The delicacy of this adjustment can be understood when it is remembered that strips of wet paper are being moved and there may be 50 h.p. driving one press of the machine. Modern instruments can detect the situation and control the speed differences accordingly. Then, as the paper is dried, it shrinks. Therefore a long set of dryers is divided into sections whose speeds can be progressively decreased. The calender and reel drives are tied in with the rest of the machine, but the slitter and winder is driven independently because the intermittent load would momentarily disturb the other motors.

Special Paper Machines.—Special machines are required for many of the endless number of pulp and paper products, from the lightest tissue to heavy building boards. These machines are adaptations of the basic Fourdrinier and cylinder designs. A high-speed machine (2,500–3,000 ft. per minute) has a short Fourdrinier wire and a so-called Yankee dryer, 12–14 ft. in diameter. A transfer attachment picks the paper from the wire and presses it against the polished surface of the dryer until dry, when it peels off like a handkerchief dried on glass. The Yankee dryer is also used for other tissues, light wrappings, and for making creped papers. Creping is done by a "doctor" that scrapes the paper off before it is quite dry and wrinkles it in doing so. At the other end of the scale are building and insulating boards up to an inch or more in thickness. Both Fourdrinier- and cylinder-type machines are used. One of the latter has two-vacuum-equipped cylinders; the Fourdrinier type has high deckle boards and special suction units. The sheet is then gradually pressed between two felts or two wires to the desired thickness and cut into slabs. The cutter moves across diagonally to compensate for the forward movement of the board and to produce square ends. The boards are then fed successively by a "tipple" to a different deck of an eight-deck dryer and carried through it on chain-driven rollers. A typical board dryer is more than 500 ft. long, with five zones at increasing temperatures. The board must be heated gradually to the point where moisture left in the centre will migrate to the overdried surface layers and give a uniformly dry product. Hardboard. such as Masonite. is pressed and dried at the same time between the plates of a hydraulic press. Board sheets are then trimmed to standard sizes and wrapped.

Finishing Operations.—Newsprint. much book and magazine paper and many wrapping papers and boards need only to be wrapped. if ordered in rolls. when they come off the paper machine. Other papers require further finishing or special treatment. some of which is done by the converter. For example. a very smooth surface on printing papers is obtained by passing the web through a supercalender. This machine is similar to the paper-machine calender. but alternate rolls are made of circles of paper compressed to a dense, hard mass and ground to a true cylinder. The special surface on writing papers is produced by building a stack of alternate sheets of paper and sheets of linen. crash. rippled cardboard, etc.. with sheets of zinc at intervals. and passing the "form" back and forth several times between rolls which exert a pressure on it of 60 to 80 tons. Another type of finish is the impression made by the embossing machine which has two rolls; one has the pattern embossed on it and the other may have a matching pattern engraved in its surface or be a roll of softer material which will take the indentation. To get sheets thicker than can be produced on the paper machine, pasting or laminating is employed. This also makes it possible to get a sheet composed of different qualities or colours. The laminator may operate with sheets or rolls. In the first case. paste is applied to both rolls of a pair. To paste two sheets. a dry sheet is placed in the collector. then two sheets are fed together, the bottom of one and the top of the other receiving paste. and so on. then a dry sheet is placed on the top of the pile, which is pressed. To get a three-layer sheet, a single sheet is fed alternately with the pairs; for a four-layer sheet. two singles are fed between pairs. The sheets are dried by hanging them with clips under a conveyor which carries them slowly through a heated drying chamber. Web pasters will laminate up to six sheets for wallboards. asphalted products. etc. In these laminators the outside sheets are fed dry, and the inner sheets pass through a bath of asphalt or adhesive, or over an applicator roll as in making moisture-proof kraft lining paper.

Coating Printing Stock.—Most important of special processes is the coating of paper for fine printing. The purpose is to fill the small depressions in the paper caused by irregularities in size of fibres or formation of the sheet and to give a surface of homogeneous material and structure which can be finished to almost perfect smoothness by the supercalenders. A mixture of clay or other white mineral matter, casein or other adhesive and dyes or other colouring matter is spread smoothly on one or both sides of the paper.

One-side coating is produced by an applicator roll and is then smoothed by brushes of finest badger hair. Two-side coating is obtained by passing the web through a bath or between a pair of applicator rolls and then between four to ten pairs of brushes. Drying of single-coated paper is done by carrying loops or festoons of paper on a conveyor. or over rollers through a drying chamber. Double-coated paper must be floated on hot air to set the coating before it contacts other support. Coating can also be carried out for certain grades and weights of paper by locating an applicator unit about two-thirds of the way down the length of the paper machine dryers. where the paper is sufficiently moist to permit penetration of the clay through the sheet. This is necessary in order to get equal smoothness on both surfaces.

Glue Sizing.—Somewhat akin to machine coating is the sizing of paper with glue. etc.. which cannot be effectively done in the beater as described above for rosin sizing. Glue. or surface. sizing is obtained by passing the paper through a size tub. with press rolls to squeeze out the excess. Drying and finishing have been described. The paper is made stronger. is resistant to spreading of ink. and fibres are not picked up by the pen. Paper is waxed in a somewhat similar way by passing the web through a bath of molten wax. then over a chilling roll to harden the wax.

Shipping Containers.—The production of paper shipping containers had become an important part of the paper industry by mid-20th century. the great majority being corrugated boxes and wrappers. Both kraft paper and straw board are used for corrugating. the latter giving particularly strong flutings.

Sizes.—Sizes of paper are expressed in inches or centimetres. according to the country of manufacture or specifications of the order. Many of the sizes in common use were given names. such as atlas. crown. demy. elephant. emperor. folio. foolscap. post. pott. royal. etc.. but names have been largely discontinued in favour of actual measurement. The folio sheet—17 × 22 in.—is generally accepted as standard for writing papers; 24 × 36 in. for wrapping and newsprint: 25 × 38 in. for book papers: and 20 × 26 in. for cover papers. A universal standard size. 25 × 40 in. (1.000 sq.in.) has been advocated. The traditional count is in quires of 24 sheets. and reams of 20 quires (480 sheets): but custom here also has changed. and most calculations are based on units of 500 or 1.000 sheets of the size and weight specified. For example. a paper order for stationery might be for 20-lb. 17 × 22 in. sheets. although the mill would ship it in sheets 22 × 34 in., and the printer would cut it into letterheads 8½ × 11 in.

The complete Hunter Museum of Paper is maintained at the Institute of Paper Chemistry. Appleton. Wis.

BIBLIOGRAPHY.—J. P. Casey. *Pulp and Paper*. 2 vol. (1952); E. M. Chamot and C. W. Mason. *Handbook of Chemical Microscopy*. 2nd ed., 2 vol. (1938–40); C. F. Cross and E. J. Bevan. *A Textbook of Papermaking*. 5th ed. (1926); American Paper and Pulp Association. *Dictionary of Paper*. 2nd ed. (1951); Julius Grant. *Wood Pulp and Allied Products*. 2nd ed. (1947); L. E. Wise (ed.). *Wood Chemistry* (1944); E. Heuser. *The Chemistry of Cellulose* (1944); Dard Hunter. *Papermaking, the History and Technique of an Ancient Craft* (1951). *Papermaking in Pioneer America* (1952). *Papermaking Through Eighteen Centuries* (1930); W. Raitt. *Digestion of Grasses and Bamboo for Paper-making* (1950); J. N. Stephenson (ed.). *Pulp and Paper Manufacture*. 4 vol. (1950–55); Edwin Sutermeister. *Chemistry of Pulp and Paper Making*. 3rd ed. (1941). (J. N. S.)

PAINT. A paint may be defined as a fluid suspension of finely divided solids which, when applied to a surface, will "dry" or set to an opaque film, either by oxidation or evaporation.

A paint consists of a mixture of (1) solid pigment (or a mixture of pigments) and (2) a liquid medium (known as the vehicle). The vehicle may be linseed or other drying oil; a water solution of casein or glue; a natural or synthetic resin solution in volatile solvents; a cotton ester solution in volatile solvent; or a natural or synthetic oil varnish base reduced for application with volatile solvent. The oil or other film-forming material is added to furnish a binder for the pigment, and the volatile material to give the paint the proper flowing consistency and to promote ease of application. When an oil paint is applied, the solvent, being volatile, rapidly evaporates from the painted surface, leaving behind the pigment and oil mixture as a wet coating; this mixture gradually dries into an elastic solid skin as a result of the oil's absorbing oxygen from the air. The solidified oil acts as a binder for the pigments and holds them in their place; a tough paint film is thus formed which adheres firmly to the surface and serves to protect and decorate.

A good quality of paint should be easily applied, cover well and be opaque or, as it is generally described, possess good hiding power. The hiding power of a paint is dependent on the amount and nature of the pigments it contains in suspension; and, as a rule, the finer the state of subdivision of the particles of the pigment the greater the hiding power. The durability of a paint is influenced greatly by the nature of the liquid portion, hence only pure drying oils or compounded vehicles of known performance should be used in its preparation. It is sometimes stated that the oil is the life of the paint. If this were true, oil alone should be more durable than paint, which is far from being the case, since, in fact, oil films do not wear as well as paint films because the addition of pigments to the oil films tends to reinforce them and to make them dry harder and become more impervious to air and moisture. Ordinary paints should dry with a glossy surface, but they can be made to dry with a flat finish by decreasing the oil content and increasing the proportion of turpentine or other volatile thinner.

The durability of an exterior paint can best be determined by practical exposure tests over a period of years. While raw or untreated drying oil is generally recommended, there are many special cases where oil processing and the addition of special resins is advantageous. On the other hand, the use of mineral oils, rosin oils, rosin varnishes or other soft resin varnish mediums may cause the rapid deterioration of paint films on exposure, resulting in the paint's cracking and chipping off after a comparatively short exposure.

The protective and anticorrosive properties of paint vary greatly with its pigment as well as its vehicle composition. For example, house paints are most satisfactorily formulated from lead, zinc and titanium oxide mixtures, properly balanced with lesser amounts of extender or suspending inerts. Where it is desired to protect ironwork, it is advisable to take advantage of the rust inhibitive properties of such pigments as red lead or the lead and zinc chromates.

Paints on exposure over a period of years may chalk (powder off), check, crack, blister or peel; the colour of the original paint may also change or even completely disappear. A high-grade durable paint for outdoor use should wear well over a period of four or five years, retain its colour, and chalk only to a moderate degree. Paints which blister or crack are unsatisfactory, inasmuch as it is then necessary to remove completely all the loose and badly adhering paint before any repainting can be done.

• **Pigments.**—These are finely divided, insoluble white or coloured powders obtained from naturally occurring earth colours or prepared by chemical manufacturing processes. In the manufacture of paint, it is essential that the colours or pigments used should be in the form of a fine dry powder; this result is achieved by subjecting them before use to a grinding and sieving process, the final particle being generally less than two microns in size.

The pigments which are commonly used in the manufacture of paints are as follows: *white pigments*—basic carbonate and basic sulphate white lead, leaded zinc, zinc oxide, titanium oxide, zinc sulphide, lithopone and, to a lesser extent, antimony and zirconium oxides; *inert pigments or extenders*—barite, blanc fixe, gypsum (terra alba), magnesium silicate, Paris white (whiting), China clay, silica; *yellow pigments*—lead chrome and zinc chrome yellow, ochre, sienna, ferrite, cadmium sulphide, organic lakes and toners; *blue pigments*—ultramarine, iron blue (Prussian, Chinese, milori), cobalt oxide, copper phthalocyanine, organic lakes and toners; *green pigments*—chrome green (iron blue–chrome yellow), chromium oxide and hydroxide, phthalocyanine, organic lakes and toners, Paris green; *red pigments*—iron oxide, Venetian red, Tuscan red, red lead, organic lakes and toners (para, toluidine, lithol, alizarine), cadmium selenide; *brown pigments*—umber, sienna, iron oxide, Vandyke; *black pigments*—carbon black, lampblack, bone black, iron oxide, organic black graphite; *metallic powders*—aluminum, copper, zinc, lead.

For a fuller description of pigments, *see* PAINTS, CHEMISTRY OF.

Mediums or Vehicles.—These are the liquid portions of paints which act as binders for pigments. The vehicle of ordinary ready-mixed oil paint consists of raw linseed oil—or a mixture of raw and processed linseed oil—with a small proportion of turpentine, which is added to make the paint more fluid and to promote ease of working. As turpentine is rather expensive, turpentine substitutes, made from a petroleum distillate (white spirit), are often used as a thinning agent. A small proportion of liquid driers (terebine) is usually incorporated in the medium; these driers are solutions of salts of lead, manganese and cobalt, and they increase the rate of drying of the oil by what is known as catalytic action. The medium used in the preparation of varnish paints, which dry with a high-gloss surface, consists of an elastic natural or synthetic resin varnish. (*See* VARNISH.) Artists' oil paints are usually made in the form of a stiff paste and sold in tubes; the vehicle consists of either poppy-seed oil or sun-bleached linseed oil, which is used in order to retain the purity of colour of the pigment. A less satisfactory medium is megilp, composed of linseed oil and mastic varnish. The vehicles for artists' water-colour paints are chiefly solutions in water of gum arabic, albumen, isinglass and size. Distemper and water paints are made with emulsified glue or casein vehicles. The mediums of the modern cellulose paints or enamels consist of a solution of cellulose esters, in acetone, amylacetate or other suitable mixed solvents.

Manufacture of Paint.—The process of manufacturing oil paint consists in mixing the dry fine pigment with sufficient medium to convert it into the form of a stiff paste. This stiff paste is then transferred to a roller mill, or other grinding machine, finely ground and finally conveyed to special paint-mixing machines, where it is thinned to the right consistency.

Usually a small proportion of paste driers or liquid driers is added at this stage to accelerate the drying of the paint.

As an immense variety of paint products are manufactured for industrial uses, it would be impossible to give more than a brief description of the most important varieties in common use.

Ready-Mixed Paint.—The commonest and most generally used paint is ordinary ready-mixed oil paint. This paint consists of pigments ground and mixed in a vehicle consisting of a mixture of raw and processed linseed oil, with a small proportion of turpentine. Pure pigments only are used in the preparation of many of these paints, but a proportion of some inert pigment or extender is sometimes added to aid in suspension and improve durability. These paints are manufactured in a large variety of colours. The most commonly used white paints are white lead and zinc oxide and titanium oxide paints.

Other pigments used in the manufacture of nonpoisonous white paints are lithopone and zinc sulphide. Titanium white was not introduced as a paint pigment until the second decade of the 20th century, but it came rapidly into favour because of its remarkable permanence and stability under all atmospheric conditions and also because of its obliterating power or opacity.

A white paint made with a mixture of zinc oxide and titanium white pigment as the base, and a vehicle consisting of processed oil or synthetic resin varnish, proved to give an excellent, durable paint suitable for exterior use.

The large variety of light shades or tints in common use are obtained by the addition of a small proportion of various-coloured pigments to white paint; thus, for example, white paint and a suitable black give grays from the lightest to the darkest hue, depending on the proportion of white and black used. Buff is obtained by tinting white with yellow ochre, cream colour results from adding a touch of chrome yellow to white and so on.

The amount of oil required to convert a pigment into paint form varies with the specific gravity of the pigment; a heavy pigment such as white lead (specific gravity 6.75) requires considerably less oil than a bulky pigment such as zinc oxide (sp.gr. 5.47) or vegetable black (sp.gr. 1.72).

Enamel or Varnish Paint.—Enamel paints dry to a brilliant surface of varying degrees of gloss. They are made by finely grinding the selected pigment or mixture of pigments in a varnish medium, and their nature and properties depend on the type of varnish used. A quick-drying variety is made from a synthetic resin-base varnish (phenolic or alkyd). It dries in two to four hours and, contrary to experiences of earlier days when such quick-drying enamels were made from short oil, natural resin or rosin varnishes, these quick-drying enamels have a high degree of toughness and abrasion resistance, retain their gloss and fullness against repeated cleaning and have proved themselves highly suitable for all interior work. For outside enamelling, slow-drying processed oil base enamels continued to be used to some extent, but certain synthetic base enamels became increasingly popular and practically displaced the processed oil and copal varnish enamels of an earlier day.

Flat Paint.—This type of paint is really a flat-drying enamel. It is made in the same way as the gloss enamels, except that the pigment is less finely ground and the vehicle contains less varnish and more volatile solvent than ordinary enamel. Because of their pleasing decorative effect, these paints are used for interior decorations, but they are not suitable for outside use.

Anticorrosion Paints.—These paints are largely used for protecting iron and steel structures from rusting. A good antirust paint is red lead paint, which is made by mixing red lead with raw linseed oil. As red lead in linseed oil rapidly sets into a hard mass if kept for any length of time, it is necessary to mix it just before use. A nonsetting red lead was introduced which obviated this defect and would keep, when mixed in linseed oil, in a liquid condition for any length of time. The use of inhibitive pigments, such as lead and zinc chromates, also became quite general, as did the use of a preliminary phosphoric chromic inhibitive wash. Graphite paints, red oxide paints and paints made from basic sulphate of lead are also used for the preservation of ironwork. Bituminous paints are also extensively used for painting ironwork, such as gas holders, bridges, docks, etc., because of their comparative cheapness and anticorrosive properties. They are composed of an asphalt or bitumen base dissolved in coal tar or naphtha solvent. They are usually black, but other colours can be obtained, which are made by the addition of strong staining pigments to the base.

Antifouling Paints.—These paints are used on ships' bottoms in order to prevent the growth of barnacles and weeds.

They are as a general rule quick-drying iron oxide paints, to which a proportion of poisonous material, such as white arsenic, copper suboxide, mercury oxide, etc., has been added. In contact with sea water, these poisonous materials gradually dissolve and thus inhibit any deposit or growth forming on the ship's bottom.

Metallic Paint.—Metallic paints, such as aluminum, copper, bronze and gold paints, are prepared by mixing the finely powdered metals or alloys with suitable varnish mediums. The metals must be in an exceedingly fine state of subdivision, and are manufactured from the metal leaf by special processes involving the use of intricate grinding machinery. The mediums used may be either thin varnishes or pyroxylin solutions.

Fireproof Paint.—These paints are made for use on woodwork, composition boards and other inflammable material. They are usually ordinary oil paints containing a proportion of fine asbestos, borax, sodium tungstate and other fire-retarding materials.

Automotive and Other Industrial Enamels.—A special class of exterior enamel for automotive or other vehicle finishing was developed on a quick-drying basis to replace the older multicoat slow-drying systems.

The lacquer-base (nitro cotton in suitable solvent) enamel introduced in the early 1920s was applied by spraying, dried in a few minutes; it could be polished to a high gloss, possessing exterior durability much superior to the copal varnish and processed oil enamels formerly used.

Synthetic resin enamels, mostly of the alkyd (glycerol phthalate) type, became increasingly popular for automotive and other industrial finishing, because of their superior gloss retention and general economy of application.

Synthetic base enamels of the phenolic, alkyd and urea resin types proved satisfactory in the finishing of household appliances; These are force dried at fairly high temperatures, have a beautiful lustre and are resistant to mechanical and chemical (washing powder, ammonia, grease, water, alcohol) abuse.

(J. G. Be.; E. E. Wa.; X.)

APPENDIX D

RESULTS OF LABORATORY CHEMICAL ANALYSES FOR SOIL SAMPLES

BROWN AND CALDWELL
CONSULTING ENGINEERS

ENVIRONMENTAL SCIENCES DIVISION

D. H. CALDWELL, PE Chairman
T. V. LUTGE, PE President
R. C. ABERLEY, PE Exec Vice Pres
S. A. FISHER, Vice Pres

August 27, 1981

Mr. Lawrence Houps
Woodward-Clyde Consultants
P.O. Box 24075
Oakland, CA 94607

705-611

Dear Mr. Houps:

Enclosed are the laboratory results from the Pacific Union/Marketplace site investigation. The volatile organic scans were performed in the same manner as in our report of 1/5/81.

If we can be of any further assistance please do not hesitate to contact us.

Very truly yours,

BROWN AND CALDWELL

Edward D Wilson

Edward Wilson
Laboratory Director

EW:sef
Enclosures

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CHEMICAL AND BIOLOGICAL LABORATORIES

BROWN AND CALDWELL
CONSULTING ENGINEERS

ENVIRONMENTAL SCIENCES DIVISION

D. H. CALDWELL, PE Chairman
T. V. LUTGE, PE President
R. C. ABERLEY, PE Exec Vice Pres
S. A. FISHER, Vice Pres

August 26, 1981

Mr. Larry Houps
Woodward-Clyde Consultants
2722 Adeline Street
Oakland, CA 94607

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705-611

TOTAL IDENTIFIABLE CHLORINATED HYDROCARBONS ANALYSIS OF SOIL

Date Sampled/Received: As Noted

Log No.	Sample Description/Identification	Results ppm
70J25	Boring #2; Sample #1; Tube #3 Date Sampled/Received: 8/3/81	Chlordane - 0.49
70K1	Boring #3; Sample #1; Tube #4 Date Sampled/Received: 7/29/81	None Detected
74H1	Boring #3D; Sample #2; Tube #3 Date Sampled/Received: 8/7/81	None Detected
70K31	Boring #4C; Sample #1; Tube #4 Date Sampled/Received: 8/4/81	Aroclor 1260 - 0.34
73C7	Boring #5A; Sample #1; Tube #3 Date Sampled/Received: 8/5/81	None Detected
70K22	Boring #8; Sample #1; Tube #4 Date Sampled/Received: 7/31/81	Aroclor 1242 - 29 Aroclor 1260 - 4.0
73C11	Boring #9; Sample #2; Tube #3 Date Sampled/Received: 8/6/81	None Detected

Log No.	Sample Desctiption/Identification	Results ppm
73C12	Boring #9; Sample #3; Tube #3 Date Sampled/Received: 8/6/81	None Detected
70K35	Boring #10; Sample #2; Tube #4 Date Sampled/Received: 8/4/81	None Detected
70J36	Boring #10; Sample #3; Tube #3 Date Sampled/Received: 8/4/81	None Detected
73C3	Boring #11; Sample #1; Tube #3 Date Sampled/Received: 8/5/81	None Detected
73D4	Boring #11; Sample #3; Tube #4 Date Sampled/Received: 8/5/81	None Detected
70J21	Boring #1; Sample #2; Tube #2 Date Sampled/Received: 7/30/81	None Detected
70J26	Boring #2; Sample #2; Tube #3 Date Sampled/Received: 8/3/81	Chlordane - 0.99
70J2	Boring #3; Sample #3; Tube #3 Date Sampled/Received: 7/29/81	None Detected
70J33	Boring #4C; Sample #3; Tube #3 Date Sampled/Received: 8/4/81	None Detected
70J12	Boring #5; Sample #1; Tube #3 Date Sampled/Received: 7/30/81	None Detected
70J13	Boring #5; Sample #3; Tube #3 Date Sampled/Received: 7/30/81	Aroclor 1260 - 0.12
70J15	Boring #6; Sample #1; Tube #3 Date Sampled/Received: 7/30/81	None Detected
70J3	Boring #7; Sample #1; Tube #3 Date Sampled/Received: 7/29/81	Aroclor 1260 - 0.19

Log No.	Sample Desctiption/Identification	Results ppm
70J23	Boring #8; Sample #2; Tube #3 Date Sampled/Received: 7/31/81	Aroclor 1242 - 9.6 Aroclor 1260 - 1.3
73C13	Boring #9; Sample #4; Tube #3 Date Sampled/Received: 8/6/81	None Detected
74H6	Boring #10D; Sample #4; Tube #3 Date Sampled/Received: 8/11/81	None Detected
74H7	Boring #11; Sample #4; Tube #3 Date Sampled/Received: 8/11/81	None Detected
74H4	Near Boring #8; Surface Tar Date Sampled/Received: 8/7/81	None Detected
74H5	Near Boring #11; Surface Tar Date Sampled/Received: 8/7/81	None Detected

The following compounds would have been reported had they appeared at or above their respective detection limits as indicated below: (ppm)

CHLORINATED PESTICIDES

Aldrin	0.01
BHC (mixed isomers)	0.01
Lindane	0.01
Chlordane	0.03
DDD	0.01
DDE	0.01
DDT	0.01
Dieldrin	0.01
Endrin	0.03
Heptachlor	0.01
Heptachlor Epoxide	0.01
Methoxychlor	0.05
Toxaphene	0.30

POLYCHLORINATED BIPHENYLS

Aroclors 1016 - 1262	0.05

Reported by: Edward Wilson
Edward Wilson
Laboratory Director

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CONSULTING ENGINEERS
ENVIRONMENTAL SCIENCES DIVISION
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Log No As Noted

Date Sampled As Noted
Date Received As Noted
Date Reported 8/26/81

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WCC #15093A

BC #705-611

Report To:
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Woodward-Clyde Consultants
2722 Adeline Street
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Oakland, CA 94607

Edward Wilson
Laboratory Director

cc.

Log No.	Sample Description
70J25	Boring #2; Sample #1; Tube #3; 7/31/81
K1	Boring #3; Sample #1; Tube #4; 7/29/81
H1	Boring #3D; Sample #2; Tube #3; 8/7/81
70K31	Boring #4C; Sample #1; Tube #4; 8/4/81
C7	Boring #5A; Sample #1; Tube #3; 8/5/81
K22	Boring #8; Sample #1; Tube #4; 7/31/81

Results mg/kg; wet weight basis

Sample Log No.	70J25	70K1	74H1	70K31	73C7	70K22
Arsenic	3.5	4.6	2.6	12	3.7	1.6
Cadmium	< 0.5	< 0.4	< 0.4	< 0.5	< 0.4	11
Chromium	46	57	63	110	50	1000
Cobalt	11	8.8	3.2	9.0	8.0	11
Copper	370	45	16	340	20	1100
Lead	340	38	7	280	44	880
Nickel	38	40	28	84	36	130
Zinc	350	83	36	430	91	2300
Total Solids, Percent	90.8%	86.9%	81.4%	84.9%	92.0%	90.0%

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Log No. As Noted

Date Sampled As Noted
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Date Reported 8/26/81

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WCC #15093A

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Oakland, CA 94607

cc.

Edward Wilson
Laboratory Director

Log No.	Sample Description
73C11	Boring #9; Sample #2; Tube #3; 8/6/81
C12	Boring #9; Sample #3; Tube #3; 8/6/81
K35	Boring #10; Sample #2; Tube #4; 8/4/81 ✓✓
70J36	Boring #10; Sample #3; Tube #3; 8/4/81 ✓
C3	Boring #11; Sample #1; Tube #3; 8/5/81
D4	Boring #11; Sample #2; Tube #4; 8/5/81

Results mg/kg; wet weight basis

Sample Log No.	73C11	73C12	✓✓ 10-2 70K35	✓ 70J36	73C3	73D4
Arsenic	2.5	2.9	18	4.4	0.50	3.4
admium	< 0.5	< 0.5	1.0	< 0.5	< 0.5	< 0.5
hromium	95	200	150	42	2.9	87
Cobalt	16	3.3	16	8.5	< 0.7	10
opper	49	42	1000	40	10	31
ead	15	14	740	9	7	9
Nickel	28	37	240	31	46	51
nc	42	81	1900	38	11	97
otal Solids, Percent	83.9%	80.6%	79.0%	89.6%	95.1%	81.2%

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Log No 73C12

Date Sampled 8/6/81
Date Received 8/6/81
Date Reported 8/26/81

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WCC #15093A

BC #705-611

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Edward Wilson
Laboratory Director

cc.

Log No.

Quality Control Data

Sample Description

A and B are duplicate analyses. Percent recovery is that percent of a standard addition made to the sample which is recovered by the analysis.

Sample Log No.	73C12A	73C12B	Percent Recovery
Arsenic	3.8	1.9	94
Cadmium	< 0.5	< 0.5	100
Chromium	110	300	98
Cobalt	4.3	2.3	100
Copper	39	44	100
Lead	14	14	100
Nickel	38	36	93
Zinc	93	68	98

Volatile Organics Scan

Summary of the Method of Analysis:

One gram of sample taken from a refrigerated volatile organics vial was added to a specially designed sparging vessel with 4mL organic-free water. The sample was then gently but finely homogenized with a spatula with care taken not to aerate the mixture. The vessel was then attached to the pruge and trap device and analyzed according to the conditions described for the particular scan.

Reference Peaks: Purgeable Halocarbon Analysis
Compound: Bromoform
Weight (ng): 18
Retention Time (min): 21
Approximate Response (ng/area): $2.29x10^{-5}$

To assist in the interpretation of the chromatographic analyses, a chromatogram of a few representative halocarbons spiked into water containing soil is presented.

Purgeable Aromatic Analysis:
Compound: Ethyl Benzene
Weight (ng): 19 (except as noted)
Retention Time (min): 14.9
Approximate Response (ng/area): $8.03x10^{-5}$

To assist in the interpretation of the chromatographic analyses, a chromatogram of a few representative aromatic compounds spiked into water containing soil is presented.

Conditions for Purgeable Aromatics

Multiple Purge and Trap Device, Tekmar ALS Unit Interfaced with a Tekmar Model LSC-2

Purge: 11 minutes
30°C
70 cc/minute Helium
Desorb: 2 minutes
200°C
40 cc/minute Helium
Bake: 25 minutes
300°C
Trap: Tenax GC

Gas Chromatograph, Varian Model 3700

Column: 5% SP- 2100/ 1-75% Bentone 34 on 100/120 Supelcoport, 6' X 1/8", stainless steel
Flow: 20 cc/minute Helium
Temperature Program: Initial; 40°C, 2 minutes
Rate; 1°C/minute
Final; 65°C, 3 minutes
Injector Temperature: 250°C
Detector Temperature: 300°C

Photoinization Detector (PID), HNU Model PI-52

Range: 1
Lamp: 10.2 eV
Lamp Intensity: 85%
Detector Temperature: 250°C

Recorder, Hewlett Packard Model 3390A

Recorder Attenuation: 4
Chart Speed: 1 cm/minute

Conditions for Purgeable Halocarbons

Multiple Purge and Trap Device, Tekmar ALS Unit Interfaced with a Tekmar Model LSC-2

Purge:	11 minutes 30°C 70 cc/minute Helium
Desorb:	4 minutes 200°C 40 cc/minute Helium
Bake:	25 minutes 300°C
Trap:	Tenax GC

Gas Chromatograph, Varian Model 3700

Column:	1% 50-1000 on Carbopack B with a 5cm precolumn of 3% SP-1000 on 100/200 Supelcoport, 8' X 2mm i.d. glass
Flow:	40 cc/minute Helium
Temperature Program:	Initial; 45°C, 3 minutes Rate; 8°C/minute Final; 220°C, 2 minutes
Injector Temperature:	250°C
Detector Temperature:	300°C

Halide Specific Detector (HSD), Tracor Model 560/700A Hall Electolytic Conductivity Detector

Range:	100
Solvent:	n-propyl alcohol
Solvent Flow:	0.5 mL/minute
Furnace Temperature:	810°C
Reaction Tube:	Nickel
Reaction Gas:	Hydrogen

Recorder, Hewlett Packard Model 3390A

Recorder Attneuation:	4
Chart Speed:	1 cm/minute

Special Notes Pertaining to PID Chromatograms:

1. The initial dip in the PID chromotagrams are assumed to be due to water vapor.

2. Sudden dips in the chromatograms marked by the presence of the letters AE or 2 are manually initiated recorder manipulations performed by the analyst in an attemp to optimize the chromatogram. They do not represent peaks and do not incur changes which effect the analytical integrity of the analysis.

3. Analyses 73C11, 73C12, 70J36, 73D4, and 70K35 contain 1 ng of Ethyl Benzene as the internal standard.

4. Although no precise quanitiation can be attempted, we estimate (based on the response of Ethyl Benzene) the levels of each peak to be in the range of 1-100 nanograms/gram of sample (ppb).

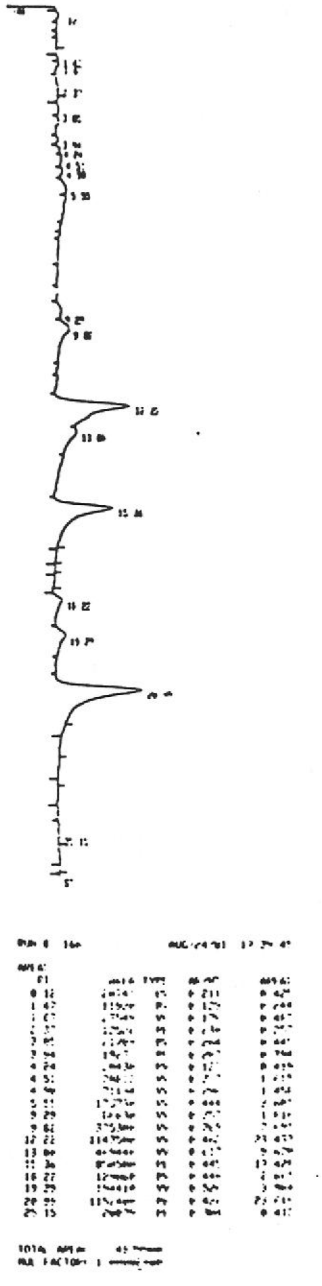
5. Some of the soils analyzed were very sandy and/or moist. No correction was made for silica or water content.

Special Notes Pertaining to HECD Chromatograms:

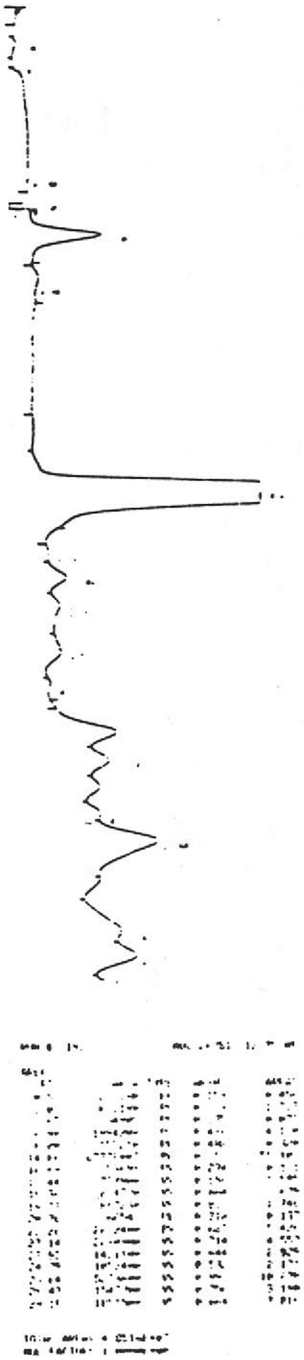
1. Although no precise quantitation can be attempted, we estimate (based on the response of Bromoform) the levels of each peak to be in the range of 1-50 nanograms/gram of sample (ppb).

2. Some of the soils analyzed were very sandy and/or moist. No correction was made for silica or water content.

3. The Hall Electrolytic Conductivity Response is dependent on the species and extent of halogenation.



HECD Scan

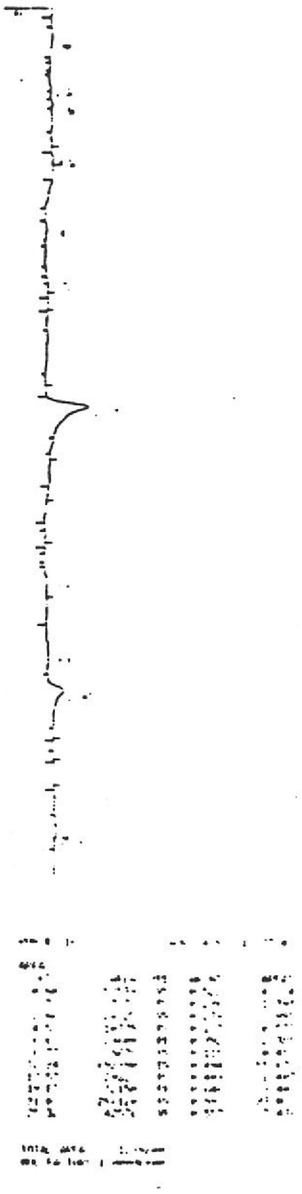


PID Scan

70J25

Boring #2; Sample #1; Tube #3

Date Sampled/Received: 8/3/81



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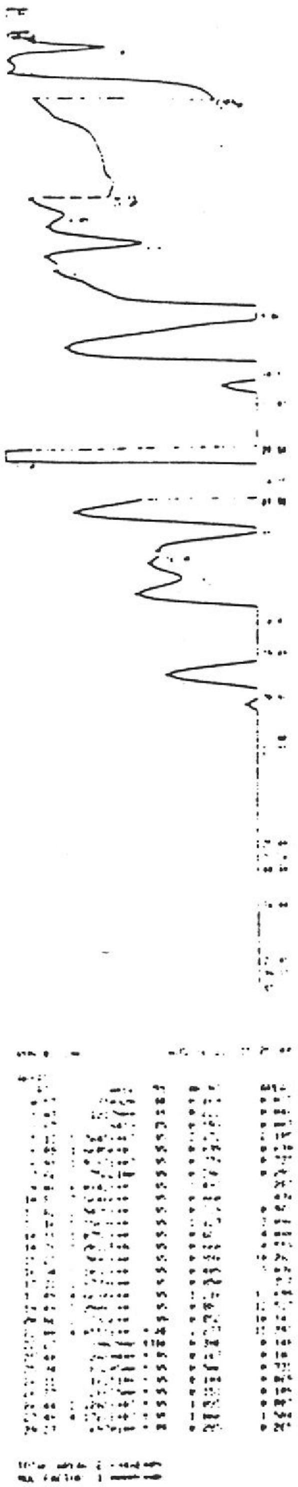
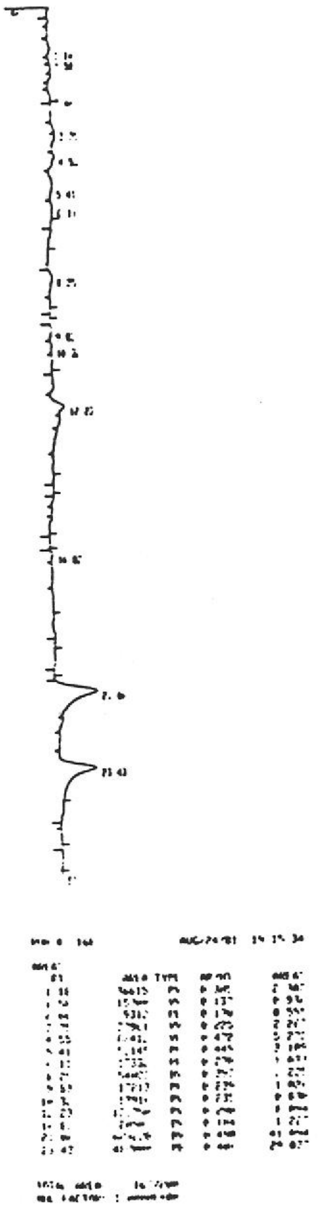


PID Scan

70K1
Boring #3; Sample #1; Tube #4
Date Sampled/Received: 7/29/81



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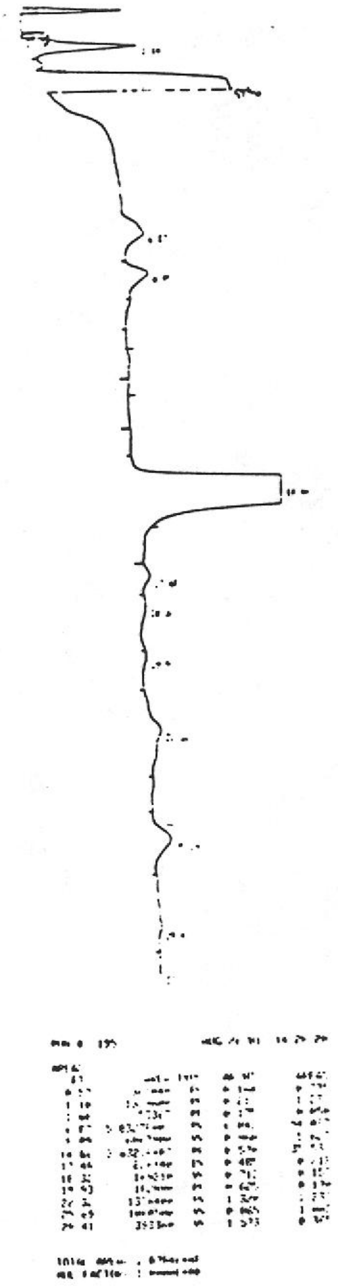
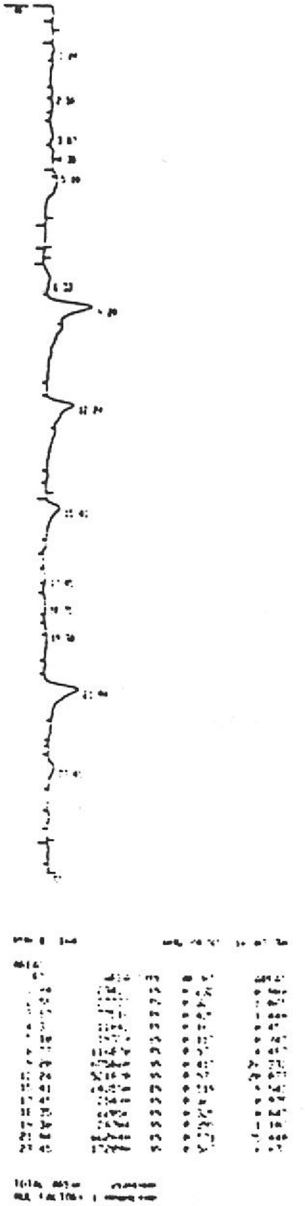


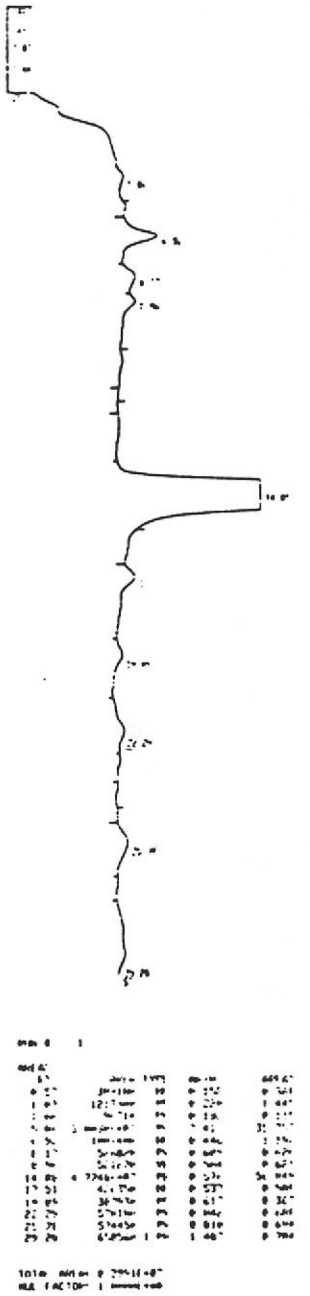
PID Scan

74H1

Boring #3D; Sample #2; Tube #3

Date Sampled/Received: 8/7/81





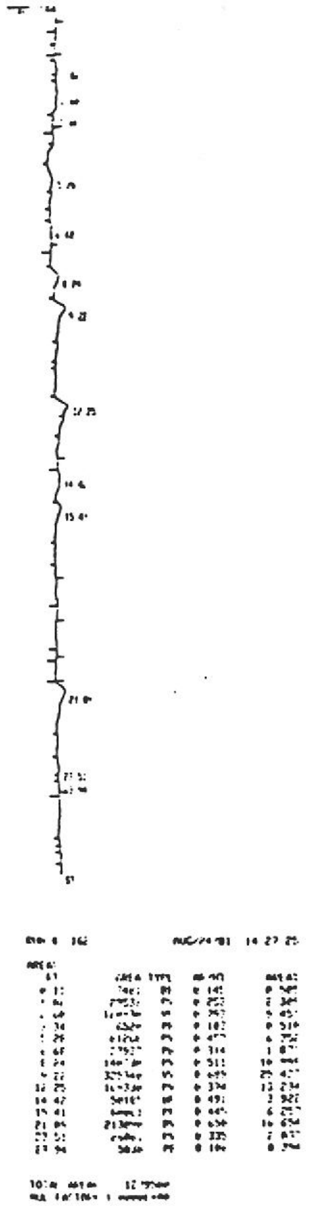
HECD Scan

PID Scan

70K31

Boring #4C; Sample #1; Tube #4

Date Sampled/Received: 8/4/81



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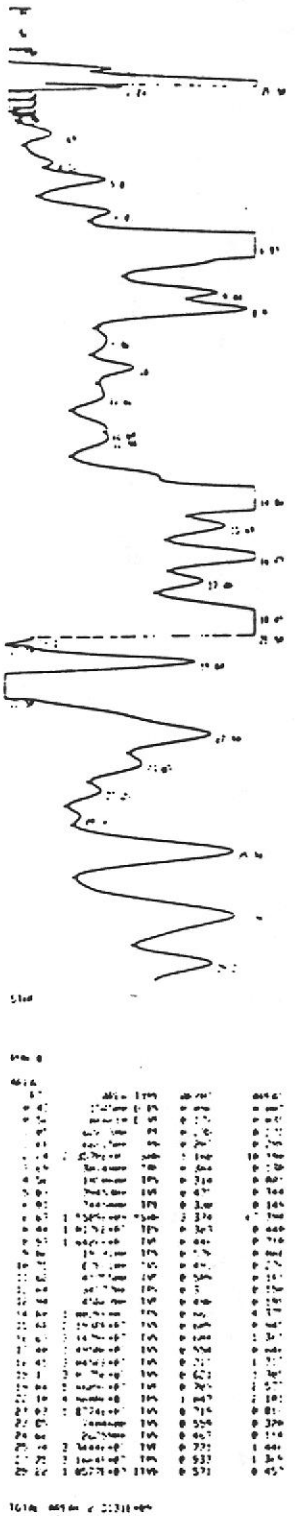
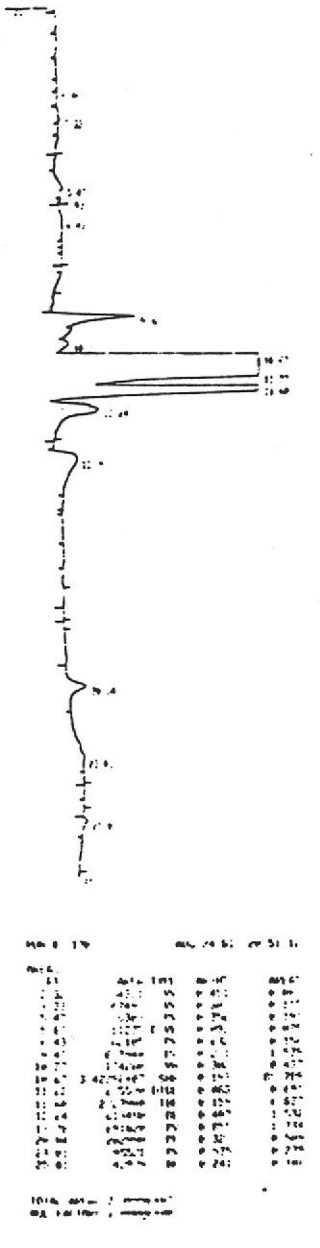
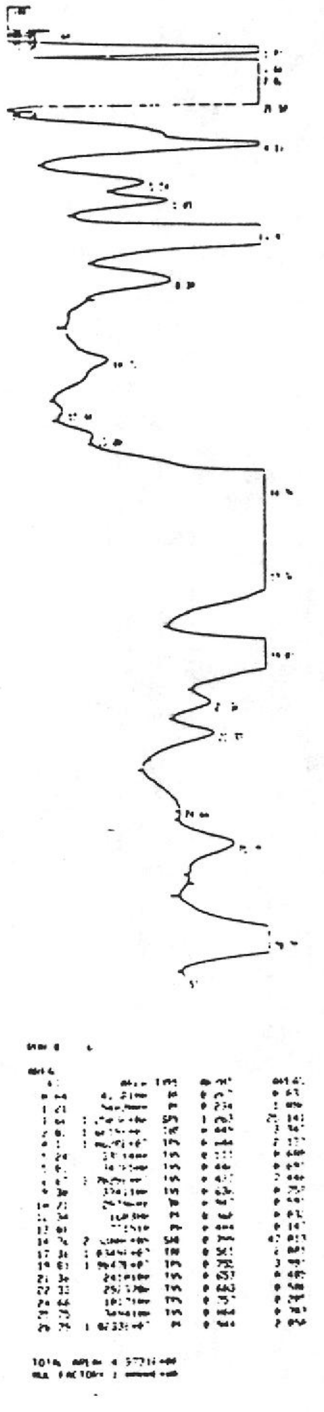


PID Scan

73C7
Boring #5A; Sample #1; Tube #3
Date Sampled/Received: 8/5/81





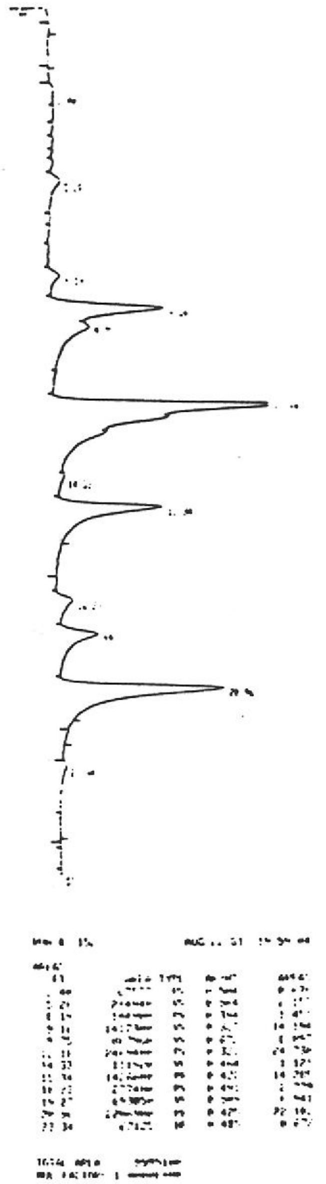
HECD Scan

PID Scan

70K22

Boring #8; Sample #1; Tube #4

Date Sampled/Received: 7/31/81



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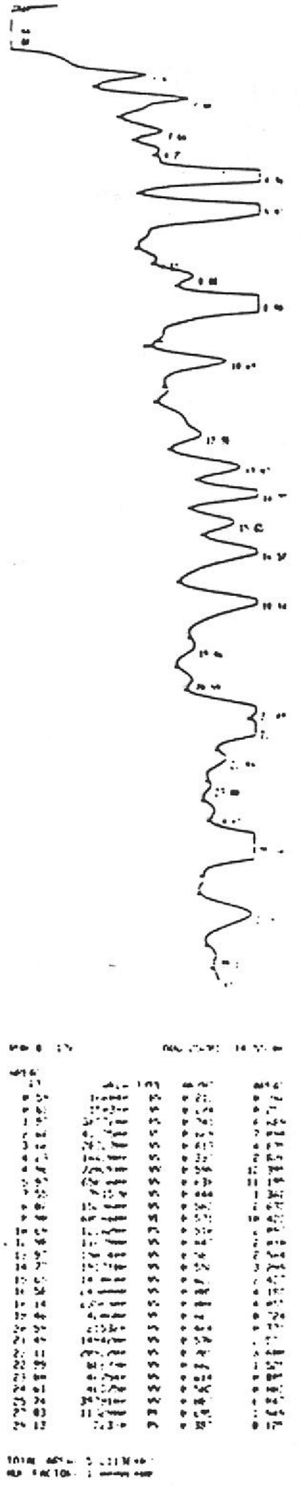
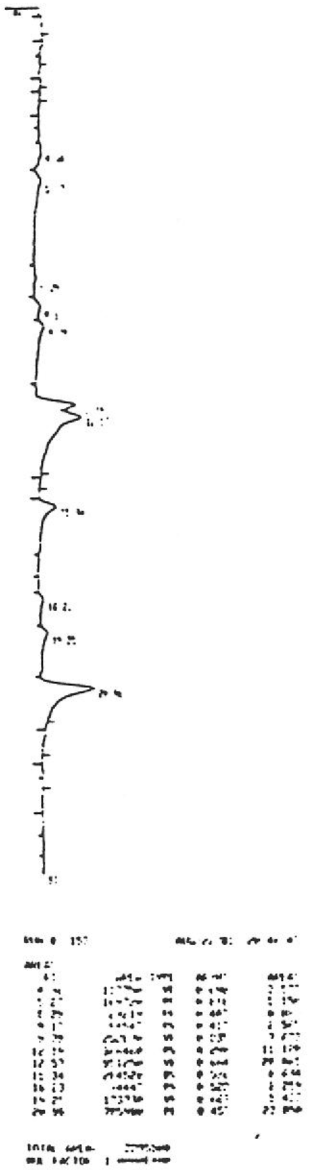


PID Scan

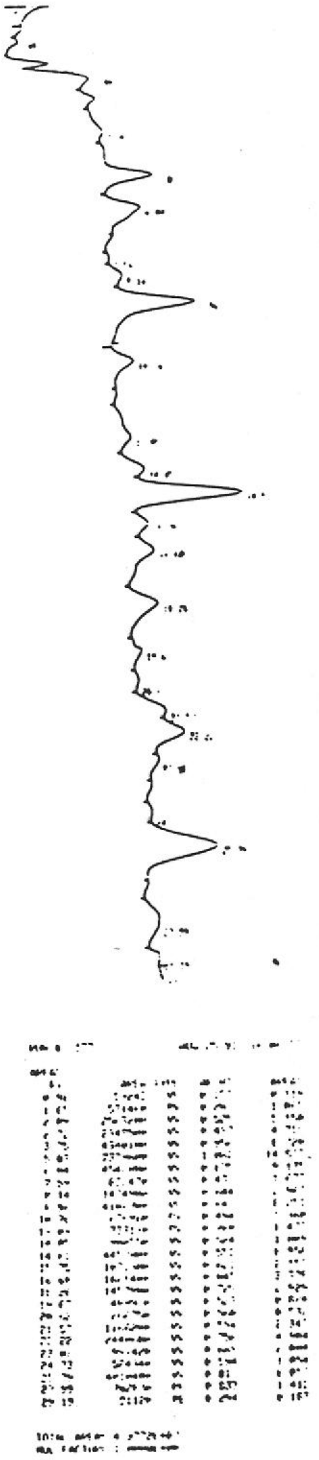
73C11

Boring #9; Sample #2; Tube #3

Date Sampled/Received: 8/6/81



HECD Scan

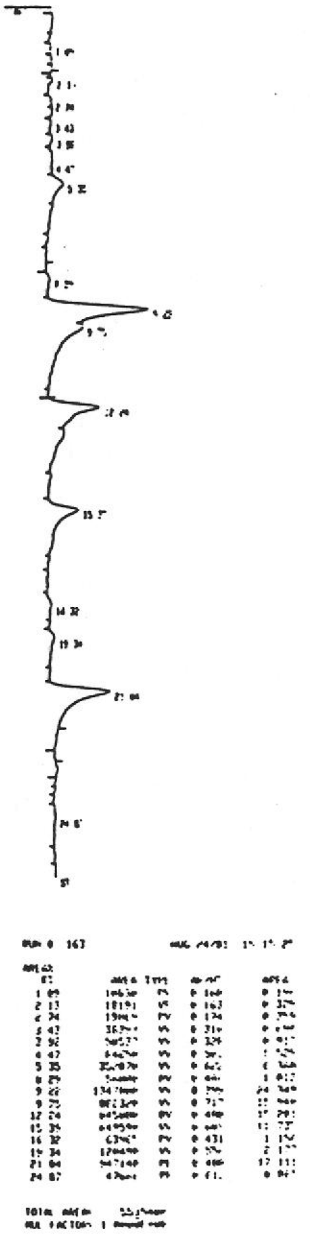


PID Scan

73C12

Boring #9; Sample #3; Tube #3

Date Sampled/Received: 8/6/81



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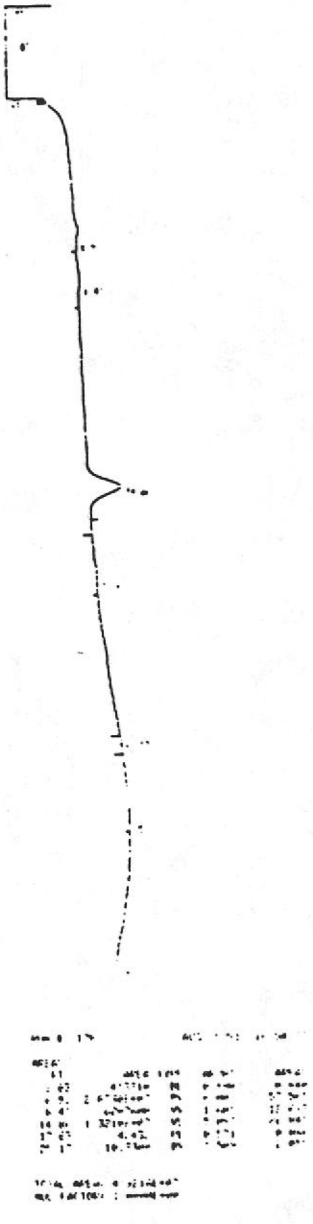
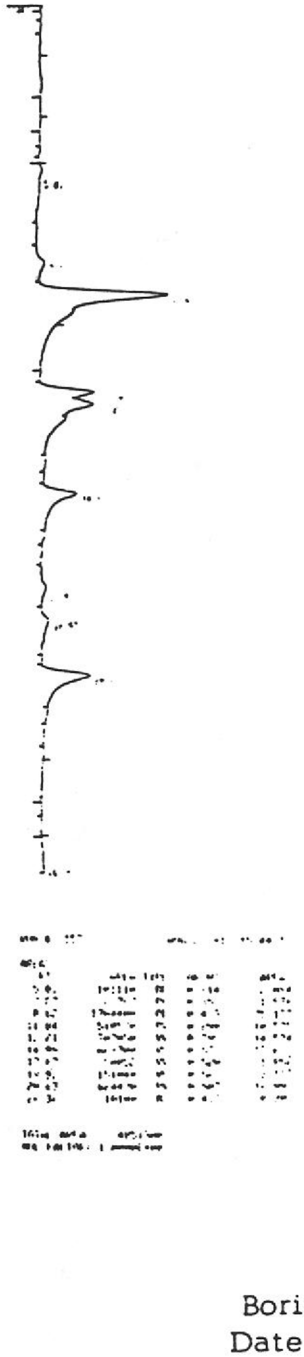


PID Scan

70K35
Boring #10; Sample #2; Tube #4
Date Sampled/Received: 8/4/81



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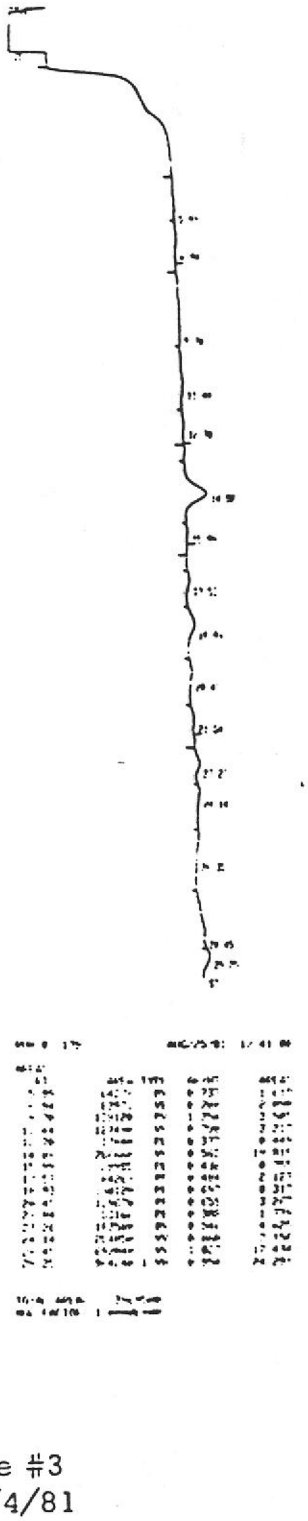
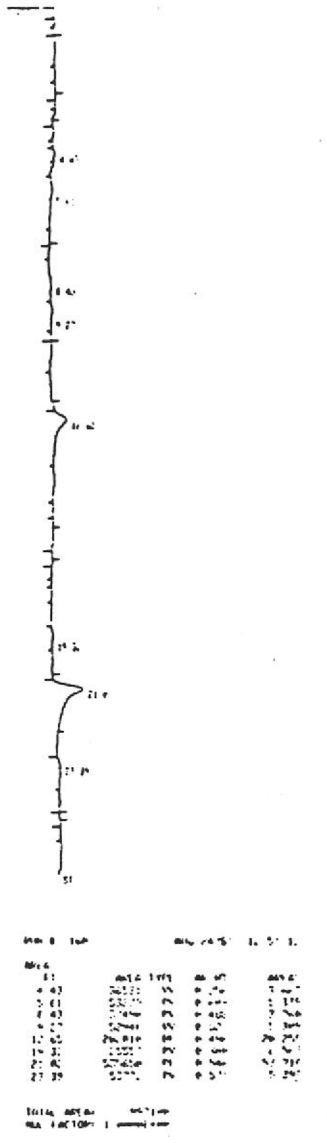
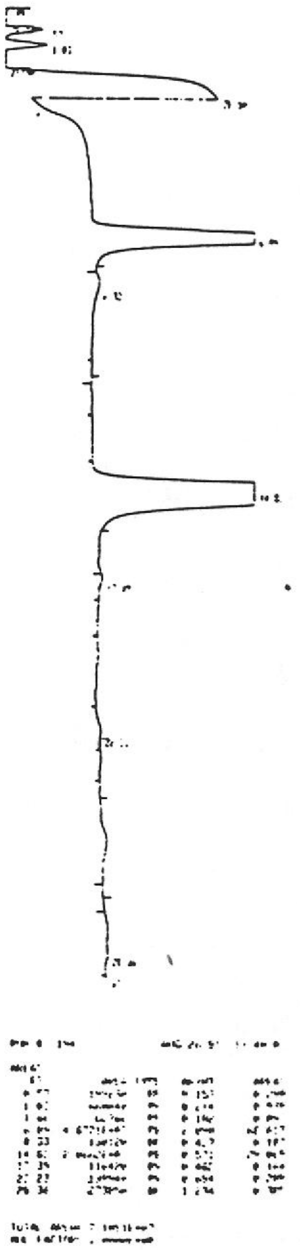


PID Scan

70J36
Boring #10; Sample #3; Tube #3
Date Sampled/Received: 8/4/81

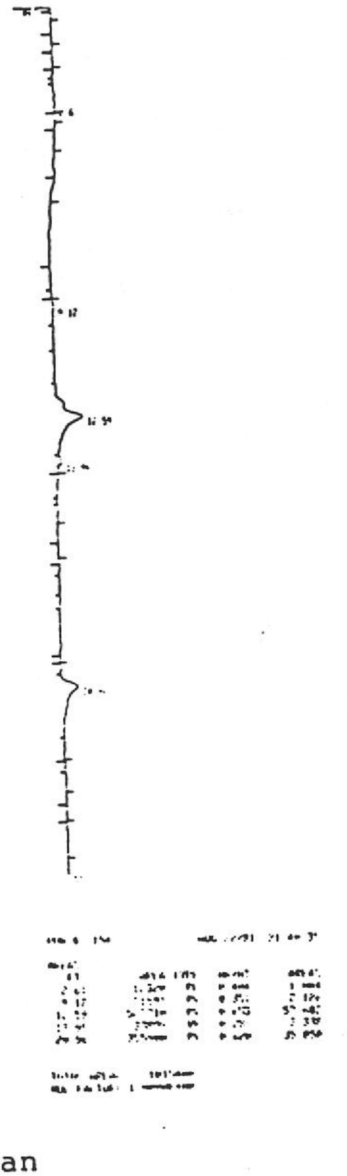


HECD Scan

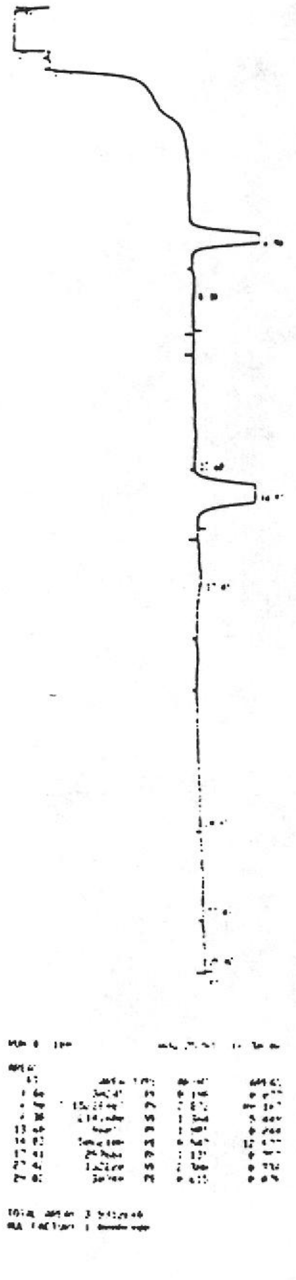


PID Scan

73C3
Boring #11; Sample #1; Tube #3
Date Sampled/Received: 8/5/81

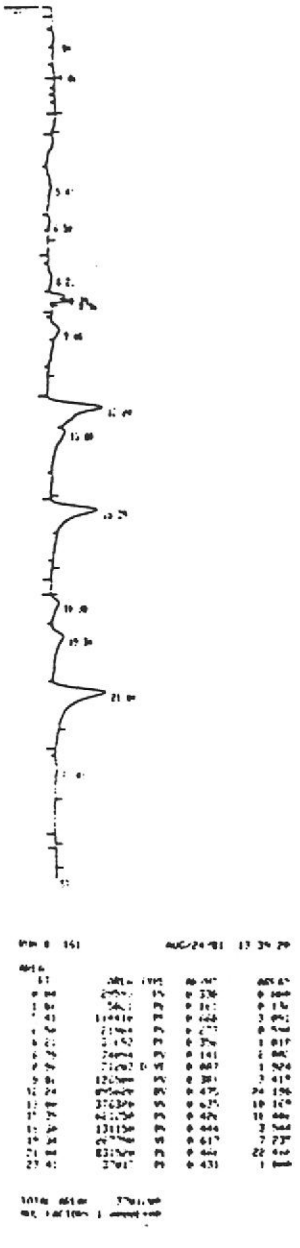


HECD Scan

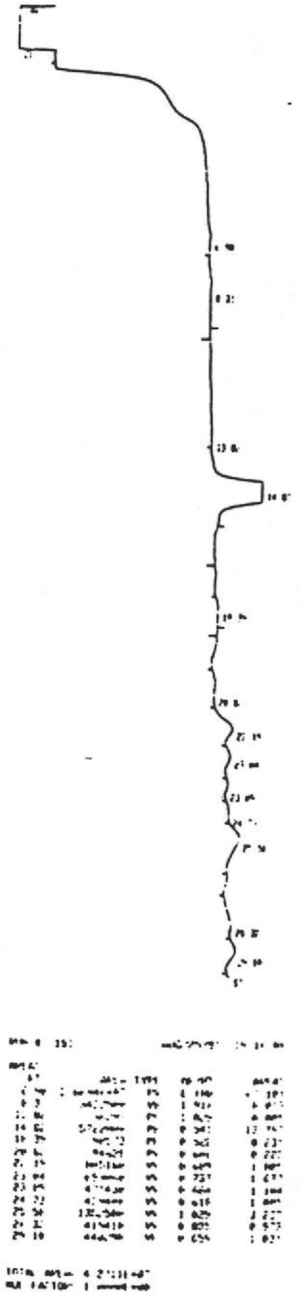


PID Scan

Duplicate Analyses
73C3
Boring #11; Sample #1; Tube #3
Date Sampled/Received: 8/5/81

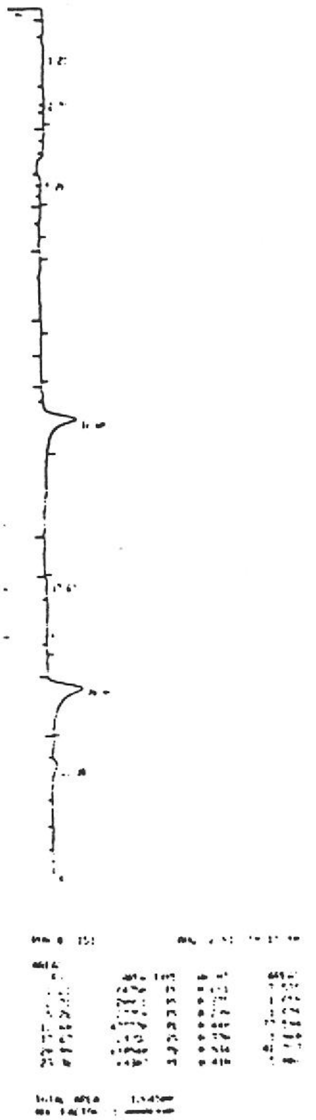


HECD Scan



PID Scan

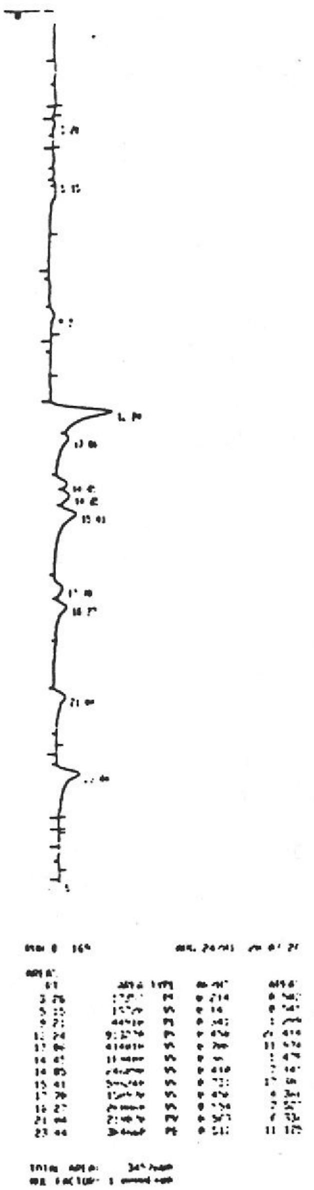
73D4
Boring #11; Sample #3; Tube #4
Date Sampled/Received: 8/5/81



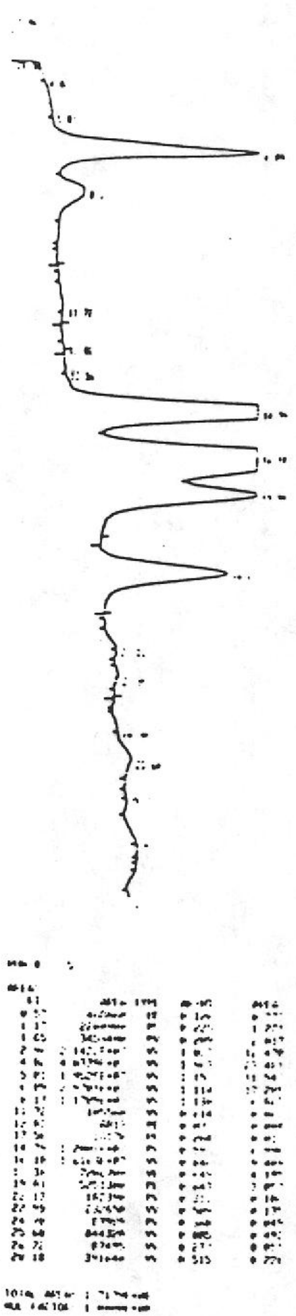
HECD Scan

PID Scan

Blanks



HECD Scan



PID Scan

SPIKES

Retention Time	Compound
5.15	Dichloromethane
12.24	Chloroform
13.06	1,2-Dichloroethane
14.45	1,1,1-Trichloroethane
14.85	Carbon Tetrachloride
15.41	Bromodichloromethane
17.70	Trichloroethylene
18.27	Dibromochloromethane
21.04	Bromoform
23.44	Tetrachloroethylene

Retention Time	Compound
6.89	Toluene
8.13	Chlorobenzene
14.79	Ethyl Benzene
16.18	p-Xylene
17.38	m-Xylene
19.81	o-Xylene

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Report To:
Mr. Larry Houps
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2722 Adeline Street
Oakland, CA 94607

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705-611

#15093A

Laboratory Director

cc.

Log No.	Sample Description
73C11	Boring #9; Sample #2; Tube #3; 8/6/81
3C12	Boring #9; Sample #3; Tube #3; 8/6/81
0K35	Boring #10; Sample #2; Tube #4; 8/4/81
70J36	Boring #10; Sample #3; Tube #3; 8/4/81
3C3	Boring #11; Sample #1; Tube #3; 8/5/81
3D4	Boring #11; Sample #2; Tube #4; 8/5/81

Results mg/kg; wet weight basis

Sample Log No.	73C11	73C12	70K35	70J36	73C3	73D4
Chromium, hexavalent	< 0.2	< 0.2	0.2	< 0.2	8.4	< 0.2

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#15093A

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Oakland, CA 94607

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Log No.	Sample Description
70J25	Boring #2; Sample #1; Tube #3; 7/31/81
0K1	Boring #3; Sample #1; Tube #4; 7/29/81
4H1	Boring #3D; Sample #2; Tube #3; 8/7/81
70K31	Boring #4C; Sample #1; Tube #4; 8/4/81
3C7	Boring #5A; Sample #1; Tube #3; 8/5/81
0K22	Boring #8; Sample #1; Tube #4; 7/31/81

Results mg/kg; wet weight basis

Sample Log No.	70J25	70K1	74H1	70K31	73C7	70K22
hromium, hexavalent	< 0.2	< 0.2	< 0.2	< 0.2	0.4	0.4

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WWC #15093A

BC #705-611

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Report To:
Mr. Larry Houps
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2722 Adeline Street
P.O. Box 24075
Oakland, CA 94607

for E Wilson
Laboratory Director

cc.

Log No.	Sample Description
70J21	Boring #1; Sample #2; Tube #2; 4'-4.5', Sampled/Received: 7/30/81
70J26	Boring #2; Sample #2; Tube #3; 4.5'-5', Sampled/Received: 8/3/81
0J2	Boring #3; Sample #3; Tube #3; 6.5'-7', Sampled/Received: 7/29/81
70J33	Boring #4C; Sample #3; Tube #3; 9'-9.5', Sampled/Received: 8/4/81
70J12	Boring #5; Sample #1; Tube #3; 2'-2.5', Sampled/Received: 7/30/81
0J13	Boring #5; Sample #3; Tube #3; 7'-7.5', Sampled/Received: 7/30/81

Results mg/kg; wet weight basis

Sample Log No.	70J21	70J26	70J2	70J33	70J12	70J13
otal Chromium	76	62	70	57	51	60
Chromium, hexavalent[a]	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Copper	30	1600	57	27	71	27
Lead	15	370	20	10	35	15
Nickel	32	52	34	49	34	23
Zinc	70	800	60	46	80	34

) Hexavalent Chromium was run only if Total Chromium result was > 50.

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P.O. Box 24075
Oakland, CA 94607

for E. Wilson
Laboratory Director

cc.

Log No.	Sample Description
70J15	Boring #6; Sample #1; Tube #3; 2.5'-3'; Sampled/Received: 7/30/81
0J3	Boring #7; Sample #1; Tube #3; 2'-2.5'; Sampled/Received: 7/29/81
0J23	Boring #8; Sample #2; Tube #3; 4.5'-5'; Sampled/Received: 7/31/81
73C13	Boring #9; Sample #4; Tube #3; 9.5'-10'; Sampled/Received: 8/6/81
4H6	Boring #10D; Sample #4; Tube #3; 15'-15.5'; Sampled/Received: 8/11/81
4H7	Boring #11; Sample #4; Tube #3; 8'4"-9'; Sampled/Received: 8/11/81

Results mg/kg; wet weight basis

Sample Log No.	70J15	70J3	70J23	73C13	74H6	74H7
Total Chromium	880	79	96	54	60	40
hromium, hexavalent[a]	0.2	< 0.2	< 0.2	< 0.2	< 0.2	---
Copper	230	52	38	61	9.5	7.5
Lead	110	52	55	9	10	10
ickel	56	55	38	44	28	30
Zinc	550	95	150	66	32	30
Cadmium	< 0.5	---	---	---	---	---

) Hexavalent Chromium was run only if Total Chromium result was > 50.

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Log No.	Sample Description
74H4	Surface Tar Sample - Near Boring #8; Sampled/Received: 8/7/81
74H5	Surface Tar Sample - Near Boring #11; Sampled/Received: 8/7/81

Results mg/kg; wet weight basis

Sample Log No.	74H4	74H5
Total Chromium	20	64
Chromium, hexavalent[a]	---	9.4
Copper	7.0	130
Lead	50	300
Nickel	91	112
Zinc	70	290

[a] Hexavalent Chromium was run only if Total Chromium result was > 50.

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WWC #15093A

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P.O. Box 24075
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Laboratory Director

cc.

Log No.

Sample Description

Quality Control Data:

A and B are duplicate analyses. Percent recovery is that percent of a standard addition made to the sample which is recovered by the analysis.

Results mg/kg; wet weight basis

Sample Log No.	70J3A	70J3B	Percent Recovery	70J33A	70J33B	Percen Recover
Total Chromium	80	78	99	56	58	95
opper	48	56	100	16	38	93
ead	50	55	103	10	10	102
Nickel	56	54	99	51	47	99
inc	90	100	101	38	55	98

a) Hexavalent Chromium was run only if Total Chromium result was > 50.

Volatile Organics Scan

Summary of the Method of Analysis:

Purgeable Halocarbon Scan

One gram of sample taken from a refrigerated volatile organics vial was added to a specially designed sparging vessel with 4mL organic-free water. The sample was then gently but finely homogenized with a spatula with care taken not to aerate the mixture. The vessel was then attached to the purge and trap device and analyzed according to the conditions described for the particular scan.

Purgeable Aromatics Scan

The procedure for purgeable aromatics is the same as that for purgeable halocarbons, with the exception that only half of a gram of sample was used for the analysis.

Reference Peaks: Purgeable Halocarbon Analysis
Compound: Bromoform
Weight (ng): 176
Retention Time (min): 19.5
Approximate Response (ng/area): $2.73\text{x}10^{-5}$

To assist in the interpretation of the chromatographic analyses, a chromatogram of a few representative halocarbons spiked into water containing soil is presented.

Purgeable Aromatic Analysis:
Compound: Ethyl Benzene
Weight (ng): 4.9 for all
Retention Time (min): 12.9
Approximate Response (ng/area): 5.25×10^{-7}

To assist in the interpretation of the chromatographic analyses, a chromatogram of a few representative aromatic compounds spiked into water containing soil is presented.

Conditions for Purgeable Aromatics

Multiple Purge and Trap Device, Tekmar ALS Unit Interfaced with a Tekmar Model LSC-2

Purge: 11 minutes
30°C
70 cc/minute Helium
Desorb: 2 minutes
200°C
40 cc/minute Helium
Bake: 25 minutes
300°C
Trap: Tenax GC

Gas Chromatograph, Varian Model 3700

Column: 5% SP- 2100/ 1-75% Bentone 34 on 100/120 Supelcoport, 6' X 1/8", stainless steel
Flow: 20 cc/minute Helium
Temperature Program: Initial; 40°C, 2 minutes
Rate; 1°C/minute
Final; 65°C, 3 minutes
Injector Temperature: 250°C
Detector Temperature: 300°C

Photoinization Detector (PID), HNU Model PI-52

Range: 1-10
Lamp: 10.2 eV
Lamp Intensity: 95%
Detector Temperature: 250°C

Recorder, Hewlett Packard Model 3390A

Recorder Attenuation: 5
Chart Speed: 0.5 cm/minute

Conditions for Purgeable Halocarbons

Multiple Purge and Trap Device, Tekmar ALS Unit Interfaced with a Tekmar Model LSC-2

Purge:	11 minutes 30°C 70 cc/minute Helium
Desorb:	4 minutes 200°C 40 cc/minute Helium
Bake:	27 minutes 300°C
Trap:	Tenax GC

Gas Chromatograph, Varian Model 3700

Column:	1% 50-1000 on Carbopack B with a 5cm precolumn of 3% SP-1000 on 100/200 Supelcoport, 8' X 2mm i.d. glass
Flow:	60 cc/minute Helium
Temperature Program:	Initial; 45°C, 3 minutes Rate; 8°C/minute Final; 220°C, 5 minutes
Injector Temperature:	250°C
Detector Temperature:	300°C

Halide Specific Detector (HSD), Tracor Model 560/700A Hall Electolytic Conductivity Detector

Range:	100
Solvent:	n-propyl alcohol
Solvent Flow:	0.5 mL/minute
Furnace Temperature:	810°C
Reaction Tube:	Nickel
Reaction Gas:	Hydrogen

Recorder, Hewlett Packard Model 3390A

Recorder Attneuation:	5
Chart Speed:	0.8 cm/minute

Special Notes Pertaining to PID Chromatograms:

1. The initial dip in the PID chromotagrams are assumed to be due to water vapor.

2. Sudden dips in the chromatograms marked by the presence of the letters ZE or 2 are manually initiated recorder manipulations performed by the analyst in an attemp to optimize the chromatogram. They do not represent peaks and do not incur changes which effect the analytical integrity of the analysis.

3. Although no precise quanitiation can be attempted, we estimate (based on the response of Ethyl Benzene) the levels of each peak to be in the range of 1-50 nanograms/gram of sample (ppb), except for 70J13. The range on this sample is 50 to 500 ppb.

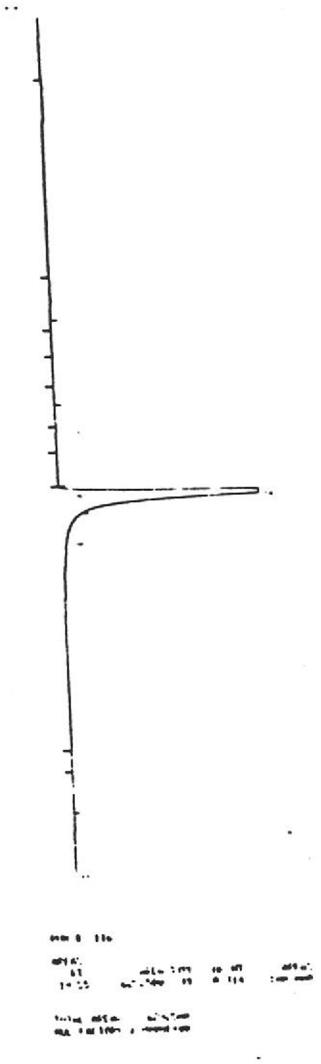
4. Some of the soils analyzed were very sandy and/or moist. No correction was made for silica or water content.

Special Notes Pertaining to HECD Chromatograms:

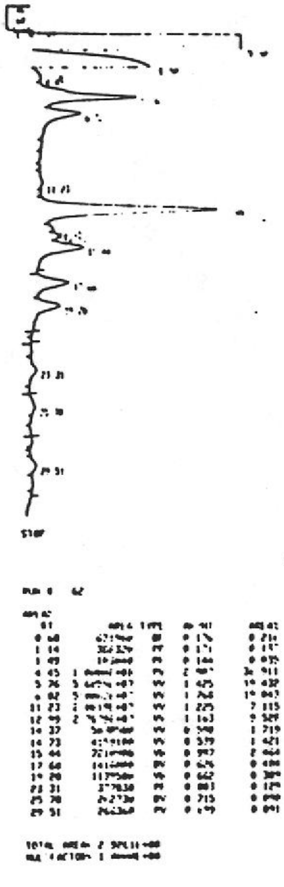
1. Although no precise quantitation can be attempted, we estimate (based on the response of Bromoform) the levels of each peak to be in the range of 1-90 nanograms/gram of sample (ppb).

2. Some of the soils analyzed were very sandy and/or moist. No correction was made for silica or water content.

3. The Hall Electrolytic Conductivity Response is dependent on the species and extent of halogenation.

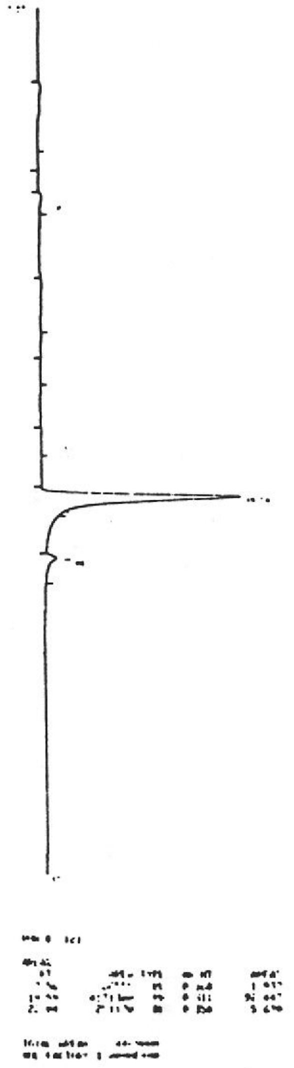


HECD Scan

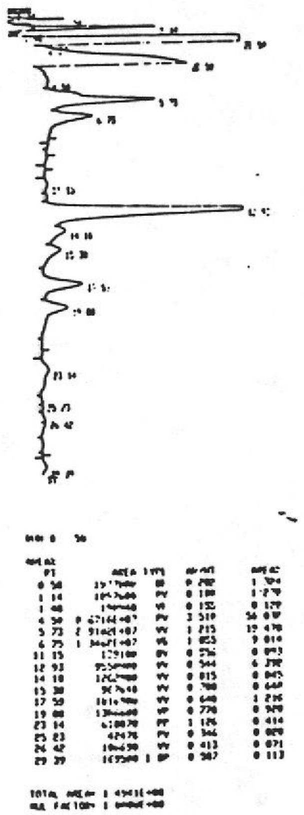


PID Scan

70J21
Boring #1; Sample #2; Tube #2
Date Sampled/Received: 7/30/81

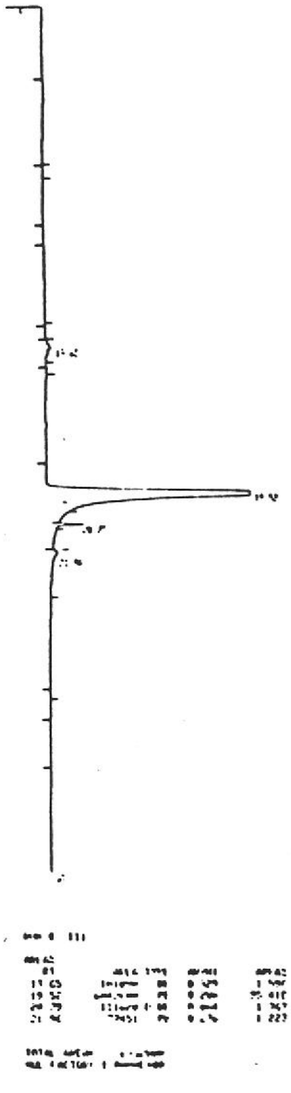


HECD Scan

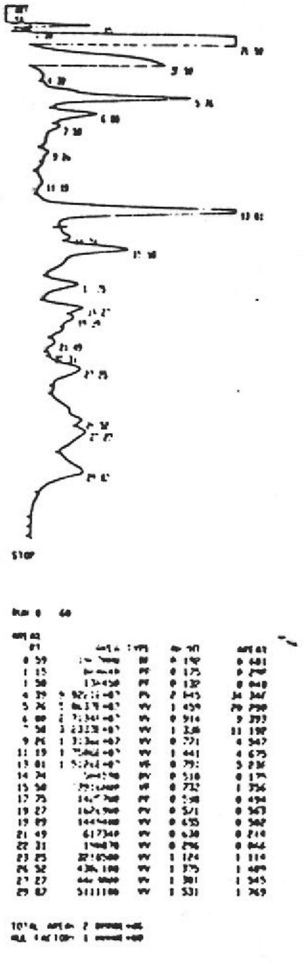


PID Scan

70J26
Boring #2; Sample #2; Tube #3
Date Sampled/Received: 8/3/81

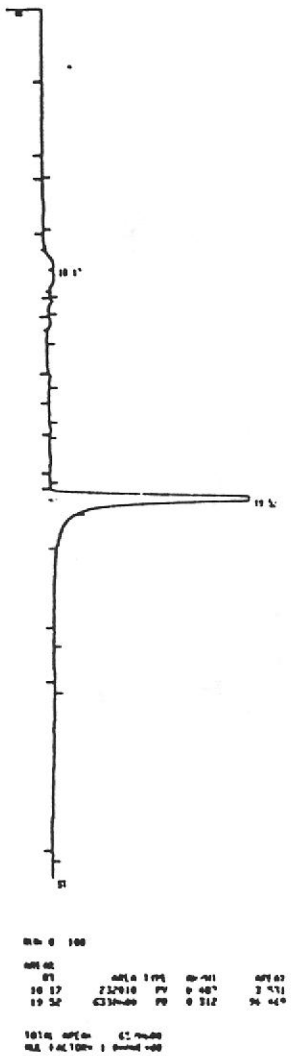


HECD Scan

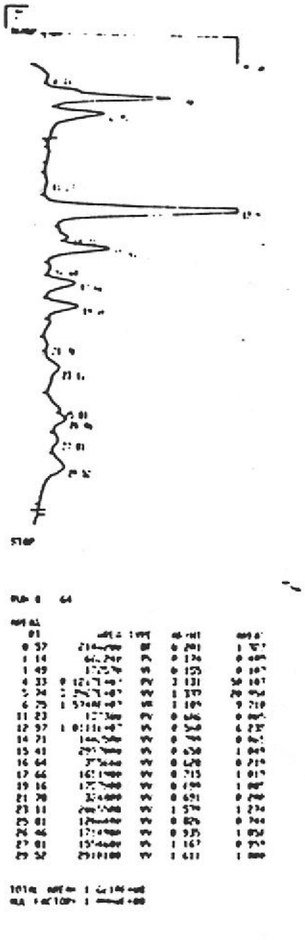


PID Scan

70J2
Boring #3; Sample #3; Tube #3
Date Sampled/Received: 7/29/81

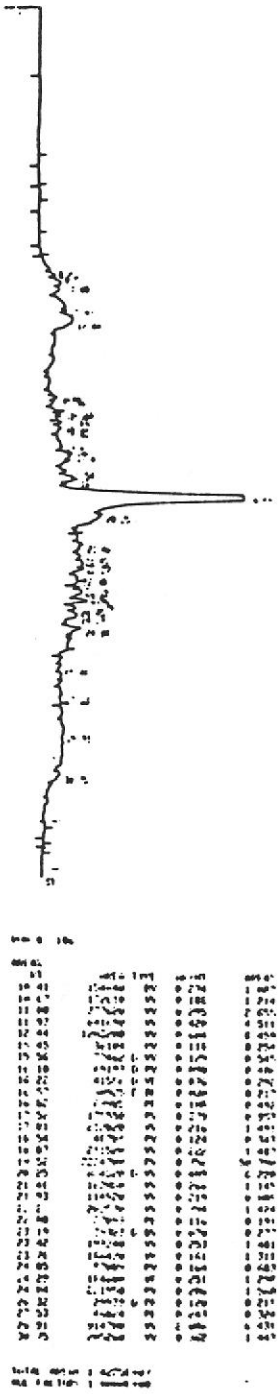


HECD Scan

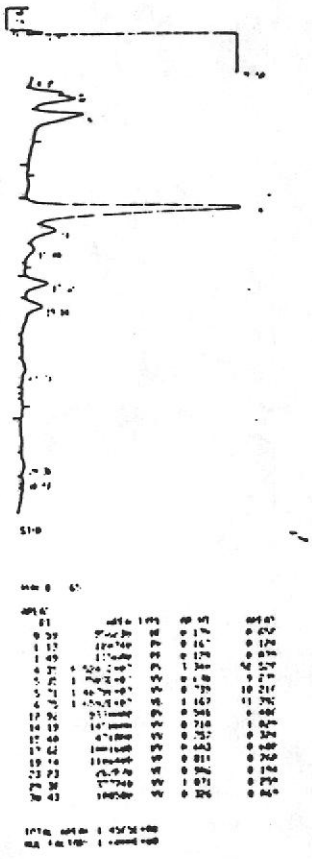


PID Scan

70J33
Boring #4C; Sample #3; Tube #3
Date Sampled/Received: 8/4/81

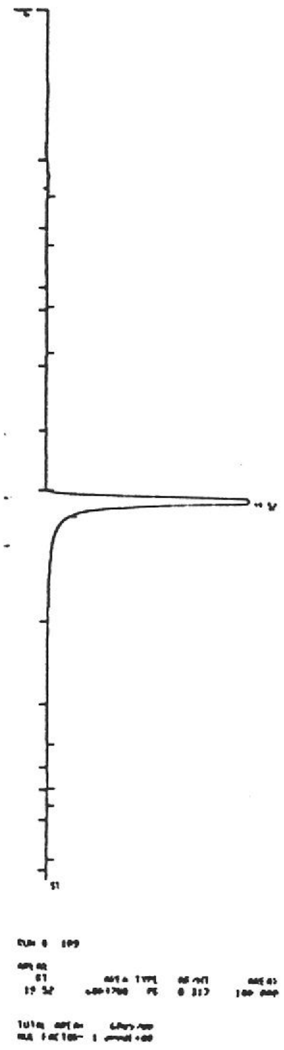


HECD Scan

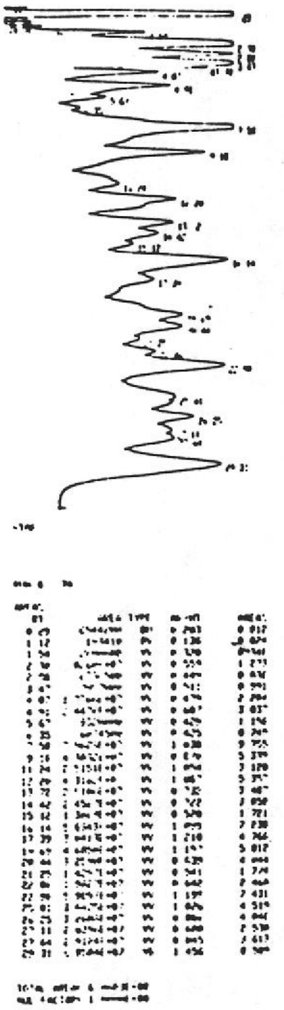


PID Scan

70J12
Boring #5; Sample #1; Tube #3
Date Sampled/Received: 7/30/81

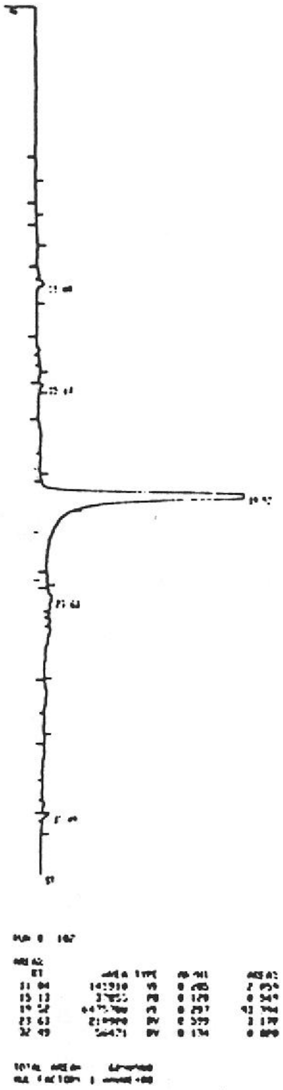


HECD Scan

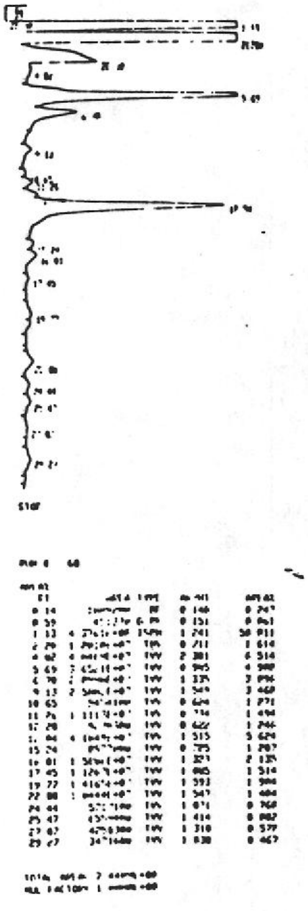


PID Scan

70J13
Boring #5; Sample #3; Tube #3
Date Sampled/Received: 7/30/81

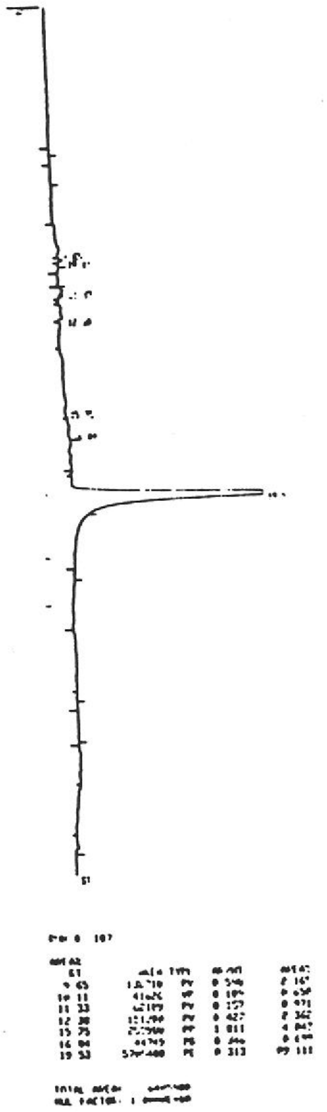


HECD Scan

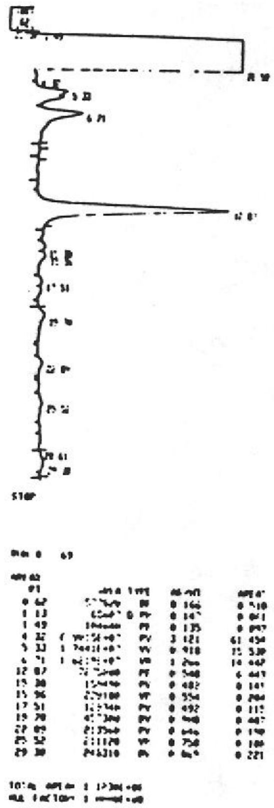


PID Scan

70J15
Boring #6; Sample #1; Tube #3
Date Sampled/Received: 7/30/81

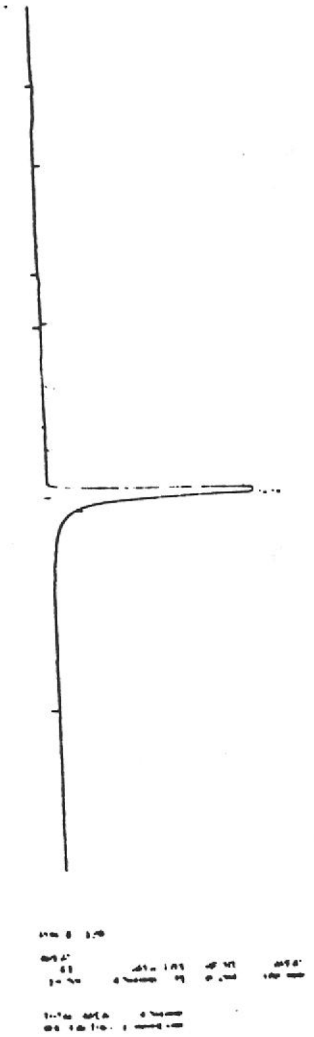


HECD Scan

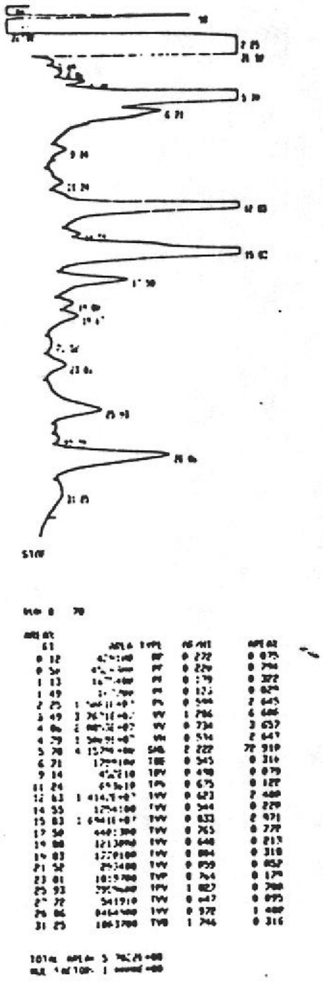


PID Scan

70J3
Boring #7; Sample #1; Tube #3
Date Sampled/Received: 7/29/81

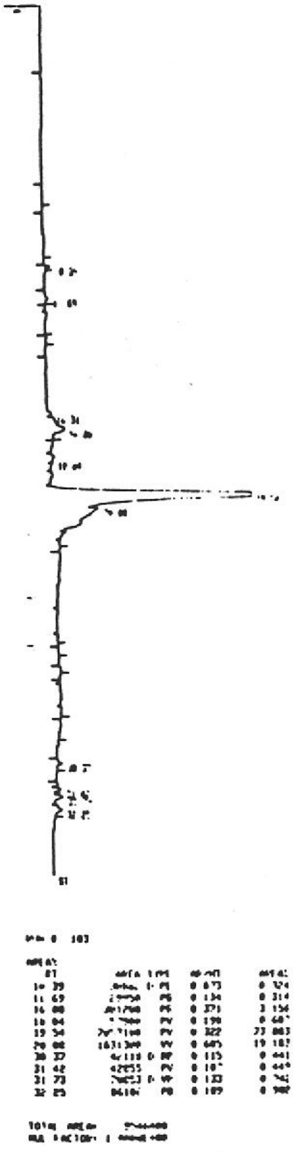


HECD Scan

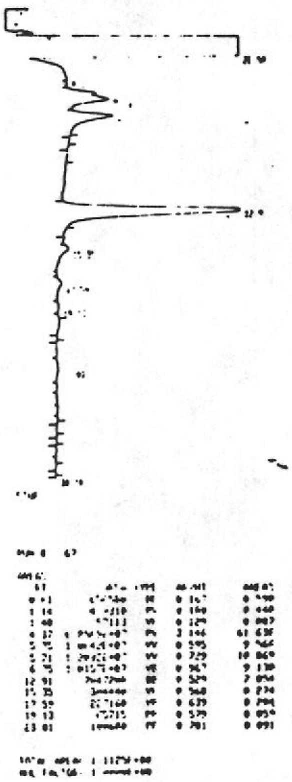


PID Scan

70J23
Boring #8; Sample #2; Tube #3
Date Sampled/Received: 7/31/81

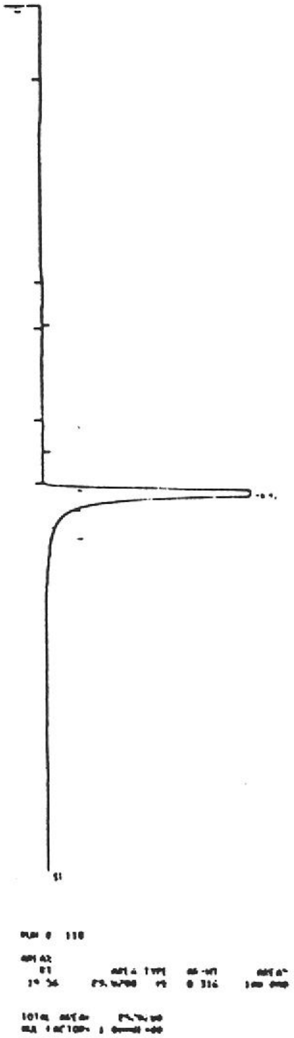


HECD Scan

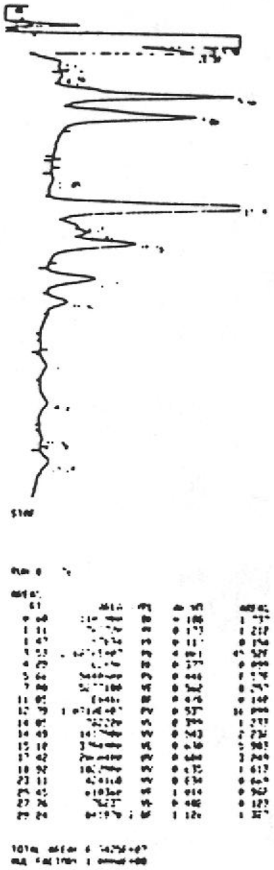


PID Scan

73C13
Boring #9, Sample #4; Tube #3
Date Sampled/Received: 8/6/81

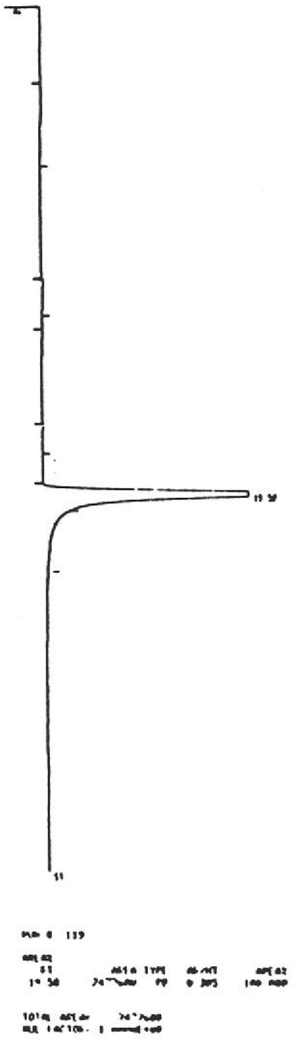


HECD Scan

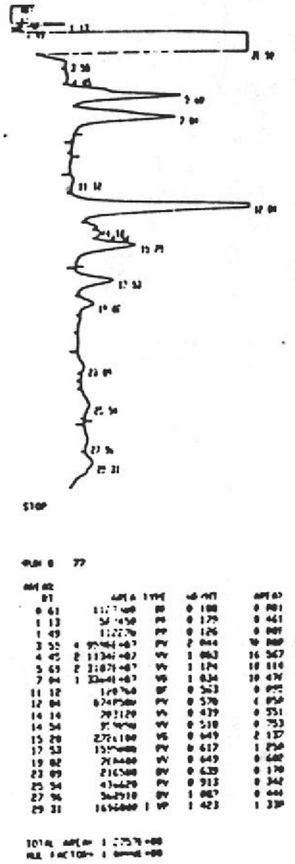


PID Scan

74H6
Boring #10D; Sample #4; Tube #3
Date Sampled/Received: 8/11/81



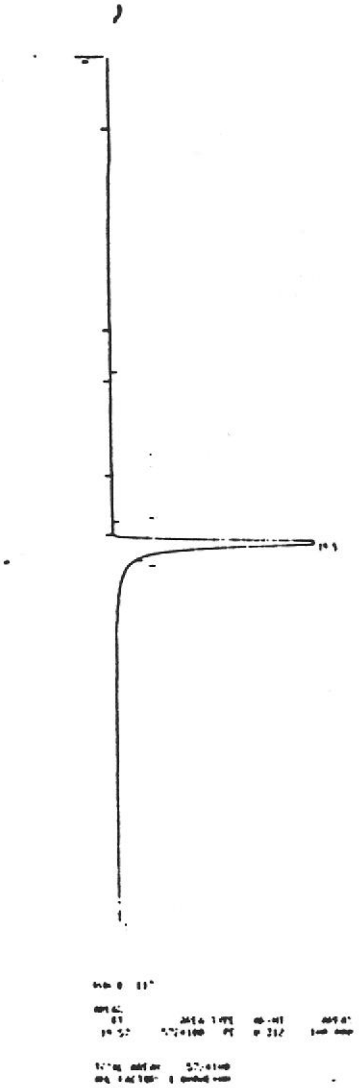
HECD Scan



PID Scan

Duplicate Analyses

74H6
Boring #10D; Sample #4; Tube #3
Date Sampled/Received: 8/11/81



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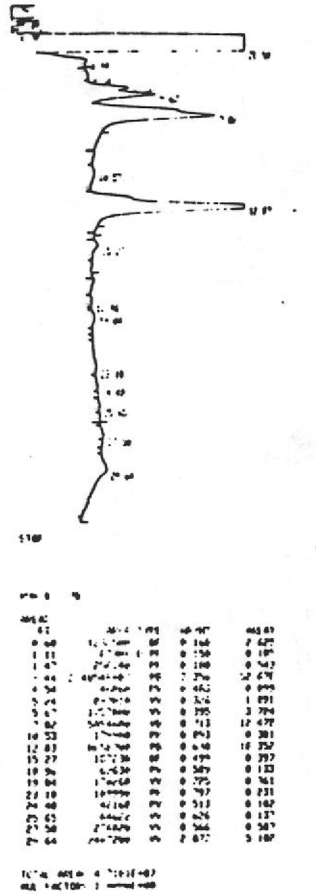
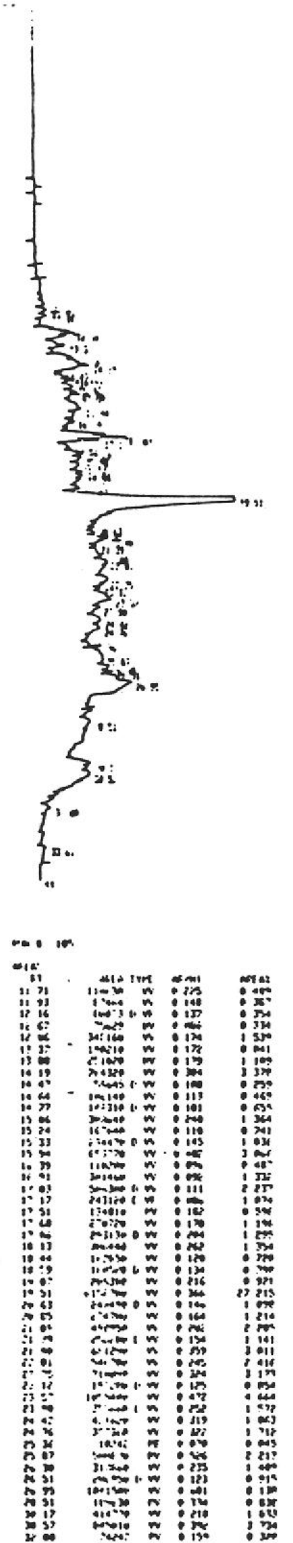
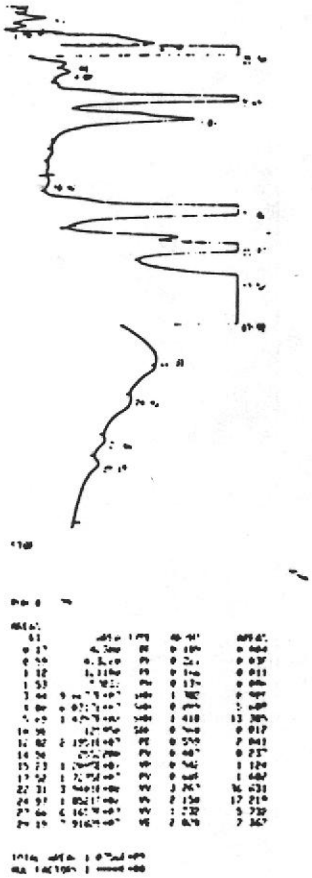


PID Scan

74H7
Boring #11; Sample #4; Tube #3
Date Sampled/Received: 8/11/81

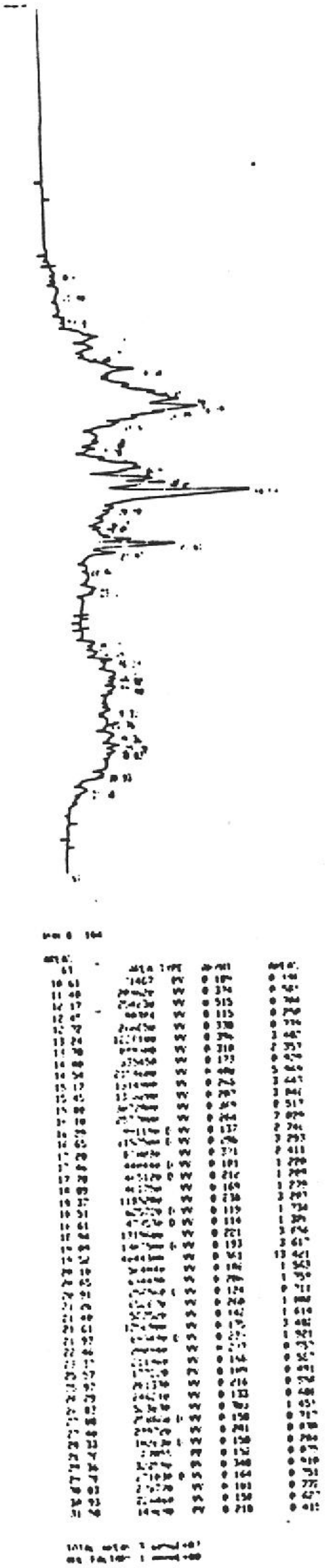


HECD Scan



PID Scan

74H4
Near Boring #8; Surface Tar
Date Sampled/Received: 8/7/81



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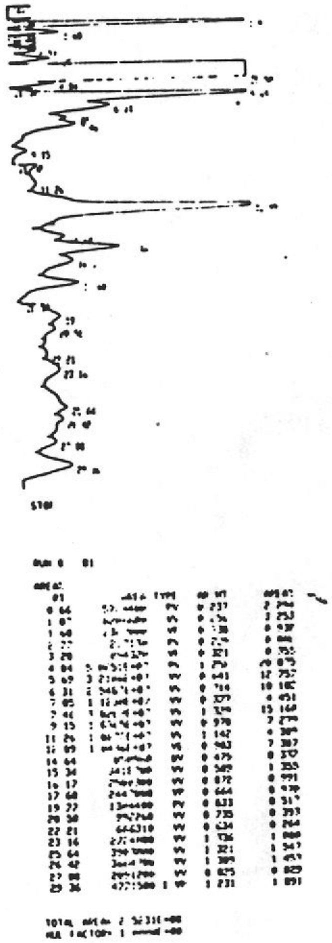
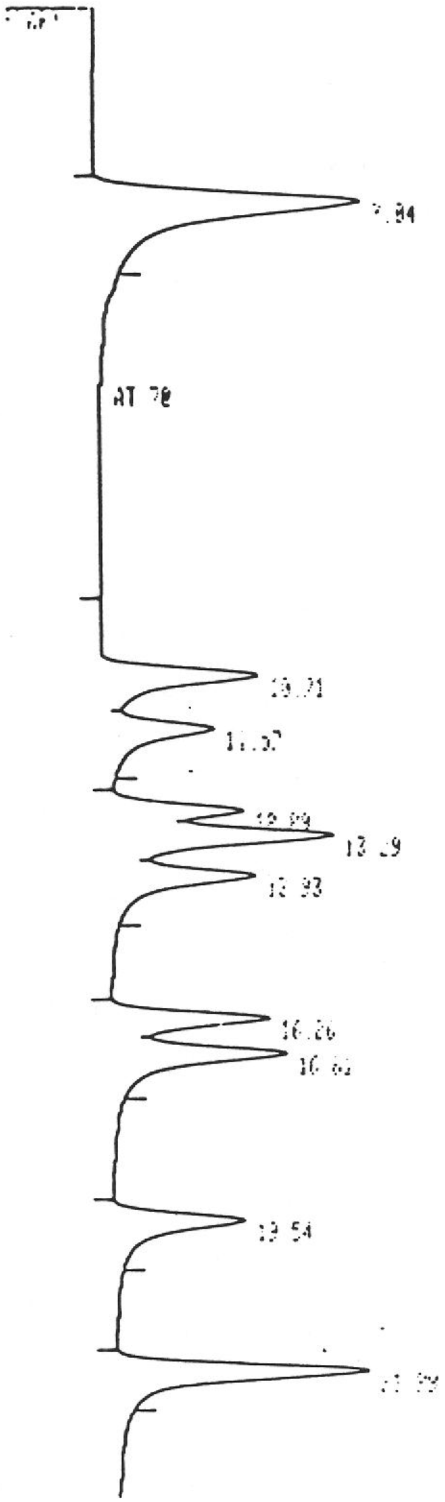


PID Scan

74H5
Near Boring #11; Surface Tar
Date Sampled/Received: 8/7/81

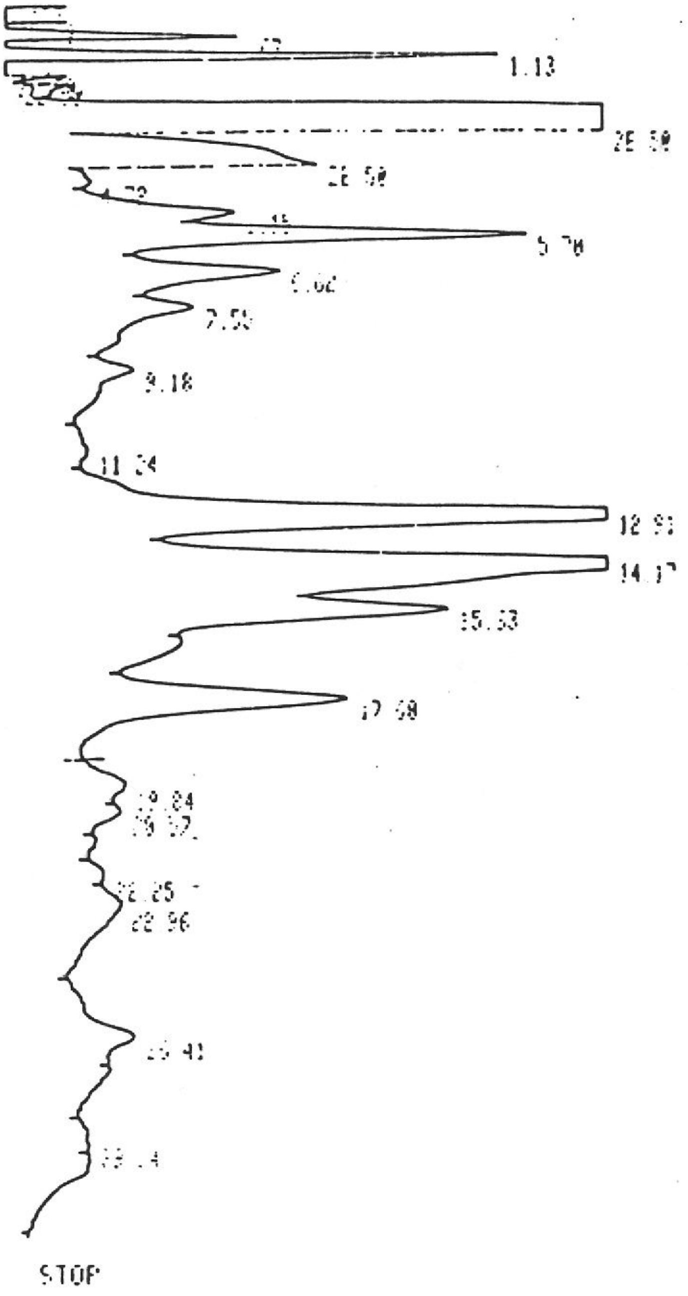


```
RUN #  114

AREA%
  RT           AREA TYPE   AR/HT        AREA%
  3.04      3415300   PB   0.476        6.358
 10.71      4921200   PV   0.298        9.161
 11.57      3265100   VB   0.358        7.383
 12.89      3640100   PV   0.258        6.776
 13.29      8179100   VV   0.335       15.226
 13.93      5356400   VB   0.353        9.972
 16.26      4801500   PV   0.293        8.939
 16.81      6465000   VB   0.348       12.035
 19.54      4747300   PB   0.340        8.838
 21.99      8224500   PB   0.297       15.311

TOTAL AREA= 5.3712E+07
MUL FACTOR= 1.0000E+00
```

HECD Scan

Halocarbon Spike

Retention Time (Minutes)	Compound
3.04	Dichloromethane
10.71	Chloroform
11.57	1,2-Dichloroethane
12.89	1,1,1-Trichloroetha
13.29	Carbon Tetrachloride
13.93	Bromodichlorometha
16.26	Trichloroethylene
16.81	Dibromochlorometha
19.54	Bromoform
21.99	Tetrachloroethylene

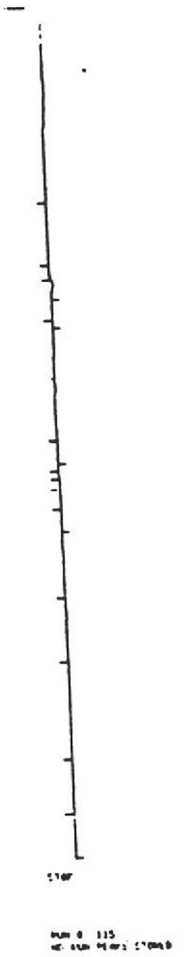


```
RUN #   82

AREA%
  RT          AREA TYPE    AR/HT        AREA%
  0.63     1436900    BV    0.197        0.404
  1.13     3256700    VV    0.204        0.916
  1.48      370000 U  VP    0.157        0.104
  4.32  6.3371E+07    PV    1.947       17.822
  5.15  2.8819E+07    VV    0.833        8.105
  5.70  2.7972E+07    VV    0.675        7.867
  6.62  3.2295E+07    VV    0.989        9.082
  7.55  3.9627E+07    VV    1.401       11.144
  9.18  3.6507E+07    VV    1.581       10.267
 11.24  2.0493E+07    VV    1.179        5.764
 12.91  3.8429E+07    VV    1.146       10.808
 14.17  3.0215E+07    VV    1.047        8.499
 15.33  1.4110E+07    VV    0.771        3.968
 17.60  1.0205E+07    VB    0.962        2.870
 19.84      942110    BV    0.719        0.265
 20.57      805020    VV    0.633        0.226
 22.25      547300    VV    0.541        0.154
 22.96     2388900    VV    1.518        0.672
 26.41     2614100    VV    1.120        0.735
 29.24     1167000    VV    0.815        0.328

 TOTAL AREA= 3.5552E+08
 MUL FACTOR= 1.0000E+00
```

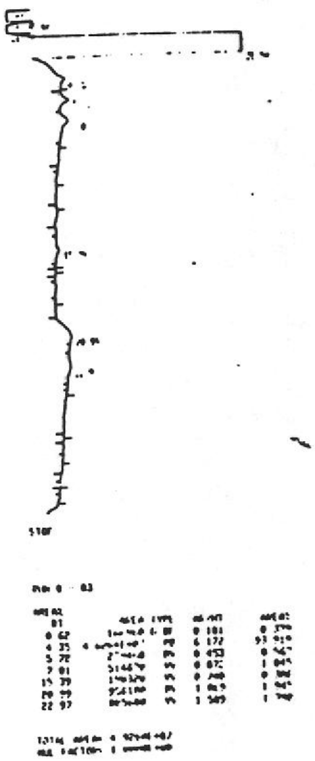
PID Scan

Purgeable Aromatics Spike

Retention Time (Minutes)	Compound
1.13	Benzene
5.70	Toluene
12.91	Ethyl Benzene
14.17	p-Xylene
15.33	m-Xylene
17.60	o-Xylene



HECD Scan



PID Scan

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APPENDIX E

RESULTS OF LABORATORY CHEMICAL ANALYSES FOR GROUNDWATER SAMPLES

BROWN AND CALDWELL
CONSULTING ENGINEERS
ENVIRONMENTAL SCIENCES DIVISION
1255 POWELL STREET
EMERYVILLE, CA 94608
PHONE (415) 428-2300

Log No. 7B

Date Sampled 1/20/81
Date Received 1/20/82
Date Reported 1/29/82

705-611

Report To:
Mr. Bob Johnston
Woodward Clyde Consultants
#3 Embarcadero Center
Suite 700
San Francisco, California 94111

Edward Wilson
Laboratory Director

cc. Mr. Larry Houps, Woodward Clyde

og No.	Emeryville Marketplace Sample Description
/B1	Well 4
7B2	Well 5
'B3	Well 10
/B4	Well 12

Results mg/L

Sample Log No.	7B1	7B2	7B3	7B4
rsenic, dissolved	< 0.0005	< 0.0005	< 0.0005	< 0.0005
hromium, dissolved	< 0.01	< 0.01	< 0.01	< 0.01
Cadmium, dissolved	< 0.01	< 0.01	< 0.01	< 0.01
obalt, dissolved	< 0.01	< 0.01	< 0.01	< 0.01
opper, dissolved	< 0.01	< 0.01	0.02	< 0.01
Lead, dissolved	0.003	<0.001	0.004	<0.001
ickel, dissolved	< 0.01	< 0.01	< 0.01	< 0.01
inc, dissolved	0.02	< 0.01	< 0.01	0.01

Note: Purgeable priority pollutant data
attached.

wcts

"Your Full Service Chemistry Laboratory" / West Coast Technical Service Inc.
17605 Fabrica Way / Cerritos, California 90701 / (213) 921-9831 or (714) 523-9200

Report

Prepared For

Brown & Caldwell
1255 Powell Street
Emeryville, CA 94608
Attn: Ed Wilson

Date

January 27, 1982

Date Received

January 22, 1982

P.O. No.

6807

Job No.

22935/vab

Description of Samples

One (1) water sample labeled 7B4.

The sample was analyzed by combined gas chromatography-mass spectroscopy. EPA Method 624 was followed for the analysis. A copy of the data is enclosed. The results are as follows:

Compound	Concentration (micrograms/liter)
Benzene	1
Ethylbenzene	2
Methylene Chloride	2
Toluene	3
Tetrahydrofuran	340*
Methylethyl Ketone	230*

* These concentrations are calculated assuming a 1 to 1 response with the internal standard.

RECEIVED
JAN 29 1982
BROWN AND CALDWELL

Page 1 of 1 pages.

We would appreciate a telephone call if you have any questions regarding this report.

I certify that this report truly represents the findings of work performed by me, or under my direct supervision.

Robert E. Swaim, Ph.D.
Staff Chemist

Reviewed and Approved.

D.J. Northington, Ph.D.
Technical Director

Memorandum

Woodward·Clyde Consultants

To: Larry Hoops

From David Liu

Office ESD-SF

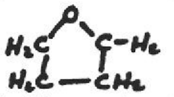
Date 26 January 1982

Subject TETRAHYDROFURAN AND METHYLETHYLKETONE (Project 15093A)

Presented below is the information I found in a quick survey of sources on hand on the subject chemicals. According to you, the concentrations of tetrahydrofuran and methylethylketone found in well water at the project site were 340 and 230 micrograms/L, respectively.

TETRAHYDROFURAN

Synonyms: Diethylene oxide, tetramethylene oxide.
Formula: C_4H_8O



Physical/Chemical Charactaristics: Liquid with ether-like odor; miscible with water and various organic solvents; reacts with strong oxidizers.

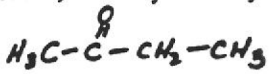
Current Standards: OSHA TLV = 200 ppm (in air)
FDA, 1.5% maximum allowed in food packaging film.
EPA (water), None.

Toxicity: Has been tested for acute toxicity by various routes of administration. Lowest reported lethal oral dose in rats is 3000 mg/kg body weight. No information was found on chronic effects, carcinogenicity, mutagenicity, or teratogenicity.

Uses: Widely used solvent for high polymers, especially PVC. Used in the synthesis of other chemicals and in the fabrication of food packages.

METHYLETHYLKETONE

Synonyms: 2-Butanone; ethylmethylketone.
Formula: C_4H_8O



$H_3C-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$

Physical/Chemical Charactaristics: Flammable liquid with acetone-like odor. Soluble in water up to 27.5%.

Current Standards: OSHA TLV = 200 ppm (in air)
FDA - none
EPA (water) - none.

Toxicity: Has been tested for acute toxicity in various laboratory animals using various routes of administration. Oral LD50 in rats reported as 3400 mg/kg body weight. Reported to be a teratogen in rats exposed to 1000 ppm in air during gestation period. No information was found on chronic toxicity, carcinogenicity, or mutagenicity.

PROBABLE HAZARD

The acute hazard from ingestion of both chemicals, given the concentrations reported in the well water, is low. Based on the OSHA TLVs and a few assumptions, the chronic hazard of both chemicals is probably low. A more comprehensive review of the literature is needed to obtain a better assessment of chronic hazard.

APPENDIX F

POTENTIAL FOR POLLUTION FROM PCB IN EMERYVILLE IN RELATION TO PLANNED HOUSING PROJECTS

(Memorandum Report,
David Keith Todd, Consulting Engineers, Inc.,
dated August 10, 1981)

DAVID KEITH TODD
CONSULTING ENGINEERS, INC.

2914 Domingo Avenue
Berkeley, California 94705
415/841-2091

August 10, 1981

MEMORANDUM REPORT

To: John H. Anderson
Emeryville Redevelopment Agency
From: David Keith Todd
Re: Potential for Pollution from PCB in Emeryville in Relation to Planned Housing Projects

Introduction

This firm was retained by the Emeryville Redevelopment Agency on August 7, 1981, and asked to analyze the pollution impact of a known PCB site in Emeryville, California, on two planned housing projects. Data were obtained from the City of Emeryville, Woodward-Clyde Consultants, and the California Department of Health Services (DOHS).

The opinions expressed here are based largely on professional judgment and only a cursory examination of limited field data. Additional subsurface data are needed to verify details of the actual field situation.

Pollution Site

The organic compound PCB was first detected in surface soil in January 1981 by DOHS on industrial property east of the Southern Pacific Railroad and south of 62nd Street in Emeryville (see Figure 1). Concentrations were found from 1.7 to 130,000 ppm. Subsequently, 30 soil samples by the U.S. Environmental Protection Agency (EPA) on Westinghouse property showed PCB concentrations ranging from not detected to 35,000 ppm. On adjoining ITT Grinnell property EPA collected 18 soil samples and found PCB concentrations varying from not detected to 1730 ppm. No information is yet available on PCB in soils at depths or in groundwater; however, visual examination of the site shows no evidence of a trench, pit, shaft, or well that could inject PCB to a significant depth underground.

Propeties of PCB

The composition of PCB is a mixture of different amounts of chlorine atoms attached to biphenyls. The compound was first manufactured in 1929 and until 1977 was widely employed as a heat transfer agent. In 1966 PCB was found to be bioaccumulative in fish tissue in the Baltic Sea. In 1968 human health was affected in Japan where PCB was discovered to have contaminated rice for human consumption. In 1971 bans on fishing for PCB-contaminated fish were first imposed in the United States.

The solubility of PCB in water lies in the range of 2 to 240 ppb, depending upon the particular chlorine content of the compound. Laboratory tests show that water concentrations after shaking with PCB-contaminated soil are the order of 10^{-4} less than that in the soil. PCB is readily adsorbed on fine-grained particles; therefore, the primary pollution hazard of PCB lies in its accumulation in fish tissue based upon its presence in surface water.

Geology of the Pollution Site

The pollution site is located on fill land adjacent to San Francisco Bay. Soil borings in the surrounding area reveal that the fill material is primarily locally available silty clay. The fill depth is approximately 4 feet thick (see Figure 2). Below this lie compressed bay muds having a thickness of about 2 feet. And beneath this lies a layer several feet thick of undisturbed silty clay.

These materials are all fine-grained and relatively impermeable, the underlying silty clay being the least permeable of the three layers. The water table occurs at a depth of about 4 feet below ground surface.

Subsurface Movement of PCB

The PCB site is located 1400 feet from a planned HUD housing project to the northeast and 1300 feet from a planned high-rise condominium project to the west (see Figure 1). An immediate concern involves the potential for pollution of these two housing sites by PCB. Movement of PCB in the underground environment can be considered in two zones: that above the water table and that below the water table.

Above the water table any transport of PCB would occur due to the percolation of rainfall. This zone contains pore spaces occupied with air and capillary water. Any movement of PCB in solution with water would be vertically downward due to gravity as indicated in the Figure 2. There would be no component causing horizontal movement. The initial PCB concentration in water, in the range of 2 to 240 ppb near ground surface, would decrease with depth as the PCB would become adsorbed on the fine-grained soil particles. Furthermore, the quantity of percolating water would be small because (a) the permeability of the fill material is low, and (b) annual evaporation rate in Emeryville is 2.5 times that of the annual rainfall.

In the zone below the water table, all the pore spaces are filled with water. Movement occurs essentially horizontally, flowing downgradient with the surrounding body of groundwater. Figure 3 shows an east-west cross-section through the pollution site and extending from San Francisco Bay to San Pablo Avenue. Note that the water table slopes westward; therefore, local groundwater drains slowly (at an estimated rate of 50 to 100 feet per year) toward San Francisco Bay. It follows from this analysis that there will be no transport of PCB by groundwater toward the HUD housing project to the northeast. But groundwater will drain toward the condominium project from the PCB site. However, there will be attenuation of the initial concentration (2 to 240 ppb) of PCB in water due to adsorption above the water table, to adsorption along the 1300-foot path below the water table, and to dilution by mixing and dispersion with the native groundwater. Thus, at the condominium site the PCB concentration should be negligible. Furthermore, if any PCB did travel that far, it would be below the water table and hence several feet underground. With paving and landscaped areas around the condominium, it is difficult to foresee any human contact with any local PCB remnant.

Mitigation Measures

The presence of PCB in surface soils at the Emeryville industrial site should be controlled in order to eliminate any continued migration of the compound from the immediate site. Scraping and removal of the polluted soil by a licensed waste management company is the direct method for mitigation of pollution. In addition, paving the ground surface will prevent infiltration of rainfall and therefore effectively isolate any PCB in the upper soil layers from moving downward to the water table.

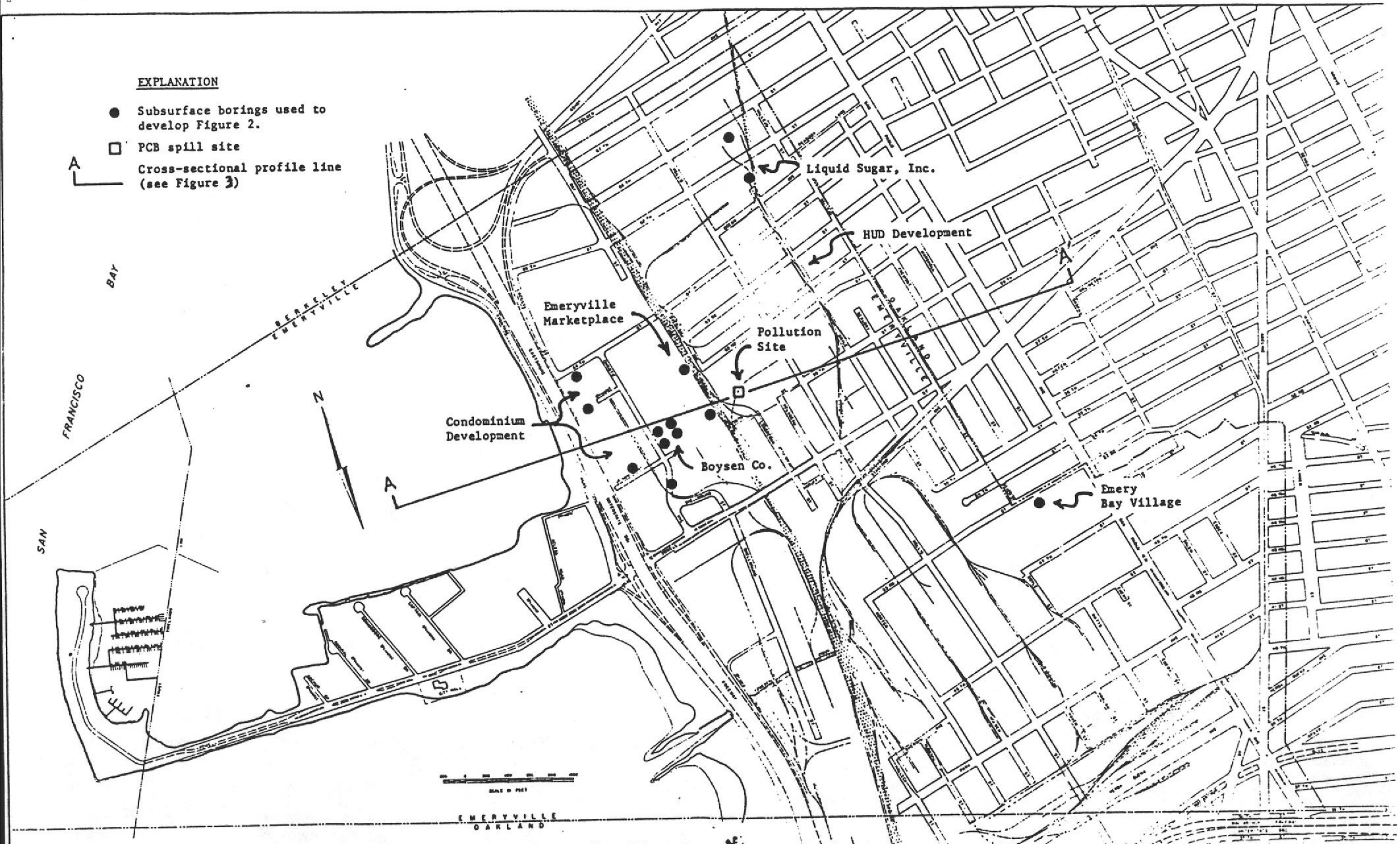
Health Hazard

Section 25117.3 of the Health and Safety Code of the State of California defines "border zone property" as property "which is within 2000 feet of a significant disposal of hazardous waste, and the wastes so located are a significant existing or potential hazard to present or future public health or safety on the land in question." Given the information available to me at the present time and the physical reasons presented in the preceding paragraphs, it is my opinion that the PCB found in surface soils at an industrial site in Emeryville does not at present constitute an existing hazard to public health at the two planned housing projects. Furthermore, assuming that adequate mitigation measures are taken to control the PCB source in the near future, it is my opinion that no potential hazard to public health in the future will occur from the known PCB site.

David K Todd

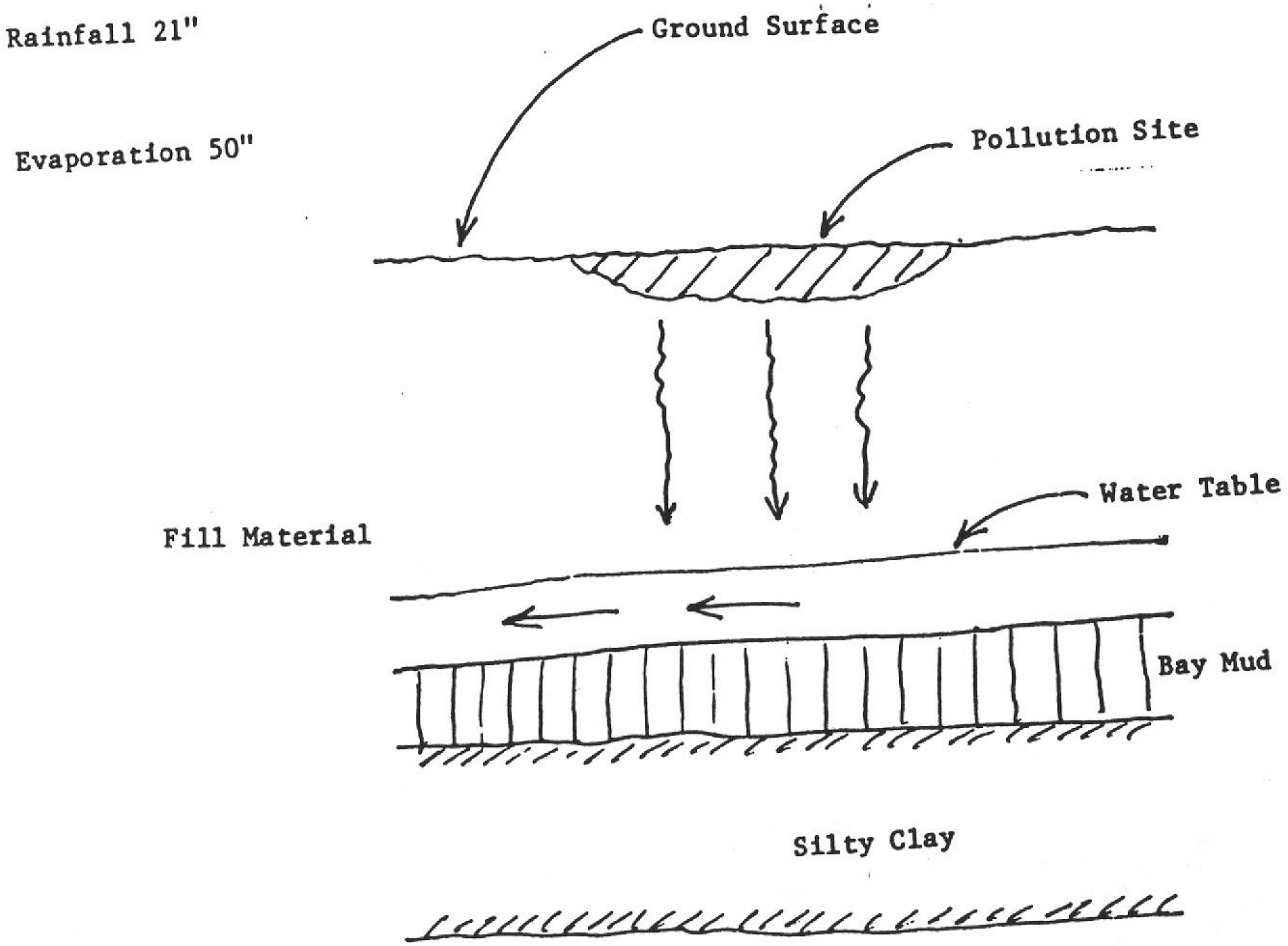
David Keith Todd
President

DKT:jd



CITY OF EMERYVILLE , CALIFORNIA

FIGURE 1. LOCATION MAP SHOWING POLLUTION SITE, SUBSURFACE BORINGS, AND CROSS-SECTIONAL PROFILE LINE



Not to scale

FIGURE 2. CROSS-SECTION OF SUBSURFACE CONDITIONS NEAR THE POLLUTION SITE.

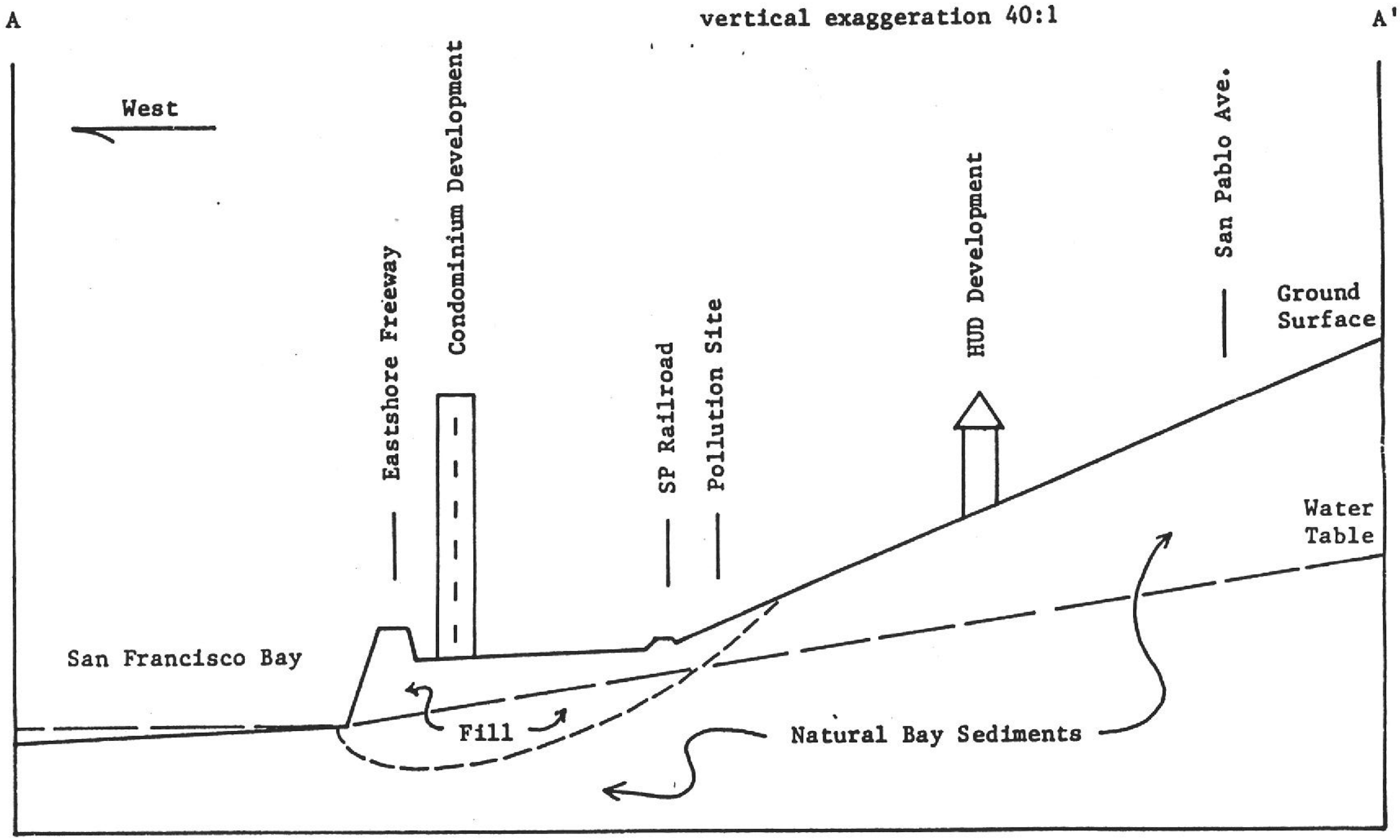


FIGURE 3. GEOLOGIC CROSS SECTION A-A'
CITY OF EMERYVILLE.

Horizontal Scale: 1 inch = 2000 feet
Vertical Scale: 1 inch = 50 feet

EXPLANATION

Fill	Artificially placed natural bay sediments with varying amounts of debris
Natural Bay Sediments	2 ft of soft to medium-stiff silty clay (bay mud) underlain by silty or sandy clay with occassional very sandy or gravelly lenses