2.0 Study Area
Field Activities

2.0 STUDY AREA FIELD ACTIVITIES

A number of field investigations were undertaken as part of the PVLF remedial investigation. The field investigations were designed to determine the nature and extent of potential contamination from the landfill along the four potential pathways of migration; namely, air, surface water, soil, and ground water. This section discusses the field activities undertaken to investigate each of these pathways. The sampling locations selected and the criteria for those selections are discussed by pathway in Section 2.1. Field and laboratory methodologies are discussed in Sections 2.2 and 2.3 respectively. Statistical evaluation methodologies used in analyzing the data are described in Section 2.4. Quality assurance/quality control methodologies used during the investigation are recounted in Section 2.5.

The results from the investigations are detailed and discussed in Section 3.0. An overview of the nature and extent of contamination at and from the PVLF is given in Section 4.0.

2.1 FIELD STUDY DESIGN

There are four potential migration pathways that can result in exposures to the public. Each of the four pathways--air, surface water, soil, and ground water--was investigated as part of the remedial investigation at the PVLF to determine whether they represent complete pathways resulting in public exposure. The field studies employed during the remedial investigation were designed to provide the essential data needed to define the nature and extent of contamination at or from the PVLF with enough certainty to evaluate potential risks posed by the site and begin evaluation of potential remedies that may be appropriate. The field studies were not designed or conducted in such a manner that all uncertainty concerning the landfill and site conditions would be removed, since that is an unobtainable goal. This sections presents the objectives and scope of the field investigations conducted as part of the remedial investigation to define the conditions of air, surface water and sediment, geology and hydrogeology, soil/sediments, and ground water at and near the PVLF.

2.1.1 Air Pathway Investigations

The potential migration of contaminants to the air was investigated under the AALGCP, the Work Plan for Additional Remedial Investigation, and the Additional Ambient Air Monitoring Work Plan. Ambient air, integrated surface gas, soil gas from boundary probes and neighborhood meter boxes, surface emissions just to the northeast of the main site, landfill gas, and gas emissions from the gas-to-energy facility and flares were all monitored and most were also sampled and analyzed. Meteorological data were collected to insure that the ambient air and surface gas sampling conformed to predetermined conditions, and to monitor the percentage of time ambient air sampling locations were upwind and downwind of the PVLF. This section discusses the objectives of the air pathway investigation and describes the scope and selection criteria for the field program.

2.1.1.1 Objectives

The overall objectives of the air pathway investigation were to characterize potential air impacts from the site, evaluate the effectiveness of the existing landfill gas control and monitoring systems at the site, and to establish ongoing monitoring programs. Seven monitoring programs were implemented to accomplish these objectives. These programs include ambient air, integrated surface gas, boundary probe, neighborhood meter box, surface flux, landfill gas, and flare emissions monitoring. Meteorological monitoring was also performed in support of the first two programs.

One full year's worth of data was collected at and near the PVLF during the period of September 1990 through August 1991 under all of the monitoring programs except the surface emission isolation flux chamber (surface flux chamber) program. Ambient air monitoring was also conducted in June and July 1994. An additional 34 months of data were collected under the integrated surface gas monitoring and perimeter probe programs during the period from September 1991 to June 1994. The surface flux chamber testing was performed during September 1993. The neighborhood meter box monitoring and flare emissions testing programs are ongoing in compliance with conditions imposed by other regulatory agencies.

2.1.1.2 Scope of Field Activities

As discussed above, a total of seven monitoring programs were undertaken as part of the air pathway study, and meteorological monitoring was performed as a support program. These monitoring programs consist of ambient air monitoring, integrated surface gas monitoring, boundary probe monitoring, neighborhood meter box monitoring, surface flux chamber testing, landfill gas characterization, and flare emissions testing.

Several of these monitoring programs were started prior to this study, and will continue for other agencies. Routine boundary probe monitoring for gas migration began in the mid-1970's to fulfill the requirements of the facility permit. Boundary probe monitoring is conducted on a monthly basis and reported to the DHS, along with the results of the neighborhood meter box monitoring. Emissions testing at the gas-to-energy facility is conducted to fulfill permit conditions and are reported to the SCAQMD. The scope of the field activities performed for the air pathway investigation, including selection criteria, are discussed in the following sections.

2.1.1.2.1 Meteorological Stations

A permanent weather station is located as shown on Exhibits 2.1-1 and 2.1-2 at the PVLF. It is located in an exposed area to allow detection of regional wind patterns, which was the primary concern for siting a meteorological station. It is surrounded by a chain link fence to prevent tampering or interference with the station in any way. The weather station is equipped with instruments to continuously record wind speed and direction. During the ambient air sampling program conducted in 1990 and 1991 and the integrated surface gas monitoring program, continuous meteorological data was collected to confirm that wind speed limits for these programs were not exceeded and to monitor wind direction for later evaluation purposes.

For the additional ambient air sampling program conducted in 1994, a temporary weather station was situated along the upwind boundary of the landfill to augment the meteorological information from the permanent weather station. The temporary station, shown on Exhibit 2.1-2, was located less than 200 feet from the main site west-southwest boundary to allow the detection of regional wind patterns. The temporary station was equipped with the instruments necessary to continuously record wind speed and direction data.

2.1.1.2.2 Ambient Air Sampling

A sampling location is considered upwind of a stationary reference point if wind from the prevailing wind direction (the wind direction most often experienced at that site at that time of day) passes over the sampling location prior to reaching the reference point. A downwind sampling location, on the other hand, is defined as that location where the prevailing wind passes over the reference point before reaching the sampling location. In the ambient air studies conducted for these remedial investigations, the PVLF was considered the reference point in determining upwind and downwind locations. Therefore, an upwind location determines the background, or non-landfill affected, air quality.

The Sanitation Districts have conducted meteorological studies of ambient conditions at the PVLF since 1983. A large amount of meteorological data have been collected in that time period including data on wind speed and wind direction. Most recently, meteorological data was collected as part of the SWAQAT program in 1986-87. For this study, CARB guidelines were used under the guidance of SCAQMD.

Wind direction data obtained from these monitoring studies show that the daytime prevailing wind direction (from 6:00 a.m. till midnight) at the PVLF ranged from southerly to westerly with southwesterly being the most frequently observed direction. The nighttime drainage wind direction (from midnight to 6:00 a.m) ranged from southeasterly to southwesterly with southwesterly being the most frequently observed direction. Upwind and downwind locations were selected based on these meteorological data.

Two ambient air programs were conducted for the PVLF remedial investigations. The first (original) program was conducted in accordance with the AALGCP. The second (additional) program was conducted in accordance with the Additional Ambient Air Work Plan. Brief descriptions of these programs are provided below.

Original Ambient Air Sampling Program

Two locations each were selected for upwind and downwind. These sampling locations for ambient air monitoring at the PVLF are shown in Exhibit 2.1-1. In order to be able to quantify the amount of contaminant attributable to the landfill, directional samplers were used for two of the locations. Directional samples are samples taken over a less than 24 hour period. The directional samplers were sited and sampled so that they collected samples during the prevailing wind conditions identified in previous meteorological studies.

Locations 1 and 4 were predominantly upwind (background) monitoring stations. Location 1 was selected as a 24 hour upwind location, while location 4 was monitored for a period of less than 24 hours to collect directional upwind samples. Similarly, locations 2 and 3 were predominantly downwind locations. Location 2 was selected as a 24 hour downwind location and location 3 was monitored for a period of less than 24 hours to collect directional downwind samples.

Prior to each scheduled sampling, site wind speed and direction as monitored at the permanent meteorological station for the previous three to four days, as well as long-term weather trends, were reviewed to determine a time period when there was a high probability of steady winds in the prevailing direction. Sampling times for the samplers at locations 3 and 4 were then determined to best obtain upwind and downwind directional data. For each sampling period, monitoring at locations 1 and 2 began at approximately 10:00 a.m. the first day and ended at approximately 10:00 a.m. the following day; directional sampling at locations 3 and 4 took place concurrently for an eight to twelve hour time period as directed by DTSC.

Bimonthly ambient air monitoring was conducted from September 1990 to August 1991 to sample and analyze both the upwind and downwind locations for air contaminants. Two sets of ambient air data were collected at each location each month and submitted to the appropriate laboratory for toxic air contaminant (TAC) analysis.

Additional Ambient Air Sampling Program

The overall objective of this PVLF monitoring program was to perform confirmation sampling of the ambient air conditions at the PVLF employing the ambient air sampling methodology set forth in EPA's Compendium Method TO-14, The Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Summa Passivated Canister Sampling and Gas Chromatographic Analysis (US EPA, 1984a). This conformation sampling was performed to support previous sampling results obtained as part of the PVLF AALGCP study.

Monitoring was conducted at the PVLF during the months of June and July 1994. Four 24-hour ambient air sampling events were completed, two in June and two in July. During each monitoring event, samples were collected at two upwind and two downwind locations. The ambient air sampling locations are shown in Exhibit 2.1-2. Locations 1 and 4 are upwind locations and locations 2 and 3 are the downwind locations.

The location 1 ambient air sampler was set up in the backyard of the residence at 23 Roanwood Drive. This location is approximately 100 feet away from the southwest boundary of the PVLF main site, and very close to the on site sampling location 1 used during the original ambient air program. This location is upwind during both prevailing and drainage wind conditions and was selected to sample background ambient air.

The location 2 ambient air sampler was placed along the northeast boundary of the main site, approximately 1,100 feet west of Crenshaw Boulevard. This location, which was also used for downwind ambient air sampling during the original ambient air sampling program, samples downwind ambient air during both prevailing and drainage wind conditions. Samples taken at this location would indicate whether any landfill gas constituents were emanating from the site in measurable (above background) quantities.

The location 3 sampler was situated on the top deck of the main site approximately 350 feet from the northeast boundary and 200 feet from Crenshaw Boulevard. The selection of this location was based upon the results of the PVLF HRA which was conducted in November 1992 under the Air Toxics Information and Assessment Act (AB 2588). The HRA was performed to provide a conservative estimate of the incremental risk to the local population resulting from possible PVLF emissions. This study estimated the ambient air concentration distribution of substances associated with PVLF emissions at the landfill and in the surrounding areas. The maximum receptor points were identified in this study. Location 3 lies within the zone of maximum emission concentrations as determined in the HRA. Ambient air samples collected at this location provide the worst case result in terms of potential landfill gas constituents emanating from the site.

The location 4 sampler was located at the City of Rolling Hills Estates City Hall, in an open area adjacent to Crenshaw Boulevard. This location was upwind of the PVLF during both prevailing and drainage wind conditions. This upwind location was purposely sited near Crenshaw Boulevard so that samples taken at this location would include the contribution of Crenshaw Boulevard vehicular emissions to background air quality. It was anticipated that monitoring results from this location would be useful in interpreting air contaminants found in samples taken at location 3, which was also located in proximity to Crenshaw Boulevard.

2.1.1.2.3 Integrated Surface Gas Monitoring

Integrated surface gas monitoring was performed on a monthly basis to sample and analyze the air just above the landfill surface for evidence of landfill gas emissions. The integrated surface gas monitoring program was designed to conform to the guidelines published by SCAQMD for Rule 1150.1. A total of 229 routes, each 225 feet in length, are distributed mainly on areas of refuse fill on the site. There are 57 routes on the South Coast Botanic Garden, 148 routes on the main site, and 24 routes on Ernie Howlett Park. Exhibit 2.1-3 shows the layout of the routes.

The integrated surface gas routes were designed to provide equivalent areal coverage to the Rule 1150.1 grid pattern. As noted above, typical spacing is 225 feet along and across the routes. These routes have been shown to be equivalent to the 50,000 square foot grids outlined in the guidance document at other Sanitation Districts' facilities to the satisfaction of the SCAQMD. Routes are much more amenable to adjustments required to easily and accurately monitor uneven topography or developed areas.

Although typical route spacing is 225 feet for the reasons stated above, exceptions to this spacing exist on the slope areas of the landfill where access is restricted and in areas where development for park and recreation purposes have been made. In landfill slope areas the routes are on parallel benches (route spacings between benches are generally less than 225 feet) and elsewhere adjustments have been made as necessary to accommodate the route layouts to be compatible with park and other recreational activities. In all cases areal coverage was maintained.

Normally, integrated surface gas monitoring was conducted monthly between 6:00 a.m. and 1:00 p.m. The hours of collection were dependent on wind conditions. Since integrated surface gas monitoring had to be conducted while the wind speed was low (as discussed in Section 2.2.9.2), sampling was started early in the morning while conditions were normally calm. Wind speed in the PVLF area tends to pick up as the day goes along, and often it was not possible to collect samples after 1:00 p.m. and remain within the specified limits. Wind speeds and directions were monitored throughout with a continuous recorder installed at the weather station.

Two samples selected randomly or otherwise were collected each month and sent to the appropriate laboratory for TAC analysis. Sample selection is discussed in Section 3.1.4. Speciation of two samples conforms to the SCAQMD guidelines for Rule 1150.1.

2.1.1.2.4 Boundary Probe Monitoring

The boundary probe monitoring system at the PVLF was discussed in Section 1.3.4.1.3 and is shown in Exhibit 1.3-8. Routine monitoring of boundary probes is conducted at the PVLF on at least a monthly basis. Probes located closer to residences are monitored more frequently. During the monitoring period of September 1990 to August 1991, each gas probe was monitored monthly. An additional 34 months of data were collected during the ongoing monitoring of probes from September 1991 to June 1994.

When methane was detected at a probe, actions were taken to eliminate methane from the area. Daily monitoring was performed until no methane was detected for a week. Actions that may be taken to prevent continued gas migration include valve adjustments on nearby gas wells, dewatering gas wells and draining piping, increasing the vacuum on gas wells, and installing new gas wells.

In addition, each month a sample was collected from one probe selected randomly and was sent to the appropriate laboratory for TAC analysis. This sample collection and analysis was conducted in addition to the original scope.

2.1.1.2.5 Neighborhood Meter Box Monitoring

The Sanitation Districts have conducted monthly neighborhood meter box gas monitoring at homes in the Country Hills Estates area to the northeast of the PVLF bounded by Hawthorne Boulevard, Rolling Hills Road, Crenshaw Boulevard, and the northeast boundary of the main site since the early 1980's. This program consists of monitoring the methane levels (using a direct reading instrument such as an organic vapor analyzer) in the water meter boxes of approximately 130 homes in this area. The results of the neighborhood meter box monitoring are reported to the Los Angeles County Department of Health Services monthly. The locations of the homes included in the neighborhood meter box monitoring program are shown in Exhibit 2.1-4.

2.1.1.2.6 Subsurface Air Migration

The potential migration of volatile contaminants via the subsurface migration pathway to the air was investigated under the "Work Plan for Additional Remedial Investigation" (Sanitation Districts, 1993b). Surface emission isolation flux chamber (surface flux chamber) testing, was performed to investigate this pathway. This section discusses the objective of the subsurface air migration pathway investigation, describes the scope and selection criteria for the field program, and provides the history and background of the EPA-recommended surface flux chamber.

An extensive field program was conducted for the subsurface air migration pathway investigation during which emission rate measurements were made using the EPA-recommended surface flux chamber. The program was designed to determine possible off site migration of landfill gas and possible migration of volatilized compounds from contaminated ground water plumes to the ground surface.

Landfill gas is a common product of organic decomposition, and contains low levels of VOCs (less than one percent) in addition to methane and carbon dioxide. At the PVLF, landfill gas migration is controlled by an extensive on site gas collection system.

Two separate VOC-contaminated ground water plumes extend beyond the boundaries of the PVLF, with their likely source being the PVLF. These plumes lie 30 to 70 feet below the land surface, extend approximately 500 to 800 feet beyond the site boundaries, and generally follow the pathways of buried canyons along Hawthorne and Crenshaw Boulevards. The estimated extent of VOC contamination at the PVLF was determined during the remedial investigations and shown on Exhibits 4.1-3 through 4.1-6.

There are several reasons the EPA surface emission isolation flux chamber methodology is the most appropriate assessment technique for measuring possible migration from the sources discussed above. First, and most importantly, the flux chamber technology is reported to provide the most sensitive detection limits for assessing area source VOC emissions when EPA Method TO-14 is used as the analytical technique (i.e., typically less than 0.1 ug/m^2-min^{-1} for most VOCs). Since the emission rates were used for risk assessment purposes, it was critical that the assessment technology offer the lowest sensitivity possible. Another important advantage is that no estimation or modeling is required for the area source assessment. All data needed for the area source assessment are measured directly with known levels of accuracy and precision. This characteristic of direct emission measurement technologies is usually the reason that this class of technologies is selected over others.

Other factors that are important in selecting an area source assessment technology include the influence of upwind interferences, the effects of meteorological conditions, and the cost and ease of implementation or data collection. The flux chamber technology is free from ambient or upwind contamination (unlike other measurement technologies such as indirect or fenceline air monitoring technologies) and is not significantly influenced by meteorological conditions. The typical equipment required for surface flux chamber sampling is portable, and measurements typically take less than an hour to collect. These facets of surface flux chamber sampling result in a cost effective, easy to implement field program.

Thirty-two locations were sampled with the surface flux chamber during the field program at the PVLF. These locations are shown on Exhibit 2.1-5. The samples collected during this program were analyzed for eight specific VOCs: vinyl chloride, 1,1-dichloroethylene, 1,1-dichloroethane, 1,2-dichloroethane, benzene, trichloroethylene, tetrachloroethylene, and p-dichlorobenzene.

The eight VOCs selected for analysis are the most important in terms of the potential risk posed by the off site subsurface air migration pathway. Of the chemicals identified in both landfill gas and ground water, it is estimated that these eight compounds represent 99 percent of the potential cancer risk due to migration from a combination of these sources. Thus, both the toxicity and relative concentrations of the VOCs present in landfill gas and ground water were used to determine the chemicals which are most important to the risk assessment.

Surface emission rate testing in residential areas often shows emissions of VOCs that are from a variety of sources, mostly related to minor surface contaminations associated with petroleum products. The eight study compounds provide a "fingerprint" of VOCs associated with the contaminants commonly found in both landfill gas and the contaminated ground water plumes.

The 32 monitoring locations were selected to represent six unique areas around the landfill: background (2 locations); over each of two off site ground water contamination plumes (6 locations each, for a total of 12 locations); beyond the estimated extent of each of these two plumes (2 locations each, for a total of 4 locations); and directly northeast of the site in a residential area (14 locations). All of the monitoring locations are shown on Exhibit 2.1-5. The exact location of each sampling point is also described in Section 3.1.1.

The background locations were selected to represent typical urban soil away from the site. These two background, or control, locations are situated in areas similar--both in land use and in geologic formation characteristics--to the areas near the site that are being investigated. The purpose of including control points in the data set is to determine the surface flux due to factors other than landfill effects. These factors could include pesticide use and adsorption of compounds from the ambient air in near surface soils.

Two off site ground water contaminant plumes are known to exist near the PVLF. The more extensive plume with relatively higher levels of VOCs is located northeast of the PVLF and roughly follows Hawthorne Boulevard. This plume may extend up to 800 feet off site. Six surface flux chamber sampling locations were situated over the estimated areal extent of this plume. Three of the locations transect the plume at the site fenceline and the remaining three locations are spaced along the plume further downgradient from the fenceline. These locations were selected to identify possible migration of volatilized compounds from the contaminated ground water plume to the ground surface. Likewise, six surface flux chamber sampling locations were situated over the estimated areal extent of the second ground water contamination plume. Again, three of the sampling locations transect the plume at the site fenceline and the remaining three locations are spaced along the plume. This second ground water contamination plume is also located northeast of the PVLF and roughly follows Crenshaw Boulevard. It may extend up to 500 feet off site.

Additional surface flux chamber sampling locations were also located beyond the estimated extent of each of the two plumes discussed above. Two locations were selected laterally or downgradient from the estimated extent of the plume at both the Hawthorne Boulevard area and the Crenshaw Boulevard area, for a total of four sampling locations. These locations were selected to determine whether there were any effects from these plumes beyond their estimated areal extent.

The surface flux chamber sampling locations to the northeast of the PVLF were selected to investigate potential effects due to landfill gas migration. This area to the northeast of the site was selected because the highest possibility for off site gas migration exists along this boundary of the PVLF. Therefore, monitoring in this area can be considered to represent the "worst case" from the standpoint that the greatest potential for gas migration, and any associated health risks, occurs here. Gas migration off site elsewhere along the PVLF boundaries would be expected to be lower. Gas migration from the northeast border of the main site is more likely because of the history of off site gas migration in this area that occurred in the early 1980's, the topography of the area where nearby houses are located down a slope at an elevation of about 30 feet lower than the landfill, and the fact that a greater depth of refuse is located near this boundary compared to other boundaries of the landfill. A total of fourteen locations to the northeast of the site were sampled. Twelve of the sampling points were co-located at six locations immediately northeast of the main site to show that surface flux chamber test data can be used to represent emissions from a given area. Two additional sampling points were selected further from the site for completeness of coverage in the area.

Each specific sample location was selected based on visual inspection and discussions with property owners. Locations were selected such that to the greatest extent feasible no surface impediment to the vertical migration of VOCs existed--that is, bare dirt was preferred over grassy or vegetated areas, and in no case were samples taken on asphalt or cement covered areas. The residents or other appropriate entity at the sampling locations were contacted and requested not to water the selected locations for a minimum of 72 hours prior to the actual sampling. Likewise, the local area was monitored for rainfall using a meteorological station at the PVLF. The sampling was also scheduled such that all samples were collected at the end of the dry season in the area.

The following paragraphs briefly describe the history and background of the EPA-recommended surface emission isolation flux chamber (surface flux chamber). The operation of the surface flux chamber is described in Section 2.2.7. This device is used to measure the emission rates from surfaces emitting gas species. The primary reference for this section is the document entitled "Measurement of Gaseous Emission Rates from Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide" (US EPA, 1986b).

Assessing the rate of emissions of gas phase species from area sources (i.e., non-point) has been, and continues to be, a challenge for scientists and engineers. The interest in assessing emission rates from area or "fugitive" sources has been steadily increasing over the past ten years, largely due to two factors:

1) Fugitive emission sources are contributing to the non-attainment of state and federal ambient air quality standards; and

2) Fugitive emissions from controlled and uncontrolled facilities are often toxic (air toxics) and the impact to receptors near these sources is an issue.

The latter has been the primary driving force in the development of the current emission assessment methods, in particular, the surface flux chamber method.

There are four basic assessment approaches for assessing air emission rates: direct measurement technologies; indirect measurement technologies; fenceline monitoring and modeling technologies; and predictive emission modeling. The most promising of these approaches is the direct measurement approach (US EPA, 1990a). One reason for this is that there is no modeling or estimation involved which reduces the uncertainty in the assessment. If emissions rate data are to be used as input to exposure assessment and health risk assessment, it is important to use measured versus modeled emission rate input data. This will reduce the uncertainty in the health risk assessment output.

Although the other approaches have been used successfully, the direct approach is versatile, provides reproducible emission rate data, and is a cost-effective assessment approach. The other advantages include superior detection limit capabilities, the lack of upwind interferences, and independence from meteorological conditions.

The use of enclosures for assessing emission rates was first reported in the literature by Zimmerman (Zimmerman, 1977) and Adams (Adams, et al, 1978). The basic approach uses an enclosure or chamber of some design to isolate a surface emitting gas species. The chamber must be well characterized and qualify as a continuously stirred reactor to provide a representative sample. Clean sweep air is added to the chamber at a controlled, fixed rate, and the contents are sampled and analyzed for species of concern. The emission rate of species i, ER_i (milligrams per minute per square meter), is calculated by knowing the sweep air flow rate, Q (cubic meters per minute), species concentration Y_i (milligrams per cubic meter), and exposed (to the chamber) surface area A (square meters) as follows:

$$ER_i = \frac{Q \cdot Y_i}{A} \qquad \text{Equation 1}$$

This emission assessment approach has been used on a variety of solid and liquid surfaces and for a variety of species (Winegar, 1993). Assessment of VOCs can be realized by using EPA Method TO-14 (US EPA, 1984a) in conjunction with the surface flux chamber for sub-part per billion (ppbv) sensitivity for these compounds.

The development of the current EPA-recommended surface flux chamber started with the need to assess the emissions of air toxics at uncontrolled hazardous waste sites (primarily superfund sites) as part of remedial investigation efforts. Literature on direct measurement technologies was used to develop surface flux chambers of different sizes, shapes, and construction materials. After several site assessment reports where this technology was used at uncontrolled superfund sites, the EPA also became interested in using the approach to characterize fugitive emissions from controlled treatment, storage, and disposal facilities (TSDFs). This interest led to a study where the most promising direct, indirect, and predictive modeling technologies were evaluated by conducting side-by-side emission rate assessments at TSDFs. The results of this study demonstrated the advantages of the surface flux chamber measurement technology when compared to the other assessment technologies. Further interest led to the redesign and parametric evaluation of the surface flux chamber as described in the EPA Users Guide (US EPA, 1986b). This design represents the best compromise in design, construction materials, and suitability for different types of applications. EPA then funded the preparation of the Users Guide, which provides the results of the surface flux chamber evaluation and recommended operating protocols.

Test data indicate that the surface flux chamber is a reliable assessment technology. Precision is reported at ± 5 percent and accuracy is ± 30 percent. The recovery studies conducted on 40 hydrocarbon species (alkanes, alkenes, aromatics, halogenated, sulfur containing, cyclic) averaged 103 percent (US EPA, 1986b). The sensitivity and range of the technology are functions of the analytical methods used, the selection of operating conditions, and the level of the emission source.

2.1.1.2.7 Landfill Gas Monitoring

The gas recovery and control system at the PVLF was discussed in Section 1.3.4.1.2 and is shown in Exhibits 1.3-5 and 1.3-6. Landfill gas monitoring was conducted to characterize the gas collected from the landfill. Landfill gas monitoring was conducted in conjunction with two programs; first, in accordance with the AALGCP, and later in accordance with the Additional Ambient Air Work Plan.

Gas samples were collected monthly from September 1990 to August 1991 as part of the AALGCP. Samples were collected from each of the two main headerlines that collect landfill gas and transport it to the gas-to-energy facility. The samples were submitted to the appropriate laboratory for TAC analysis. Two landfill gas sampling events were also conducted as part of the additional ambient air program, one each in June and July of 1994. These samples, also collected from each of the two main headerlines, were submitted to the appropriate laboratory for analysis using EPA Method TO-14. Landfill gas sampling locations are shown on Exhibit 2.1-6.

During both programs, samples were collected from each of the headerlines; one of which collects landfill gas from the gas migration wells located around the perimeter of the South Coast Botanic Garden and the main site, and the other which collects landfill gas from the gas recovery wells located in the central portion of the main site. As their names indicate, these two well systems are operated differently to achieve different goals. The gas migration wells typically have lower methane and trace organics contents because more ambient air is drawn into this system to ensure that gas migration does not occur. The gas recovery wells have higher methane levels because they are deeper and are located in areas where the majority of the landfill gas is being generated. Gas collection system operation was discussed in more detail in Section 1.3.4.1.2.

2.1.1.2.8 Flare Emissions Testing

Collected landfill gas is combusted in the gas-to-energy facility with gas flares serving as backup. The locations of the gas-to-energy facility and the two flare stations are shown on Exhibit 1.3-6. Flare emissions were tested each quarter and the gas-to-energy facility was tested once. Emissions testing is conducted to meet SCAQMD permit conditions.

2.1.2 Surface Water and Sediment Investigations

The potential migration of contaminants to the surface water and sediment was investigated as part of the SWSCP, the HCP, and the Work Plan for Additional Remedial Investigations. The surface water runoff and the soil cover were investigated under the SWSCP and the Work Plan for Additional Remedial Investigations. The surface water hydrology at the PVLF site was investigated under the SWSCP. The integrity of the storm drain along Hawthorne Boulevard and the South Coast Botanic Garden lake and stream channel were investigated under the HCP. Because the work from these plans complemented each other, they are combined in this section for reporting purposes. This section discusses the objectives of the surface water and sediment investigations and describes the scope of the field activities.

2.1.2.1 Objectives

The overall objective of the surface water and sediment investigations was to characterize the nature and extent of potential contamination that results from surface water runoff and water transported sediments at the PVLF. To achieve this overall objective, the surface water and sediment investigation was divided into six components. The first component evaluated the total runoff water from the PVLF. The second component investigated the storm drain pipeline along Hawthorne Boulevard, adjacent to the PVLF and the subsurface barrier, to determine if it contained landfill derived contaminants, or was acting as a pathway for off site migration of contaminants. The third component evaluated the soil cover at the PVLF which is a potential source of sediment in the runoff water. The fourth component was designed to assess the water and sediments in the South Coast Botanic Garden lake and stream channel for the presence of landfill contaminants. The fifth component evaluated whether water in the South Coast Botanic Garden lake and stream channel was seeping into the subsurface, and potentially acting as a source of leachate. The sixth component analyzed the field hydrology at the PVLF to ensure that the site grading and drainage structures provide adequate drainage to prevent excessive infiltration from rainwater runoff, while preventing excessive erosion due to high velocity surface flow.

2.1.2.2 Scope of Field Activities

The scope of field activities for each of the surface water and sediment investigation components are discussed below. The scope of field activities includes a discussion of the sampling that occurred, the sampling locations, and the selection criteria for the locations.

2.1.2.2.1 Runoff Water and Sediment

The first component of the surface water and sediment investigations was to evaluate the rainfall runoff water at the PVLF. To complete this first component, a runoff water sampling and analysis program was initiated. Runoff water samples were obtained at eighteen locations at and around the PVLF to characterize the rainfall runoff. For each location the runoff water samples were obtained during four different rainfall events.

The sampling locations for the runoff water samples are shown in Exhibit 2.1-7. The exhibit also shows the drainage reaches, typical runs, and drainage system network for the PVLF. The selection criteria for the runoff sampling locations was based on sample representativeness and location accessibility. Each location collects runoff from a different area of the landfill, and together virtually all of the runoff areas of the landfill are covered by the sampling points. The runoff sampling locations included both upgradient locations to characterize background conditions as well as downgradient locations to characterize runoff from the PVLF.

The eighteen different locations were split into four tracks (sets of sample locations). The sample locations of each track drain a certain area of the landfill and flow into the same drainage system along that track. Three of the four tracks include both background and downgradient sampling locations. Samples from a specific location were gathered only if the samples from every location in that track (set) could be obtained. This ensured that the background and down-canyon samples associated with a given area would be obtained in the same storm event. Track 1 included locations 15, 14, and 1 covering Ernie Howlett Park. Track 2 included locations 12, 5, 13, 4, 3, and 2 covering the west side of the main site. Track 3 included locations 11, 10, 9, 8, 16, 6, and 7 which cover the South Coast Botanic Garden and the east side of the main site. Track 4 included locations 17 and 18 covering the northeast boundary area of the main site. A summary of the sample locations is given below by track.

Track 1 Sample Locations

Sample location 15 is located off site of the PVLF west of Ernie Howlett Park. Runoff from a natural ravine located west and upgradient of Ernie Howlett Park is collected at this point. There is a homeowner's riding ring and stables located adjacent to the sampling area. The samples taken at this location are representative of background runoff water.

Sample location 14 is located at the bottom of a corrugated metal pipe (CMP) drain on the south side of Track 1 (next to Hawthorne Boulevard). Runoff from the east side of Ernie Howlett Park (including the asphalt driveway entrance to the park) was collected at this location.

Sample location 1 is located at the southeast corner of Track 1. Runoff from the south and east sides of Ernie Howlett Park feeds into the storm water system at this location.

Track 2 Sample Locations

Sample location 12 is located off site of the PVLF south of the main site (Track 2). The location receives the runoff of a horse stable area prior to entering a major trunk drainage pipe. This sample is representative of background runoff water.

Sample location 5 is located at the bottom of a storm drain manhole located on the south side of the main site (Track 2). The location collects water from a main storm drain channel that receives runoff water from Crenshaw Boulevard. The location also receives water from developed areas (Roanwood Drive and an alley near the Baptist Church) south of the main site. Although the location can receive some water from the main site, the amount is most likely minimal because of the slope of the land around this location. However, since this location may receive runoff from the PVLF, it was not considered representative of background.

Sample location 13 is located off site of the PVLF at the southwest side of the main site (Track 2). The location receives water from Moccasin Lane upgradient of the main site. This water is representative of background runoff water.

Sample location 4 is located on the west side of the main site. The location receives water from the main site, mainly that coming off of an unpaved parking area.

Sample location 3 is located on the northwest side of the main site. The water at this location consists mainly of runoff from the northwest side of the main site.

Sample location 2 is located at the bottom of a storm drain manhole located on Rolling Hills Road near Hawthorne Boulevard. This location collects water from a main trunk line. Numerous drainage pipes converge into this main trunk line prior to this sampling point. The water includes runoff from sampling locations 15, 14, and 1 (located on Track 1) and locations 12, 5, 13, 4, and 3 (located on Track 2). Trunk lines that receive runoff from Hawthorne Boulevard and Crenshaw Boulevard also converge into the main trunk line prior to this sampling point. Therefore, this location collects runoff water from numerous sources, many of which are outside the PVLF.

Track 3 Sample Locations

Sample location 11 is located on the south side of Track 3. The location receives runoff from upgradient of the South Coast Botanic Garden from dirt lined ravines. The sample collected at this location is representative of background runoff water.

Sample location 10 is at the South Coast Botanic Garden lake. The sample is taken on the southeastern side of the lake as near to the southern surface water runoff inlet as is feasible. The water is a combination of runoff from the South Coast Botanic Garden as well as some makeup city tap water that is pumped into the lake.

Sample location 9 is located in the central part of Track 3 downstream from the lake. The sample receives runoff from the South Coast Botanic Garden as well as stream water originating at the lake.

Sample location 8 is located on the north side of Track 3 next to Crenshaw Boulevard. The location gets runoff mainly from the South Coast Botanic Garden with a smaller volume from Crenshaw Boulevard above the entrance to the South Coast Botanic Garden.

Sample location 16 is located on the north side of Track 3 very close to Sample Location 8. The location collects runoff only from Crenshaw Boulevard, due to a curb that directs any landfill runoff to location 8. This location collects background runoff water.

Sample location 6 is located on the east side of Track 3. The location receives runoff mainly from the eastern side of the main site, and also from Crenshaw Boulevard above the site entrance.

Sample location 7 is located on the northeast corner of Track 3. The location collects runoff water from the main site, and also from Crenshaw Boulevard above the site entrance.

Track 4 Sample Locations

Sample location 17 is located along the first bench of the northeast boundary at a reinforced concrete lattice channel. Water from benches 2, 3, 4, and the top deck of the northeast boundary area collects and flows down this reinforced concrete lattice channel prior to flowing over a grate and into a storm drain inlet. The sample for this location is collected at the end of the channel just before it flows over the grate and into the storm drain inlet.

Sample location 18 is located along the first bench of the northeast boundary near the reinforced concrete lattice channel described above. This location collects runoff that enters the grate from the area between the first and second benches. Two streams of water (one from the direction of Crenshaw Boulevard and one from the direction of Hawthorne Boulevard) constitute the runoff from this area. Because these two side streams typically contain equal volumes of runoff water, the samples consist of equal amounts of runoff from each of these side streams that enter the grate at this location.

2.1.2.2.2 Hawthorne Boulevard Storm Drain

A major storm drain pipeline runs along Hawthorne Boulevard adjacent to the PVLF and bisects the subsurface barrier located in the northern corner of the main site. The second component of the surface water and sediment investigation was to investigate this storm drain pipeline to determine if it contained landfill derived contaminants, or was acting as a pathway for off site migration of contaminants. The original scope of work at the storm drain involved investigating only the backfilled storm drain trench using a geophysical survey followed by soil borings and soil sampling. The interior of the storm drain was not addressed. However, after a review of the subsurface barrier as-built drawings, it was noted that the storm drain trench had been sealed off by the landfill barrier (Earth Logics, 1986, Panel Log No. PV-55B), meaning that any contaminants potentially contained in the trench would be dammed up at the barrier, and eventually percolate to the ground water level and be pumped out and treated in the PVLF extraction well system. Therefore, the only storm drain feature which appeared to be a potential pathway for contaminants was the interior of the storm drain itself. The scope of the work was modified to investigate the interior of the storm drain, and not the trench backfill materials. The scope of field activities performed to complete this component of the surface water and sediment investigation included an organic vapor survey in the storm drain, and a water and sediment sampling and analysis program of the Hawthorne Boulevard storm drain contents. The field activities for the survey and the sampling program are discussed below.

Hawthorne Boulevard Storm Drain Volatile Organic Vapor Survey

A volatile organic vapor survey was conducted on October 20, 1992, by Sanitation Districts technicians assigned to the PVLF. The survey was performed along the Hawthorne Boulevard storm drain, adjacent to the PVLF main site, to assess the presence of organic vapors which could indicate the presence of contaminants. The survey locations are shown on Exhibit 2.1-5. The survey locations were selected to assure representation and accessibility. Survey locations were selected at all accessible manhole locations (S-1 through S-7) and a street gutter drain (S-9). Sample locations were established upgradient of the PVLF in the Rolling Hills Estates City Hall parking lot (S-7), along the landfill (S-1 through S-5), and downgradient of the PVLF (S-6 and S-9). Readings were taken by attaching rubber tubing to the tip of an organic vapor analyzer (OVA) calibrated at the start of the day to methane, and lowering the tubing to the bottom of the storm drain. The OVA readings were allowed to stabilize for approximately one minute before the value was recorded in the field notebook. The percent oxygen in the air sample and the presence of explosive vapors were also measured. The survey was conducted while the storm drain blower system was operating, as this represents normal conditions in the drain.

Hawthorne Boulevard Storm Drain Water Sampling Program

Likely sources of contaminants, if any, in the storm drain along the PVLF include intermittent inflow of street-derived contaminants (i.e. trash, waste oil, metals, solvents), contaminants already in the storm drain from upgradient sources, or inflow of contaminants from the PVLF via surface runoff or subsurface inflow through undiscovered cracks in the drain.

To assess the presence of contaminants, seven water samples were collected from inside the storm drain on October 20, 1992, by Sanitation Districts technicians trained for confined space entry. Sample locations are shown on Exhibit 2.1-7, and have the same number as their corresponding organic vapor survey stations; no water sample was collected at S-9, which was a vapor survey station only. The selection of the water sampling locations was based on sample representation and accessibility. An upgradient sample was required to assess the background storm drain water quality. However, no storm drain access could be located along Hawthorne Boulevard upgradient of the PVLF. Therefore, upgradient sample S-7 was collected at the Rolling Hills Estates City Hall parking lot in the storm drain which is a tributary to the Hawthorne Boulevard storm drain (Exhibit 2.1-7).

2.1.2.2.3 Soil Cover

A potential source of the constituents within the rainfall runoff water is the soil cover. As the rainfall impacts the soil cover and drains from the watershed, the water may extract constituents from the soil through dissolution, and pick up sediment in the erosion process. Therefore, the third component of the surface water and sediment investigation was the sampling and analysis of the soil cover. The purpose of the soil cover sampling and analysis program was to collect soil cover samples that could be the source of sediments in the runoff samples, characterize the cover soil for comparison with the surface runoff results, and characterize areas at the PVLF that are used most intensively by the public and site workers.

Soil cover sampling was performed at the PVLF in accordance with the SWSCP in October 1990, and again in October 1993 in accordance with the Work Plan for Additional Remedial Investigation. These two programs are described in the following sections.

2.1.2.2.3.1 Original Soil Cover Sampling Program

Thirty-four soil cover samples were collected at different locations at the PVLF to characterize the soil cover. The locations of the soil cover samples are shown in Exhibit 2.1-57. The locations were chosen based on sample representativeness and location accessibility. An attempt was made to take soil cover samples that were representative of sediment that may be carried into the runoff water. This was accomplished by selecting sampling locations at areas that showed surface soil erosion or from uncovered (non-vegetated) soil areas that are prone to surface soil erosion.

As shown in Exhibit 2.1-7, the locations were taken from different drainage areas and are easily accessible. Soil cover locations 1, 2, 3, 22, 23, and 24 are located on Ernie Howlett Park and are representative of sediment found in runoff water locations 1, 2, and 14. Soil cover locations 4, 5, 6, 7, 14, 15, 16, 17, 18, 19, and 20 are located on the east side of the main site and are representative of sediment found in runoff water locations 2, 3, and 4. Soil cover locations 8, 9, 10, 11, 12, and 13 are located on the west side of the main site and are representative of sediment found in runoff water locations 6 and 7. Soil cover locations 25, 33, and 34 are located on the west side of the South Coast Botanic Garden and are representative of sediment found in runoff water location 8. Soil cover samples 26, 27, 28, 29, 30, 31, and 32 are located on the central and western parts of the South Coast Botanic Garden and are representative of sediments found in runoff water locations 9 and 10.

2.1.2.2.3.2 Additional Soil Cover Sampling Program

Additional soil cover samples were collected from four different areas of the PVLF. These four areas include the Equestrian Center, the main site horse trail, the South Coast Botanic Garden lake and stream area, and the north corner of the third deck near the access road where PAHs were previously identified. These areas were selected as representative of the

2.1.2.2.2.1 Criteria for Sampling Area Selection

This section describes the selection criteria and procedures for conducting soil cover sampling and analysis in areas at the PVLF that are used most intensively by the public and site workers, and additional soil cover sampling and analysis in an area near SC6, which was sampled in October 1990. An additional 22 sampling locations were selected--six at the Equestrian Center, six at the main site horse trail, six at the South Coast Botanic Garden lake and stream area, and four near SC6--as shown on Exhibit 2.1-7.

Areas Used Most Intensively

The criteria used in selecting the areas to be sampled included access to the area, frequency of occupation by the public or site workers, types of current and past use, age of current users, and the physical condition of the area. Not all areas of the PVLF are currently equally accessible; nor are those areas that are accessible used to an equal degree. The past uses also vary within the PVLF. These factors affect how heavily a particular area within the PVLF is used, and the potential exposures associated with that use.

Public access and uses of the PVLF are shown on Exhibit 1.3-4. The general uses of the PVLF are discussed in the following paragraphs.

The South Coast Botanic Garden is operated by the County of Los Angeles through their Regional Parks and Recreation Department. Ernie Howlett Park and the Equestrian Center are operated by the City of Rolling Hills Estates (City). Access to other parts of the landfill are allowed by the Sanitation Districts on a limited use basis. The recycle center is open to the public Wednesday through Saturday from 8:00 a.m. to 4:00 p.m. It is located on a paved area of the main site accessible from Crenshaw Boulevard. The horse trail on the top deck of the main site is open for public use every day from dawn till dusk. Wood chips are spread on the horse trail to control dust and demarcate it from the surrounding area.

The lawn area of the main site is used for overflow parking for special events in the neighborhood (e.g., the yearly California Classic Driving Event, a horse and buggy race, and the Peninsula Committee of the Children's Hospital Horse Show) two or three times a year. The ham radio area on top of the main deck is used by the Northrop Radio Club once a year. The main site is also open to the Chadwick High School cross country running team which runs on the site predominately in the fall. Also, the City has an annual 5K and 10K run, and it's course often traverses part of the main site.

The Sanitation Districts also operate a gas-to-energy facility, which is located in the northern corner of the main site. Other areas of the main site that Sanitation Districts personnel access in the course of their work include the technician trailer area, located in the western corner of the main site, a gardener's area southwest of the Equestrian Center, and other areas as required for monitoring and sampling activities.

Based on the general discussion above, the PVLF was divided into nine areas for consideration in determining those areas used most intensively by the public and site workers. These nine areas are Ernie Howlett Park, the main site horse trail, the South Coast Botanic Garden, the Equestrian Center on the main site, the recycle center, the main site technician trailer area, the gas-to-energy facility, the main site gardener's area, and all other areas of the main site not included in any of the previous categories. Each of these areas was then evaluated on six criteria to determine from which areas soil cover samples should be collected. These criteria include accessibility, frequency of use, past use, current use, age of users, and the current physical condition of the area. The evaluation is discussed in the remainder of this section and shown on Table 2.1-1.

Ernie Howlett Park is operated as a public park by the City. Between dawn and dusk, the park is open to everyone. Several City employees, who maintain this and other City parks, have office and supply quarters at the park. Many local residents use the park frequently for horse riding, tennis, baseball, or other sports and activities. Therefore, as shown in Table 2.1-1, accessibility and frequency of use by both workers and the public was determined to be high. The past use of Ernie Howlett Park included landfilling under permit as a Class II disposal area. According to Sanitation Districts' records, mainly inert materials (such as dirt, bricks, asphalt, and other construction materials) were disposed of there. No refuse fill is present under the tennis court area. The current uses of the park were discussed above. Typically, park users are of all ages since families use the facilities extensively. The parking area is partially paved. The remaining parking area is dirt, as are the riding rings and the baseball diamonds. The rest of the area which is not covered by buildings or tennis courts is vegetated with grass, trees, and bushes.

The horse trail located on the top deck of the main site is open to the public from dawn to dusk. Members of the surrounding communities are the main users of the trail; this is reflected in the rating of public accessibility and frequency as high on Table 2.1-1. Since the horse trail is not an assigned work location, the accessibility and frequency of worker use is not applicable. The horse trail is located mainly on areas of the main site previously permitted as a Class I landfill. Currently, both horse riders and joggers use the trail. The typical age range for horse riders is six

TABLE 2.1-1

CRITERIA FOR SAMPLING AREA SELECTION

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

	Ernie Howlett Park	Main Site Horse Trail	South Coast Botanic Garden	Equestrian Center	Recycle Center	Main Site Technician Trailers	Gas-to-Energy Facility	Main Site Gardener's Area	Other Areas of Main Site
Accessibility: worker public	High High	---- High	High High	High High (restricted)	High High	High ----	High ----	High ----	Medium Low to Medium
Frequency: worker public	High High	---- High	High High	High High	High Low	High ----	High ----	High ----	Medium Low to Medium
Past Use	Inert waste; no fill at tennis courts	Mainly Class I permitted landfill	Class II permitted landfill; no fill at main building, lake and stream	Class I permitted landfill; no fill at most of stables; up to 90' refuse fill in other areas	Class I permitted landfill	Class II permitted landfill	No fill	No fill	Class I or Class II permitted landfill
Current Use	Horse riding, tennis, baseball, other sports and activities	Horse riding, jogging	Botanic garden, walking, playing	Horse riding and care	Recyclables collection	Office area	Electricity generation	Utility area	Running, parking, special events, monitoring and sampling (site workers)
Age of Users	All	Horse riders: mainly 6 & up Other: mainly 13 & up	All	All; few under 6	All	Adult workers	Adult workers	Adult workers	Adult workers Other: mainly 13 & up
Physical Condition	Parking, tennis courts paved; dirt parking, riding rings, baseball areas; grass, trees, elsewhere	Wood chips over dirt	Entryway, some parking paved; dirt trails; various plants	Dirt	Paved	Paved	Paved	Dirt	Grass, trees on slopes; seasonally grass on top deck; dirt roads

years old and up; that of joggers or runners is thirteen years old and up. As noted previously, wood chips are placed on the horse trail.

The South Coast Botanic Garden is operated by the Los Angeles County Department of Parks and Recreation, and is open to the public for a small entrance fee. Both administrative and maintenance personnel are assigned to the site. Therefore, as shown in Table 2.1-1, accessibility and frequency of use by both workers and the public was determined to be high. The South Coast Botanic Garden was permitted for use as a Class II landfill, and received both municipal and industrial wastes. The main buildings, the lake, and the stream, however, are situated in areas where refuse was not placed. The current use of the area as a botanic garden encourages visitors to walk around the site, with some of the most frequented areas being the lake and stream area. Some activities, such as Shakespearean plays, are conducted on grassy areas on an annual basis. Visitors to the park are of all ages, and some events are planned specifically for children. This includes tours for students from local school districts and members of local scouting troops. The entryway and a portion of the parking area is paved. The trails through the park are dirt, and the park is, of course, the home to a variety of plant species.

The Equestrian Center, located on the southern corner of the main site, is leased from the County by the City. It is generally used by members who board their horses in the stables, and have access to the center during its normal operating hours of 7:00 a.m. to 9:00 p.m. Therefore, as shown in Table 2.1-1, accessibility and frequency of use by both workers and the public was determined to be high, although accessibility is mainly limited to members. The Equestrian Center is located in an area of the main site permitted as a Class I landfill, although it is not known how much, if any, hazardous materials were placed here. There were no known hazardous waste injection wells (which were drilled into the refuse for disposal of liquid hazardous wastes) in the Equestrian Center area. Most of the stable areas are located on land that was not refuse filled; other portions of the center are underlain by up to 90 feet of refuse. The area is used for horse riding and horse care. The center is open to all ages; however, few children under the age of six frequent it. The Equestrian Center is unpaved.

The recycle center is located at the main site, with access from Crenshaw Boulevard. It is operated by the Sanitation Districts, and is open to the public during the hours of 8:00 a.m. to

4:00 p.m., Wednesday through Saturday. Worker access and frequency were determined to be high, as was public access, as shown on Table 2.1-1. However, public frequency was determined to be low because most people visit the recycle center for possibly an hour every few weeks. The center is located on an area of the main site permitted as a Class I landfill. All ages visit the recycle center when bringing in recyclable materials. The area occupied by the recycle center is paved.

Technicians employed by the Sanitation Districts and assigned to the PVLF have office and other facilities located in trailers at the western corner of the main site. Their duties include monitoring, sampling, and maintaining the landfill gas control system, so they do not spend all of their time at the trailers. This area is not normally open to the public; therefore, accessibility and frequency of use for workers were determined to be high, and are not applicable to members of the public. The technician trailers are located in an area that was permitted for Class II landfilling. The area is used by adult workers. The road to the technician trailers and the area in front of them are paved.

The gas-to-energy facility operated by the Sanitation Districts is located in the northern corner of the main site. The facility is operated 24 hours a day, and the operators assigned to the facility generally do not have duties that take them outside this area. Public access to the facility is very limited; therefore, as shown in Table 2.1-1, accessibility and frequency of use by workers was determined to be high and at the same time not applicable to the general public. The gas-to-energy facility generates electricity from combusting landfill gas in a boiler and turbine system. This facility is located in an area where no refuse was placed, and is paved.

There is one other location at the main site that is frequently used by Sanitation Districts employees. This is the gardener's area, located southwest of the Equestrian Center. Gardening tools and supplies are located here, although the gardening crew also spends much of its time away from this area. This area is generally not accessible to the public, so only worker accessibility and frequency were determined. As shown on Table 2.1-1, they were found to be high. The gardener's area is located in an area where no refuse was placed. It is currently unpaved and the users are adult workers.

Other areas of the main site which were not included in any of the other categories are accessible to both the public and Sanitation Districts technicians and gardeners, as discussed above.

However, the activities which bring community members into these areas are generally held infrequently. As discussed at the beginning of this section, the lawn area of the main site is used for overflow parking for special events in the neighborhood two or three times a year, the Northrop Radio Club uses an area on the top deck once a year, the main site is open to the Chadwick High School cross country running team (which runs on the site predominately in the fall), and the City has an annual 5K and 10K run partially on site. Sanitation Districts technicians perform monitoring, sampling, and maintenance activities as required over most of the main site. The accessibility and frequency of use by workers to other areas of the site was determined to be medium, and visitors' accessibility and frequency of use was determined to be low to medium for the other areas of the main site.

The selection process for determining the most heavily used areas of the landfill was based on the information discussed above, and summarized in Table 2.1-1. The first consideration was whether or not a potential exposure existed, based on the past and current uses of the area. Those areas where no refuse fill was placed, or where primarily inert fill materials were placed, were not considered since the potential for exposure in these areas is low even if they are used frequently. These areas include Ernie Howlett Park, the gas-to-energy facility, and the gardener's area on the main site. Also, areas that are mostly paved were not considered since no soil cover is accessible for exposure to occur. This included the recycle center, the technician trailer area, and the gas-to-energy facility.

Of the remaining four areas, it was determined that the South Coast Botanic Garden, the Equestrian Center, and the main site horse trail are the most heavily used. Other areas of the main site not included in any of the other eight categories were found to be used at a low to medium frequency, so they are not considered to be among the most heavily used areas of the PVLF. Furthermore, when evaluating the use of the South Coast Botanic Garden, it was determined that visitors tend to spend more time at the gardens developed near the main building, and also near the lake and the stream. The gardens near the main building are densely vegetated or otherwise covered (i.e., wood chips and other mulch material has been placed in the rose garden area), so there is a lesser chance of exposure in these areas. Therefore, based on this evaluation, the three areas selected for additional soil cover sampling because they are more heavily used are the Equestrian Center, the South Coast Botanic Garden lake and stream, and the main site horse trail.

Area Near SC6

The results of previous soil cover sampling and analysis at the PVLF, conducted in October 1990, revealed one location where polynuclear aromatic hydrocarbons (PAHs) were identified at levels higher than elsewhere. The results of the sampling and analysis indicated a possible hot spot, which it was determined should be investigated further. No other soil cover sampling locations sampled in 1990 showed results significantly different from background results; therefore, the additional investigations of previously sampled locations focused on the area near SC6 only.

Criteria for Sample Location Selection

The initial and perhaps most critical element in a sampling program is the plan for sampling itself. If the sampling plan is scientifically defective, the analytical results generated will have limited utility. To prevent this situation, a basic understanding of applied statistics should be employed in the early developmental stages of a sampling plan. Applied statistics is the science of employing techniques that allow the uncertainty of inductive inferences (general conclusions based on partial knowledge) to be evaluated.

From a scientific perspective, the primary objectives of a sampling plan for solids are twofold: namely, to collect samples that will allow measurement of the chemical properties of the media of interest that are both accurate (i.e., the closeness of a sample value to its true value) and precise (i.e., the closeness of repeated sample values). Collection of representative samples, defined as exhibiting average properties of the whole, is required to address both accuracy and precision. Enough samples (but in no case less than four samples [US EPA, 1986a]) must be collected to represent the variability of the media of concern.

Statistical techniques for obtaining accurate and precise samples are relatively simple and easy to implement. Sampling accuracy is usually achieved by some form of random sampling, unless adequate knowledge about the medium to be sampled exists. In random sampling, every unit in the population (e.g., every location) has a theoretically equal chance of being sampled and measured. In other words, the sample is representative of the population. One of the most common methods of selecting a random sample is to divide the population by an imaginary grid, assign a series of consecutive numbers to the units of the grid, and select the numbers (units) to be sampled through the use of a random-numbers table. Previous sample results or a knowledge of the process from which the material was developed may allow satisfactory results from non-random sampling.

It should be noted that the word random has more than one meaning. When used in statistical discussions, it does not mean haphazard; it means that every part of a media of concern has a theoretically equal chance of being sampled. Random sampling, which entails detailed planning and painstaking implementation, is distinctly different from haphazard sampling, which may introduce bias into the collection of samples and the resulting data. It is important to emphasize that a haphazardly selected sample is not a suitable substitute for a randomly selected sample. That is because there is no assurance that a person performing undisciplined sampling will not consciously or subconsciously favor the selection of certain units of the population, thus causing the sample not to be representative of the population.

Section 9.1 of SW-846 (US EPA, 1986a) describes three basic random sampling strategies: simple random, stratified random, and systematic random sampling. If little or no information is available concerning the distribution of chemical constituents in the media of concern, simple random sampling is the most appropriate sampling strategy. More complex stratified random sampling is appropriate if the solid to be sampled is known to be nonrandomly heterogeneous in terms of its chemical properties. Stratified random sampling can be applied when the knowledge of the solid characteristics allows stratum of maximum between-strata variability and minimum within-strata variability to be defined. Systematic random sampling provides for selection of the first sampling point on a random basis, and then all subsequent units are taken at fixed intervals from that first point. Sampling locations are easily identified with systematic random sampling, and distributed more evenly over the population than simple random sampling points.

The soil cover sampling program for the Equestrian Center, main site horse trail, and the South Coast Botanic Garden lake and stream area was designed based on the guidelines contained in SW-846 (US EPA, 1986a). Simple random and systematic random sampling strategies were used to select the locations for sample collection. Stratified random sampling was not selected because little information is known about the distribution of chemical constituents in these areas. Simple random sampling was used to select the sampling locations at the Equestrian Center and the South

Coast Botanic Garden lake and stream. Because of the shape of the main site horse trail, systematic random sampling was used to equally space the samples along the length of the trail.

The soil cover sampling program for the area at the northern corner of the third deck access road was designed to represent the area near SC6. Since the previous sampling results from this location indicated the presence of PAHs, four samples arranged such that the original sampling location was resampled and step-out samples in three directions were collected. The sampling locations were not randomly selected; rather, they were identified with respect to the previous sampling location and generally were selected within a ten to fifteen foot range from the original sample location, except where existing facilities (such as a road) necessitated larger distances.

The sampling locations for the Equestrian Center and the South Coast Botanic Garden lake and stream were selected by overlaying a ten foot by ten foot grid on the selected areas. In general, each box of the grid that was within the selected area and over an area that was refuse filled was assigned a unique number. Exceptions to this procedure were made for areas covered by buildings, since surface soils are not accessible from covered areas, and two portions of the Equestrian Center. The areas excluded from the random sampling selection procedure at the Equestrian Center consist of the horse stables and the riding rings. The horse stables were excluded so that no particular owner, or horse occupant, would be disturbed. The riding rings were excluded to minimize disruptions of the center's operation and to minimize damage to the prepared surface of the rings. .

After assigning unique numbers to each box of the grid that was to be a candidate for sampling, a list of random numbers was selected from the random number tables contained in the <u>CRC Handbook of Tables for Probability and Statistics</u> (Chemical Rubber Company, 1966). Six soil cover sampling locations each were selected for the Equestrian Center and the South Coast Botanic Garden lake and stream. Alternate sampling locations were also selected in case the primary locations were inaccessible; however, it was not necessary to sample at any of the alternate locations because all of the primary locations were found to be accessible.

<u>Equestrian Center.</u> The Equestrian Center is located in the southern corner of the main site. The land for the Equestrian Center is leased by the City from the County. The Equestrian Center has been at the current location since 1976; previously, it was located in the eastern corner of the main site (on what is now known as Parcel 6 of the landfill) prior to fill operations conducted in that area. Portions of the Equestrian Center, in particular most of the stables, are located in areas that were not refuse filled. Other areas of the center are located over refuse fill of up to 90 feet in depth. The area was permitted as a Class I landfill; however, it is not known how much, if any, hazardous materials were placed here. There were no known hazardous waste injection wells (which were drilled into the refuse for disposal of liquid hazardous wastes) in the Equestrian Center area.

The Equestrian Center is open to the public; however, only horses stabled at the center may be ridden at and through the center. Approximately 300 people, consisting of owners, friends of owners, persons taking riding lessons, and observers, use the center monthly (personal communication with Linda Fitton, manager, 1993). Adults and children use the center; however, children under the age of six are less frequent visitors. Riding lessons are typically given for ages six and up. The stables are capable of housing 112 horses; this capacity is normally filled. The hours of operation at the center are 7:00 a.m. to 9:00 p.m. daily. The ground surface is not paved in any area. There is access to the horse trail on the top deck of the main site through a gate at the rear of the center. Seven people work at the center, four full time and three part time.

The Equestrian Center is one of the more heavily used areas of the landfill due to its development as a recreational area, and since its stables are normally filled to capacity. Both adults and children use the center on a regular basis. Therefore, it was selected as one of the locations for collection of additional surface cover samples to provide additional assurance that surface soil within the heaviest use areas of the landfill do not pose a risk, and to provide a sufficient data base of on site soil cover information for discussions with surrounding community members.

A ten foot by ten foot grid was overlain onto the Equestrian Center, and each box of the grid outside those areas mentioned previously (buildings, horse stables, and riding rings) was assigned a unique number. Six soil cover sampling locations were selected randomly from the 1,456 grid boxes overlaying the center for sampling during the additional remedial investigations. The sampling locations at the Equestrian Center are numbered SC35 through SC40 (the previous soil cover samples were numbered SC1 through SC34). The sampling locations are shown on Exhibit 2.1-7.

South Coast Botanic Garden Lake and Stream. The South Coast Botanic Garden is located to the south of Crenshaw Boulevard, which separates it from the main site. The County Department of Parks and Recreation operate the South Coast Botanic Garden; the property is owned by the County. The County developed the South Coast Botanic Garden after fill operations were completed at the site in 1965. The South Coast Botanic Garden is open to the public, and is used by approximately 100,000 people per year. All 83 acres of the site are open to the public. The hours of operation at the South Coast Botanic Garden are 9:00 a.m. to 5:00 p.m. every day, with the exception of Christmas day when it is closed. The ground surface is generally not paved, with the exception of the main entrance road and part of the parking area. Approximately eight people work full time at the South Coast Botanic Garden; an additional six persons work part time and about another ten persons volunteer their time to assist in running the gift shop.

The lake and stream at the South Coast Botanic Garden are situated on native materials (i.e., they are not underlain by refuse fill). However, refuse fill exists under areas surrounding the lake and stream about ten to twenty feet away. The South Coast Botanic Garden, also known as Parcel 1 of the PVLF, was permitted as a Class II landfill. It was not permitted to receive hazardous materials.

The South Coast Botanic Garden is one of the more heavily used areas of the landfill due to its development as a recreational area, and since it is easily accessible and frequently used by both members of the community and as an assigned work location for an administrative and maintenance staff. Many of the site visitors spend much of their time near the lake, where benches are situated, or walking along the paths encompassing the lake and stream. Therefore, the lake and stream area of the South Coast Botanic Garden was selected as one of the locations for collection of additional surface cover samples to provide additional assurance that surface soil within the heaviest use areas of the landfill do not pose a risk, and to provide a sufficient data base of on site soil cover information for discussions with surrounding community members.

A ten foot by ten foot grid was overlain onto the areas surrounding the South Coast Botanic Garden lake and stream. Each box of the grid located over refuse fill was assigned a unique number. Four soil cover sampling locations were selected randomly from the 634 grid boxes overlaying the lake area, and two soil cover sampling locations were selected randomly from the 943 grid boxes overlaying the stream area for sampling during the additional remedial investigation. The sampling locations at the South Coast Botanic Garden lake and stream area are numbered SC41 through SC46. The sampling locations are shown on Exhibit 2.1-7.

Main Site Horse Trail. The main site horse trail is located on the top deck of the main site. It makes a loop around the level area of the top deck, with access from both the horse trail that borders the landfill to the southwest and the Equestrian Center. The area covered by the main site horse trail was permitted as a Class I landfill.

The main site horse trail is open to the public from dawn to dusk. Members from nearby horse stables and nearby residents that keep their own horses are the most frequent users of the horse trail. Some nearby residents also walk or jog along the horse trail, and members of the Chadwick High School cross country team have access to the trail for training, mainly during the autumn. Use of the trail is not monitored. Typically, adults and children over the age of six ride along the horse trail for pleasure or as part of riding lessons offered through the horse stables. Walkers or joggers on the horse trail tend to be of high school age or older. The surface of the horse trail is covered with wood chips to control dust and to demarcate the trail area. There is access to the horse trail from the Equestrian Center operated by the City on the landfill and from the horse trail that runs along the southwestern edge of the landfill through a gate near Roanwood Drive. The main site horse trail is not a work location for any employees of the Sanitation Districts, City, or other.

The main site horse trail is one of the more heavily used areas of the landfill due to its development as a recreational area, and due to its easy access to the public. Both adults and children use the horse trail on a regular basis. Therefore, it was selected as one of the locations for collection of additional surface cover samples to provide additional assurance that surface soil within the heaviest use areas of the landfill do not pose a risk, and to provide a sufficient data base of on site soil cover information for discussions with surrounding community members.

The main site horse trail (top deck section only) was divided into six sections by length, with the sampling location at the midpoint of each section. To apply the systematic random sampling methodology to this process, the length of the horse trail was first measured. Then a number from the random number tables contained in the <u>CRC Handbook of Tables for Probability and Statistics</u>

(Chemical Rubber Company, 1966) was selected. This number, measured in feet from the intersection of the horse trail with the access trail from Roanwood Drive, determined the point from which the trail was divided into six equal sections. Six soil cover sampling locations were selected at the midpoints of each section, as noted above, for the main site horse trail. These six sampling locations, numbered SC47 through SC52, were sampled during the additional remedial investigations. The sampling locations selected by systematic random sampling for the main site horse trail are shown on Exhibit 2.1-7.

Soil Cover Sampling Program for Area Where PAHs Were Identified. Location SC6 was near one of the roads that provides access around the site. A total of four additional samples were collected from this area as part of the additional remedial investigations. One of the additional samples from this area, SC53, was collected as close as possible to the original sample location (SC6). Two additional samples, SC54 and SC56, were collected parallel to the road, about ten feet north and fifteen feet east, respectively, from the location of SC6. The final sample was collected to the south of SC6, approximately 33 feet from the prior sampling location, and on the other side of the road.

2.1.2.2.4 Lake and Stream Water Sediments

The fourth component of the surface water and sediment investigation was to evaluate the water and sediments in the South Coast Botanic Garden lake and stream channel for the presence of landfill contaminants. The scope of field activities performed to complete this fourth component included a water and sediment sampling and analysis program of the South Coast Botanic Garden lake and stream channel.

Contaminants, if present in the lake and stream channel, would likely originate from surface water and sediment runoff from the South Coast Botanic Garden and off site, upgradient sources, or from the tap water used to resupply the lake and stream channel. To assess the presence of contaminants, eleven water and ten sediment samples were collected from the lake and stream channel by Sanitation Districts technicians. Sample locations are shown on Exhibit 2.1-7, and were selected to provide representative data across the entire water body area.

Samples LW-1 through LW-6 were water samples collected from the lake area, and samples LW-9 through LW-12 were water samples collected from the standing water in the stream channel. LW-7 was a tap-water sample collected from the 2-inch irrigation line located on the island which is used to recharge the lake. Samples LS-1 through LS-6 were sediment samples collected from the lake bed, and samples LS-9 through LS-12 were sediment samples collected beneath the standing water in the stream channel. There is intentionally no LS-7 sample, as a sediment sample could not be collected from the tap water (LW-7).

2.1.2.2.5 Lake and Stream Water Balance

The fifth component of the surface water and sediment investigation was the lake and stream water balance. This was completed by performing a month long mass balance/water budget study at the South Coast Botanic Garden lake and stream channel to evaluate the occurrence of water seepage. For the South Coast Botanic Garden lake seepage study, no particular scope of work was proposed in the HCP. Instead, several options were presented on how to investigate the integrity of the lake liner. However, after consideration, the Sanitation Districts decided that a mass balance (water budget) approach was the most efficient method for performing a preliminary evaluation of potential seepage from the lake. Prior to beginning the remedial investigations, no evidence was found to indicate that significant, if any, leakage from the lake was occurring. Therefore, a less invasive investigation methodology--a mass balance study of the lake and stream channel--was incorporated into the remedial investigation.

2.1.2.2.6 Surface Hydrology

The sixth component of the surface water and sediment investigation was to analyze the hydrology at the PVLF. The surface hydrology investigation was divided into three steps. First, the natural watershed areas of the for the PVLF were determined, and the peak runoff for each area that would occur for a 100-year storm was calculated using the Rational Method. Secondly, the design capacity for the on site drainage structures was calculated using either Manning's equation or the orifice equation. Finally, the total calculated peak runoff impacting each drainage structure was compared to its design capacity to evaluate the effectiveness of the structure.

To determine the natural watershed areas or reaches for the PVLF, a current aerial was taken to get the existing topography. The drainage reaches were based on the topography of the land and the existing drainage patterns. These drainage reaches are shown in Exhibit 3.2-3. Also shown on the map are the typical run for each reach which was based on existing drainage patterns. The area of each drainage reach along with the length and slope of the typical run were used to calculate the peak runoff using the Rational Method. Also shown in Exhibit 3.2-3 are the surface drainage structures for the PVLF area. These structures included channels, pipes, ditches, and roadways capable of conveying surface water runoff in a measurable amount. Field measurements of the structures (i.e., type of structure, slope, and size) were taken for each structure. This information was used to calculate the drainage capacity of each structure.

2.1.3 Geologic and Hydrogeologic Investigations

The investigations performed to fulfill the geologic and hydrogeologic requirements of the remedial investigation were outlined in the HCP and in the Work Plan for Additional Remedial Investigation. The Sanitation Districts conducted a multi-phased hydrogeologic investigation to address geologic and hydrogeologic data gaps. The first step consisted of collecting and reviewing pertinent published and unpublished literature concerning the stratigraphy, structural geology, hydrogeology, seismicity, and paleontology of the Palos Verdes peninsula and surrounding areas. The other portions of the hydrogeologic investigations consisted of drilling exploratory boreholes and installing ground water monitoring wells or vadose zone lysimeters downgradient and upgradient of the PVLF. The ensuing sections will discuss the objectives and field activities associated with the hydrogeologic investigations.

2.1.3.1 Objectives

The objective for the first part of the hydrogeologic investigations was to research all available literature, both published and proprietary, to develop an understanding of the regional and local geology of the PVLF. The information obtained from these reports, referenced in Section 8.0, was used to develop a standardized description based on current stratigraphic nomenclature and definitions for each geologic unit (i.e., members of the Monterey Formation) expected to be encountered during field investigations. The geologic objective for the next portion of the hydrogeologic investigations was to define the structural and stratigraphic relationships of geologic units downgradient of the PVLF. The geologic objective for the third portion of the hydrogeologic investigations was to define the structural and stratigraphic relationships of the geologic units upgradient of the PVLF. The geologic objective of the final portion of the hydrogeologic investigations was to further define the structural and stratigraphic relationships of geologic units downgradient of the PVLF, focusing on the occurrences of ground water and the physical characteristics of the ground water bearing units. The cumulative objective for these work phases was to obtain sufficient areal coverage of geologic and hydrogeologic data to develop a data base upon which could be developed a geologic and then a hydrogeologic model of the PVLF and the surrounding area. These models were the first modeling steps in the development of the risk assessment.

2.1.3.2 Scope of Field Activities

The first portion of the hydrogeologic investigations involved extensive research and literature review to obtain references on the geology of the Palos Verdes peninsula and surrounding areas. The majority of this work was performed by the Sanitation Districts staff beginning in 1989. Work conducted by the Sanitation Districts consisted of obtaining and compiling geologic literature and data pertaining to both the regional and site specific geology of the Palos Verdes peninsula and the PVLF from in-house files, government agencies, professional consultants, academic libraries, professional information retrieval services, and personal contacts.

The field work conducted for the hydrogeologic investigations was conducted in three phases. The first one consisted of drilling boreholes at seventeen locations to characterize the geology, hydrogeology, and ground water and soil chemistry downgradient of the PVLF. The next part of the field work consisted of drilling boreholes at eighteen locations to characterize the geology, hydrogeology, and ground water and soil chemistry upgradient of the PVLF. These two phases were performed in June through October of 1990 in accordance with the HCP. The final part of the field work consisted of drilling boreholes at eleven locations to further characterize the geology, hydrogeology, and ground water and soil chemistry downgradient of the PVLF. This final phase of the hydrogeologic investigations was performed in December 1993 and January 1994 in accordance with the Work Plan for Additional Remedial Investigation. During the field work for the hydrogeologic investigation, specific geologic and hydrogeologic field activities consisted of the following:

- Sampling and geologic logging of all overburden materials (alluvium, colluvium, topsoil, fill, etc.) at five foot intervals;
- Continuous coring and geologic logging of all bedrock strata;
- Identifying geologic contacts;
- Identifying zones of naturally occurring hydrocarbon deposits;
- Identifying ground water occurrences;
- Aquifer testing of discrete bedrock intervals;
- Borehole geophysics;
- Microfossil analyses;
- Physical analyses of all rock types encountered; and
- Collection of samples (both soil/sediment and ground water) for chemical analyses.

Complete descriptions of the methodologies used during the hydrogeologic investigation are discussed in Section 2.2. Since the hydrogeologic field investigations were performed under two work plans over two distinct time periods, phases one and two will be described below in Section 2.1.3.2.1, which the final phase of the field investigations is described in Section 2.1.3.2.2.

2.1.3.2.1 Downgradient and Upgradient Hydrogeologic Field Program

As noted in the previous section, seventeen downgradient boring locations and eighteen upgradient boring locations were drilled during the first portion of the field investigations in accordance with the HCP, for a total of 35 boring locations. The actual boring locations deviated in some cases from the planned locations due to sitting considerations (e.g., overhead or underground obstructions, local resident concerns, etc.) or technical considerations determined as the field work progressed. Some of the technical considerations included location of thick sand deposits closer to the landfill than anticipated; this resulted in the relocation of some borings and the deletion of one boring altogether. The discussions in this report focus on the borings drilled during the study. The locations of these 35 borings are indicated on Exhibits 2.1-8 and 2.1-9.

Borehole locations were selected to intercept all geologic strata present beneath and immediately surrounding the PVLF. The main focus of the hydrogeologic investigation, however, was not only to define the geologic conditions surrounding the PVLF, but also to define the local and site ground water quality and hydrogeologic conditions. Therefore, the boring locations were selected based on both geologic and hydrogeologic criteria. The selection criteria for each boring location are listed below:

Boreholes RFB1, RFB6, RFB7, RFB10, RFB11, RFB16, and RFB32 were located near the PVLF to record geologic conditions as close as possible to the landfill. Boreholes can not be drilled directly through the landfill because direct contaminant migration pathways would be created from the landfill into potential ground water zones and because of the potential danger of exposure or fires when drilling in areas with trace VOC concentrations and high methane concentrations.

Boreholes RFB10, RFB11, and RFB12 were located to intercept the remnants of ancient alluvial drainage pathways which crossed the PVLF site prior to landfilling operations.

Boreholes RFB2, RFB3, and RFB4 were drilled to investigate the extent of the contaminant plume near the subsurface barrier system.

Boreholes RFB8, RFB9, RFB13, RFB14, RFB17, and RFB40 were drilled to investigate the geologic and hydrogeologic relationship between the San Pedro Formation and the underlying Monterey Formation. These boreholes were also strategically placed to investigate the effects of the Palos Verdes fault zone on stratigraphy and ground water flow.

Borehole RFB15 was located near the Walteria reservoir to investigate the effects of the reservoir on ground water elevation and quality.

Boreholes RFB18 and RFB19 were located at the top of Butcher Hill to investigate the geologic structure of Butcher Hill and, using cross-hole geophysics, to locate the mine adits rumored to be located in the vicinity.

Boreholes RFB20, RFB21, RFB22, RFB23, RFB24, RFB25, RFB26, RFB28, RFB29, RFB30, and RFB31 were drilled at locations upgradient of the PVLF. These boreholes were drilled to investigate the geologic conditions deep beneath the site (due to the general northward dip of the strata), and to investigate and monitor ground water quality upgradient of the site.

Borehole RFB27 was drilled to investigate the geologic and ground water conditions of the Malaga Mudstone member at a location relatively upgradient of the PVLF.

Boreholes RFBL1, RFBL2, and RFBL3 were drilled with the specific intent of installing vadose zone monitoring lysimeters in each of the three members of the Monterey Formation in a background (upgradient) location.

Boreholes, monitoring wells, and lysimeters were located in public right-of-ways to the maximum extent possible. The purpose of selecting public right-of-way locations was to minimize the long-term impacts to local residents and business, while still fulfilling the technical requirements for the remedial investigation.

In several instances, it was not possible to meet technical needs with public right-of-way locations. In these instances, approval from the appropriate governmental body or an agreement with the private owner were obtained and signed, respectively. Locations outside of public right-of-ways include RFB9, RFB14, RFB15, M53B (RFB16), RFB18, RFB19, M54B (RFB20), M55B (RFB21), M59B (RFB27), and M62B/L9 (RFBL3). Several of these locations are on property belonging to the City of Torrance, or on easements granted to the City of Rolling Hills Estates for other purposes. RFB9 is located in Portola Park, which is owned and operated by the City of Torrance. RFB14, RFB15, and M59B (RFB27) are located on Torrance Water Department property. In addition to approval for drilling, the Torrance Water Department allows the Sanitation Districts access to M59B (RFB27) for routine sampling and monitoring purposes. Both M54B (RFB20) and M55B (RFB21) are located on easements granted to the City of Rolling Hills Estates for bridle trails, sewer lines, and other purposes. The City of Rolling Hills Estates allows the Sanitation Districts regular access to these wells via their easements for sampling and monitoring purposes.

Three locations necessary for technical reasons could not be located anywhere except private property. Two of these locations (RFB18 and RFB19) are situated on an undeveloped parcel of land called Butcher Hill in the City of Torrance. An agreement between the owner and the Sanitation Districts was signed for drilling of these borings followed by abandonment of the boreholes. One location, M62B/L9 (RFBL3), is situated at the Empty Saddle Riding Club. Both a ground water monitoring well (M62B) and a vadose zone lysimeter (L9) were installed at this location. The Sanitation Districts signed an agreement with the property owners allowing their installation and ongoing sampling and monitoring.

M53B (RFB16) is located in the eastern corner of the main site. This final location not in the public right-of-way is situated on Parcel 6 of the PVLF, which is currently owned by the Sanitation Districts.

2.1.3.2.2 Additional Downgradient Hydrogeologic Field Program

Field activities for the additional remedial investigation program, conducted in accordance with the Work Plan for Additional Remedial Investigation, were conducted to the northeast of the PVLF during the months of December 1993 and January 1994. The only ground water pathway of concern in this area, based on discussions between DTSC and Sanitation Districts personnel after evaluation of the geologic and hydrogeologic information gathered during previous investigations in the area, is that in the overburden and weathered bedrock. For purposes of this study, overburden is defined as: alluvium, colluvium, topsoil, mine tailings, slope wash, anthropogenic fills, and/or all other recent, unconsolidated, non-formational lithologic materials. Bedrock includes all members of the Monterey, Fernando, and San Pedro formations. After careful review of the existing data, geologic, ground water flow, and contaminant transport models, potential ground water pathways were identified in these overburden deposits.

The additional geologic and hydrogeologic investigations consisted of exploratory drilling, geologic logging, lithologic sampling, physical laboratory analyses, monitoring well installation and development, and aquifer testing. Although not described in the original work plan, a microfossil analysis was conducted on two soil samples to help determine the stratigraphic relationship of these samples. Chemical analyses of subsurface soil and ground water samples, as described in Sections 2.1.4 and 2.1.5 of this report, were also performed in conjunction with these investigations.

A total of eleven borings were drilled during this investigation. The boring locations are shown on Exhibit 2.1-8. Eight of these borings were completed as ground water monitoring wells based on ground water encountered during the drilling activities or based on evidence of possible ground water movement in the geologic units encountered. The location and selection criteria for each borehole are given below.

AB1 was located at the northeast boundary of the PVLF downgradient of the subsurface barrier system, east of Hawthorne Boulevard and south of Rolling Hills Road. The purpose of this exploratory borehole was to further delineate the extent of ground water occurrence and contamination in this area. During previous investigations, ground water was found at M49A, M07A/B, PV-3, and M25A; however, ground water was not encountered at RFB6 drilled to the east of this area. Previous ground water sampling detected contamination in nearby monitoring wells M49A, M07A/B, PV-3, and M25A.

AB1a (completed as M64B) was drilled because ground water was not encountered in AB1. AB1a was also located downgradient of the subsurface barrier system, but off site in the parking lot for the Rolling Ridge Plaza. It was also east of Hawthorne Boulevard and south of Rolling Hills Road. The purpose of this exploratory borehole was to further delineate the extent of ground water occurrence and contamination in this area.

AB2 (completed as M63B) was located in an empty lot behind the Rolling Hills Business Center on the northeastern corner of the intersection of Rolling Hills Road and Hawthorne Boulevard. Historic aerial photographs and topographic maps depict a narrow, but deep channel created by the intersection of Valmonte and Agua Negra Canyons. This narrow channel may not be adequately monitored by the existing suite of monitoring wells. AB2 was located to intercept the projected path of this channel.

AB3 (completed as M65B) was located in the Country Hills Estates along Carolwood Drive east of RFB7. Historic aerial photographs and topographic maps depict a drainage channel running through this area that may have been graded away or filled in. Previously, RFB7 encountered 13 feet of overburden but no ground water. AB3 was located to monitor any ground water which preferentially follows this historic drainage, if it still exists.

AB4 (completed as M66B) was located in the Country Hills Estates along Carolwood Drive between AB2 and RFB10. AB4 was selected for the same purpose as AB3. There was no overburden encountered in RFB10, so AB3 and AB4 effectively close the remaining data gaps in this area.

AB5 was located near RFB11 along Briarwood Drive in the Country Hills Estates area. Ground water was encountered in RFB11 in overburden material consistent with a historic, northeast trending drainage channel (no monitoring well was installed). AB5 was located to intersect any ground water which preferentially follows this historic drainage channel and determine whether contamination exists in this area.

AB5a was drilled because ground water was not encountered in AB5. AB5a was located closer to the site of RFB11 at the intersection of Briarwood Drive and Carolwood Drive.

AB6 (completed as M69B) was located on Hidden Lane near Crenshaw Boulevard in the Estates Townhome and Condominium complex to the northeast of the South Coast Botanic Garden. Historic aerial photographs and topographic maps depict a significant drainage channel running through the South Coast Botanic Garden along the southeastern side of Crenshaw Boulevard. AB6 was located to intercept the projected path of this drainage channel and, if it still exists, to determine whether or not ground water contaminants are migrating along this pathway.

AB7 (completed as M70B) was located along Rolling Hills Road east of the Estates Townhome and Condominium complex and to the north of the South Coast Botanic Garden. Historic aerial photography and topographic maps depict a small, east-trending drainage channel running through the South Coast Botanic Garden near the site of M39A. AB7 was located to intercept the projected path of this drainage channel and, if it still exists, to determine whether or not ground water contaminants are migrating along this pathway.

AB8 (completed as M67B) was located on Whiffletree Lane just northeast of Rolling Hills Road in the Country Hills Estates area of Torrance. AB8 was located near RFB8. Ground water was encountered in RFB8 during previous investigations (no monitoring well was installed).

AB9 (completed as M68B) was located on Whiffletree Lane next to De Portola Park. AB9 was located just southwest of RFB9, which was drilled in De Portola Park in 1990. Ground water was encountered in RFB9 (no monitoring well was installed).

2.1.4 Soil Investigations

The potential migration of contaminants to the subsurface soils was investigated under the SCP and the Work Plan for Additional Remedial Investigation. Originally, the scope of work for the SCP consisted of collecting subsurface soil samples from six borings unaffected by the landfill. However, since a number of boreholes were planned for the HCP to investigate upgradient areas unaffected by the landfill as well as downgradient areas, it was determined that soil samples would be collected from the same boreholes used in the hydrogeologic investigation. Likewise, since a number of additional boreholes were planned for the Work Plan for Additional Remedial Investigation, it was determined that soil samples would also be collected from these boreholes. This section discusses the objectives of the soil investigation and describes the scope and selection criteria for the field program.

2.1.4.1 Objectives

The objective of the soil/sediment investigation was to determine if soil/sediment contamination is present in the subsurface soils around the PVLF; and if present, to determine the extent and magnitude of the contamination. The SCP was developed after reviewing existing subsurface soil/sediment data for the PVLF area. Based on this review, it was determined that there was a data gap in the existing information with regard to background soil/sediment conditions. To address this data gap, the SCP was developed. The purpose of the soil/sediment investigation was to fill this data gap by characterizing the background soil/sediment conditions. In addition to this stated scope, the Sanitation Districts expanded the investigation to include a statistical comparison of the analytical results from background and down-canyon samples. The down-canyon samples were collected during the field investigations for the HCP and the Work Plan for Additional Remedial Investigation.

The objective of the soil/sediment investigation did not encompass investigation into the characteristics of the various fill materials deposited in the area from mining activities and development activities (mainly as residential areas) because the origin of many of these materials is unknown. Fill materials were deposited at different times as various mining and quarrying interests conducted activities and as developers put in local housing tracts. These fills are known to be heterogeneous, having been drawn from many sources. The characteristics of the original materials being unknown, and since there are no reasons to expect that those materials used as fill in non-landfill affected areas originated in the same place as materials used in potentially landfill affected areas, it was determined that characterizing the fill materials would not serve the purposes of the remedial investigation.

2.1.4.2 Scope of Field Activities

The original scope of the soil investigation included drilling six borings to collect soil/sediment samples unaffected by the landfill. These six borings were located where samples could be collected from the three members of the Monterey Formation, the native geologic materials which principally underlie the PVLF. Samples from the Malaga Mudstone member were to be collected from two of the borings, samples from the Valmonte Diatomite member were to be collected from another two borings, and samples from the Altamira Shale member were to be collected from the final two borings. These geologic units are discussed in greater detail in Section 3.3.4.2.

As the field investigations for the SCP and another work plan, the HCP, were developed, the Sanitation Districts determined that there was considerable overlap in the field work required. The work scope for the HCP, designed to collect information on site geology and hydrogeology, included drilling eighteen borings down-canyon of the PVLF and seventeen borings upgradient of the PVLF. In addition, eleven down-canyon borings were drilled for the Work Plan for Additional Remedial Investigation. The down-canyon and background boring locations are shown on Exhibits 2.1-6 and 2.1-7, respectively. The down-canyon borings were drilled during the field work for the HCP and the Work Plan for Additional Remedial Investigation. These borings were all located either on the landfill or in the City of Torrance. The background borings were drilled during the field work for the HCP. They were located for the most part in the City of Rolling Hills Estates, with the exception of three borings located in the City of Torrance and one boring located in an unincorporated area of the County. All of the field work for the HCP was performed in June through October of 1990 by the Sanitation Districts' consultant, Herzog Associates. The additional remedial investigation field work was performed in December 1993 and January 1994 by the Sanitation Districts' consultant, Dames & Moore.

The determination of the down-canyon and upgradient directions had been established from historical information and from previous studies performed at the site by the Sanitation Districts and others. It is generally accepted that the alluvial flow conditions at the site follow former canyon bottoms from the southwest to the northeast. The upgradient areas are topographically higher than the PVLF, and any surface water infiltration upgradient would not have contacted the landfill. Previous studies, including one performed by Kleinfelder (Kleinfelder, 1988), have identified fracture flow conditions in the bedrock units that also appear to flow generally from the southwest to the northeast. In addition, the work performed as part of the remedial investigations confirmed these conditions.

Down-canyon and upgradient (background) conditions are important in the context of the soil/sediment investigation because, besides acting as an exposure pathway, soil/sediment contamination may contribute to ground water contamination and vice versa. Ground water contamination, consisting of VOCs, is known to exist in two localized areas to the northeast, or down-canyon, of the PVLF. Soil/sediment samples in these areas cannot be considered to represent background conditions; neither have previous studies shown any indication that the ground water contamination is caused by, or is causing, soil/sediment contamination. For the purposes of this study, soil/sediment samples collected up-canyon of the landfill will be considered to represent background conditions. This can be considered a valid hypothesis because of the following: 1) VOCs have rarely been found in the background ground water samples; 2) VOCs have rarely been found in background soil/sediment samples collected previously (Kleinfelder, 1988); and 3) boundary probe monitoring during the past ten years has not identified any areas of consistent gas detection, indicating that little, if any, gas migration has occurred.

Since the hydrogeologic field investigations consisted of more borings in upgradient, or background, locations than defined for the soil/sediment investigation, the Sanitation Districts decided to combine the field work for the SCP and the HCP. A total of 59 background samples were collected during the remedial investigation field work. Of these samples, six were taken from RFB32 just outside of the South Coast Botanic Garden. These samples were considered to be too close to a landfilled area to be representative of the background conditions, since there was the possibility that they may have been affected by gas generated at the landfill. Therefore, the determination of background conditions was based on 53 soil samples. These 53 background soil samples consisted of ten samples from the Malaga Mudstone member of the Monterey Formation, ten samples from the Valmonte Diatomite member of the Monterey Formation, 29 samples from the Altamira S e member of the Monterey Formation, one sample from the San Pedro Formation, and (urden samples.

Many of the samples collected during the hydrogeologic field work w statistical comparison of background and down-canyon sample results. These samples, cc borings drilled off site and down-canyon of the PVLF, represent the main area under i gation to determine whether there are any impacts on ground water from the landfill. A total of 63 down-canyon samples were collected during the HCP field work, and 34 down-canyon samples were collected from the additional remedial investigation field work. The determination of down-canyon conditions was based on 85 of these samples. Samples taken from RFB1 and RFB16, drilled at Ernie Howlett Park and the main site, respectively, were not considered to be representative of down-canyon conditions since they are located on the landfill and are therefore known to be affected by the landfill. The samples representative of down-canyon conditions consisted of 28 samples from the Malaga Mudstone member of the Monterey Formation, eight samples from the Valmonte Diatomite member of the Monterey Formation, 22 samples from the San Pedro Formation, 26 overburden samples, and one sample from the Pico Formation.

2.1.5 Ground Water Investigations

This section discusses the objectives of the ground water quality monitoring investigations. The section also discusses the scope of field activities used to accomplish the objectives and the justification of the field activities with respect to the study objectives. Exhibit 2.1-8 shows the locations of all monitoring wells. Exhibit 2.1-11 shows the locations of all vadose zone lysimeters.

2.1.5.1 Objectives

Ground water monitoring at the PVLF serves several purposes. The objectives of the ground water monitoring include:

- Assessing the water chemistry in the area of the landfill;
- Collecting and evaluating upgradient water quality in an attempt to define background conditions;
- Evaluating seasonal and spatial variations and trends in water quality;
- Responding to concerns for the possible presence of dioxins and radioactivity in the ground water raised by community members;
- Evaluating ground water elevation data for use in a ground water flow model; and
- Assessing the nature and extent of ground water contamination at the site.

To these ends, the ground water quality investigation involved quarterly sampling and water level measurements at 42 ground water monitoring wells from 1987 or their installation (for those wells installed after 1987) through June 1994; quarterly sampling and water level measurements at eight ground water monitoring wells from their installation in January 1994 through December 1994; quarterly sampling at four vadose zone lysimeters and two collection sumps from 1987 or their installation (for those lysimeters installed after 1987) through June 1994; and semi-annual monitoring at three vadose zone lysimeters from 1987 through June 1994. The next sections present the justification for the selection of monitoring points, monitoring parameters, and monitoring frequencies.

2.1.5.2 Scope of Field Activities and Relationship to Objectives

The Sanitation Districts selected ground water sampling locations based on a set of criteria developed through the consideration of the objectives. The criteria are:

- Hydrogeologic setting of a well is in a known or potential contaminant pathway;

- Well has not been sampled enough to develop an historical database;
- Well is located downgradient of a well showing elevated concentrations of indicator parameters; and
- Well is hydrogeologically upgradient of the landfill and may provide background water quality data for downgradient wells in migration pathways.

These criteria respond to the objectives of: 1) defining the nature and extent of contamination; 2) the assessment of water quality (downgradient and upgradient) in the area of the landfill; and 3) the evaluation of ground water elevation data for the development of a hydrogeologic model. Section 2.1.5.2.1 describes the ground water monitoring locations with respect to the above selection criteria.

The Sanitation Districts selected the ground water monitoring parameters to:

- Allow for a determination of general water quality in the landfill area;
- Allow for a determination of the nature and extent of contamination; and
- Allow for a determination of contaminant transport phenomena which may be occurring in the ground water.

These criteria respond to the objectives of: 1) assessment of water quality; and 2) determination of the nature and extent of contamination. Section 2.1.5.2.2 will discuss the selected monitoring parameters with respect to the above criteria.

Two special ground water monitoring programs were undertaken in response to concerns voiced by community members at a community meeting held in June 1990. Selected ground water monitoring wells were sampled for dioxins and radioactivity during the remedial investigation for these special programs. Section 2.1.5.2.3 discusses these two programs.

2.1.5.2.1 Monitoring Location Selection

A total of 50 ground water monitoring wells at the PVLF are monitored and sampled on a regular basis. Thirty-five of these wells are located at or downgradient of the landfill, while the remaining fifteen wells are located upgradient of the landfill. The wells that are regularly monitored and sampled in the PVLF area are discussed in the following paragraphs.

Agua Negra Canyon

The Agua Negra Canyon is the major canyon underlying the main site. Based on the detection of VOCs in the alluvial barrier monitoring wells, this canyon is an identified contaminant migration pathway. The Sanitation Districts selected the three barrier monitoring wells which consistently show the highest concentrations of VOCs (M06A, M06B, and M07A) for the ground water investigation. The ground water investigation does not include the other eleven barrier monitoring wells because they provide redundant information.

The detection of VOCs in Ernie Howlett Park wells (P4-6 through P412) indicates that the canyon underlying Ernie Howlett Park is also a contaminant migration pathway. The Sanitation Districts selected two of the seven Ernie Howlett Park monitoring wells (P4-6 and P410) for the ground water investigation. The investigation does not include the other five Ernie Howlett Park monitoring wells because they provide redundant information.

Off site wells M23A through M25A, M49A, and PV-3 lie downgradient of the site within the buried Agua Negra Canyon drainage. The Sanitation Districts selected these wells for the ground water investigation because these wells have shown reoccurring VOC detections and they are within the pathway for the migration of landfill contaminants. Well M26A lies downgradient of the buried Agua Negra canyon drainage in the West Coast Basin Aquifer. The Sanitation Districts included this well in the ground water monitoring investigation.

The Sanitation Districts installed wells M50B (RFB3), M51B (RFB4), M63B (AB2), and M64B (AB1a) during the remedial investigation. These locations were selected for the installation of monitoring wells because they are downgradient of the buried Agua Negra Canyon drainage, to develop an historical water quality database for these locations, and to further delineate the extent of ground water contamination in this area. These wells are included in the ground water monitoring investigation.

Sepulveda and Agua Magna Canyons

The Sepulveda and Agua Magna Canyons underlie Crenshaw Boulevard and the South Coast Botanic Garden respectively. Detections of VOCs in wells M44A and M37A indicate that both of these canyons are contaminant migration pathways. Wells M36A, M37A, M38A, M39A, M40A, M43A, and M44A monitor these canyons downgradient of and at the landfill and therefore were selected for the ground water investigation.

The Sanitation Districts installed wells M53B (RFB16), M69B (AB6), and M70B (AB7) during the remedial investigation. These wells also monitor the contaminant pathways along Crenshaw Boulevard. These wells were selected because they monitor a contaminant pathway, to develop an historical water quality database for this well, and to further delineate the extent of ground water contamination in this area.

The Sanitation Districts installed well M52B (RFB13) during the remedial investigation. This location was selected for the installation of a monitoring well because it is downgradient of the buried Sepulveda and Agua Magna Canyons drainage and to develop an historical water quality database for this location. This well is included in the ground water monitoring investigation.

Fractured Bedrock

A potential contaminant pathway through fractures in the bedrock which underlies the landfill exists. Wells M30B and M32B through M35B monitor the ground water in the bedrock fractures along the northeast boundary of the main site. Prior to the start of the remedial investigation, the fracture water had not shown significant evidence of being a current contaminant pathway; however, the Sanitation Districts included these wells in the ground water investigation to monitor this potential contaminant pathway.

The Sanitation Districts installed wells M65B (AB3) and M66B (AB4) during the remedial investigation. These locations were selected for the installation of monitoring wells because they are downgradient of the landfill and upgradient of the Palos Verdes fault zone in the fractured bedrock to the northeast of the main site and to develop an historical water quality data base for these locations. These wells are included in the ground water monitoring investigation.

The Sanitation Districts installed wells M67B (AB8) and M68B (AB9) during the remedial investigation. These locations were selected for the installation of monitoring wells because they are in the West Coast Basin immediately tot he northeast of the Palos Verdes fault zone downgradient of the landfill and to develop an historical water quality data base for these locations. These wells are included in the ground water monitoring investigation.

Upgradient Wells

Wells M42A and M43A monitor the Agua Magna and Sepulveda Canyons upgradient of the landfill. Wells M45A, M47B, and M48A monitor the Agua Negra Canyon and the small canyon which underlies Ernie Howlett Park upgradient of the landfill. These wells may provide background water quality data for downgradient wells in contaminant pathways and therefore are included in the ground water investigation. Well M46A monitors Hawthorne Canyon upgradient of the landfill; however it does not provide background water quality data unaffected by landfilling because it is downgradient of the HCLF (a small municipal waste landfill). This well is included in the ground water investigation to monitor the potential contribution of contaminants from the HCLF, but is not included in summaries or calculations of background water quality.

Wells M54B (RFB20) through M58B (RFB26) were installed during the remedial investigation. These wells monitor ground water upgradient of the landfill in the Agua Negra Canyon and the unnamed canyon upgradient of Ernie Howlett Park. The Sanitation Districts included these wells in the ground water investigation to develop an historical water quality database for these wells, and because these wells may provide background water quality information for downgradient wells in contaminant pathways.

Wells M60B (RFB29) and M61B (RFB31) were installed during the remedial investigation. These wells monitor ground water upgradient of the landfill in the Agua Magna and Sepulveda Canyons. The Sanitation Districts included these wells in the ground water investigation to develop an historical water quality database for these wells, and because these wells may provide background water quality information for downgradient wells in contaminant pathways.

Well M59B (RFB27) and M62B (RFBL3) were also installed during the remedial investigation. These wells are located in an area which is unaffected by the landfill and monitor the Malaga Mudstone, which is found in wells downgradient of the landfill but not in wells directly upgradient of the landfill. The Sanitation Districts included these wells in the ground water investigation to develop an historical water quality database for these wells, and because these wells may provide background water quality information for the downgradient wells which lie within the same geologic unit.

Vadose Zone Lysimeters

Lysimeter L1 monitors the vadose zone at the upgradient edge of the landfill and may provide background information for the downgradient lysimeters. Lysimeters L2 through L6 monitor the vadose zone at the downgradient edge of the landfill. The vadose zone beneath the landfill is a possible contaminant pathway; and therefore these lysimeters are included in the ground water investigation. Lysimeter L1 has been dry since its installation and is not monitored. Samples collected from Lysimeters L2 and L3 have consistently shown VOC contamination; and therefore these lysimeters are monitored quarterly. Lysimeters L4, L5, and L6 have never indicated any landfill related contamination and are monitored semi-annually.

Lysimeters L7 (RFBL1), L8 (RFBL2), and L9 (RFBL3) were installed during the remedial investigation to monitor the vadose zone upgradient of the landfill. L7 (RFBL1) monitors the vadose zone in the Valmonte Diatomite member of the Monterey Formation, L8 (RFBL2) monitors the vadose zone in the Altamira Shale member of the Monterey Formation, and L9 (RFBL3) monitors the vadose zone in the Malaga Mudstone member of the Monterey Formation. The Sanitation Districts included these lysimeters in the ground water investigation to develop an historical water quality database for these lysimeter locations, and because these lysimeters may provide background water quality for the downgradient lysimeter locations.

2.1.5.2.2 Monitoring Parameters and Monitoring Frequency

The ground water monitoring wells discussed in the last section are sampled on a regular basis for a number of chemical constituents. This section tabulates those analytes tested for, the reasons they were selected for testing, and the frequency at which testing is performed.

Quarterly Ground Water Parameters

Table 2.1-2 lists the parameters which are monitored on a quarterly basis. Quarterly monitoring allows for the determination of seasonal and overall trends. The slow ground water flow rates in the underlying sediments do not indicate that more frequent monitoring is necessary to detect changes in ground water quality. The quarterly monitoring parameters include:

- General water quality parameters (i.e. major anions, major cations, Ph, dissolved solids, organics, indicator parameters, metals without maximum contaminant levels (MCLs)). These parameters determine the general nature of the water quality in the formations around the landfill. Large increases in the concentrations of these parameters may indicate a release from the landfill, although they are not considered to be contaminants. The Sanitation Districts monitor for general parameters to define water quality around the PVLF and to aid identification of landfill effects on off site areas.

- Metals (those with MCLs). These parameters are considered to be contaminants, though they do exist naturally in the environment. Therefore, the Sanitation Districts monitor these to aid in the determination of the nature and extent of contamination at the site and to define the nature of water quality at the site.

- Volatile Organic Compounds (VOCs). VOCs do not generally exist naturally in the environment, therefore, all detections are considered indications of contamination from some man-made source. Certain VOCs are breakdown products of other VOCs. The Sanitation Districts monitor for VOCs to determine the nature and extent of contamination at the site and to aid in the identification of contaminant transport phenomena which may be occurring.

TABLE 2.1-2

GROUND WATER MONITORING PARAMETERS AND SAMPLING FREQUENCY

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

PARAMETERS	FREQUENCY QUARTERLY	 SEMIANNUALLY
METALS		
Arsenic	X	X
Barium	X	X
Cadmium	X	X
Calcium	X	X
Total Chromium	X	X
Hexavalent Chromium		X
Copper		X
Iron		X
Lead	X	X
Magnesium	X	X
Manganese		X
Mercury	X	X
Nickel		X
Potassium	X	X
Selenium	X	X
Silver	X	X
Sodium		X
Zinc		X
MAJOR ANIONS		
Bicarbonate	X	X
Carbonate	X	X
Chloride	X	X
Sulfate	X	X
Sulfide	X	X
Nitrate As Nitrogen	X	X
GENERAL CHEMICAL PARAMETERS		
pH	X	X
Alkalinity	X	X
Electrical Conductivity (Specific Conductance)	X	X
Total Dissolved Solids	X	X
Total Kjeldahl Nitrogen	X	
Chemical Oxygen Demand	X	X
Biochemical Oxygen Demand	X	X
ORGANIC COMPOUNDS		
Purgeable Organic Compounds		X
Volatile Halogenated Organic Compounds	X	
Volatile Aromatic Organic Compounds	X	
Semivolatile Organic Compounds		
Pesticides and PCBs		X
Total Organic Carbon (TOC)	X	X
Total Organic Halogens (TOX)	X	X
Total Recoverable Oil and Grease	X	X
RADIOCHEMICAL PARAMETERS		
Gross Alpha		X
Gross Beta		X

Note: Purgeable organic compounds are analyzed semiannualy in place of volatile halogenated and aromatic organic compounds.

Semi-Annual Ground Water Parameters

The Sanitation Districts monitor certain parameters on a semi-annual basis. These parameters are generally, or potentially, landfill related contaminants that have not been detected at the landfill. Quarterly monitoring is not necessary because trends and seasonality are not applicable to parameters that are never or rarely detected. The semi-annual parameters include:

- Pesticides and PCBs. The Sanitation Districts seldom detect pesticides in ground water near the PVLF. These parameters are, however, potentially landfill related contaminants. Semi-annual monitoring of pesticides and PCBs provides a detection monitoring system for these potential landfill contaminants.

- Semi-Volatile Organic Compounds (semi-VOCs). The Sanitation Districts seldom detect semi-VOCs in ground water near the PVLF. These parameters are, however, potentially landfill related contaminants. Semi-annual monitoring of semi-VOCs provides a detection monitoring system for these potential landfill contaminants.

- Gross Alpha and Gross Beta Radioactivity. These radioactivity parameters are general indicators for other radioactive isotopes. Because the landfill never knowingly accepted radioactive wastes, the Sanitation Districts do not expect these compounds to be detected at levels over background. Semi-annual monitoring of gross alpha and gross beta radioactivity provides a detection monitoring system for these potential landfill contaminants.

Lysimeter Parameters

Samples from lysimeters L3, L4, and L5 have never indicated landfill related contamination. The Sanitation Districts monitor these lysimeters semi-annually to provide a detection monitoring system for the unsaturated zone. All other lysimeters are monitored on a quarterly basis.

Lysimeters typically provide very small volumes of sample of inadequate size to run all of the regularly scheduled analyses. The analyses for lysimeter samples are generally prioritized as follows:

- VOCs;
- Ph, conductivity, total dissolved solids;
- Metals: cadmium, total chromium, copper, lead, mercury;
- Nitrate nitrogen, total Kjeldahl nitrogen; and
- TOC, COD, BOD.

2.1.5.2.3 Dioxins and Radioactivity Monitoring Programs

The possibility of dioxins and radioactivity contamination from the PVLF to the ground water was investigated under various work plans described in Section 1.2. The following paragraphs discuss the objectives and field activities of these monitoring programs.

Dioxins Monitoring Programs

In the course of the community relations activities for the PVLF RI/FS, questions were raised by community members regarding dioxins. These questions focused on whether dioxins were disposed of at the landfill, and if so, whether there are any impacts to the public at this time. The Sanitation Districts researched the possibility of any historical disposal or presence of dioxins in the landfill, and determined that no conclusive evidence was present to confirm or deny the disposal of dioxins. Following this determination, the Sanitation Districts developed the "Sampling and Analysis Plan for Dioxins and Radioactivity at the Palos Verdes Landfill" (Sanitation Districts, 1990b). This plan provided for testing ground water samples taken from monitoring wells at the PVLF to determine if there was any possible dioxin contamination. DTSC reviewed and approved the plan after two of the monitoring well locations were modified (DTSC letter dated October 26, 1990). The Sanitation Districts made these changes in the finalized work plan, dated November 1990; and implemented the plan in December 1990. A total of eleven samples (including quality assurance/quality control samples) from eight locations were analyzed by EPA Method 8280 for dioxins with a detection limit of less than or equal to 10 parts per trillion.

An examination of the results and the QA/QC data by the Sanitation Districts indicated that contamination of one sample taken from monitoring well M30B appears to have occurred due to field equipment, and that one dioxin isomer was detected at a low concentration at one sampling location (Sump 7). Further examination of the results indicated that the less toxic dioxin isomers were detected. Consequently, given the above findings, the Sanitation District resampled location M30B and developed a modified monitoring program designed to last for one year. The modified sampling and monitoring program along with the sampling locations and the selection criteria for the locations are discussed below.

As noted above, the initial sampling and monitoring program provided for the collection and analysis of a total of eleven samples from eight locations at the PVLF. The locations sampled included EW7, M30B, M33B, M57B, M61B, P4-7, P410, and Sump 7. The original sampling locations were changed for the modified sampling and monitoring program at the request of DTSC to provide a better spatial representation of the area downgradient of the PVLF and in the general direction of the ground water flow. The locations sampled included three wells upgradient of the PVLF (M46A, M57B, and M61B), one extraction well (EW9), seven downgradient wells (M30B, M35B, M37B, M38A, M39A, and PV-3), and one sump (Sump 7). The sampling locations for dioxins are shown in Exhibit 2.1-5. The selection criteria for these sampling locations was based on sample representativeness and spatial location. The selection criteria for each sample location are listed below.

Extraction well EW9 was selected to represent extraction water taken from behind the subsurface barrier. There are a total of eleven extraction wells located behind the subsurface barrier. Previously, in December 1990, EW7 was sampled for dioxins. No dioxins were detected at EW7.

Monitoring well PV-3 was selected for spatial distribution purposes to represent ground water that flows along the buried Agua Negra Canyon located north of the main site along Hawthorne Boulevard. Samples from this well have shown recurring VOC detections and it is within the pathway for the potential migration of landfill contamination. Previously, in December 1990, monitoring wells P4-7 and P410 (located upgradient of PV-3 in the Aqua Negra Canyon) were sampled for dioxins. No dioxins were detected at these wells.

Monitoring wells M30B, M33B, and M35B were selected for spatial distribution purposes to represent ground water along the northeast boundary of the main site downgradient of the PVLF. Previously, in December 1990, monitoring wells M30B and M33B were sampled for dioxins. Dioxins were detected in the sample from monitoring well M30B; however, the same dioxin isomers detected in the field sample were detected at comparable levels in the equipment blank collected at the same time. This indicates that some sort of contamination of the samples occurred. M30B was resampled in February 1991, at which time no dioxins were detected. Location M30B was kept as part of the modified monitoring program for confirmation and monitoring purposes. Dioxins were not detected in the sample from monitoring well M33B in the December sampling event, but location M33B was included in the modified sampling program for spatial and temporal purposes.

Monitoring well M37A was selected for spatial distribution purposes to represent ground water that flows along the buried Agua Magna Canyon located north of the main site along Crenshaw Boulevard. Samples from this well have shown recurring VOC detections and it is within the pathway for the potential migration of landfill contamination. Monitoring well M37A was not previously sampled in December 1990 as part of the initial monitoring program.

Monitoring wells M38A and M39A were selected for spatial distribution purposes to represent ground water taken from the northeast boundary of the South Coast Botanic Garden downgradient of the PVLF. Monitoring wells M38A and M39A were not previously sampled in December 1990 as part of the initial monitoring program.

Sump S7 is the outlet from an underdrain located beneath the northeast portion of the main site (Parcel 6). Previously, in December 1990, sump S7 was sampled for dioxins and low concentrations of one dioxin isomer were detected. Therefore sump S7 was kept as part of the modified monitoring program for confirmation and monitoring purposes.

Monitoring wells M46A, M57B, M61B were selected for spatial distribution purposes to represent ground water upgradient of the PVLF. Previously, in December 1990, monitoring wells M57B and M61B were sampled for dioxins and none were detected. Sample location M46A was added to the modified sampling program at the request of DTSC (refer to DTSC letter dated October 8, 1991, to the Sanitation Districts). Monitoring well M46A was not previously sampled in December

1990 as part of the initial monitoring program. Although monitoring well M46A is upgradient of the main site of the PVLF, it lies immediately downgradient of the Hawthorne Canyon Landfill. This small off site canyon was filled in the late 1960s by the Sanitation Districts under agreement with the City and the owners at that time, and in accordance with a permit obtained from the Regional Water Quality Control Board.

Radioactivity Monitoring Programs

In the course of the Community Relations activities for the PVLF RI/FS, questions were raised by community members regarding radioactive wastes. These questions focused on whether radioactive wastes were disposed of in the landfill, and if so, whether there are any impacts to the public at this time. Subsequently, DTSC requested that the Sanitation Districts research the possibility of any historical disposal or presence of radioactive related wastes in the landfill.

Based on a file search, it was found that hazardous waste discharge permits dating from 1964, 1966, and 1970 (RWQCB Resolution 64-9, 66-4, and RWQCB Order 70-3, respectively) do not prohibit the disposal of radioactive wastes at the landfill. In 1976, RWQCB Order 76-106 prohibited the site from accepting radioactive wastes. From 1964 until 1970 there was no comprehensive manifest system for waste identification at the landfill, and the manifest system installed in 1970 did not include a category for radioactive wastes. Therefore, there are no records regarding the disposal of radioactive wastes at the landfill. However, due to the fact that the Nuclear Regulatory Commission strictly controlled high level radioactive wastes, the Sanitation Districts have no reason to believe that high level radioactive wastes were disposed of at the PVLF. Based on disposal practices at the time, low level radioactive wastes were not strictly regulated, if at all. Therefore, there is no evidence regarding the presence or absence of low level radioactive wastes at the landfill.

In 1986, the Sanitation Districts sampled selected wells at the PVLF for gross alpha radioactivity (GAR) and gross beta radioactivity (GBR). Some radioactivity was detected but gamma scans of the samples confirmed the source to be potassium-40, a naturally occurring radionuclide.

The Sanitation Districts developed a Sampling and Analysis Plan for radioactivity at the PVLF in October 1990. This plan was submitted to DTSC for review and approval. DTSC approved the plan in November 1990, and the Sanitation Districts implemented the plan in December 1990. A total of eleven samples were taken from ten locations. The locations sampled included EW7, P4-7, P410, M30B, M33B, M38A, M39A, M57B, M61B and Sump 7. A re-sample of two locations was performed in May 1991. In addition to the regular GAR and GBR monitoring, the samples were analyzed for tritium, strontium-90, radium 226+228, and uranium. The results are discussed in "Evaluation of Radioactivity Monitoring Data at the PVLF", submitted to DTSC in September 1992 along with a modified sampling and analysis plan for radioactive compounds.

Comments from the September 1992 modified sampling and analysis plan for radioactive compounds were received in December 1992. The sampling and monitoring plan was revised and resubmitted to DTSC in June 1993. Final approval of the plan was received from DTSC in September 1993. The final plan required quarterly monitoring for one year of ten sampling locations for the following parameters: GAR, GBR, tritium, strontium-90, radium 226+228, uranium, potassium-40, vanadium-48, thorium, and plutonium. The locations sampled included two wells upgradient of the PVLF (M57B and M61B), one extraction well (EW7), six downgradient wells (P4-7, P410, M30B, M33B, M38A, and M39A), and one sump (Sump 7). The sampling locations for the radioactivity sampling are shown in Exhibit 2.1-5. The selection criteria for these sampling locations was based on sample representativeness and spatial location. The selection criteria for each sample location is listed below.

Extraction well EW7 was selected to represent extraction water taken from behind the subsurface barrier. There are a total of eleven extraction wells located behind the subsurface barrier.

Monitoring wells P4-7 and P4-10 were selected for spatial distribution purposes to represent ground water that flows from the buried Valmonte and Agua Negra Canyons downgradient of the PVLF. These two wells along with extraction well EW7 provide adequate coverage of the northern corner of the landfill where much of the area ground water flow is concentrated.

Monitoring wells M30B and M33B were selected for spatial distribution purposes to represent ground water along the northeast boundary of the main site downgradient of the PVLF.

Monitoring wells M38A and M39A were selected for spatial distribution purposes to represent ground water along the northeastern boundary of the South Coast Botanic Garden downgradient of the PVLF. Monitoring well M38A is located at the drainage exit of the buried Agua Managa and Sepulveda Canyons.

Sump 7 is the outlet from an underdrain located beneath the northeast portion of the main site (Parcel 6).

Monitoring wells M57B and M61B were selected for spatial distribution purposes to represent ground water upgradient of the PVLF.

Field activities for the final Sampling and Monitoring Plan for Radioactivity began in November 1993 and were completed in September 1994.

2.2 FIELD METHODOLOGIES

This section discusses the sampling and analysis methodologies used for the field activities during the remedial investigations. All methodologies conformed to work plans prepared by the Sanitation Districts and approved by DTSC (see Section 1.2). The majority of the field methodologies were outlined in the Site Sampling and Analysis Plan for Palos Verdes Landfill (Sanitation Districts, 1989b); methodologies not included in this plan were outlined in the Work Plan for Additional Remedial Investigation and the Additional Ambient Air Work Plan. The field activities discussed include the drilling of the boreholes, soil/sediment sampling and microfossil analysis, geologic logging, geophysical analysis, and hydraulic properties analysis. The field installation methods for the monitoring wells and lysimeters are discussed in this section. Finally, the field methodologies used in taking the air and water samples and the field chemical analyses performed are included in this section.

Field activities for the PVLF remedial investigations, including borehole drilling and logging, monitoring well and lysimeter installation, and sampling for physical and chemical analyses, were performed by Sanitation Districts personnel and members of various consulting firms retained by the Sanitation Districts. Ambient air sampling was performed by Sanitation Districts personnel, with training on the use of canisters and flow controllers provided by Dr. Chuck Schmidt. Surface gas, boundary probe, meter box, and landfill gas monitoring and sampling were all performed by Sanitation Districts personnel. Surface flux chamber sampling was performed by the Sanitation Districts' consultant, Dr. Chuck Schmidt. Surface water runoff and cover soil sampling were performed by Sanitation Districts personnel. The Hawthorne Boulevard storm drain monitoring and the South Coast Botanic Garden lake and stream sampling were performed by Sanitation Districts and Dames & Moore personnel. Drilling and soil sampling was performed by Herzog Associates and their subcontractor, PC Drilling, and by Dames & Moore and their subcontractor H-F Drilling. Geophysical logging was performed by Welenco, Inc., a subcontractor of Herzog Associates. Monitoring well and lysimeter installation and aquifer testing were also performed by Herzog Associates and Dames & Moore. Ground water samples from open boreholes were obtained by Herzog Associates. The first ground water sample from the new monitoring wells installed for the remedial investigations were collected by the Sanitation Districts' consultants, Herzog Associates and Dames & Moore. Routine quarterly ground water sampling was performed by Sanitation Districts personnel.

2.2.1 Drilling

A total of five drilling methods were used to drill 54 borings during the field investigations. Selection criteria for each drilling method used were determined from the drilling conditions and lithologies encountered during previous drilling programs, and also by the predetermined purpose for the boring. Some lithologies, such as sand, gravel, and cobble conglomerate, require the use of certain drilling techniques, whereas thick plastic clay and siltstone allow the use of others. Specific criteria and the drilling methods used are discussed in the following sections.

2.2.1.1 Hollow Stem Auger Drilling

Hollow stem auger drilling with air as the drilling medium was used to drill through the shallow portions of borings, where unconsolidated materials (alluvium, colluvium, etc.) predominated. Augers will meet refusal in conglomerates, and drill very slowly at depths greater than 100 feet. When air is used as the drilling medium, saturated material can be detected almost immediately. Representative ground water samples can be collected at the shallowest horizon.

Subsequent, deeper ground water encountered, however, may be commingled with the shallower ground water which will travel down the borehole either along the side walls or down the auger flights. When deeper saturated intervals are to be sampled, surface casing must be used to prevent vertical communication between ground water in a boring. The hollow stem augers used were five feet in length, and six, eight, or ten inches in outside diameter. Six inch diameter augers were used when only drilling and sampling were performed, eight inch diameter augers were used when either drilling and sampling were performed or when drilling boreholes for the purpose of installing monitoring wells, and ten inch diameter augers were used when drilling boreholes for the purpose of installing monitoring wells.

The drilling procedure consists of turning the auger, which advances the hole to the desired depth. Cut materials (called "cuttings") rise to the surface on the auger flights, and can be collected for visual examination and disturbed sample testing. Compressed air is added to the system through the hollow stem of the augers, which also provides the conduit for the split spoon sampling equipment (see Section 2.2.2.1).

2.2.1.2 Rotary Core Drilling

Rotary core drilling can be performed using a variety of drilling fluids. Air, water, and water-based muds were the drilling fluids used during this investigation, with water-based muds used only in the event that the hole could not otherwise be stabilized. The advantages of rotary core drilling include the recovery of continuous core samples for geologic logging and laboratory analyses, and penetration to the depths necessary for this investigation. The well diameter that can be installed using rotary core drilling is dependent on the equipment used; wells of relatively large diameters can be installed. However, rotary core drilling through clay or broken materials may not yield good core returns, and hole conditions may require the use of water or mud as the drilling medium. When using air as the drilling medium, saturated material can be detected immediately and ground water samples can be collected from any saturated zones. The use of water or mud precludes both identification of saturated zones and collection of representative ground water samples. In addition, soil samples collected while using mud as the drilling medium may not yield representative chemical analysis results.

During this investigation, rotary core drilling was used after reaching the overburden-bedrock contact or auger refusal. HQ-sized core barrels were used. Coring was performed using a Christensen wire line core assembly, and the borings were continuously cored to total depth. Water was used as the main drilling medium for the borings drilled downgradient of the PVLF, while air was the main drilling medium used upgradient.

All core was stored in pre-labeled, weather-resistant core boxes, which were marked with the appropriate depth notations. Lids were nailed over the core boxes for long-term storage, or until photographs were taken. Photographs were made of upgradient core prior to disposal. Downgradient core is in long-term storage.

2.2.1.3 Dual Wall Reverse Rotary Drilling

Dual wall reverse rotary drilling with air as the drilling medium works well in deep, unconsolidated sands and gravels, as well as in consolidated bedrock. Drilling proceeds quickly through variable lithologies. This type of drilling is capable of reaching the total depths that were required in this investigation. Soil samples were collected through the use of split-spoon or other thin-walled sampling tubes. Saturated materials are detected immediately, and ground water sampling is possible from any depth in the boring. Wells of relatively large diameters can be installed when using dual wall reverse air rotary drilling. Dual wall reverse air rotary drilling was used in several of the downgradient borings which intersected the San Pedro Formation. None of the borings upgradient of the PVLF were drilled using this method.

The drilling setup consists of a drill pipe and drill bit inside two drill casings, which are all continuously advanced into the hole with the drill bit. The drilling medium can consist of compressed air, water or drilling mud; however, in this investigation, air was used exclusively. The compressed air is pumped downward between the inner and outer casings, forcing cuttings upward through the drill bit and inner casing to the surface. This method of drilling requires using a large-capacity centrifugal or jet pump.

2.2.1.4 Rotary Tricone Drilling

Rotary tricone drilling for this investigation used air as the drilling medium. The advantages of using this method are primarily speed and the ability to penetrate dense lithologies that are difficult to drill through with the other methods described in this section. Relatively large diameter wells can be installed using air rotary tricone drilling. Saturated material can be detected immediately and ground water samples can be collected from any saturated zones. Geologic logging and sampling are limited to the observation and collection of drill cuttings, since it is not possible to correlate drill cuttings to discrete drilled intervals. Therefore, no soil samples were collected for this investigation when using this drilling method.

This drilling method was used upgradient of the PVLF primarily when difficult drilling conditions prevented the use of other drilling methods. Air rotary tricone drilling was used sparingly, since no soil samples were collected from the portions of the borings where it was used. None of the downgradient borings were drilled with this method.

The drilling setup consists of a drill pipe and drill bit inside a single drill casing, which are all continuously advanced into the hole with the drill bit. The drilling medium can consist of compressed air, water or drilling mud; however, in this investigation, air was used exclusively. The compressed air is pumped downward through the drill stem and bit, forcing cuttings upward through the drill casing to the surface.

2.2.1.5 Bucket Auger Drilling

Bucket auger drilling was performed by H-F Drilling, Inc., using a Calweld Earth-Drill bucket rig with an eighteen inch bucket. At locations M67B (AB8) and M70B (AB7) bucket auger drilling was employed to facilitate the installation of the conductor casing. After the pilot hole was drilled, the borehole was reamed to a depth of one foot below the base of the perched zone using an eighteen inch diameter bucket auger. A sixteen inch diameter carbon steel conductor casing was then placed down the hole and driven to the base of the perched zone using the weight of the kelly bar. Neat cement was placed between the conductor casing and the borehole wall to effectively seal off the perched zone from the underlying primary water-bearing units. The remainder of each borehole was drilled using a ten inch hollow stem auger as described above to provide an appropriate annulus for monitoring well installation.

2.2.2 Subsurface Lithologic Sampling and Physical Analysis

Split-spoon and core sampling were used to collect subsurface samples during the remedial investigation field work. The sampling method used was dependent on the drilling technique. These two methods and their attributes are discussed in Sections 2.2.2.1 and 2.2.2.2. Bulk sampling is discussed in Section 2.2.2.3. The physical testing done on the subsurface lithologic samples is discussed in Section 2.2.2.4. The microfossil analysis performed on the subsurface lithologic samples is discussed in Section 2.2.2.5.

2.2.2.1 Split-Spoon Sampling

Relatively undisturbed lithologic samples were obtained using a California modified split-spoon sampler fitted with stainless steel rings. Samples were collected at five foot intervals by driving the sampler through the hollow stem of the auger and into the undisturbed sediments or sedimentary bedrock below. The sampler was driven eighteen inches, or until meeting refusal, with a standard 30-inch drop of a 140-pound hammer. Hammer blow counts were recorded over the interval of sampler penetration. After the sampler was retrieved, the stainless steel sampling rings were removed from the split-spoon and visually inspected and logged. Selected sample rings were then capped with Teflon caps and tape. Labels were fixed to the sample containers containing the following information: boring number, sample depth, date, collector's name, site name, and time of collection.

Because lithologic samples were obtained for both physical and chemical analyses, all lithologic sampling equipment was decontaminated prior to drilling each borehole, and between each sampling event. Split-spoon samplers and stainless steel rings were washed in a non-phosphate detergent, rinsed in tap water, double rinsed in distilled water, and then allowed to air dry between each sampling event. The hollow stem augers were steam-cleaned between boreholes.

2.2.2.2 Core Sampling

Rock core was recovered from the borings when the rotary core drilling technique was used. Six inch samples of the rock were collected at twenty foot intervals immediately after retrieving the core barrel. A portion of the core sample was placed into a VOC vial for field analyses and the remainder was sealed in labeled 6-inch stainless steel rings, capped with Teflon-lined plastic caps taped onto the ring's ends. These samples were used for chemical and physical testing.

All of the core samples collected in the VOC vials and stainless steel rings were stored on ice until field analyses were performed or they were submitted to the appropriate laboratory for chemical analysis or physical testing.

2.2.2.3 Bulk Sampling

Bulk samples of the auger cuttings were collected in plastic bags at each change in lithology. Bulk sampling was not conducted if mixing by the augers precluded the separation of different lithologic units by depth. Bulk samples were used only for physical analyses such as moisture content and maximum density/optimum moisture content.

2.2.2.4 Physical Testing

During the hydrogeologic investigations performed in 1990 in accordance with the HCP two types of physical testing were conducted in the field; field percent moisture content and soil pore liquid content. Sample analysis was performed by Herzog Associates. The methods employed for these procedures are as follows:

- Field Percent Moisture Content of soil was evaluated at ten foot intervals from the hollow stem auger borings. The field moisture was evaluated using a microwave drying oven and scales. Wet and dry weights of the soil were used to calculate moisture content by weight. The soil sample was weighed wet, then dried and reweighed. When a stabilized weight was achieved, the soil moisture content was calculated as the difference between the wet and dry soil weights divided by the dry soil weight, and this value was multiplied by 100 to give percent moisture. Because moisture evaporation from the sample would reduce its moisture content, soil-filled rings were capped, taped, and stored at room temperature until the sample was processed at the field laboratory.

- <u>Field Soil Pore-Liquid Content</u> was measured in soil samples collected every ten feet in the augered boreholes. Soil moisture matrix potential was measured by using a "Quick Draw" tensiometer, Soil Moisture Model Number 2900F. Prior to testing a soil sample, the tensiometer was set to zero and was checked for its capability to hold a vacuum. Two identical tensiometers were periodically run together on the same sample to make sure the equipment was functioning properly (similar readings). The tensiometer was installed into a hole either drilled or cored into a ring sample. It was allowed to stabilize prior to recording the matrix potential value (measured in centibars of soil suction). The time required for stabilization ranged from 15 to 30 minutes. For very dry soil, or very fine-grained soils, such as clays, the tensiometer was constantly adjusted in order to bracket the soil-pore liquid matrix potential. Because the soil matrix potential is dependent upon its moisture content, special care was used to minimize the loss of moisture prior to and during matrix potential measurement. The soil-filled rings were capped, taped and stored at room temperature until the sample was processed at the field laboratory.

Selected physical properties were also determined in the laboratory during these investigations from core samples. These tests included particle size, Atterberg Limit, specific gravity, density, direct shear and consolidation, expansiveness, and triaxial permeability testing. During the upgradient portion of the hydrogeologic investigation, direct shear, consolidation, and expansiveness testing were eliminated from the program, since a review of these parameters from the earlier downgradient program indicated that they would not provide useful information for characterization of the site's hydrogeologic framework. This modification was discussed with and approved by DTSC. Atterberg Limit and particle size analyses were selected to classify unconsolidated sediments according to the Unified Soil Classification System (USCS), and to aid in monitoring well design. Specific gravity and density analyses were used to determine porosity. Permeability testing is discussed in Section 2.2.6. All laboratory testing was performed in accordance with the appropriate ASTM Standards.

During the additional hydrogeologic investigation performed in 1993-1994 in accordance with the Work Plan for Additional Remedial Investigation one or two lithologic samples from each borehole that was converted to a monitoring well were selected for analysis of various physical characteristics. The purpose of these analyses was to help assess the characteristics of the identified flow zones within a well. Physical analyses were performed by Dames & Moore's Soils Testing Laboratory in Los Angeles, California, and by PNP Laboratories, Inc., of Santa Fe Springs, California. Physical testing was conducted in accordance with the following test methods:

Grain Size Distribution (Sieve Analysis)	ASTM D-421
Grain Size Distribution (Hydrometer Analysis)	ASTM D-422
Moisture Content	ASTM D-2216
Specific Gravity	ASTM D-854-83
Atterberg Limits	ASTM D-4318
Maximum Density	ASTM D-1557-78
Air Permeability/Conductivity	API RP 40
Water Permeability/Hydraulic Conductivity	EPA Method 9100

Samples were also tested for effective porosity and bulk and dry density. The results of the physical testing are summarized in Section 3.3.2.

2.2.2.5 Microfossil Analysis

Sections of core were submitted for a microfossil analysis in an attempt to correlate the geologic sequence with a biologic sequence. Microfossil analysis is based on the identification of silicate and/or carbonate tests of microorganisms such as diatoms, fusulinids, foraminifera, or radiolaria that have been preserved in marine sedimentary rocks. Their skeletons are composed of silica, a highly resistant mineral, and are well preserved in the geologic record. Individual microfossils are manually extracted from the lithologic sample and are then individually identified. A biostratigraphic relationship can be made between the lithologic sample and the known occurrences of certain fossils or fossil assemblages if the sample contains a time-definitive species or alternatively by the youngest identified species. Microfossil analyses were not a part of the original investigation scope but were required to help identify anomalous geologic units encountered during the field programs and to determine approximate contacts between geologic units which were not visually or physically discernable.

During the downgradient and upgradient hydrogeologic program in 1990 radiolarian microfossils were examined by Dr. Jon Sloan (California State University, Northridge) who has previously performed related work within the Palos Verdes area (Sloan, 1987). Microfossil assemblages were determined based on the range of radiolarian species, and on the common occurrences and ratios of several of the species. The assemblages identified are known to have lived within certain approximate periods during the Miocene epoch, thus dating the geologic units which contain them. This method of dating was used to determine approximate contacts between geologic units which were not visually or physically discernable.

During the additional downgradient hydrogeologic program lithologic samples were selected from borings M70B (formerly AB7) at 35 feet bgs and M67B (formerly AB8) at 150 feet bgs and submitted to Dr. Lowell Stott of the University of Southern California in Los Angeles, California. Additionally, the sample from M70B (formerly AB7) was forwarded to Dr. John Barron of the U. S. Geological Survey in Menlo Park, California for a second opinion specific to diatom biostratigraphy. The results of the microfossil analyses are discussed in Section 3.3.2.

2.2.3 Surface Soil/Sediment Sampling

The surface soil/sediment sampling included surface soil cover sampling and lake and stream sediment sampling. The field methodologies for these surface soil samples are discussed below.

2.2.3.1 Surface Soil Cover Sampling

Two methods of surface soil cover sampling were performed during the remedial investigations. The first type, hand trowel sampling, was performed in October 1990 in accordance with the SWSCP. The second type, core sampling, was performed in October 1993 in accordance with the Work Plan for Additional Remedial Investigation. These two methods are described below.

2.2.3.1.1 Hand Trowel Sampling

At each sampling location, two samples were retrieved with a disposable plastic hand trowel and placed in a wide-mouth glass container and sealed with a Teflon-lined cup. Both samples were submitted to the laboratory. One sample was used for the prescribed analysis, while the remaining sample was used as a backup sample or as a comparison/quality control check.

2.2.3.1.2 Core Sampling

Relatively undisturbed soil cover samples were taken using two inch by six inch stainless steel sample tubes, or rings, and a thread on core sampler with a hammer attachment. The samples were taken from the surface to a depth of six inches. Prior to taking the samples, the top one-half to one inch of material was removed from the surface. In particular, wood chips, organic material (such as grass), and any other extraneous materials were removed from the sampling location prior to sample collection. To obtain the soil sample, the core sampler with the sample tube was placed on the cleared location and an attempt was made to push the core sampler into the soil. If the soil was so dense that the sampler could not be pushed or manually driven, the soil sampler was hammered into the soil. In such case, the number of blows required to drive the core sampler into the ground was recorded.

Prior to pulling the tube from the sampling location, the core sampler was twisted at least two revolutions to shear the sampler off bottom. After taking the core sampler from the ground, the sample tube was removed from the core sampler. Both ends of the sample tube were immediately sealed with Teflon tape and capped with plastic caps. The tubes were then labelled and placed on ice for storage and transport.

2.2.3.2 Lake and Stream Sediment Sampling

For the lake and stream sediment samples, a decontaminated stainless beaker attached to the end of a 3-foot long stainless steel rod was pushed down approximately six inches into the sediments directly below where a water sample had been collected. The beaker was dragged a distance of approximately two feet to ensure a good sample. The sediment filled beaker was then returned to shore, where any water which had migrated to the top of the beaker was decanted off, and then the sample was poured into the laboratory supplied glass containers. For each sample, two liters of sediment were needed for a complete chemical analysis. The outside of the containers were cleaned with water and wiped dry, and then sealed, labeled, manifested on a chain-of-custody form, and placed in an ice-cooled container until transport to the analytical laboratory. The beaker was decontaminated as described in Section 2.4.1.4 before each sample.

2.2.4 Geologic Logging

Geologic logging of subsurface materials was conducted on all borings drilled under the scope of this investigation. All geologic logging was either personally performed by or under the direct supervision of geologists registered in the State of California. Subsurface cuttings, sediment samples obtained from split-spoon sampling tubes, and cores were used to log each hole at the time of drilling.

Geologic logging methodologies varied with the type of subsurface material encountered. Unconsolidated strata, such as alluvium, colluvium, and unconsolidated quaternary deposits were described and classified according to the USCS. Consolidated bedrock was classified according to standard geologic practice for megascopic determination of sedimentary and igneous rocks, and described in accordance with the specific requirements detailed below. Relative density indications were recorded in the form of blow counts for all borings. Each geologic log contains the information listed on Table 2.2-1.

In addition to the logging described in Table 2.2-1, detailed descriptions of the bedrock materials encountered were performed. In analyzing the bedrock materials, the items discussed below were considered.

Degree, Thickness, and Extent of Weathering of the Bedrock

Weathering can be defined as the group of processes, such as the chemical breakdown of rock due to the action of air, rain water, and bacteria, and the mechanical action of exposure to temperature changes which lead to variable changes in character, strength, color, and content of the

TABLE 2.2-1

LIST OF INFORMATION ON GEOLOGIC LOGS

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

- Soil boring/monitoring well number
- Date(s) of boring
- Times of day drilling began and ended
- Type of equipment utilized, including manufacturer make and model for special modifications
- Name(s) of geologist(s) responsible for log descriptions
- Name(s) of other personnel assisting in the logging
- Weather conditions
- Legend describing any symbols, colors or patterns used in the log
- Drilling advancement in feet/hour or feet/minute
- Descriptions of any adverse hole conditions
- Depths and elevations (MSL) of sampling interval(s)
- Systematic descriptions of lithologic and structural conditions
- Descriptions of faults, gouges, slickensided material and shear zones
- Descriptions of fractures, fracture systems, and joints
- Depths, elevations (MSL) and thicknesses of strata and any changes in geologic conditions
- Depths, thicknesses, extent, and degrees of weathering
- Soil moisture measurements
- Field descriptions and measurements of fossils
- Descriptions of any substructures or unusual features
- Descriptions of mineral seams and fracture fillings
- Presence and depths to saturated zones, borehole seeps, or groundwater
- Notes on hydrologic characteristics of the subsurface based on drilling/sampling observations
- Descriptive log sketches directly matched to verbal descriptions

TAB22_1.WP

rock. A complete description of weathering, including depth and thickness, is important because as the degree of weathering of a material increases the likelihood that water can migrate through it increases.

The Presence of Fractured Rock

As with weathered rock, areas of extreme fracturing must be carefully noted and described because of possible water migration. In describing the fracture spacings the following were used:

Fracture Description	Spacing of Fractures
Intensely Fractured (crushed)	Less than 2 inches
Highly Fractured	2 inches to 1 foot
Moderately Fractured	1 foot to 3 feet
Slightly Fractured	3 feet to 10 feet
Massive	Greater than 10 feet

The Condition of Fractures

The fracture surfaces were investigated by breaking open the rock during sampling. In this manner the spacing, the degree of tightness, and the "roughness" or "smoothness" of the fracture were determined, and then described and noted in the logs.

For separation of the fracture walls, the following criteria were used:

Description	Separation in Millimeters
Closed	0
Very Narrow	0-0.1
Narrow	0.1-1
Wide	1-5
Very Wide	5-15+

As with fracture separation, the smoothness or roughness of the fractures could have a bearing on the ability of the fracture to transmit water. Rough fracture surfaces indicate irregular breaks whereas smooth surfaces indicate clean breaks. Clean breaks provide a better flow path for pore water relative to rough breaks.

The amount of fracture filling could also have a bearing on the ability of the fracture to transmit water. If the fracture has been infilled, it is less likely to transmit water. The criteria for fracture filling is:

Description	Definition
Clean	No fracture filling
Stained	Discoloration of fracture
Filled	Fracture filled with recognizable material

The Moisture Content of the Bedrock

The moisture content of the bedrock was described by the geologist as dry, damp, moist, wet, or saturated.

The Presence of Wetted Bedrock Fractures

If the presence of wetted bedrock fractures was detected, the geologist noted the occurrence in their logs.

The Degree of Induration

Induration has been defined as the process of hardening sediments through cementation, pressure, heat, or other causes. The degree of induration could affect the permeability and porosity of bedrock material and was noted by the geologist.

2.2.5 Geophysical Analysis

Both down-hole and cross-hole geophysical analyses were run as part of the field hydrogeologic investigation. These analyses, in general, were run to supplement correlation and hydrogeologic data gained from geologic logging and core analyses, to aid in the determination of hydraulic properties, and to aid in designing monitoring wells.

2.2.5.1 Down-Hole Geophysical Logging

Selected exploratory borings were geophysically logged immediately after drilling. This logging program was used to aid in the correlation of subsurface strata, and in interpreting the occurrence of liquids in the subsurface, especially in cored borings drilled with water as the drilling medium. Specifically, the logs were used to detect and assist in interpreting changes in geology and hydrogeology, and were used in the field to aid in setting monitoring well screens.

The number and type of downhole geophysical logs obtained were selected to be compatible with the drilling methodologies used, and also with the subsurface conditions. The geophysical logging suite used in this field investigation included caliper, resistivity/spontaneous potential, natural gamma ray, and neutron logging.

Caliper logs were run to determine changes in borehole diameter and associated conditions which may affect other geophysical logs, packer seating, and well installation. Resistivity/spontaneous potential and natural gamma ray logs were run to correlate geologic beds, estimate their thicknesses, and qualitatively characterize their relative permeabilities. Neutron logs were run as indicators of porosity under saturated conditions, and as lithologic indicators in the absence of core recovery. The selection criteria for each type and a complete description of each geophysical analysis follows.

2.2.5.1.1 Caliper Logs

Caliper logs were run to aid in determining the amount and location of borehole erosion which may have occurred during or after drilling, or the presence of large fractures in resistant bedrock. This information was useful when assessing any borehole conditions which might have affected other geophysical logs, packer seating, and well installation. They were therefore selected for use in those borings where unstable conditions were anticipated or encountered in unconsolidated material, and for use in all borings where such conditions would affect in-situ permeability testing or aquifer testing.

The caliper tool consists of a probe with adjustable arms that can measure the diameter of a borehole. The probe was lowered into the borehole and a continuous measurement of the diameter recorded as the caliper tool was slowly withdrawn. The results were previewed in the field from a monitor inside the logging truck for quality assurance and tool calibration purposes, and the resulting logs were recorded on reproducible film along with pertinent identification and calibration information.

2.2.5.1.2 Resistivity Logs

Resistivity logs were run to correlate geologic beds, estimate bed thicknesses, and qualitatively characterize relative permeabilities between strata. Resistivity logs measure the apparent electrical resistivity of subsurface strata, and for this reason, are sometimes referred to as "E-logs". When combined with spontaneous potential logs, they provide useful information concerning the lithologic character and thicknesses of these strata. Variability in resistance indicates changes in both the geologic materials and the mineral content of pore waters in changing subsurface strata. Resistivity logs were selected to be run where ground water resistivity might be affected by mineral or contaminant content.

Guard logs are specialized resistivity tools which are designed to measure resistivity in situations where subsurface strata are thinly bedded, or where resistivity contrasts are large. For this reason, they are said to have a "higher resolution". Guard logs contain focusing currents which control the path of the measuring current. In general, the resulting penetration into the formation is deeper than in conventional resistivity logging, resulting in less effect from the borehole, and greater resolution of thinly bedded subsurface strata. Guard log tools are always run in combination with gamma ray tools, and are referred to as gamma guard logs. Gamma guard logs were selected to be run where ground water resistivity might be affected by mineral or contaminant content, and where thin beds precluded running conventional resistivity logs.

The resistivity tool consists of a probe containing electrodes evenly spaced sixteen inches apart (called a 16" normal tool). The probe was lowered into a borehole filled with clear, potable water, and an electric current was induced from the electrodes in the probe upward toward receiving electrodes near the top of the hole. These currents penetrated into the subsurface strata as they traveled up the borehole. The current loss, or resistance, was recorded continuously as the probe was withdrawn from the borehole.

The guard log tool consists of a probe containing special focusing electrodes above and below conventional electrodes (spaced three feet apart), which was operated in the same manner as a conventional resistivity tool. This tool was always run in combination with a natural gamma ray tool and the resulting log is called a gamma guard log.

The results of all resistivity logging were previewed in the field from a monitor inside the logging truck for quality assurance and tool calibration purposes, and the resulting logs were recorded on reproducible film along with pertinent identification and calibration information.

2.2.5.1.3 Spontaneous Potential Logs

Spontaneous potential (SP) logs were run to correlate geologic beds, estimate their thicknesses, and qualitatively characterize their relative permeabilities. The theory behind SP logging is not completely understood, but spontaneous potential has been recognized as a measurable geophysical phenomena for many years. Spontaneous potential is sometimes called "self potential", since "potential" is roughly defined in the industry as the chemical and physical nature of subsurface strata. SP logging measures the changes in these properties at contacts between different types of subsurface materials. The changes recorded in the SP log approximate lithologic changes, and are useful in detecting permeable strata. The selection criteria for SP logs were the same criteria used for resistivity logs.

The SP log setup consists of a surface electrode with a fixed potential, and a probe containing an electrode which continuously measures the potential of the subsurface strata along the borehole as it is slowly withdrawn. The results were previewed in the field from a monitor inside the logging truck for quality assurance and tool calibration purposes, and the resulting logs were recorded on reproducible film along with pertinent identification and calibration information.

2.2.5.1.4 Natural Gamma Ray Logs

Natural gamma ray logs were run to correlate geologic beds, estimate their thicknesses, and qualitatively characterize their relative permeabilities. Natural gamma ray logging measures the naturally occurring radioactivity of subsurface materials. Natural gamma ray logs can be used in either a cased or open borehole. Since the three radioactive isotopes of thorium, uranium, and potassium tend to concentrate in the minerals associated with finer-grained shales and clays, these strata show up on natural gamma ray logs as high gamma ray readings. Strata with little to no clays or shaley minerals, such as quartz sands, have low gamma ray readings. This type of logging is useful for correlating subsurface strata in cased boreholes in the same manner as SP logs are used. Natural gamma ray logs are considered a primary geophysical correlation tool and were run in almost every borehole selected for down-hole geophysical analyses.

The natural gamma ray tool consists of a radioactive sensor attached to a probe, which was used in an open borehole during the remedial investigation. The probe is lowered into the borehole and measures the naturally occurring radioactivity levels of the subsurface materials as it passes by. The results were previewed in the field from a monitor inside the logging truck for quality assurance and tool calibration purposes, and the resulting logs were recorded on reproducible film along with pertinent identification and calibration information.

2.2.5.1.5 Neutron Logs[1]

Neutron logs were run as indicators of porosity under saturated conditions, and as lithologic indicators in the absence of core recovery, and for indicating moisture in unsaturated zones.

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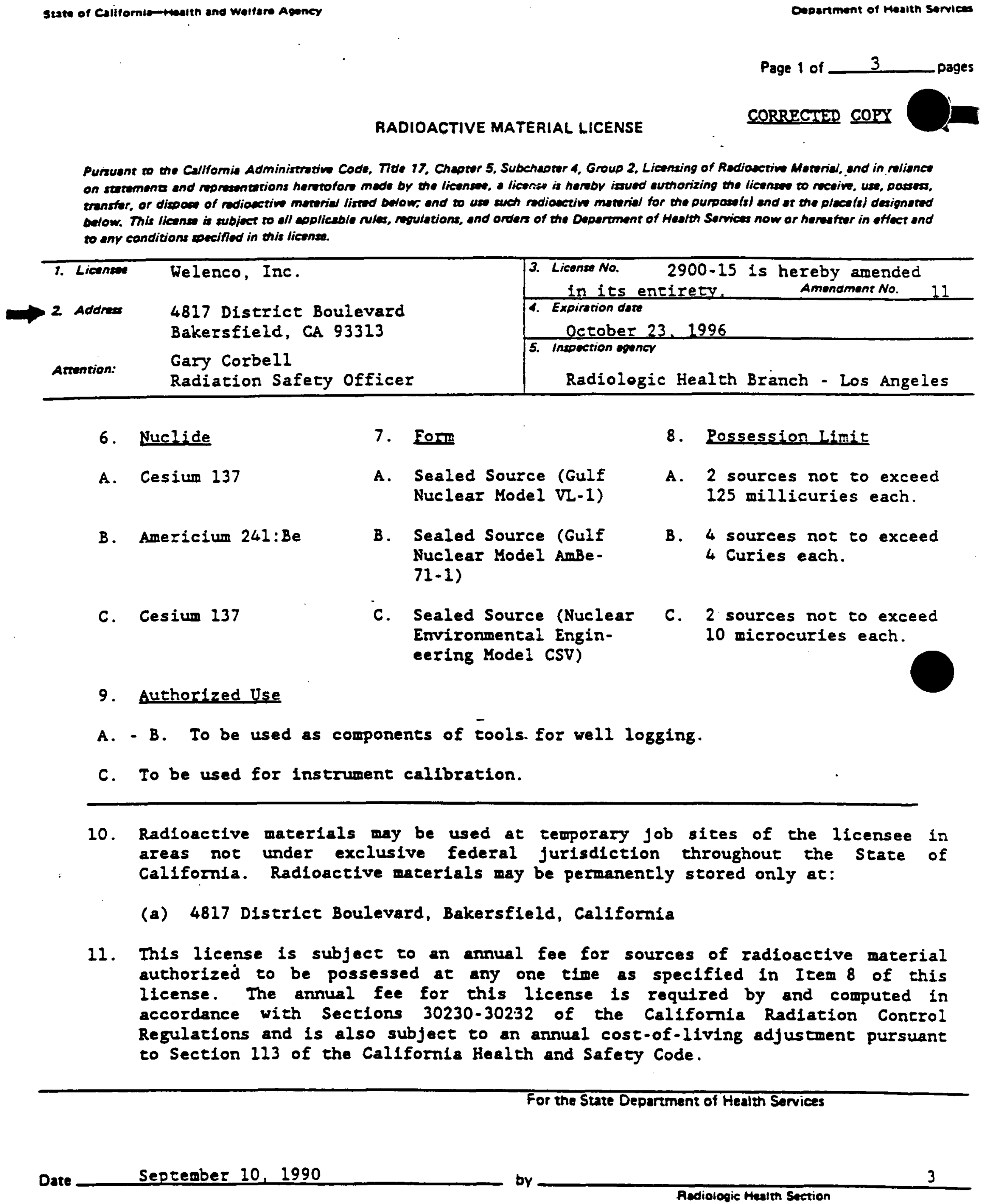
[1] Neutron logging per requirements and conditions of Radioactive Material License No. 2900-15, Condition 19, (Figure 2.2-1), granted by DTSC pursuant to 17 CCR (Chapter 5, Subchapter 4, Group 2) to Welenco, Inc. (amended September 1990).



State of California—Health and Welfare Agency

Department of Health Services

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CORRECTED COPY

RADIOACTIVE MATERIAL LICENSE

Pursuant to the California Administrative Code, Title 17, Chapter 5, Subchapter 4, Group 2, Licensing of Radioactive Material, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, use, possess, transfer, or dispose of radioactive material listed below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules, regulations, and orders of the Department of Health Services now or hereafter in effect and to any conditions specified in this license.

1. *Licensee*	Welenco, Inc.	3. *License No.*	2900-15 is hereby amended in its entirety. *Amendment No.* 11
2. *Address*	4817 District Boulevard Bakersfield, CA 93313	4. *Expiration date*	October 23, 1996
Attention:	Gary Corbell Radiation Safety Officer	5. *Inspection agency*	Radiologic Health Branch - Los Angeles

6. Nuclide	7. Form	8. Possession Limit
A. Cesium 137	A. Sealed Source (Gulf Nuclear Model VL-1)	A. 2 sources not to exceed 125 millicuries each.
B. Americium 241:Be	B. Sealed Source (Gulf Nuclear Model AmBe-71-1)	B. 4 sources not to exceed 4 Curies each.
C. Cesium 137	C. Sealed Source (Nuclear Environmental Engineering Model CSV)	C. 2 sources not to exceed 10 microcuries each.

9. Authorized Use

A. - B. To be used as components of tools for well logging.

C. To be used for instrument calibration.

10. Radioactive materials may be used at temporary job sites of the licensee in areas not under exclusive federal jurisdiction throughout the State of California. Radioactive materials may be permanently stored only at:

(a) 4817 District Boulevard, Bakersfield, California

11. This license is subject to an annual fee for sources of radioactive material authorized to be possessed at any one time as specified in Item 8 of this license. The annual fee for this license is required by and computed in accordance with Sections 30230-30232 of the California Radiation Control Regulations and is also subject to an annual cost-of-living adjustment pursuant to Section 113 of the California Health and Safety Code.

For the State Department of Health Services

Date September 10, 1990 by 3

Radiologic Health Section
744 P Street, Sacramento, CA 95814

FIGURE 2.2-1

RADIOACTIVE MATERIAL LICENSE

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RADIOACTIVE MATERIAL LICENSE

License Number 2900-15

Supplementary Sheet

Amendment Number 11

12. Radioactive material shall be used by, or under the supervision and in the physical presence of, the following individuals:

(a)	Gary Corbell	(h)	Joseph L. Newman
(b)	Dirk L. Craig	(i)	Michael C. Ridder
(c)	William D. Bramham	(j)	Steven R. Roberti
(d)	William D. Christy	(k)	Mark F. Sharpless
(e)	Ray Federwisch	(l)	David Lockerbie
(f)	Craig S. Newman	(m)	Richard LaPorte
(g)	Bailey J. McDuff		

13. Except as specifically provided otherwise by this license, the licensee shall possess and use radioactive material described in Items 6, 7, and 8 of this license in accordance with statements, representations, and procedures contained in the documents listed below. The Department's regulations shall govern unless the statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.

    (a) The application with attachments dated August 30, 1989, signed by Joseph L. Newman, as modified by the letter with attachments dated August 3, 1990, signed by Gary Corbell.

14. The radiation safety officer in this program shall be Gary Corbell.

15. Sealed sources described in Subitems A and B of this license shall be tested for leakage and/or contamination at intervals not to exceed 6 months.

16. The following individuals are authorized to collect wipe test samples of sealed sources possessed under this license using leak test kits acceptable to the California Department of Health Services:

    (a) The Radiation Safety Officer.

    (b) Qualified individuals designated by the Radiation Safety Officer.

17. Records of leak test results shall be kept in units of microcuries and maintained for inspection. Records may be disposed of following Department inspection. Any leak test revealing the presence of 0.005 microcuries or more of removable radioactive material shall be reported to the Department of Health Services, Radiologic Health Branch, 744 P Street, P.O. Box 942732, Sacramento, CA 94234-7320, within five days of the test. This report shall include a description of the defective source or device, the results of the test, and the corrective action taken.

For the State Department of Health Services

Date September 10, 1990

by 3

Radiologic Health Branch
714/744 P Street
P. O. Box 942732
Sacramento, CA 94234-7320

FIGURE 2.2-1 (Cont.)

EHRHB (Int. 9/89)

RADIOACTIVE MATERIAL LICENSE

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RADIOACTIVE MATERIAL LICENSE

License Number 2900-1

Supplementary Sheet

Amendment Number 11

18. Analytical tests for leakage and/or contamination of sealed sources shall be performed only by persons specifically authorized to perform that service.

19. The licensee is authorized to conduct well logging studies only in well bores drilled for mineral exploration and in test wells. Such studies shall be conducted subject to the provisions of California Radiation Control Regulations, and to the following requirements:

    (a) The wells shall be cased and shall not penetrate into potable water zones. Nonpotable water is defined as having greater than 3,000 milligrams per liter of total dissolved solids or the water is deemed to be otherwise nonpotable by the presence of toxic materials as established by proper regulatory agencies.

    (b) The licensee shall maintain available for inspection such records as are necessary to establish compliance with requirements of this condition for all radioactive material introduced into well bores. These records shall include the kinds and amounts of radioactive materials, dates introduced into well bores, and locations and identification of the well bores. These records shall be maintained subject to inspection at the well site for the duration of work at the site and at the address specified in Condition 10(a) following completion of such work.

20. Each source holder and logging tool containing radioactive materials shall b a legible and visible marking. The marking shall bear the conventi radiation symbol and the following wording: IF FOUND - DANGER - RADIOACTIVE - DO NOT HANDLE - NOTIFY CIVIL AUTHORITIES.

21. The licensee shall report by telephone within 24 hours to the Department of Health Services or to the nearest field office the loss or potential abandonment down-hole of any sealed source containing licensed material. In addition, a written report shall be submitted within 30 days for the lost or abandoned source which shall include information regarding isotope, amount, location, depth, method of immobilization, sealing, placarding, and notations to be placed in public records.

For the State Department of Health Services

Date September 10, 1990

by 3

Radiologic Health Branch
714/744 P Street
P. O. Box 942732
Sacramento, CA 94234-7320

EHRHB (Int. 9/89)

FIGURE 2.2-1 (Cont.)

RADIOACTIVE MATERIAL LICENSE

A neutron tool consists of a probe containing a constant radioactive source mounted some distance from a radioactive sensor. When the tool is lowered into the borehole, many of the neutrons emitted from the source collide with nuclei of the subsurface material, lose energy, and are captured before reaching the sensor. Since the greatest energy loss occurs in a collision with a hydrogen nucleus, and hydrogen is a principal component of water, the energy loss indicates the amount of water present. Differences in count rates have also been established for certain lithologies, which, in the absence of water, allow for some subsurface correlation. During this investigation, neutron logs were also used to differentiate between the lithologies of chert, dolostone and shale in the absence of core recovery. Neutron logs are considered a primary geophysical correlation and hydrogeologic condition indicator and were therefore run in every borehole selected for down-hole geophysical analysis.

The neutron tool is lowered into the borehole, and the retrieved neutron count was recorded continuously as the probe was slowly withdrawn from the borehole. The results were previewed in the field from a monitor inside the logging truck for quality assurance and tool calibration purposes, and the resulting logs were recorded on reproducible film along with pertinent identification and calibration information.

2.2.5.2 Cross-Hole Geophysical Survey

A cross-hole geophysical survey was added to the scope of this investigation in an attempt to locate evidence of historical mining adits under Butcher Hill. Borings RFB18 and RFB19 were drilled and completed for this survey. The cross-hole survey was performed to determine the seismic compressional (P) wave velocity in the subsurface to a depth of approximately 250 feet. No physical evidence for these old adits exists other than historical aerial photographs containing features which could be interpreted as air ducts. The locations and depths of the two borings were selected based on the alignment of these features and estimates of typical mining practices during the fist half of the century.

The cross-hole geophysical survey was designed to identify if any low velocity zones, which potentially indicate former mining activity, exist under Butcher Hill. If in existence, such zones could create a man-made ground water pathway for potential contaminant migration. In preparation for the survey, the two boreholes were drilled to total depth about 50 feet apart from each other.

Boring RFB18, the receiver hole, was completed with 2.5-inch-diameter Schedule 40 blank PVC casing, and boring RFB19, the shot hole, was completed with 2-inch-diameter Schedule 40 blank PVC casing. The annular space in both borings was backfilled with sand to the ground surface. A down-hole triaxial geophone was coupled to the borehole casing wall in boring RFB18 with a rubber wedge system and energy coupling was provided in boring RFB19 by filling the borehole with potable water.

The procedure consisted of detonating small explosive charges at predetermined depths in the shot hole, and recording the resulting seismic energy detected by the geophone in the receiver hole. Seismic travel times were measured by a Geometrics ES-1210F engineering 12-channel enhancement seismograph and a high voltage blaster.

2.2.6 Hydraulic Properties

The hydraulic properties measured or calculated during this investigation consist of permeability, hydraulic conductivity, transmissivity, storativity, and leakage coefficient values. Permeability values were measured in the laboratory on undisturbed core and sediment samples taken from selected borings. Hydraulic conductivity values were calculated from in-situ conductivity testing utilizing packers. Transmissivity, storativity, and leakage coefficient values were calculated from aquifer tests (drawdown and recovery, step-drawdown, and slug tests) performed in the field. The selection criteria and methodologies for the measurement or calculation for each of these properties is discussed below.

2.2.6.1 Laboratory Hydraulic Property Testing

Permeability is the capacity of a porous or fractured rock, sediment, or soil for transmitting a fluid, and is measured in units of centimeters per second. Laboratory permeability is measured through several inches of undisturbed sediment sample (taken from core) under controlled conditions. Permeability testing was performed on one sample each from eight downgradient boring locations. The samples were taken from the formation or zone considered representative of the primary ground water pathway for each location. These formations were determined to be either the San Pedro Formation or the Malaga Mudstone member of the Monterey Formation, depending on the location.

During the additional downgradient hydrogeologic program, relatively undisturbed soil samples were submitted to PNP Laboratories, Inc., Santa Fe Springs, California, for analysis of hydrogeologic properties. Analyses performed included: 1) moisture content by ASTM Method D2216; 2) Density, total porosity, effective porosity, pore water saturation, native state effective air permeability and native state effective air conductivity by API Method RP 40; and 3) native state effective water permeability and native state effective hydraulic conductivity by EPA Method 9100. The tests were performed on vertically-oriented samples, as this is the direction in which the samples were collected in the field (vertically-driven split-spoon sampler).

2.2.6.2 Aquifer Testing

In-situ conductivity testing using packers, drawdown and recovery testing, short-duration step-drawdown testing, and rising head slug testing were performed during the remedial investigation field studies. The methodologies for the field testing and hydraulic parameter calculations from the results of the field tests are described in the following sections.

2.2.6.2.1 In-Situ Hydraulic Conductivity Testing

Open borehole testing for hydraulic conductivity was performed at fourteen of the 35 boring locations; seven from upgradient boring locations and seven from downgradient boring locations. The purpose of such testing is to obtain in-situ hydraulic conductivities (a macroscopic measurement of permeability) for water-bearing horizons. Specifically, hydraulic conductivity is the rate of flow of water through a cross section of one square foot under a unit hydraulic gradient, adjusted for temperature. It is measured in units of either centimeters per second, or gallons per day. Hydraulic conductivity is measured directly in the field by performing single borehole aquifer drawdown and recovery tests, measured over several feet of strata. The fourteen tests were conducted at locations which were not selected for monitoring well installation, or where information was desired on a horizon above a planned monitoring well's screened interval, in order to augment other aquifer test data. In addition, open borehole testing was performed in order to assess potential uplift pressures or similar problems that may occur during the construction and operation of deeper monitoring wells. A minimum of three tests were attempted per selected boring, but were not always completed, due to adverse borehole conditions. The test intervals were selected to provide information for the range of physical characteristics encountered during drilling. Such characteristics included bedding plane orientations, fractured and unfractured conditions, varying lithologies, varying degrees of weathering and mineralization, and the occurrence of other structural influences, such as shear zones. All hydraulic conductivity testing was performed in accordance with the methodology defined in the Ground Water Manual (U.S. Bureau of Reclamation, 1981).

Open borehole hydraulic conductivity testing was performed using double packers to seal off the intervals to be tested (Figure 2.2-2). Once the test intervals were selected, a Tigre Tierra pneumatic straddle (double) packer assembly was placed into the borehole, straddling the test zone. The packers were inflated using pressurized nitrogen gas, and a pressure test was performed.

The type of pressure test conducted was a modification of the conventional slug test, as presented by Papadopolous and Cooper (1967). This method was chosen as the most efficient at evaluating low-permeability formations within a reasonable time period, and without the built-in assumption of a steady state condition or flow rate, which is typically only found within large ground water aquifers. Such an aquifer does not exist underneath the PVLF. A conventional slug test is conducted by causing an instantaneous water level change and observing its decay in an open borehole; the modified method used was conducted by filling the borehole to the surface with water, and suddenly pressurizing the straddle-packed section of the borehole with an additional amount of water. The straddle-packed borehole was then shut in and the decay of only the additional pressurization head is observed. The method used contains two critical assumptions which apply at the PVLF: 1) the flow in the test interval is primarily radial; and 2) the hydraulic properties of the tested interval remain constant throughout the test.

The first assumption is valid because the height of the test intervals is much larger than the diameter of the boring, and because the greatest hydraulic conductivity is in the horizontal direction. The second assumption is valid in tests where the fluid pressure is limited such that the initial pressure head change is of a magnitude only sufficiently large to be adequately measured, to avoid opening fractures or altering local permeability. With the modified packer system used, which utilized pressure transducers, head changes of 0.1 psi were easily measured. Thus initial pulse pressures of 15 psi, too small to cause significant changes in rock properties, were sufficient for the pressure tests.

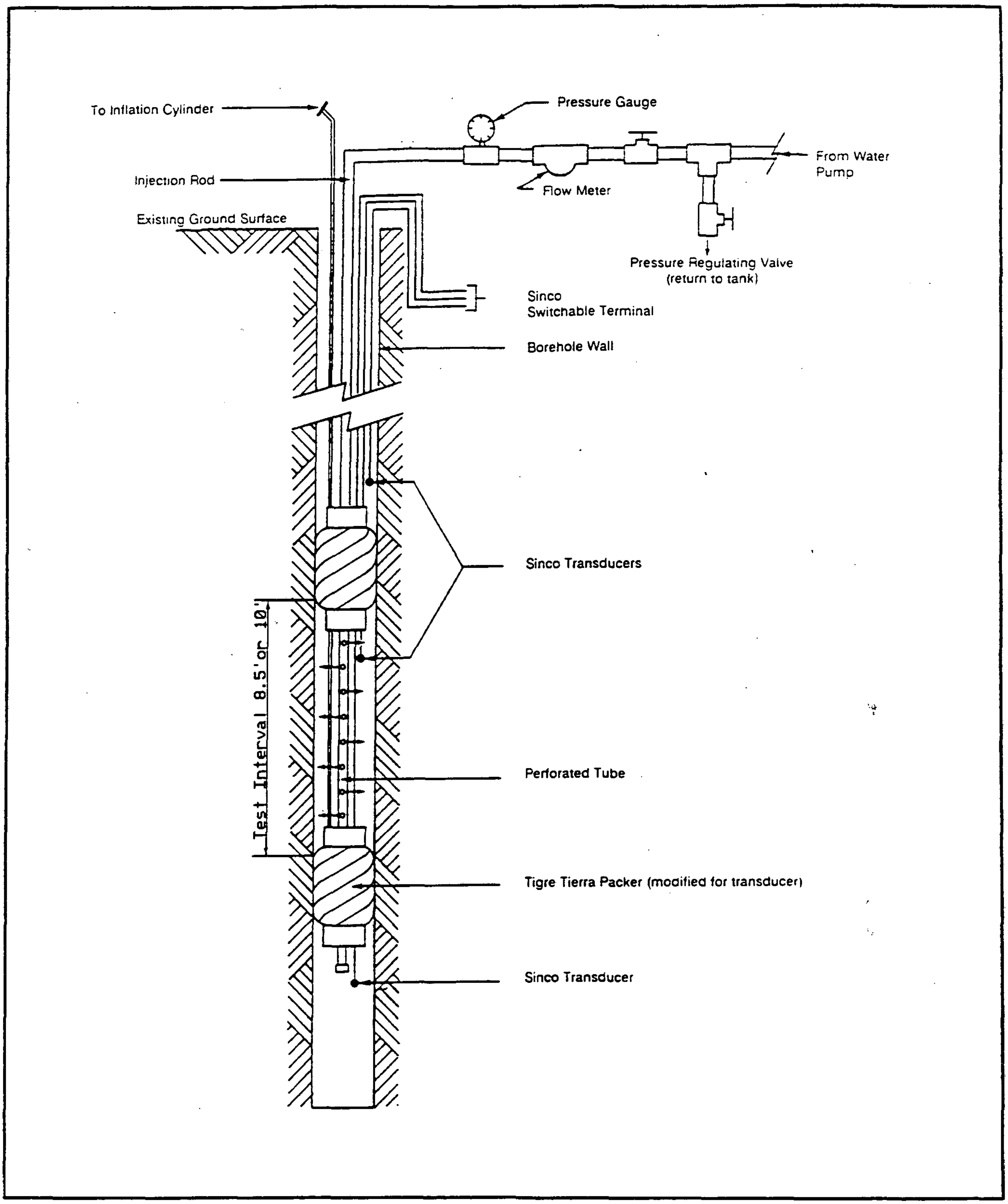

FIGURE 2.2-2

PACKER PERMEABILITY
TESTING SCHEMATIC

PALOS VERDES LANDFILL
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SOURCE: HERZOG ASSOCIATES, 1991

As discussed above, the testing method used requires precise measurement of pressure head or water level decay. Conventional packer setups (see upper right hand corner of Figure 2.2-2) are not able to collect this caliber of data; therefore, the packer assembly used employed new pneumatic packers modified for use with pressure transducers, as shown on Figure 2.2-2. Three SINCO transducer were placed above, below and within the test interval. Pressure readings from these transducers were obtained from a switchable terminal with digital readout to the ground surface. The placement of these transducers provided the data for a comprehensive understanding of the hydraulic characteristics of the packer assembly and provided quality assurance of the testing, since pressure changes in the transducers above or below the packers would indicate leaks across the packers.

Hydraulic conductivity analysis begins with the preparation of a family of type curves on semilogarithmic paper. A ratio of the head change over time (H) over the initial head change upon pressurization (H_o) is then plotted against time on the same scale on semilogarithmic paper, and the data are matched to a type curve by keeping the Y axis coincident and moving the plots horizontally. Then selected values from the matched type curve and the matchpoint of the data curve are used to graphically determine the transmissivity and storage coefficient of the tested interval. Hydraulic conductivity is derived from these values and knowledge of the thickness of the reservoir.

2.2.6.2.2 Drawdown and Recovery Testing

Additional aquifer drawdown and recovery testing was performed in all eight of the upgradient monitoring wells after completion of monitoring well development. This included M54B (RFB20), M55B (RFB21), M56B (RFB24), M57B (RFB25), M58B (RFB26), M60B (RFB29), M61B (RFB31) and M62B (RFBL3). The test at M62B (RFBL3) was conducted at the geologic contact between the San Pedro Formation and the Malaga Mudstone member of the Monterey Formation, and the other eight were performed in wells screened in the Altamira Shale member of the Monterey Formation.

The single-well aquifer drawdown and recovery tests were performed following completion of the monitoring well development and first sampling. Each aquifer test started with a step-drawdown test, followed by a 1- to 12-hour continuous pumping drawdown test, and a recovery test that was terminated when at least 90 percent recovery was achieved. In two monitoring wells, M56B (RFB24) and M58B (RFB26), pumping at the lowest possible flow rate of 0.1 gallons per minute (gpm) caused such significant discharge that the step-drawdown test never experienced recovery, and the test sequence became one continuous pumping drawdown test.

Data were collected using an Instrumentation Northwest, Inc., data logger. This equipment consists of a multi-channel logger, 10 and 30 psi transducers, a 200-foot extension cable, and a Toshiba T1000 field computer. The field computer utilized Terrasys version 3.0 software for data handling. Figure 2.2-3 shows a schematic diagram of the aquifer test set-up.

Water levels in the monitoring wells were measured throughout the tests using pressure transducers set just above the pump intake. The pumping rate chosen for each monitoring well was based on the results of the step-drawdown pumping test. The pumping rates were stabilized throughout the pumping period by periodically checking the discharge readings. Fine adjustments to the flow rate were made as necessary throughout the duration of the pumping period. Water levels in the pumping wells were also monitored with a water level indicator. When the continuous discharge pump test was completed, the submersible pump was shut down, and the data recorder reprogrammed to collect recovery test data. The recovery test was conducted, and the level of the water surface above the transducer was recorded at various time intervals until 90 percent recovery had been achieved. At the end of the test, the final water surface elevation was recorded, and the data logger and transducers were retrieved.

Ground water discharged from the pumping well was stored in portable tanks, and was later transported to the PVLF for disposal to the sanitary sewer in accordance with the Sanitation Districts' existing Industrial Waste Discharge permit.

Aquifer pump test data were analyzed to obtain quantitative estimates for the aquifer parameters of transmissivity, storativity, and leakage coefficient. All aquifers encountered are potentially unconfined, and all wells are partially penetrating and affected by casing storage (due to low-yielding aquifers). Therefore, drawdown data were analyzed using one or more of the following: the Jacob (1950) straight-line method, the Theis (Theis, 1935), Papadopolous-Cooper (1967), and Hantush (1972) curve fitting methods. The effects of partial penetration and delayed yield on the test data cannot be evaluated using Neuman (Neuman, 1974) due to the short duration of pumping

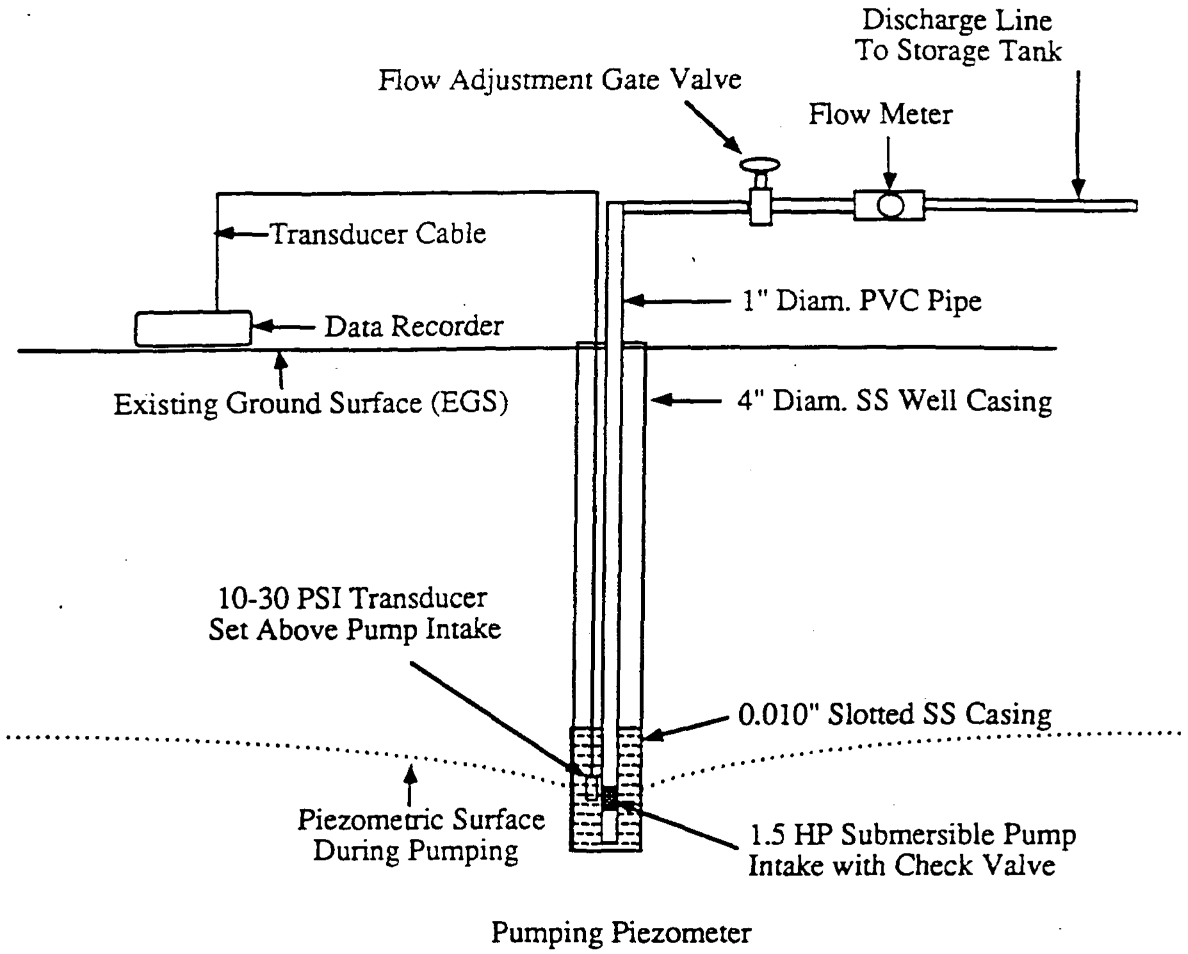

FIGURE 2.2-3

SCHEMATIC DIAGRAM OF
AQUIFER TEST EQUIPMENT

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SOURCE: HERZOG ASSOCIATES, 1991

made necessary by community relations constraints. Residual drawdown data were analyzed using the Theis recovery (straight-line) method. For certain aquifers, residual drawdowns were converted to a recovery data format which was then analyzed by Theis and Papadopolous-Cooper curve-filling methods.

2.2.6.2.3 Step-Drawdown Tests

Short-duration step-drawdown tests were performed on each new well to assess the specific capacity of each well measured as gallons per minute foot of drawdown (gpm/ft), which is a measure of the performance capabilities of a well. The step-drawdown tests consisted of pumping ground water at a constant rate for a specified period of time (first step), and then increasing the pumping rate and holding it constant for the same period of time (second step). This process continued for a total of three pumping rates, or three steps. Water level responses observed during the well development, purging, and sampling were used to pre-design step-drawdown test discharge rates.

Hydraulic response (water level decline) to the pumping was monitored using a 20-psi pressure sensitive transducer connected to the Insitu Hermit 1000-C digital data logger. The data logger collected time-drawdown data on a pre-programmed logarithmic time scale so that rapid readings would be collected in the early stages of each step, but diminish towards the end of each step.

The wells were pumped using either a two inch or four inch diameter Grundfos stainless steel submersible pump capable of providing steady discharge rates from approximately 100 milliliters per minute (ml/m) to 6 gpm (two inch pump) or 20 gpm (four inch pump). Discharge rates were measured using King variable area flow meters with a 2.5 percent full scale accuracy. Ground water removed during the tests was stored in a tank on the pump trailer until it could be transferred to a Baker Tank located at the PVLF. A schematic of the setup for the step-drawdown testing is shown in Figure 2.2-3.

Each step-drawdown test consisted of the following tasks:

- Decontaminate all equipment put down the well.
- Measure depth to water (static level) using an electric well sounder.
- Lower the submersible pump into the well so that the pump intake is located near the bottom of the well screen.
- Lower the transducer into the well to a depth of approximately one to three feet above the pump. Secure the transducer cable to the well casing.
- Wait until the water returns to static levels.
- Initialize the data logger and establish the static level as the baseline level (0 drawdown).
- Start the test by simultaneously turning on the data logger and pump to the first-step pumping level.
- After the specified period of time, reset the datalogger and increase the pump rate for the second step.
- After the specified period of time, reset the datalogger and increase the pump rate for the third step.
- After the specified period of time, reset the datalogger, stop the pump, and collect water level recovery readings.
- Remove all equipment from the well. End of test.

2.2.6.2.4 Slug Tests

Rising head slug tests were also performed in the new wells to obtain aquifer characteristics such as hydraulic conductivity (K), transmissivity (T), and storativity (S). Hydraulic response (water level rise) to the slug removal was measured using a 20-psi transducer connected to the Insitu Hermit 1000-C digital data logger. Time-drawdown data were recorded logarithmically with time such that very frequent readings were collected during the early stages of the test, but with less frequent measurements taken during the latter portions of the test.

The same slug was used for all test. It was constructed of a polyvinyl chloride (PVC) pipe filled with #3 Monterey sand and sealed at each end with flush threaded PVC caps. The slug measured 5.479 feet long and 0.183 feet in diameter, producing a volume of 0.145 cubic feet. A clamp on one end of the slug was used to attach a 1/8 inch diameter nylon rope used to rapidly raise and lower the slug.

Each rising head slug test consisted of the following tasks:

- Decontaminate all equipment put down the well.
- Measure depth of water (static level) using an electric well sounder.
- Lower the transducer into the well to a depth of approximately three feet above the bottom of the well. Secure the transducer cable to the well casing.
- Lower the slug into the well to a depth of approximately three feet below the water table.
- Wait until the water level returns to static level.
- Initialize the data logger and establish the static level as the reference level (0 drawdown).
- Start the test by simultaneously activating the data logger and removing the slug completely out of the well.
- Terminate test after the water level returns to within 90 percent of static level by turning off the data logger.
- Remove all equipment from the well.

2.2.7 Monitoring Well Installation

A total of 21 monitoring wells were installed during the PVLF remedial investigations. Monitoring wells were installed during all three phases of the hydrogeologic field investigations. The first two phases, referred to as the downgradient and upgradient hydrogeologic field program, were performed in June through October of 1990 in accordance with the HCP. Thirteen monitoring wells were installed during this program as described below in Section 2.2.7.1. The final phase, referred to as the additional downgradient hydrogeologic filed program, was performed in December 1993 and January 1994 in accordance with the Work Plan for Additional Remedial Investigation. Eight monitoring wells were installed during this program, as described below in Section 2.2.7.2.

2.2.7.1 Downgradient and Upgradient Hydrogeologic Field Program

Of the 35 boring locations drilled during this field program, a total of thirteen were selected as new monitoring well locations; four downgradient and nine upgradient locations. These thirteen boreholes and the corresponding well designations are summarized on Table 2.2-2. All of the monitoring well locations were chosen as locations which contributed to the best overall areal coverage of potential ground water flow, based on the knowledge gained from the literature and from previous studies conducted at the site, and from conditions encountered in the field. A complete discussion of the selection criteria used for selection of monitoring well locations monitored as part of the remedial investigation is contained in Section 2.1.5.2 of this report.

Monitoring wells M50B (RFB3), M52B (RFB13), and M53B (RFB16) were constructed within dual wall drill casing. Monitoring well M51B (RFB4) was constructed within hollow stem augers, and monitoring wells M54B (RFB20), M55B (RFB21), M56B (RFB24), M57B (RFB25), M58B (RFB26), M59B (RFB27), M60B (RFB29), M61B (RFB31), and M62B (RFBL3) were reamed by the rotary air or hollow stem auger methods, and constructed within the open hole. Monitoring wells were constructed and developed according to the design seen on the left side of Figure 2.2-4 and the procedures described below.

Type 304L, 4-inch inside diameter stainless steel, flush threaded casing and screen lengths were decontaminated with an acid and detergent wash, and then rinsed with clean water prior to delivery to the site. They were kept wrapped in plastic until installed into the borehole. The screen consisted of wire-wrapped, continuous slot stainless steel, with a stainless steel base plate welded into the bottom section. A screen slot size of 0.01-inches was used for each monitoring well.

After installing the casing and screen into the borehole, a sand filter pack was installed. The sand filter pack consisted of an acid washed and graded Lonestar #1/20-mesh silica sand, which was matched to the screen slot size used. The sand filter material was clean and free of oil, acid, organic matter, and other deleterious substances. The sand was poured from the surface to a maximum thickness of three to five feet above the top of the screen. After the sand filter pack was added, the monitoring well was pre-developed prior to the placement of the bentonite seal. This pre-development was performed by bailing and surging to remove fines entering the screen. This

TABLE 2.2-2

BOREHOLES CONVERTED TO MONITORING WELLS DURING THE DOWNGRADIENT AND UPGRADIENT HYDROGEOLOGIC FIELD PROGRAM

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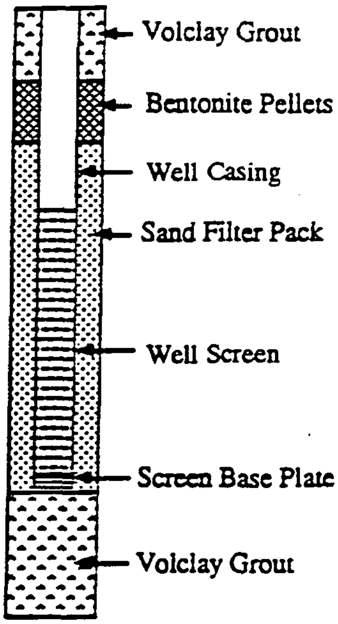
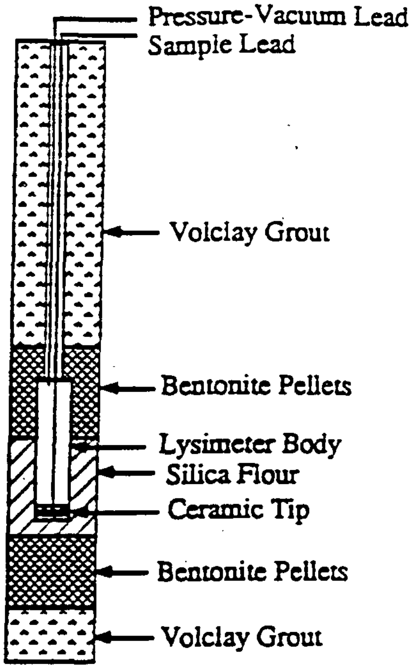
EXPLORATORY BOREHOLE	MONITORING WELL
RFB3	M50B
RFB4	M51B
RFB13	M52B
RFB16	M53B
RFB20	M54B
RFB21	M55B
RFB24	M56B
RFB25	M57B
RFB26	M58B
RFB27	M59B
RFB29	M60B
RFB31	M61B
RFBL3	M62B



MONITORING WELL
DESIGN SCHEMATIC



LYSIMETER
DESIGN SCHEMATIC

FIGURE 2.2-4

MONITORING WELL AND LYSIMETER
DESIGN SCHEMATIC
FOR DOWNGRADIENT AND UPGRADIENT
HYDROGEOLOGIC FIELD PROGRAM

PALOS VERDES LANDFILL
REMEDIAL INVESTIGATION RE
SANITATION DISTRICTS, JANUA 1995

SOURCE: HERZOG ASSOCIATES, 1991

continued until water entering the screen became visibly clearer. The level of the sand filter pack was measured after pre-development to ensure that the top of the filter pack was still three to five feet above the top of the screen. All pre-development water bailed from the monitoring well was tested and stored in portable tanks pending test results. If necessary, this water was treated in the Sanitation Districts' air stripper and disposed of in accordance with an existing Industrial Waste Discharge permit at the PVLF.

Once pre-development was completed, a sodium bentonite seal, composed of bentonite pellets, was placed. This seal was installed directly on top of the sand filter pack, after which potable water was added to hydrate the pellets. Hydration was allowed to continue for 30 minutes to one hour. Individual thicknesses of the bentonite seals are given in the monitoring well construction details contained in Appendices D.1 and D.2.

The remaining annular space above the bentonite seal was filled with Volclay grout from the top of the bentonite plug to within two feet of the ground surface. The grout was tremied into the auger or drilling casing, which was then pulled out above the level of grout as it rose. The monitoring wells were then completed at the surface with at-grade, traffic rated covers embedded in non-reinforced concrete. In accordance with the manufacturer's recommendations, the grout seal was allowed to cure (rigid gel) a minimum of eight hours for each well prior to development.

Each monitoring well was developed in order to remove fines from the slotted screen and filter pack. The well development equipment was steam-cleaned between monitoring wells to minimize the potential for introduction of contaminants into the monitoring wells during development. Before removal of the ground water, a bailer was used to surge the screened interval. As ground water was removed during bailing, the pH, temperature, and electrical conductivity were recorded. Monitoring well development continued until no appreciable fines were found in the ground water, and until three consecutive similar measurements of pH, temperature, and electrical conductivity were recorded. Sampling was then performed.

2.2.7.2 Additional Downgradient Hydrogeologic Field Program

During this field program, monitoring wells were installed in each borehole where ground water was encountered. In total, eight monitoring wells were installed during this investigation. Table 2.2-3 summarizes the exploratory boreholes converted to monitoring wells and the corresponding borehole and well designations. Monitoring wells were constructed using four inch diameter, Schedule 5, Type 316L stainless steel, flush-threaded casing and well screen. A two foot long sediment sump (blank casing) was installed beneath the well screen in each monitoring well. A schematic of a typical monitoring well installed during the additional remedial investigations is shown in Figure 2.2-5. The blank casing, well screen, and sediment sump were decontaminated with an acid and detergent wash, and then rinsed prior to delivery to the site.

The well screen length, slot size, and filter pack size distribution varied with each well, depending on the geologic materials encountered. To estimate the filter pack distribution and screen slot size, sieve analysis data was used from two previously drilled exploratory boreholes: RFB8 and M53B (formerly RFB16). The sieve analysis data from M53B (formerly RFB16) represents an alluvial flow zone, and the sieve analysis data from RFB8 represents a flow zone in the San Pedro Formation. These sieve analysis data were compared to available grain size information from various sand suppliers. The filter packs were selected to retain most of the formation fines, yet allow for maximum flow out of the formation for the purposes of aquifer testing. An appropriate screen slot size was then chosen which would retain a minimum of 80 percent of the filter pack. This approach in "predesigning" to typical wells was approved in advance by DTSC. Modifications to the type well design were made in the field by the field geologist based on the observed geologic materials encountered in each exploratory borehole.

Each monitoring well was installed inside the hollow stem of the augers, and the filter pack was added around the outside of the screen to approximately two to four feet above the top of the screen. The sand consisted of a prewashed silica sand which was clean and free of oil, acid, organic material or other deleterious substances. Following installation of the filter pack, the well was pre-developed by surging to loosen fines and settle the filter pack. A seal composed of bentonite pellets was then emplaced on top of the sand, and potable water was added to hydrate the pellets. The thickness of the bentonite seal ranged from 2.5 to four feet for the new wells. The remaining

TABLE 2.2-3

BOREHOLES CONVERTED TO MONITORING WELLS DURING THE ADDITIONAL DOWNGRADIENT HYDROGEOLOGIC FIELD PROGRAM

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

EXPLORATORY BOREHOLE	MONITORING WELL
AB1a	M64B
AB2	M63B
ABB3	M65B
AB4	M66B
AB6	M69B
AB7	M70B
AB8	M67B
AB9	M68B

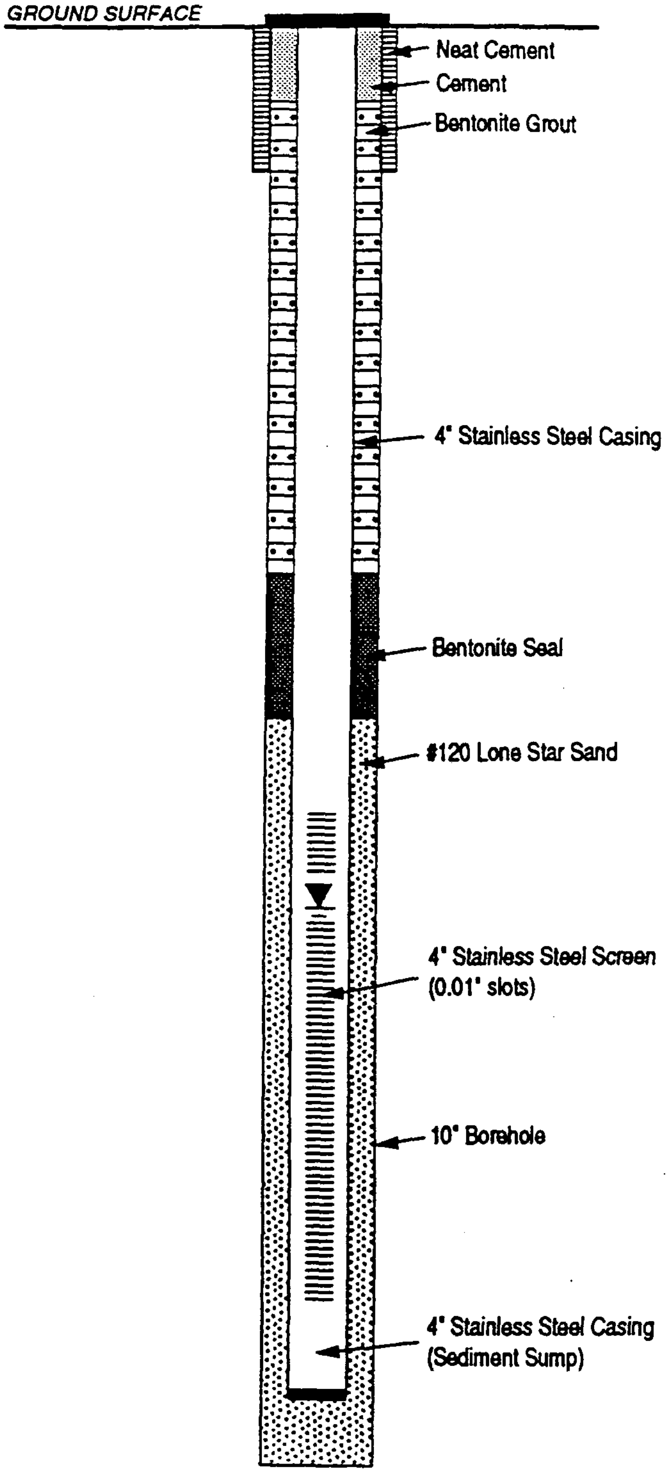


FIGURE 2.2- 5

MONITORING WELL SCHEMATIC DIAGRAM
FOR ADDITIONAL DOWNGRADIENT
HYDROGEOLOGIC FIELD PROGRAM

PALOS VERDES LANDFILL
REMEDIAL INVESTIGATION REPORT
SANITATION DISTRICTS, JANUARY

SOURCE: DAMES & MOORE, 1994

annular space above the seal was filled with bentonite grout to about one foot bgs. The wells were completed at the surface with at-grade traffic-rated well covers in cement. As-built diagrams of each monitoring well are included in Appendix C.4.

2.2.8 Lysimeter Installation

Three Soilmoisture Model 1940 Hi/Pressure lysimeters were installed during the field investigation; they are located at upgradient locations L7 (RFBL1), L8 (RFBL2), and L9 (RFBL3) (see Exhibit 2.1-11). The lysimeters were installed to collect and monitor unsaturated zone soil pore fluids to provide data for possible migration pathway evaluation. A complete discussion of the selection criteria used for selection of lysimeter locations is contained in Section 2.1.5.2.1 of this report.

As shown on the right side of Figure 2.2-4, a lysimeter probe consists of a tubular lysimeter body capped on the lower end with a porous ceramic cup. The upper end of the lysimeter body is attached to two flexible tubes encased in a solid casing leading to the ground surface. One of the flexible tubes, the "sample lead", extends down through the lysimeter body to the ceramic cup. The other flexible tube, the "pressure vacuum lead", is attached only at the upper end of the lysimeter body. Special screening material surrounds the lysimeter body. The lysimeter is operated after installation by creating a strong vacuum in the lysimeter body through the pressure-vacuum lead, and then sealing the lead to maintain the vacuum for a designated collection period. Soil pore liquids travelling downward through the unsaturated zone in the immediate vicinity of the lysimeter are then pulled by the force of the vacuum within the lysimeter from the pore spaces in the soil, through the porous ceramic cap, where they are retained. At sampling time, the sample is pumped to the surface through the sample lead.

Prior to delivery, the lysimeters are prepared for installation in the laboratory by washing the exteriors of the ceramic cups with an acid solution. Next, the cup is immersed in a vat of acid wash solution and the acid wash vacuumed through the pores in the cup for approximately one hour. Still under vacuum, the cup is then removed from the acid vat, and the residual acid solution evacuated. The cup is then submerged in a vat of distilled water under vacuum, and the distilled water is pulled through the cup for a minimum of eight hours. The distilled water bath is then replaced with deionized, purified water (pH of 5.2 to 5.8), which is similarly drawn through the cup for approximately four hours, or until the pH of the water passed through the cup is within 0.2 pH units of the water in the vat.

The ceramic cup is then connected to the lysimeter body, and the two flexible tube leads connected as described above. At this point, the entire lysimeter assembly is pressure-tested by submerging it in water and applying a positive pressure of 20 psi to the pressure-vacuum lead. If no air leaks are observed in the sampling leads, cup joints or body, the pressure is increased to 50 psi and a second check for air leaks is made. After completing the pressure test, the lysimeter is removed from the water and the pressure-vacuum lead evacuated to approximately 80 centibars. If there is no change in the vacuum pressure after fifteen minutes, the lysimeter is considered to be in good condition, and packaged for transport to the site.

At the site, each lysimeter is also field checked prior to installation, using the same vacuum pressure test conducted at the laboratory. Installation of the lysimeters begins with connecting the lysimeter body to the base of 1.5-inch diameter solid PVC casing. The casing is joined together with rivets; no PVC solvent adhesives were used. The boring for the lysimeter was prepared for installation by placing Volclay grout at the base, topped with bentonite pellets which were hydrated for 30 minutes to one hour.

To ensure continuity between the ceramic cup and the borehole wall, two to four gallons of silica flour slurry (mixture of distilled water and silica flour) is placed in the borehole, using a 2-inch diameter, threaded PVC tremie pipe. After the silica flour slurry is placed in the borehole, the lysimeter is then lowered into the slurry mixture, and the lysimeter is vacuum checked once more. After observing no vacuum loss, a minimum three-foot thick sodium bentonite seal composed of bentonite pellets, is placed in the borehole directly on top of the silica flour slurry. Potable water is then added to the pellets, and the seal allowed to hydrate for approximately 30 minutes. The remaining annular space is then filled with Volclay grout from the top of the bentonite seal to within approximately two feet of the ground surface, using the tremie method. The lysimeter is then completed to the surface with an at-grade traffic rated cover embedded in non-reinforced concrete. After installation, the lysimeter is evacuated to collect any excess water present in the silica flour slurry.

2.2.9 Air Sampling

The field methods used during the ambient air and landfill gas portion of the remedial investigation are described below. Various sampling methods were used in the field to collect the air and landfill gas samples. The following sections describe the various sampling methods and sampling equipment that were employed.

2.2.9.1 Ambient Air Sampling

Ambient air sampling was conducted under two separate programs. The first (original) program was conducted in September 1990 through August 1991 in accordance with the AALGCP. The second (additional) program was conducted in June and July of 1994 in accordance with the Additional Ambient Air Work Plan. Since different methodologies were used during these programs, they are discussed separately in the following sections.

2.2.9.1.1 Original Ambient Air Sampling Program

The ambient air sampler used for the original ambient air sampling program was designed in conformance with SCAQMD's specifications. The sampling unit consisted primarily of a DC operated pump, a flowmeter, a 10-liter Tedlar bag, a 12-volt battery and a programmable timer capable of turning the sampler on or off at preset times. Table 2.2-4 summarizes the specifications of the ambient air sampler components.

The sampling unit's components were assembled and contained within a steel, weather-proof enclosure designed to prevent tampering and weather damage. When operating, ambient air was drawn into the unit and collected in the 10-liter Tedlar bag. An extension tube was attached to the sampling unit's sample inlet so that samples were taken at a height of four to five feet above the ground.

On the scheduled sampling days, the ambient air samplers were placed at the specified sampling locations. An empty 10-liter Tedlar bag, which had been repeatedly flushed with ultra-pure nitrogen, was connected to each sampler. Each sampler was manually activated to check its operation

TABLE 2.2-4

SPECIFICATIONS FOR SAMPLER COMPONENTS DURING AMBIENT AIR SAMPLING WITH TEDLAR BAGS

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

Parts	Vendor Model	Specification	Comments
Pump	Brailford TD-2N	9-14 V DC pump Viton,without pump lubrication	SCAQMD recommended
Bag	SKC West 10-liter	Tedlar bag with push-pull valve and Viton o-ring seal.	SCAQMD recommended
Flowmeter	Scott Speciality Gases 52-31S-4-3	Borosilicated glass tube with stainless steel fittings and ending. Flow range: 3-35 cc/min	SCAQMD recommended
Clock Timer	Paragon Model EC72D	Programmable timer 12 volt - two channel time control	SCAQMD recommended
Fittings, valves		stainless steel	
Tubings		316 stainless steel or teflon	
Battery		12 volt marine battery	

and to adjust the sampling flow rate. The flow rate was set to ensure that approximately ten liters of sample would be collected during the sampling period. The sampler timer was set to the predetermined start and stop time. At the start and several times during the sampling period, each sampler was visually checked to ensure its continued operation.

During sampling, the meteorological conditions outlined below were continuously monitored using a Climatronic weather station which was permanently installed at the site. Throughout the monitoring period of ambient air sampling at the PVLF, these specific sampling conditions were met. These sampling conditions are as follows:

- No sampling was performed during precipitation;
- The maximum average wind speed for any 30 minute period was 15 miles per hour; and
- The maximum instantaneous wind speed was 25 miles per hour.

Exhibit 2.1-1 shows the site location of the weather station. The station contained: F460 wind sensors capable of measuring wind speed and direction having a threshold of 0.5 mph; a barometric pressure sensor; an ambient air temperature sensor; and a precipitation gauge. Table 2.2-5 summarizes the specifications of the weather station components.

All of the meteorological data were recorded on a multiplex strip chart recorder and on IMD-860 data logger modules with the capability of being downloaded to a personal computer. The weather station equipment and its location conformed to the requirements of CARB and SCAQMD. The requirements for the wind speed sensor are that it consist of a three cup assembly, with a range of 0 to 50 miles per hour with a threshold of 0.75 mile per hour or less, wind direction sensor with a vane with range of 0 to 540 degrees with a threshold of 0.75 mile per hour or less, wind sensors located nine to twelve feet above the ground, and the weather station equipped with a continuous strip chart recorder. The location of the weather station should be a minimum of 60 feet away from obstacles such as trees, shrubbery, and buildings.

At the end of the sampling period, the Tedlar bags, containing the ambient air samples, were removed from the sampling unit and placed in sealed cardboard boxes to prevent light from

TABLE 2.2-5

SPECIFICATIONS FOR PERMANENT WEATHER STATION COMPONENTS

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

Parts	Vendor Model	Specification	Comments
Flowmeter	Climatronic Wind Speed Sensor P/N 100075 Cups P/N 10128 Wind Direction Sensor P/N 100076 Vane P/N 101288	Wind Speed Threshold - 0.15 mph Range (0 - 125) Wind Direction Threshold 0.5 mph Range (0 - 540) Degrees.	SCAQMD recommended
Continuous recorder	Climatronics Multiplex Recorder P/N 100586-1	Five Channels Recorder for Wind Speed, Wind Direction, Air Temperature, Rainfall and Barometric Pressure	SCAQMD recommended
Mast	Climatronic 100253	Expandable 10-foot tripod mast	SCAQMD recommended

causing photochemical reactions. The Tedlar bag samples were analyzed at the site for total organic carbon (TOC) as methane using a portable OVA with a lower detection limit of 2 ppm methane. The results of the OVA analyses were recorded at the field technicians' trailer and the Tedlar bag was transported to the appropriate laboratory for TAC analysis.

2.2.9.1.2 Additional Ambient Air Sampling Program

Ambient air monitoring for the additional ambient air sampling program was conducted in accordance with EPA Method TO-14. This method is based on the collection of whole air samples in SUMMA passivated stainless steel canisters. EPA Method TO-14 presents procedures for sampling into canisters to final pressures both able and below atmospheric pressure (respectively referred to as pressurized and subatmospheric sampling). Subatmospheric sampling of ambient air was conducted primarily because it does not require electrical power at the sampling locations.

The ambient air sampling units consisted of a six-liter stainless steel evacuated canister, a calibrated flow controller, and a particulate filter. Table 2.2-6 summarizes the specifications of the ambient air sampler components. Just prior to sampling on each sampling date, the vacuum pressure of each canister was checked to ensure that the canister had been evacuated to the Method TO-14 specified pressure. The flow controllers were set in the lab to a flow rate (3 ml/min) which would fill 80 percent of the canister volume (4.8 liters) over a 24-hour period. The flow controllers were also checked in the field to ensure that the setting had not been altered during shipment. The flow controllers were checked by attaching the controller to a "dummy" (not used for sampling) evacuated canister and measuring the flow rate at the sample inlet. The flow rate was measured using a J & W Scientific, acoustic displacement type, digital flowmeter (model no. ADM 3000). If the flow rate measured in the field was more than a few tenths of a ml/min different than the preset level, the flow controller was adjusted to the desired flow rate of three ml/min.

Once the canister vacuum pressure and the flow controllers' flow rate were verified, the flow controller with a particulate filter on the sample inlet was connected to the canister. Once assembled, the sampling units were transported to one of the four ambient air sampling locations. Each sampling location had one primary and one duplicate canister for sampling. At the sampling

TABLE 2.2-6

SPECIFICATIONS FOR SAMPLER COMPONENTS DURING AMBIENT AIR SAMPLING WITH STAINLESS STEEL CANISTERS

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

Component	**Vendor/Model**	**Specification**
Canister	Biospherics Research Corporation Model: 87-300	Six liter stainless steel SUMMA canister.
Flow Controller	J & W Scientific Model: SA 202-3(5)2 Porter Instrument Company Model: ZCD-1000	Stainless steel flow controller with a built-in span adjustment. Flow range: 1 cc/min to 1000 cc/min
Flowmeter	J & W Scientific Model: ADM 3000	Acoustic displacement type. Flow range: 1 to 750 mL/min

locations, the canisters were affixed to a steel tripod such that they were elevated approximately six feet above ground level as specified by CARB's Testing Guidelines for Solid Waste Disposal Sites.

At the start of sampling, the canister valve was opened and the system was given time to stabilize. The samplers at all four locations were operated for 24 hours from approximately 12:00 p.m. each sampling day to 12:00 p.m. the following day. The sampling flow rate was checked periodically at the start of sampling then again after approximately one hour, four hours, twenty hours, and 24 hours (at the end of sampling). This was accomplished without disrupting the ongoing sampling by attaching the J & W Scientific digital flowmeter directly to the sample inlet tube to the flow controller. At the conclusion of sampling, the canister valve was closed and the flow controller was removed. The vacuum pressure of each canister was again measured before the canisters were packaged and shipped to the appropriate laboratory for analysis per EPA Method TO-14.

During sampling, the meteorological conditions outlined below were continuously monitored using a Climatronic weather station which was temporarily installed at the site near upwind monitoring location 1. Additional meteorologic information was also available from the permanent weather station discussed in the previous section. During the additional ambient air sampling program, the following conditions were met:

- No sampling was performed during precipitation;
- The maximum average wind speed for any 30 minute period was 15 miles per hour; and
- The maximum instantaneous wind speed was 25 miles per hour.

Exhibit 2.1-2 shows the site location of the temporary weather station. The station contained wind sensors capable of measuring wind speed and direction having a threshold of 1 and 0.75 mph respectively. Table 2.2-7 summarizes the specifications of the temporary weather station components.

All of the meteorological data were recorded on a continuous two channel recorder. The temporary weather station was located about 200 feet from the main site boundary in an area clear of obstacles such as trees, shrubbery, and buildings.

TABLE 2.2-7

SPECIFICATIONS FOR TEMPORARY WEATHER STATION COMPONENTS

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

Parts	Vendor Model	Specification
Flowmeter	Climatronic, Inc. Wind Speed: Sesor P/N 100075 Cups P/N 10083 Wind Direction Sensor P/N 100076 Vane P/N 101288	Wind Speed Threshold - <1 mph Range (0 - 25) Wind Direction Threshold - <0.75 mph Range (0 - 540) Degrees.
Continuous recorder	Climatronics, Inc. Rustrak Recorder P/N 100388	Two Channels Recorder for wind speed and wind direction
Mast	none	1 1/4 in. dia. steel pipe set into 2 in. dia. pipe driven into ground Sensors approx. 11 ft 10 in. above ground

2.2.9.2 Integrated Surface Gas Monitoring

The integrated surface gas (ISG) sampler used for the remedial investigation was designed to conform with SCAQMD's specifications. The ISG sampler is a self contained, hand held, portable unit which consists primarily of a DC operated pump, a flowmeter, a 10-liter Tedlar bag, 9-volt battery, and a sample collection funnel. Table 2.2-8 summarizes the specifications of the ISG sampler components.

The sampling unit components were assembled and contained within a plastic box with the exception of the Tedlar bag and funnel. The Tedlar bag was enclosed within a sealed cardboard box to protect it from light and attached to a fitting on the outside of the sampling unit. An extension tube with the collection funnel secured to one end was attached to the sampling unit's air sample inlet port. The tube was configured so that when the sampler was hand carried the funnel remains within two to three inches of the ground surface.

Prior to performing the scheduled sampling, the meteorological conditions at the site were checked. Sampling conditions that were met during the integrated surface gas sampling were as follows:

- The average wind speed (for ten minutes) was less than five miles per hour;
- The instantaneous wind speed did not exceed ten miles per hour; and
- The landfill surface was dry, with no rainfall during the 72 hours preceding sampling.

The site's weather station, discussed in Section 2.2.9.1, was used to check the meteorological conditions. If conditions were suitable, one or more ISG sampling units, depending upon the number of routes to be sampled, were checked to ensure proper operation and to adjust the sampling flow rate.

As discussed in Section 2.1.1.2.3, each integrated surface gas (ISG) sampling route was approximately 225 feet in length. Each route took approximately three minutes to walk. Consequently, the sampling flow rate was set to ensure that an eight to ten liter sample would be collected during the three minutes required to sample one route.

TABLE 2.2-8

SPECIFICATIONS FOR INTEGRATED SURFACE GAS SAMPLER COMPONENTS

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

Parts	Vendor Model	Specification	Comments
Pump	Brailford TD-2N	9-14 V DC pump with Viton, without pump lubrication	SCAQMD recommended
Bag	SKC West 10-liter	Tedlar bag with push-pull valve and Viton o-ring seal.	SCAQMD recommended
Flowmeter	Scott Speciality Gases 52-31S-4-3	Borosilicated glass tube with stainless steel fittings and ending. Flow range: 3-35 cc/min	SCAQMD recommended
Funnel		3 inch diameter stainless steel	
Fittings, valves		stainless steel	
Tubings		316 stainless steel or teflon	
Battery		12 volt battery	

At the start of sampling an ISG route, an empty 10-liter Tedlar bag, which had been repeatedly flushed with ultra-pure nitrogen, was attached to the sampler. The sampler was activated, and the sampling technician walked along the sampling route while keeping the collection funnel within two to three inches of the surface. At the end of the route, the sampler was turned off and the Tedlar bag removed, labeled with the route number, and stored in a light-tight bag. At the end of the day of ISG sampling the Tedlar bag samples were analyzed at the site for TOC as methane using an OVA and the results were recorded at field technicians' trailer at the site. Samples selected for TAC analysis were collected as described above except that the sample bags were enclosed in a light-tight box during and after sampling. As described in Section 2.1.1.2.3, after the samples were analyzed for TOC as methane by a technician at the site (using an OVA), they were transported to the appropriate laboratory.

Meteorological conditions were continuously monitored during ISG sampling. Whenever meteorological conditions exceeded the requirements discussed above, ISG sampling was terminated.

2.2.9.3 Boundary Probe Monitoring

The ISG sampler, as described in Section 2.2.9.2, was modified for boundary probe monitoring. The ISG sampler was modified by removing the extended steel sample collection funnel which was attached to the sampling unit's inlet port. This allowed the sampler inlet to be attached directly to the polyethylene sampling tube of a probe (probe construction details are described in Section 1.3.4.1.3). The probes were monitored for TOC as methane using a dual range natural gas indicator (Gas Tech Model No. NP 204) and the modified ISG sampling unit. The natural gas indicator measures TOC as methane. It was calibrated, as specified by the manufacturer, prior to monitoring.

At the start of monitoring, the modified ISG sampler's inlet was connected to the perimeter probe sampling tube. The sampler was activated to evacuate the probe gases. The evacuated gases were periodically sampled using the natural gas indicator which measured the TOC concentration. Monitoring stopped when the TOC concentration of samples, measured over a 30 second period, remained constant. The constant value was recorded on the field data sheets as the probe's measured TOC concentration.

TAC monitoring was performed at randomly selected perimeter probes, as discussed in Section 2.1.1.2.4. The TAC monitoring was performed immediately following the TOC monitoring unless laboratory scheduling required TAC monitoring to be performed prior to the completion of TOC monitoring of perimeter probes. An empty 10-liter Tedlar bag, which had been repeatedly flushed with ultra-pure nitrogen, was attached to the modified ISG sampler's outlet. The sampler was operated until the 10-liter Tedlar bag was filled with a sample from the probe. A sample from the Tedlar bag was analyzed for TOC as methane using an OVA. The result was recorded, on the field data sheets as the probe's TOC concentration. The Tedlar bag, which was contained within a sealed box to prevent photochemical reactions, was then transported to the appropriate laboratory for TAC analysis.

2.2.9.4 Neighborhood Meter Box Monitoring

A portable OVA was used for neighborhood meter box monitoring, conducted at the water meter boxes in front of the homes in the County Hills Estate area between Hawthorne and Crenshaw Boulevards, Rolling Hills Road, and the landfill. The OVA, which measures TOC as methane, had a lower detection limit of 2 ppm methane. The OVA sampling probe was placed into the subsurface water meter box being sampled to collect and analyze the gases inside the meter box. The samples were drawn into the OVA, analyzed, and the results were recorded on the field data sheets.

2.2.9.5 Surface Flux Chamber Air Sampling

The equipment required for surface flux chamber sampling includes the surface emission isolation flux chamber (flux chamber), tubing, connectors and valves, a supply of ultrapure air or nitrogen, direct reading instruments, and a sample container. During the investigations conducted at the PVLF, the equipment used included a flux chamber made of stainless steel and plastic (both nonreactive materials), an organic vapor analyzer (OVA), thermocouples, ultrapure air, and stainless steel canisters. The flux chamber, tubing, connectors, valves, rotameter, and thermocouples were supplied by the Sanitation Districts' consultant Dr. C. E. Schmidt. The stainless steel canisters used for sample collection were supplied by Environmental Analytical Service, Inc., of San Luis Obispo, California.

The flux chamber can be used on any liquid, source, or solid surface. The only requirement regarding application is that there must be access to the surface for testing. If the surface cannot support the chamber, the chamber must be suspended or equipped with a flotation device. The most critical issue regarding application is that the number of locations for testing be sufficient so that these data can be used to calculate the total emissions from the emitting surface area. The Users Guide (US EPA, 1986b) provides guidance that relies on the area involved and the homogeneity of the source or the coefficient of variation of these emission data for determining representative testing.

The operation of the flux chamber involves: 1) identifying the test area; 2) initiating sweep air flow rate to the flux chamber; 3) operating the chamber for at least five residence times; 4) collecting exhaust gas for analysis and/or recording instrument response; 5) decontaminating the chamber; and 6) relocating the measurement equipment to the next test area. The specific operating protocol for land surfaces is given below.

1) The flux chamber, sweep air, real-time gas analyzer, thermocouples, sample collection equipment, and field documents were transported to the test location.

2) The site information, location information, equipment information, name of sampler, date, and proposed time of testing were documented on the Emissions Measurement Field Data Sheet.

3) The exact test location was selected and the chamber was placed on the soil surface. The thermocouples were placed inside and outside of the chamber in order to monitor soil/air temperature. Temperature data are used to show that the emission event was not disturbed during the measurement or to correlate emission rate to temperature.

4) The sweep air flow rate was initiated and the rotameter was set at five liters per minute. Constant sweep air flow rate was maintained throughout the measurement.

5) The chamber was operated at five liters per minute and data (gas analyzer and thermocouple readings) were recorded every residence time (six minutes) for five residence times or 30 minutes. The sample line was continuously purged by withdrawing exhaust gas with an Organic Vapor Analyzer or intermittently with a hand pump. The air not withdrawn by these methods was exhausted out of the pressure equalization port in the top of the chamber at a rate of at least 2.5 liters per minute. Therefore, the chamber was operated at near atmospheric pressure and ambient air entrainment was prevented.

6) At steady-state (five residence times or more), gas samples were collected in evacuated stainless steel canisters. This was accomplished by connecting an evacuated canister, provided by Environmental Analytical Service, Inc., to the purged sample line. The canister valve was then slowly opened, until the desired sample collection rate of about two liters per minute was reached. This resulted in a sample collection time of about six minutes, and prevented unwanted entrainment of ambient air. The canister valve was then closed, and the canister was disconnected from the exhaust manifold and capped.

7) After sample collection, all samples were labeled and documented on the data sheet.

8) After labeling, all samples were stored in closed cardboard boxes. Within 24 hours, the samples collected were shipped to the laboratory via next day delivery service.

9) Sample collection was documented in the field master log book.

10) After sampling, the flux measurement was discontinued by shutting off the sweep air, removing the chamber, and securing the equipment.

11) The chamber was decontaminated where contact was made with the surface using a clean paper towel to remove any soil or moisture.

12) The sampling equipment was then relocated to the next test location and steps 1 through 11 were repeated.

2.2.9.6 Landfill Gas Monitoring

Landfill gas monitoring was conducted under two separate programs. The first (original) program was conducted in September 1990 through August 1991 in accordance with the AALGCP. The second (additional) program was conducted in June and July of 1994 in accordance with the Additional Ambient Air Work Plan. Since different methodologies were used during these programs, they are discussed separately in the following sections.

2.2.9.6.1 Original Landfill Gas Sampling Program

The sampling equipment used for landfill gas monitoring during the original sampling program consisted of a hand-operated pump, a 10-liter Tedlar bag enclosed in a light-tight container, and a dual-range natural gas indicator (Gas Tech Model No. NP 204). When sampling, the pump inlet was attached to a permanently installed sampling port in the headerline. The pump outlet was connected to an empty 10-liter Tedlar bag which had been repeatedly flushed with ultra-pure nitrogen prior to sampling. The pump was operated until an eight to ten liter sample was collected in the Tedlar bag.

The Tedlar bag samples were analyzed at the site for TOC as methane using the natural gas indicator. The results of the analysis were recorded in the site trailer on chain of custody forms and the Tedlar bags were transported to the appropriate laboratory for TAC analyses.

In addition to the landfill gas sample collection methodology described above for TOC as methane and TAC analysis, an additional methodology was followed to obtain samples slated for hydrogen sulfide analysis. This methodology, referred to as the Impinger Method for the Determination of Hydrogen Sulfide, is discussed in the Laboratory QA/QC Plan contained in Appendix B.1.

2.2.9.6.2 Additional Landfill Gas Sampling Program

Landfill gas monitoring during the additional sampling program was conducted in accordance with the applicable sections of EPA Method TO-14 utilizing SUMMA evacuated canisters. Although SUMMA canister sampling is usually limited to dilute sample types such as ambient air samples, it can also be employed for collection of landfill gas samples. As with ambient air monitoring, subatmospheric sampling of landfill gas was conducted.

The landfill gas sampling units consisted of a six liter stainless steel evacuated canister, particulate filter, and vacuum gauge to verify the vacuum of the canister before and after sampling. Just prior to sampling on each sampling date, the vacuum pressure of each canister was checked to ensure that the canister had been evacuated to the specified pressure. Once the vacuum pressure in a canister had been verified, the canister was connected via teflon tubing to the headerline sampling prot and the canister inlet valve was opened. After approximately fifteen seconds the canister valve was closed and the canister disconnected from the headerline. All of the landfill gas canisters were then packaged and shipped to the appropriate laboratory for analysis per EPA Method TO-14.

2.2.9.7 Flare Emissions Monitoring

The Sanitation Districts contracted with Carnot, a company which conducts source testing, to perform flare emissions monitoring at the PVLF. The sampling equipment and methods employed by Carnot were consistent with SCAQMD requirements. Detailed discussions of the sampling procedure are contained in Appendix E.10.

2.2.10 Water Sampling

The field analytical methods used for water sample monitoring are described in this section. Various sampling methods were used in the field to collect the various types of water samples. The following sections describe the various sampling methods and sampling equipment that were employed.

2.2.10.1 Runoff Sampling

The runoff water samples were collected using a decontaminated beaker or pail. Care was taken to obtain a representative liquid/suspended solids runoff sample and to exclude solids such as vegetable debris, man made debris (floating paper parts, etc.), or in-situ soil (mud, sand pebbles, etc., along the bottom of the drain). The sample bottles were first rinsed with the runoff water before the final sample was obtained. The bottles were filled using a decontaminated funnel. Every effort was made to ensure no contamination of the runoff water by avoiding any touching of the beaker/pail, bottles, or bottle lids with human hands. The 250 milliliter VOC sample bottle was filled slowly and overfilled before being capped to ensure that there were no gas bubbles (air space) in the samples. After the samples were collected, the sample bottles were decontaminated and placed in ice chests for later transport to the appropriate laboratory.

2.2.10.2 Hawthorne Boulevard Storm Drain

The Hawthorne Boulevard storm drain water samples were obtained at various man-hole entrances. To collect the samples it was necessary to access the storm drains by climbing down ladders at the man-hole entrances. The water samples were collected by placing a decontaminated stainless steel beaker into the path of the water until it was full. The contents of the beaker was transferred into a decontaminated stainless steel bucket. This process was repeated until the bucket was full, or until a sufficient volume of sample had been collected. For each sample, over 9-liters of water was needed for a complete chemical analysis. The bucket was raised to the surface using a nylon rope, and the water transferred into the appropriate laboratory supplied glass containers. The containers were then sealed, labeled, manifested on a chain-of-custody form, and placed in an ice-cooled container for transport to the appropriate analytical laboratory.

2.2.10.3 Lake and Stream

For the lake and stream water samples, a decontaminated stainless steel bucket was dipped into the water about six inches below the water surface being careful not allow algae, leaves, or other debris to enter the bucket. The bucket was then taken to shore, where the contents were gently poured into the laboratory supplied containers. For each sample, over nine liters of water was needed for complete chemical analysis. The containers were sealed, labeled, manifested on the chain-of-custody form, and placed in an ice-cooled container until transported to the appropriate analytical laboratory.

2.2.10.4 First Water in Boring

First ground water samples were retrieved from all open boreholes which were drilled with hollow stem auger or air rotary methods, and in which saturated zones were encountered. The collection and testing of these samples permitted field pre-screening and preliminary evaluation of relative water quality in the boreholes. Drilling was temporarily suspended to allow collection of a first ground water sample from the saturated zone in the open borehole. The first ground water samples were collected using precleaned stainless steel sampling bailers. The sampling equipment was cleaned prior to use and between uses with a non-phosphate detergent wash followed by a potable water rinse and two distilled water rinses. Additional steam-cleaning or rinsing procedures were used as deemed necessary. When feasible, a Teflon-bottom emptying device was used with the bailers to minimize agitation while drawing the samples. Water samples were placed in laboratory provided sterilized borosilicate glass and plastic containers. The samples were put on ice immediately after collection and were transported to the appropriate laboratory within 24 hours of the time of collection.

2.2.10.5 Lysimeter

The procedure used to remove soil-pore liquids is consistent throughout the sampling periods. One week prior to taking the soil-pore sample, any liquid from the sampling cup is purged and the initial vacuum pressure is set. To set the initial vacuum, the pressure-vacuum lead is attached to the vacuum inlet on a hand pump. The pump is equipped with both vacuum and pressure gauges. The ring clamp on the pressure-vacuum lead is removed and a vacuum pressure of 60 to 80 centibars is set on the lysimeter. The vacuum pressure emplaced on the lysimeter is recorded. The ring clamp is reset onto the pressure-vacuum lead, and the lead is carefully removed from the hand pump so that no vacuum pressure is lost.

After setting the initial vacuum on the lysimeter, a one week period elapses before taking the soil-pore sample. The first step in taking the soil-pore sample is to clean off the tip of the lysimeter sample lead so as not to contaminate the sample. Next, the pressure-vacuum lead is attached to the vacuum inlet on the hand pump. The ring clamp is then removed and the vacuum pressure is recorded. The lead is then removed from the vacuum outlet fitting on the pump and is attached to the pressure fitting. The ring clamp is removed from the sampling lead which is placed into a sterilized glass bottle. A pressure of approximately 30 psi. is then applied (via the hand pump) to move the liquid from the lysimeter sample cup to the sample bottle. Once the entire sample has been evacuated, the sample lead is doubled over and the ring clamp is reset.

After the sample is retrieved, the volume of the liquid is estimated and recorded. The sample is then separated into several amber glass containers with Teflon-lined caps; each container is used for a different suite of chemical analyses. All samples are kept on ice between the time they are collected until they can be submitted to the laboratory for analyses. Due to the normally low sample yield provided by lysimeters, it is necessary to prioritize the sample analyses to be performed in the event that only limited sample can be collected. Maximum lysimeter yield is typically less than 700 milliliters (ml). Therefore, samples are collected first for volatile organic compounds. This analysis requires at least 40 ml. Any remaining sample is submitted for analysis of pH and metals. Prioritization for lysimeter sample analyses is described in Section 2.1.5.2.2.

2.2.10.6 Monitoring Well

Ground water monitoring well samples are taken at least 24 hours after development of each monitoring well and on a quarterly basis (or as designated in the SSAP) after that. The following field procedures are followed when taking the ground water monitoring well sample.

Prior to taking the water sample, a head-space gas reading is taken to determine the percent methane and percent oxygen in the wellbore. Then the depth to water in the wellbore is measured. An air piston bladder pump, such as a Grundfos RediFlo2 Environmental Submersible pump, is used to purge the wells and to take the water sample. The pump is connected to an air inlet line, an air exhaust line, and a water line. The use of the air bladder pump using a low flow rate (approximately 100 ml per minute) ensures that the water sample is not aerated while being sampled. For samples collected for VOC analysis, a teflon bailer with a bottom release valve was used on some occasions. The use of the bailer with a bottom release valve provides an extra precautionary measure to prevent the samples from being aerated while being sampled. The pump along with the attached lines are steam cleaned prior to any sampling.

At each sampling, a minimum of three casing volumes of ground water are purged from each monitoring well prior to sample collection. The purged water is contained in storage tanks or drums, and is eventually disposed of in accordance with the accepted protocol developed for the site. The ground water field indicator parameters of pH, temperature, and electrical conductivity are measured during of the purging of the wellbore, and the purging is continued until these indicator parameters are stabilized. The pH, temperature, and electrical conductivity meters are calibrated each day before beginning field activities, and checked once each day to verify meter performance. The water samples are collected in the appropriate laboratory supplied bottles. The bottles are sealed, labeled, manifested on a chain of custody form, and placed in an ice cooled container for transport to the appropriate analytical laboratory.

2.2.11 Field Chemical Analysis

Various field chemical analyses were performed for the air, soil/sediment, and water samples. The field chemical analyses performed on these samples are discussed below.

2.2.11.1 Air

An organic vapor analyzer (OVA) and a dual range natural gas indicator (Gas Tech Model No. NP 204) were used to take field air measurements. Both instruments measure total organic carbon as methane (i.e., they are calibrated to methane). The OVA was used to measure the TOC as methane in samples for the original ambient air, integrated surface gas, boundary probe (bag samples only), neighborhood meter box, surface flux chamber, Hawthorne Boulevard storm drain, and portions of the borehole drilling programs. The dual range natural gas indicator was used to measure TOC as methane and the percent oxygen in samples for the boundary probe, original landfill gas, and Hawthorne Boulevard storm drain sampling programs.

2.2.11.2 Soil/Sediment

Soil/sediment sampling was conducted under two separate programs. The first program, referred to as the downgradient and upgradient hydrogeologic field program, was conducted in June through October 1990 in accordance with the SCP and HCP. The second program, referred to as the additional downgradient hydrogeologic field program, was conducted in December 1993 and January 1994 in accordance with the Work Plan for Additional Remedial Investigation. Since different methodologies were used during these programs, they are discussed separately in the following sections.

2.2.11.2.1 Downgradient and Upgradient Hydrogeologic Field Program

During the downgradient and upgradient hydrogeologic field program, field pre-screening was conducted for VOCs on all auger sediment samples and on core samples collected at approximately 20-foot intervals during the drilling and sampling portion of the field investigation. Quantitative screening results were obtained for benzene, vinyl chloride, trichloroethylene, and tetrachloroethylene, using field pre-screening methods. In order to minimize the loss of volatiles, the VOC sample was the first sample obtained from each drive soil sample. The sample was removed from the lower-most ring, using a clean knife. Approximately ten grams (g) of soil sample were placed into a certified clean 40 milliliter (mL) volatile organic analysis (VOA) vial which contained 10 mL of distilled water. Approximately 20 mL of headspace remained in the VOA vial for field gas chromatograph (GC) analysis. The vial was immediately capped with a teflon-lined septum, labeled, and placed on ice until analyzed in the field with a Photo Vac Model 10S50 GC. The remainder of the ring soil sample was capped with Teflon-lined caps taped onto the ring's ends and stored at room temperature until field moisture and soil pore-liquid measurements were performed. The cored bedrock VOC samples were collected and handled in a manner similar to the VOC soil samples. The gas chromatograms are included in Appendix B of the Herzog Phase I and II (Herzog, 1991a, b) field investigation reports (Appendices D.1 and D.2).

Prior to analyzing any samples, the field GC was calibrated for benzene, vinyl chloride, trichloroethylene, and tetrachloroethylene on a daily basis. The GC calibrants were prepared in accordance with "PhotoVac Technical Bulletin No. 27, Preparation of Aqueous Standards for Ground

Water Analysis" (PhotoVac, 1986) and supplemented by information in "The Use of Portable Instruments in Hazardous Waste Site Characterizations", by Clay and Spittler (Clay and Spittler, 1983). These compounds, when identified, were listed in the GC print-out. The VOC concentrations were then measured relative to the calibrant peak heights and widths (calibrant concentrations). Other VOCs that may have been present in the soils were listed as "unknown" because these compounds were not programmed into the GC's memory. Because the GC was equipped with an oven, the calibrant and sample head space gases were analyzed for VOCs at a constant temperature, thereby eliminating shifts in retention time based on differences in the temperatures between the standards and the samples. The GC oven was operated at a temperature of 40° C for calibration and sample analyses.

At the time of analysis, a 50 micro-liter head space sample was removed from the VOA vial using a clean syringe. After each sample injection into the GC, ambient air was injected into distilled water to ensure that the syringe was working properly. All GC samples were run at a gain of 20 for 600 seconds to aid in rapid, accurate detection of the target VOCs.

A statistical analysis of each day's data was performed for each boring. The statistical analysis was used to determine which samples would be sent to the laboratory for analysis. The mean VOC concentration and standard deviation from the mean were calculated from the GC data for each VOC screened for each boring. Samples with VOC concentrations exceeding one standard deviation from the mean were submitted to the appropriate laboratory within 24 hours for chemical analysis.

2.2.11.2.2 Additional Downgradient Hydrogeologic Field Program

Soil/sediment samples from the additional downgradient hydrogeologic field program were pre-screened in the field using a direct reading instrument with a photo ionization detector (PID). The soil/sediment sample collected in the uppermost stainless steel ring lining the split spoon sampler employed during the drilling was pre-screened using a PID. The sample was extruded from the liner directly into an air tight plastic bag and labeled. This sample was then broken up, and set aside to volatilize for fifteen minutes. After volatilization, the PID probe will be inserted into the plastic bag, and a reading of the total volatiles concentration in the air space within the bag was recorded by the field geologist on the boring log. At the end of each day, the average and standard deviation of the PID pre-screening values from each borehole was calculated.

A minimum of two soil samples from each boring was submitted to the Sanitation Districts' San Jose Creek Water Quality laboratory (SJCWQL) for analysis. The criteria for selecting the soil samples to be submitted to the lab for analysis were:

- All samples where the PID field pre-screening results exceed the average for that borehole by more than one standard deviation;
- At least one sample from each geologic unit encountered;
- All samples which are noticeably, artificially discolored; and
- All samples containing non-geologic material.

In some cases, the above criteria resulted in more than two samples per boring being selected for analysis.

2.2.11.3 Water

Water samples from a number of sources were collected during the remedial investigation. The chemical analyses performed on these samples are discussed by sampling program in the following sections.

2.2.11.3.1 Hawthorne Boulevard Storm Drain

Field water quality parameters taken for the Hawthorne Boulevard storm drain water samples included pH, conductivity, and temperature. The pH was measured using a Cole-Parmer or equivalent hand held pH meter which was calibrated each day prior to use. The conductivity was measured using a Hach or equivalent meter which was calibrated each day prior to use. The pH, conductivity, and temperature parameters were recorded in a field notebook and are discussed in Section 3.2.2.

2.2.11.3.2 Lake and Stream

Field water quality parameters taken for the South Coast Botanic Garden lake and stream channel water samples were pH, conductivity, and temperature. The pH was measured using a Cole-Parmer or equivalent hand held pH meter which was calibrated each day prior to use. The conductivity was measured using a Hach or equivalent meter which was calibrated each day prior to use. The pH, conductivity, and temperature parameters were recorded in a field notebook and are discussed in Section 3.2.4.

2.2.11.3.3 First Water In Boring

Field pre-screening analyses were performed on-site for each first ground water sample collected. The drilling was temporarily suspended to allow collection of a ground water sample from the saturated zone in the open borehole. The location, depth, and time of sample collection were recorded in the field log books. Pre-screening analyses included volatile organics and selected inorganic parameters. Volatile organics analyzed during pre-screening included benzene, vinyl chloride, trichloroethylene and tetrachloroethylene. The field-analyzed parameters consisted of the following: pH, conductivity, temperature, total dissolved solids, sulfate, sodium, calcium, chloride, color, odor, total alkalinity, redox potential, dissolved carbon dioxide, hydrogen sulfide, dissolved oxygen, and nitrates. The results of these analyses are summarized in Appendix G in the Herzog Phase I and II (Herzog, 1991a, b) field investigation reports (Appendices D.1 and D.2).

Pre-screening of VOCs was performed for each ground water sample collected, using a head space analysis designed to work with a Photovac Model 10S50 GC, which was retrofitted with a capillary column and isothermal unit. Approximately 20 mLs of ground water were placed into a certified clean 40-mL volatile organic analysis (VOA) vial, leaving approximately 20 mL of head space in the vial for field GC analysis. The vial was immediately capped with a teflon-lined septum, labeled, and placed on ice until analyzed. At the time of analysis, a 50 micro-liter head space sample was removed from the VOA vial using a clean syringe. After each sample injection into the GC, ambient air was injected into distilled water to ensure that the syringe was working properly. All GC samples were run at a gain of 20 for 600 seconds to aid in rapid, accurate detection of the target VOCs.

Because the GC was equipped with an oven, the calibrant and sample head space gases were analyzed for VOCs at a constant temperature, thereby eliminating shifts in retention time based on differences in the temperatures between the standards and the samples. The GC oven was operated at a temperature of 40° C for calibration and sample analyses.

Prior to analyzing the samples, the field GC was calibrated daily for benzene, vinyl chloride, trichloroethylene, and tetrachloroethylene. The GC calibrants were prepared in accordance with "PhotoVac Technical Bulletin No. 27, Preparation of Aqueous Standards for Ground Water Analysis" and supplemented by information in "The Use of Portable Instruments in Hazardous Waste Site Characterizations", by Clay and Spittler (Clay and Spittler, 1983). These compounds, when identified, were listed in the GC print-out. The VOC concentrations were then measured relative to the calibrant peak heights and widths (calibrant concentrations). Other VOCs that may have been present are listed as "unknown" because these compounds were not programmed into the GC's memory. The results and gas chromatographs for the VOC prescreening of the first ground water samples are given in Appendix B in the Herzog Phase I and II (Herzog, 1991a, b) field investigation reports (Appendices D.1 and D.2).

2.2.11.3.4 Lysimeter

Field water quality parameters taken for the lysimeter soil-pore water samples are pH, conductivity, and temperature. The pH and conductivity were measured using a Cole-Parmer or equivalent hand held pH conductivitity meter. The pH conductivity meter was calibrated each day prior to use. The pH, conductivity, and temperature parameters were recorded in a field notebook.

2.2.11.3.5 Monitoring Well

Field water quality parameters taken for the monitoring well water samples included, at a minimum, pH, conductivity, and water temperature. For some samples, air temperature, color, odor, total alkalinity, dissolved carbon dioxide, H_2S (ppm), and dissolved oxygen were also measured. The pH is measured using an Orion or equivalent pH meter which is calibrated each day with two standard buffer solutions prior to use. The conductivity is measured using a Hach or equivalent conductivity meter which is calibrated each day with high and low standard solutions prior to use.

The total alkalinity and dissolved carbon dioxide are measured by titration. The hydrogen sulfide is measured using a Lamotte or equivalent H_2S kit. Prior to taking the monitoring well sample, the percent methane and percent oxygen is obtained from the head space gas reading. The percent methane is measured using a Gastech or equivalent natural gas indicator which is calibrated each day prior to use. The percent oxygen is measured using a Gastech or equivalent oxygen indicator which is calibrated each day prior to use. These parameters are recorded in the field notebook.

2.3 LABORATORY ANALYTICAL METHODOLOGIES

This section will discuss the laboratory analytical methodologies selected for the chemical analysis of the samples. Air and landfill gas samples collected in Tedlar bags were analyzed at the Sanitation Districts' Joint Water Pollution Control Plant, while air and landfill gas samples collected in stainless steel canisters were analyzed by Environmental Analytical Service, Inc., (surface flux chamber samples only) or Performance Analytical, Inc. The air sampling analysis was done by Sanitation Districts methods (refer to Appendix B.1) or EPA Method TO-14. All water and soil samples were initially sent to the Sanitation Districts' SJCWQL for sample control purposes. Water samples that were not analyzed by SJCWQL were sent to either the Sanitation Districts' Joint Water Pollution Control Plant or the appropriate laboratories under contract to the Sanitation Districts. Contract laboratories used during the remedial investigations included Montgomery Laboratory, National Environmental Testing Laboratory, and ENSECO Laboratory. Soil samples were analyzed either at the Sanitation Districts' laboratories or by outside contract laboratories including Montgomery Laboratory, Brown and Caldwell, National Environmental Testing Laboratory, and ENSECO Laboratory. These laboratories are all certified for the soil and water hazardous waste analyses they performed by the Department of Health Services.

2.3.1 Air

VOCs, which are produced during the decomposition of organic matter, are found in landfill gas. VOCs are comprised of hundreds of compounds; however, only a relatively small number of these compounds are regarded as significant environmental contaminants at the levels detected in landfill gas. This small group of VOCs consists largely of chlorinated and aromatic compounds.

In the early 1980's the SCAQMD developed a rule for control of VOCs from active landfills (Rule 1150.1). As part of that rule, a core group of toxic or hazardous VOCs were identified and referred to as toxic air contaminants (TACs). For the remedial investigation at the PVLF, samples collected in Tedlar bags during the ambient air/landfill gas program were analyzed for TACs as defined by the SCAQMD as follows: ambient air, integrated surface gas, and boundary probe samples were analyzed for all TACs except hydrogen sulfide; landfill gas samples were analyzed for all TACs and also for permanent gas constituents. Table 2.3-1 contains a list of SCAQMD's core VOCs, defined as TACs, along with the permanent gas constituents.

The Sanitation Districts' JWPCP Laboratory employed the same methodology on all field air samples collected in Tedlar bags and analyzed for permanent gases and TACs. A list of the methodologies used for each analysis is included in Table 2.3-1. The samples were analyzed using a gas chromatograph following the procedures outlined in the Laboratory QA/QC Plan outlined in Appendix B.1. The methodology followed for the analysis of hydrogen sulfide in landfill gas is also described in the Laboratory QA/QC Plan contained in Appendix B.1.

EPA Method TO-14 was used for analysis of ambient air and landfill gas samples collected during the additional ambient air program in six liter SUMMA canisters. This method was also used for analyzing the samples collected during the surface flux chamber testing. During laboratory analysis with EPA Method TO-14, water vapor is reduced in the gas stream by a Nafion dryer, and the VOCs are then concentrated by collection into a cryogenically-coiled trap. The cooler is removed and the temperature of the sample is raised to volatilize the sample into a high resolution gas chromatograph. The gas chromatograph temperature is increased through a temperature program and the compounds are eluted from the column on the basis of boiling points into one or more detectors for identification and quantitation.

The target analyte list for ambient air and landfill gas samples analyzed by EPA Method TO-14 included the 43 compounds which are given in Table 2.3-2. For landfill gas samples, the analytical strategy was the same except that the samples were quantitatively diluted to reduce the sample concentration to within the detectable limits (this process results in higher detection limits than in ambient air).

TABLE 2.3-1

ANALYSES AND ANALYTICAL METHODS FOR TACS IN AIR AND GAS SAMPLES

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

CONSTITUENT	ANALYTICAL TEST METHOD
Permanent Gases, Total	LACSD Method 1203 B
Oxygen (O2)	LACSD Method 1203 B
Argon (AR)	LACSD Method 1203 B
Nitrogen (N2)	LACSD Method 1203 B
Methane (CH4)	LACSD Method 1203 A & B
Carbon Dioxide (CO2)	LACSD Method 1203 A
Methylene Chloride	LACSD Method 600A or 600B or 600D[1]
Chloroform	LACSD Method 600A or 600B or 600D[1]
1,1,1-Trichloroethane	LACSD Method 600A or 600B or 600D[1]
Carbon Tetrachloride	LACSD Method 600A or 600B or 600D[1]
1,1-Dichloroethane	LACSD Method 600A or 600B or 600D[1]
Trichloroethylene	LACSD Method 600A or 600B or 600D[1]
Tetrachloroethylene	LACSD Method 600A or 600B or 600D[1]
Chlorobenzene	LACSD Method 600A or 600B or 600D[1]
Vinyl Chloride	LACSD Method 600A or 600B or 600D[1]
1,1-Dichloroethane	LACSD Method 600A or 600B or 600D[1]
1,2-Dichloroethane	LACSD Method 600A or 600B or 600D[1]
Benzene	LACSD Method 600A or 600B or 600D[1]
Toluene	LACSD Method 600A or 600B or 600D[1]
Acetonitrile	LACSD Method 600C
Benzyl Chloride	LACSD Method 600A or 600B or 600D[1]
Xylenes	LACSD Method 600A or 600B or 600D[1]
Dichlorobenzenes	LACSD Method 600A or 600B or 600D[1]
Hydrogen Sulfide	LACSD Method 281 (Impinger)

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[1] Method is dependent upon the instrument used for the analysis.

LACSD: Los Angeles County Sanitation Districts

TACs: Toxic Air Contaminants as defined by SCAQMD.

TABLE 2.3-2

VOLATILE ORGANIC COMPOUNDS ANALYZED WITH EPA METHOD TO-14

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

NO.	COMPOUND
1	Chloromethane
2	Vinyl Chloride
3	Bromomethane
4	Chloroethane
5	Acetone
6	Trichlorofluoromethane
7	1,1-Dichloroethene
8	Methylene Chloride
9	Carbon Disulfide
10	Trichlorotrifluoroethane
11	trans-1,2-Dichloroethene
12	1,1-Dichloroethane
13	Methyl tert-butyl Ether
14	Vinyl Acetate
15	2-Butanone
16	cis-1,2-Dichloroethene
17	Chloroform
18	1,2-Dichloroethane
19	1,1,1-Trichloroethane
20	Benzene
21	Carbon Tetrachloride
22	1,2-Dichloropropane
23	Bromodichloromethane
24	Trichloroethene
25	cis-1,3-Dichloropropene
26	4-Methyl-2-Pentanone
27	trans-1,3-Dichloropropene
28	1,1,2-Trichloroethane
29	Toluene
30	Dibromochloromethane
31	2-Hexanone
32	1,2-Dibromoethane
33	Tetrachloroethene
34	Chlorobenzene
35	Ethylbenzene
36	Bromoform
37	m&p-Xylene
38	o-Xylene
39	Styrene
40	1,1,2,2-Tetrachloroethane
41	1,3-Dichlorobenzene
42	1,4-Dichlorobenzene
43	1,2-Dichlorobenzene

The samples collected during the surface flux chamber testing were analyzed for eight specific VOCs: vinyl chloride, 1,1-dichloroethylene, 1,1-dichloroethane, 1,2-dichloroethane, benzene, trichloroethylene, tetrachloroethylene, and p-dichlorobenzene. The eight VOCs selected for analysis are the most important in terms of the potential risk posed by the off site subsurface air migration pathway. Of the chemicals identified in both landfill gas and ground water, it is estimated that these eight compounds represent 99 percent of the potential cancer risk due to migration from a combination of these sources. Thus, both the toxicity and relative concentrations of the VOCs present in landfill gas and ground water were used to determine the chemicals which are most important to the risk assessment.

All surface flux chamber samples were analyzed by high resolution gas chromatography/mass spectroscopy (GC/MS) following EPA Method TO-14. Samples were analyzed by GC/MS operated in the selective ion mode (SIM) for the eight target analytes. The SIM was required to achieve the low detection limits desired (less than 0.1 ppb for all analytes except p-dichlorobenzene, which had a detection limit of less than 0.2 ppb). This type of scan, rather than a full scan, is often done when a limited list of target analytes are selected.

Carnot was contracted by the Sanitation Districts to perform flare emissions monitoring at the PVLF. The analytical methods employed by Carnot were consistent with SCAQMD requirements. A discussion of the methodology is contained in the Carnot report included in Appendix E.10.

2.3.2 Soil/Sediment

Table 2.3-3 lists the constituents analyzed as well as the sample analysis method for the soil/sediment samples. The soil/sediment samples include the subsurface soil samples, the soil cover samples, and the South Coast Botanic Garden lake and stream channel sediment samples.

In general, all of the compounds listed on Table 2.3-3 were analyzed for in the soil/sediment samples collected throughout the remedial investigations. The one exception was the additional soil cover samples collected in October 1993 (SC35 through SC56). VOC analyses were not performed on these samples, and an additional method for semi-VOC analysis, EPA Method 8310,

TABLE 2.3-3

ANALYSES AND ANALYTICAL METHODS FOR SOIL/SEDIMENT SAMPLES

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

CONSTITUENT	EPA TEST METHOD[1]
Antimony	7041
Arsenic	7061
Barium	7080, 7081, 6010
Beryllium	7091, 6010
Cadmium	7130, 7131, 6010
Total Chromium	7191, 6010
Cobalt	7201, 6010
Lead	7421, 6010
Mercury	7471
Molybdenum	7481, 6010
Nickel	7520, 6010
Selenium	7740, 7741
Silver	7760, 7761, 6010
Thallium	7841
Vanadium	7911, 6010
Zinc	7950, 7951, 6010
Calcium	7140, 6010
Iron	7380, 7381, 6010
Magnesium	7450, 6010
Manganese	7460, 7461, 6010
Potassium	7610, 6010
Sodium	7770, 6010
pH	9045, 423
Specific Conductance	9050, 120.1
Chloride	9252, 325.3
Nitrate	9200, 353.3
Sulfate	9035, 375.4
Volatile Organic Compounds	8010, 8020, 8240
Semi-Volatile Organic Compounds	8270
Total Petroleum Hydrocarbons	Modified 8015

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[1] EPA Method 3005 is used for digestion where appropriate.

was added. The VOC analysis was deleted for these samples because these compounds were not expected to be present in surface samples due to volatilization into the air. The additional semi-VOC analytical method was added to obtain lower detection limits for polynuclear aromatic hydrocarbons (PAHs).

2.3.3 Water

The laboratory analyses performed on water samples collected during the remedial investigations are discussed in the following sections. The suite of analyses specified varied according to whether the sample was collected as part of an ongoing monitoring program (i.e., quarterly ground water monitoring well samples) or as part of a limited field investigation program (i.e., lake and stream samples from the South Coast Botanic Garden).

2.3.3.1 Surface Water Runoff Samples, First Water in Borings, and First Ground Water Samples from New Monitoring Wells

Table 2.3-4 lists the constituents analyzed as well as the sample analysis method for the surface water samples, the first water from borings, and the first ground water samples from newly installed monitoring wells. The surface water samples include the runoff water samples, the Hawthorne Boulevard storm drain water samples, and the South Coast Botanic Garden lake and stream channel samples. The first water from the borings are the first ground water samples taken from open boreholes; the first ground water samples were collected after well installation and development but before aquifer testing. In many of these samples, metals analyses were performed on both unfiltered and field filtered aliquots.

2.3.3.2 Ongoing Ground Water Monitoring Well Samples

Table 2.3-5 lists the constituents analyzed as well as the sample analysis method for the ongoing ground water monitoring well samples. The table lists the analysis performed for both the quarterly and semi-annual samples. Since January 1991, both unfiltered and field filtered samples were analyzed for metals.

TABLE 2.3-4

ANALYSES AND ANALYTICAL METHODS FOR SURFACE WATER, FIRST WATER IN BORING, AND FIRST MONITORING WELL WATER SAMPLES

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

CONSTITUENT	EPA TEST METHOD[1]
Antimony	204.2
Arsenic	206.2, 206.3
Barium	208.2, 200.7
Beryllium	210.2, 200.7
Cadmium	213.2, 200.7
Total Chromium	218.2, 200.7
Cobalt	219.2, 200.7
Lead	239.2, 200.7
Mercury	245.1
Molybdenum	246.2, 200.7
Nickel	249.1, 200.7
Selenium	270.3
Silver	272.1, 200.7
Thallium	279.2
Vanadium	286.2, 200.7
Zinc	289.2, 200.7
Calcium	215.1, 200.7
Iron	236.2, 200.7
Magnesium	242.1, 200.7
Manganese	243.2, 200.7
Potassium	258.1, 200.7
Sodium	273.1, 200.7
pH	423
Specific Conductance	120.1
Chloride	325.3
Nitrate	353.3
Sulfate	375.4
Volatile Organic Compounds	601/602
Semi-Volatile Organic Compounds	625
Total Petroleum Hydrocarbons	Modified 8015

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[1] EPA Method 3005 is used for digestion where appropriate.

TABLE 2.3-5

ANALYSES AND ANALYTICAL METHODS FOR ONGOING MONITORING WELL WATER SAMPLES

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

CONSTITUENT	EPA TEST METHOD[1] FOR QUARTERLY SAMPLING	EPA TEST METHOD[1] FOR SEMIANNUAL SAMPLING
Arsenic	206.2, 206.3	206.2, 206.3
Barium	208.2, 200.7	208.2, 200.7
Cadmium	213.2, 200.7	213.2, 200.7
Calcium	215.1, 200.7	215.1, 200.7
Total Chromium	218.2, 200.7	218.2, 200.7
Hexavalent Chromium	Not Tested	218.5
Copper	Not Tested	220.1, 200.7
Iron	Not Tested	236.2, 200.7
Lead	239.2, 200.7	239.2, 200.7
Magnesium	242.1, 200.7	242.1, 200.7
Manganese	Not Tested	243.2, 200.7
Mercury	245.1	245.1
Nickel	Not Tested	249.1, 200.7
Potassium	258.1, 200.7	258.1, 200.7
Selenium	270.3	270.3
Silver	272.1, 200.7	272.1, 200.7
Sodium	273.1, 200.7	273.1, 200.7
Zinc	Not Tested	289.2, 200.7
Bicarbonate	310.1	310.1
Carbonate	310.1	310.1
Chloride	325.3	325.3
Sulfate	375.4	375.4
Sulfide	376.2	376.2
Nitrate	353.3	353.3
pH	150.1	150.1
Alkalinity	310.1	310.1
Specific Conductance	120.1	120.1
Total Dissolved Solids	160.1	160.1
Total Kjeldahl Nitrogen	351.2	351.2
Chemical Oxygen Demand	410.1	410.1
Biological Oxygen Demand	405.1	405.1
Volatile Organic Compounds	601/602	624
Semi-Volatile Organic Compounds	Not Tested	625
Pesticides and PCBs	Not Tested	608
Total Organic Carbon (TOC)	415.1	415.1
Total Organic Halogens (TOX)	9020[2]	9020[2]
Oil and Grease	413.1	413.1
Gross Alpha Radioactivity	Not Tested	900.0
Gross Beta Radioactivity	Not Tested	900.0

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[1] EPA Method 3005 is used for digestion where appropriate.

[2] Method 9020 from SW-846 is used as there is no EPA method for water.

2.3.3.3 Ground Water Samples for Dioxins Monitoring Program

The ground water samples collected for the dioxins monitoring program were analyzed for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans. These compounds were analyzed for using EPA Method 8280 with a detection limit of ten parts per trillion (ppt). Sample holding times were in compliance with those outlined in the referenced EPA method. This procedure uses a matrix-specific extraction, analyte-specific cleanup, and high resolution capillary column gas chromatography/low resolution mass spectrometry (HRGC/LRMS) technique. If interferences are encountered, the method provides for the use of selected cleanup procedures to aid the analyst in their elimination. The analyses were performed by Cal Analytical/ENSECO laboratory which is currently certified by DHS for this method.

2.3.3.4 Ground Water Samples for Radioactivity Monitoring Program

Ground water samples for radioactivity were analyzed by Thermo Analytical Inc., Montgomery Laboratories, and Lockheed Analytical Services. All of these laboratories are certified by the U.S. EPA Environmental Radioactivity Laboratory. The radioactivity samples were analyzed for GAR, GBR, tritium, strontium-90, radium-226, radium-228, uranium (either isotopic or total), potassium-40, vanadium-48, thorium isotopes, and plutonium isotopes. The GAR and GBR were analyzed using EPA method 900.0. For this method, an aliquot of a preserved water sample is evaporated and plated onto a stainless steel counting planchet. The alpha and beta decays are then counted using a scintillation detector system.

The other radionuclides were analyzed using Lockheed Analytical Laboratory procedures. The tritium analysis was performed using LAL-91-SOP-0066. The strontium-90 analysis was performed using LAL-91-SOP-0065. The radium-226 and radium-228 analyses were performed using LAL-91-SOP-0073 and LAL-91-SOP-0074, respectively. The potassium-40 and vanadium-48 were analyzed by gamma spectrometry using method LAL-91-SOP-0063. The uranium, thorium, and plutonium isotopic analyses were performed using LAL-91-SOP-0108. For some of the samples, a total uranium analysis was performed using LAL-91-SOP-0068. The total uranium concentration values were measured in ug/l. The ug/l of total uranium were converted to pCi/l by assuming isotopic equilibrium (1.0 ug/l uranium is equivalent to 0.68 pCi/l).

2.3.3.5 Lysimeter Water Samples

Table 2.3-6 lists the constituents analyzed as well as the sample analysis method for the lysimeter water samples. Due to the limited sample quantity obtainable from a lysimeter, it is often not possible to test for all compounds; therefore, the constituents have been prioritized. Since VOCs are of primary importance at this site, they are given the highest priority, followed by general water quality parameters and metals as shown on Table 2.3-6.

2.4 STATISTICAL EVALUATION METHODOLOGIES

Several types of statistical analyses were applied to the data sets obtained during the remedial investigations. Where appropriate, descriptive and comparative statistical methodologies were applied to the results of the environmental sampling. The selection of the specific types of statistical analyses was dependent on the characteristics of the data set; characteristics such as the percent of non-detected values and the total number of data points influenced the selection of statistical methods.

There are several issues commonly encountered when dealing with data sets that must be resolved prior to performing statistical analyses. Two of these issues, censored data and significance level, will be addressed in this section since they play a part in the analysis of the remedial investigation data. Following the discussions on these issues, the descriptive and comparative statistical methodologies applied to the various data sets from these investigations where appropriate are described.

2.4.1 Censored Data

One of the common issues encountered in environmental data analysis is the handling of censored data. Censored data may include results reported as not detected, detected above the instrument detection limit but below the method detection limit, detected but not quantitated (i.e., trace detection), or data reported with an associated quality assurance/quality control flag. For example, instrument detection capabilities represent defacto censoring in an absolute sense. Non-detected values, which result from this censoring, were common for many of the monitored parameters in the various environmental media.

TABLE 2.3-6

ANALYSES AND ANALYTICAL METHODS FOR LYSIMETER WATER SAMPLES

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

CONSTITUENT[1]	EPA TEST METHOD[2]
Volatile Organic Compounds	624
pH	423
Specific Conductance	120.1
Total Dissolved Solids	160.1
Cadmium	213.2, 200.7
Total Chromium	218.2, 200.7
Copper	220.1, 200.7
Lead	239.2, 200.7
Mercury	245.1
Nitrate	353.3
Total Kjeldahl Nitrogen	351.2
Biochemical Oxygen Demand	405.1
Chemical Oxygen Demand	410.1

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[1] The constituents are listed in order that tests are performed as sample volume allows.

[2] EPA Method 3005 is used for digestion where appropriate.

Several methods have evolved to handle non-detected values. Simple methods include ignoring the non-detected values when analyzing the data set or substitution of zero, one-half the detection limit, or the detection limit for the non-detected values. More involved methods require generation of random numbers between zero and the detection limit, and then substituting these values for the non-detected values. Of greatest concern for the manner in which these data are handled is whether the results of the data analysis will be biased by the method selected for non-detected value treatment. Biases are introduced when the non-detected values are ignored, or when zero or the detection limit are substituted for the non-detected values. Substituting one-half the detection limit or a random number between zero and the detection limit is unbiased for calculating the mean of the measurements if the analytical measurement technique cannot result in negative measurements, and if all measurements between zero and the detection limit are equally likely to occur (Gilbert, 1987).

Typically, the simple substitution of one-half the detection limit was used in the descriptive statistical analyses employed with the data sets discussed in this report. Nonparametric comparative statistical tests, which were the type of comparative statistical analyses used in this study, do not require any type of substitution for non-detected values due to the nature of these tests (see Section 2.4.4.2 for a discussion of nonparametric comparative statistical testing).

In some cases, the analytical instrument will have a lower detection limit than an EPA analytical method specifies as the quantitative detection limit. In this situation, the value detected by the instrument will be recorded in the data sheet, with a note that it was detected above the instrument detection limit but below the method detection limit. These detections can be handled in various ways. Often, when simple substitution is used for censored data, these data points will be treated as non-detected values and the same substitution will be applied. Or, if more involved types of substitution are selected, the value as determined by the instrument may be used. For the purposes of this study, these data were treated as non-detected values and the simple substitution methods employed for other non-detected values were also employed for data points detected above the instrument detection limit but below the method detection limit.

On occasion, a compound will be identified as present at a trace level but not quantified. This can occur when there are matrix interferences or when an instrument is calibrated such that multiple compounds are detected together. There are methods to deal with these situations;

however, since there were no data reports containing an identification of a compound at a trace level, these methods will not be elaborated on in this report.

Data points may also be reported with an associated QA/QC flag. For example, the analyte of interest in a field sample may also have been detected in the laboratory blank associated with the QA/QC batch in which that sample was included. The implication of these types of QA/QC flags are that the data points so marked should be interpreted with care, since these results may not be representative of the levels of the species of interest actually present in the environmental media (i.e., they may represent laboratory contamination). In this report, all analytical results for which there is an associated QA/QC flag of this nature are discussed in the same way as the rest of the results, and the existence of the flag is noted with the proper precautionary language for the interpretation of these results.

2.4.2 *Significance Level*

There is an inherent uncertainty to the calculation of representative values for the true characteristics of a given population. For example, the mean is an estimate of a population's true average. The true average cannot be exactly determined because it would require perfect sampling and analysis for every theoretically possible sampling event. When sampling environmental media, this would require collecting an infinite number of samples until every point in the population, or the environmental media involved, had been sampled. After collecting these samples, each one would have to be analyzed with perfect accuracy and precision. Both of these requirements are impossible in the real world, which is why statistical methods are used to design both the sampling program and to check the analytical results in a QA/QC program.

Confidence intervals can be constructed about the representative values estimated from a sample set that contain the true characteristics of the population from which the sample set was obtained. These confidence intervals can be selected such that the probability of this occurring is known. This probability is called the significance level. For example, confidence intervals can be constructed about the mean that contain the true average with the degree of probability specified as ten percent, five percent, one percent, or any other value desired.

In addition, confidence intervals can be selected when performing statistical tests to compare two or more data sets. The purpose of these comparisons, as performed on the data contained in this report, is to determine whether the data sets are likely to be from the same population, rather than representative of two different populations. The probability, or significance level, used in selecting these confidence intervals is set at a level that identifies real differences between groups while maintaining a low probability of falsely indicating differences when there are none. A significance level of 0.05, or five percent, is typically chosen for this purpose. In this case, 100 comparisons involving groups with no differences will falsely indicate five differences. A significance level of 0.01, or one percent, is also often used to minimize false indications of differences, but lower significance levels risk failure to detect real differences. A five percent significance level was chosen for this program.

2.4.3 Descriptive Statistics

The descriptive statistics used to characterize the chemical concentration results from the remedial investigations at the PVLF included the mean, the range (minimum and maximum values), the standard deviation, the standard error of the mean, and the percent of the analyses with non-detected values. Not all of these descriptive statistics were applied to all of the results obtained during the study; they were only applied where the results were meaningful. For example, the range and the mean provide no meaningful data when all of the results for a particular constituent in a particular media are below the detection limit.

The mean is an estimate of a population's true average. The true average cannot be exactly determined because it would require perfect sampling and analysis for every theoretically possible sampling event, as discussed in the previous section. The mean represents an estimate of the average as calculated from a subset of all possible monitoring events. The accuracy and precision of the mean for representing the true average is subject to a number of factors such as variations in sample collection and analysis, and variations in environmental conditions.

The range and standard deviation help describe the sample variation due to the factors mentioned above. The range defines the breadth of the parameter of concern in the sampled subset. When considered with the mean, it yields an overall idea of the distribution of the data--i.e., whether the data may be somewhat normally distributed or whether it is skewed to either the high or low end. The standard error of the mean is derived from the sample variation which is measured by the standard deviation. It is used to calculate confidence intervals for the mean.

The percentage of measurements where the constituent being analyzed for was below the detection limit also gives an idea of the overall distribution of that constituent. If the constituent is less than the detection limit 100 percent of the time, the possibility that it is not present in the sample set must be considered.

2.4.4 Comparative Statistics

Comparative statistics are used to make comparisons between two or more data sets taken at different times or places or collected by different measurement techniques. They are used to determine whether the difference in the mean values from two populations is truly representative of a difference in the actual population averages (i.e., the data sets are indeed from different populations) or is the result of random fluctuations (i.e., the data sets are from the same population). Either parametric or nonparametric tests can be used for this purpose; both were applied to various data sets, but not necessarily to all data sets, compiled during the remedial investigations. Nonparametric tests do not require that data follow a normal distribution or any other specific distribution, and many of these tests can accommodate some percentage of non-detected values without biasing the test results. For these reasons, nonparametric tests were used more often in evaluating the results from the remedial investigations.

2.4.4.1 Parametric Comparative Statistics

A standard analysis of variance (ANOVA) with an equality of means test was used to compare different results. ANOVA generally requires less information to detect significant differences than other methods. However, it has the disadvantage that it requires equality of variances between groups. Variance is related to the standard deviation of the data. Many kinds of environmental data have unequal variances. Another statistic, Levene's test, was used to determine the equality of variances. In cases where the variances were significantly different, a second parametric method which does not require equality of variances, Welch's equality of means test, was employed. These methods were implemented within a mainframe statistical package (Dixon, 1988).

The first step in evaluating the comparative statistical results is to determine whether the variances are unequal using Levene's test. Levene's test produces an F statistic for which, from common statistical texts, an associated probability value can be determined. Probability values greater than 0.05 for the Levene's statistic indicates that the variances are not significantly different. In this case the ANOVA equality of means test is used. However, values of 0.05 or less for the Levene's test indicates that the variances are significantly different and Welch's equality of means test should be used. For either equality of means test, values of 0.05 or less indicate that the means are significantly different.

2.4.4.2 Nonparametric Comparative Statistics

The nonparametric test used most often in this report is the Wilcoxon rank sum test. The Wilcoxon rank sum test may be used to test for a shift in location between two independent populations; that is, the measurements from one population tend to be consistently larger or smaller than those from the other population. This test does not require normally distributed data sets, but does assume that the distributions of the populations being compared are identical in shape. This assumption is generally valid for environmental sampling.

The Wilcoxon rank sum test is based on the relative ranks of the data from two data sets. Suppose there are n_1 and n_2 data pieces in data sets D_1 and D_2. The Wilcoxon rank sum test tests the null hypothesis, H_O, versus the alternative hypothesis, H_A, where:

H_O: The two data sets are drawn from the same population (i.e., they have the same mean).

H_A: The two data sets are drawn from different populations (i.e., they have different means).

All values from both data sets to be compared are combined into one data set containing M ($M = n_1 + n_2$) data pieces. The values are ordered from lowest to highest, and a rank is assigned to each value. The datum with the lowest value is assigned a rank of 1 and the largest datum is assigned a rank of M. Non-detected data points are assigned a value of zero and ranked accordingly. When several values are tied, the tied values are assigned a rank equal to their midrank, i.e., the average of the ranks that would otherwise be assigned to those data. For example, if the first three data points in a combined data set are identical, all three data points will be assigned a rank of 2 (2 being the average of 1 + 2 + 3). Next, the sum of the ranks assigned to the values from data set D_2 is calculated. This sum is used to calculate a test statistic designated as Z_{rs}. For large sized sample sets (n_1 and n_2 greater than 10), the test statistic has been shown to be normally distributed with a mean of zero and a standard deviation of one (Gilbert, 1987). If Z_{rs} is less than the comparison statistic designated as Z_{1-a} (taken from a standard normal distribution table, where 'a' is the specified significance level), or Z_{rs} is greater than $-Z_{1-a}$, then hypothesis H_O is accepted. If Z_{rs} is greater than or equal to Z_{1-a}, the mean of D_2 is greater than the mean of D_1. If Z_{rs} is less than or equal to $-Z_{1-a}$, the mean of D_1 is greater than the mean of D_2. For the purposes of these investigations, D_1 (Group 1) contains the background values, and D_2 (Group 2) contains the study area values. Therefore, if the mean of D_2 is greater than the mean of D_1, possible landfill effects may be indicated and investigated further.

When both n_1 and n_2 are less than or equal to 10, the normal approximation does not apply. An alternative test for Z_{rs} is used. The alternative hypothesis, H_A, is stated slightly differently:

H_A: The second data set has a larger mean.

The test statistic is equal to the sum of the ranks of the data in D_2. The null hypothesis is accepted if:

$$Z_{rs} > n_2 * (M + 1) - z(a, n_1, n_2),$$

where $z(a, n_1, n_2)$ is taken from the appropriate tables (Hollander, 1973), and 'a' is the specified significance level.

The Kruskal-Wallis test is a generalized form of the Wilcoxon rank sum test applied to more than two sample sets (Hollander, 1973). The Kruskal-Wallis method was implemented within a mainframe statistical package (Dixon, 1988).

Both the Wilcoxon rank sum test and the Kruskal-Wallis test are able to handle a moderate level of non-detected values. For these investigations, it was assumed that fifty percent represents this "moderate level". For those data sets with greater than fifty percent non-detected values, quantitative statistical analysis was not performed.

2.5 QUALITY ASSURANCE/QUALITY CONTROL METHODOLOGIES

This section will discuss the field and laboratory QA/QC methodologies and sample handling procedures used for field samples collected during the remedial investigations. The QA/QC data are included in Appendix B.

Field sampling QA/QC procedures are designed to ensure that the field sampling units generate valid and complete samples when deployed. The purpose of having a documented laboratory sample QA/QC program is to ensure that the laboratory results accurately reflect the concentration of constituents present at the time of sample collection.

Sanitation Districts personnel performed many of the sampling programs. New field technicians are trained by experienced technicians during their first few months on the job. In addition, they are acquainted with all Sanitation Districts' standard operating procedures pertinent to field sampling.

For air sampling, all aspects of field sampling are covered including the procedures for deploying ambient air samplers, collecting samples for ambient air, integrated surface gas, boundary probes, neighborhood meter box monitoring, and landfill gas samples. The technicians are trained to understand the assembly and operation of all of the sampling equipment. They are trained in how to operate the weather station and obtain information from the weather tapes, i.e., wind speed, wind direction, precipitation quantities, temperature, and barometric pressure. The technicians are also trained in how to fill out the chain of custody and quality control forms.

For water sampling, all aspects of field sampling are covered in training including the procedures for taking storm water runoff, ground water, and lysimeter samples. The technicians are trained to understand the assembly and operation of all of the sampling equipment. They are trained in how to test for the field parameters, i.e., pH, electrical conductivity, etc., that are obtained when collecting water samples. The technicians are also trained in how to fill out the chain of custody and quality control forms.

Field activities for the PVLF remedial investigations, including borehole drilling and logging, monitoring well and lysimeter installation, and sampling for physical and chemical analyses, were performed by Sanitation Districts personnel and members of various consulting firms retained by the Sanitation Districts. Ambient air sampling was performed by Sanitation Districts personnel, with training on the use of canisters and flow controllers provided by Dr. Chuck Schmidt. Surface gas, boundary probe, meter box, and landfill gas monitoring and sampling were all performed by Sanitation Districts personnel. Surface flux chamber sampling was performed by the Sanitation Districts' consultant, Dr. Chuck Schmidt. Surface water runoff and cover soil sampling were performed by Sanitation Districts personnel. The Hawthorne Boulevard storm drain monitoring and the South Coast Botanic Garden lake and stream sampling were performed by Sanitation Districts and Dames & Moore personnel. Drilling and soil sampling was performed by Herzog Associates and their subcontractor, PC Drilling, and by Dames & Moore and their subcontractor H-F Drilling. Geophysical logging was performed by Welenco, Inc., a subcontractor of Herzog Associates. Monitoring well and lysimeter installation and aquifer testing were also performed by Herzog Associates and Dames & Moore. Ground water samples from open boreholes were obtained by Herzog Associates. The first ground water sample from the new monitoring wells installed for the remedial investigations were collected by the Sanitation Districts' consultants, Herzog Associates and Dames & Moore. Routine quarterly ground water sampling was performed by Sanitation Districts personnel.

Samples collected during the remedial investigations were submitted to various laboratories for chemical, physical, and microfossil analysis. Air and landfill gas samples collected in Tedlar bags were analyzed at the Sanitation Districts' Joint Water Pollution Control Plant, while air and landfill gas samples collected in stainless steel canisters were analyzed by Environmental Analytical Service, Inc., (surface flux chamber samples only) or Performance Analytical, Inc. The air sampling analysis was done by Sanitation Districts methods (refer to Appendix B.1) or EPA Method TO-14.

All water and soil samples were initially sent to the Sanitation Districts' SJCWQL for sample control purposes. Water samples that were not analyzed by SJCWQL were sent to either the Sanitation Districts' Joint Water Pollution Control Plant or other appropriate laboratories under contract to the Sanitation Districts. Contract laboratories used during the remedial investigations included Montgomery Laboratory, National Environmental Testing Laboratory, and ENSECO Laboratory. Soil samples were analyzed either at the Sanitation Districts' laboratories, SJCWQL and the Joint Water Pollution Control Plant laboratory, or by outside contract laboratories including Montgomery Laboratory, Brown and Caldwell, National Environmental Testing Laboratory, and ENSECO Laboratory. Soil/sediment samples were submitted to Herzog Associates, Dames & Moore's Soil Testing Laboratory, or PNP Laboratories for physical analyses. Samples selected for microfossil analysis were submitted to California State University (Northridge), the University of Southern California or the U.S. Geological Survey. Split samples for soil/sediment and ground water were also transferred through chain-of-custody protocol to DTSC personnel. All of the laboratories to which soil/sediment or water samples were submitted for chemical analyses were DHS certified for the analyses performed at that particular laboratory. Equivalent certification does not exist for the other types of analyses performed.

2.5.1 Sample Handling

The following section outlines the sample handling procedures for the air, soil/sediment, and ground water samples. All samples collected during the additional remedial investigations were treated as low-hazard concentration level samples for the purpose of handling and shipping. This assumption was based on the results of the previous field investigations, and no field analyses or final analytical results indicated that more stringent handling procedures were required.

2.5.1.1 Sample Documentation

Field observations and all other pertinent sampling information were recorded in field log books. The data recorded for each sample includes date, time, sample number, type of sample, sample appearance, and name of the person collecting the sample. In addition, general information was recorded in the log book, including personnel present at the site, level of protection (if other than level D), and weather conditions. Direct monitoring instrument readings obtained in the field were also be recorded in the log book.

2.5.1.2 Sample Containers and Preservation

Three environmental matrices were sampled as part of the additional remedial investigations. Air, soil/sediment, and water samples were collected during the various portions of this study. The sample containers used and the preservation methods employed in the field for these matrices are discussed in the following sections.

2.5.1.2.1 Air

Ambient air and landfill gas samples were collected in either Tedlar bags or evacuated stainless steel canisters. Surface gas and boundary probe samples were all collected in Tedlar bags. All surface flux chamber samples were collected in evacuated stainless steel canisters. Tedlar bags were provided by the Sanitation Districts' JWPCP laboratory. All Tedlar bags were cleaned prior to sampling by repeatedly flushing them with nitrogen per the procedures described in Appendix B.1. The stainless steel canisters were provided by the analytical laboratory used for the chemical analyses. They were cleaned by the laboratory and batch certified for cleanliness in conformance with EPA Method TO-14 prior to shipment to the site. Before collecting the sample, the vacuum in each canister was checked using a vacuum gauge. If the measured vacuum in the canister was less than 27 inches, that canister was tagged and shipped back to the laboratory, and not used for sampling. When used for ambient air sampling with stainless steel canisters, flow controllers were set in the laboratory to a flow rate (approximately 3 ml/min) which would fill 80 percent of the canister volume (4.8 liters) over a 24-hour sampling period. The flow controllers were checked upon receipt to confirm that the flow rate was 3 ml/min. A J & W Scientific, acoustic displacement type, digital flow meter (model no. ADM3000) was connected to the flow controller, which was attached to an evacuated canister. Any flow controller with a flow rate significantly different (more than a few tenths of a ml/min) than the desired flow rate was adjusted in the field to the proper setting. The sampling flow rate was checked periodically at the start of sampling then again after approximately one hour, four hours, twenty hours, and 24 hours at the end of sampling. The measured flow rates during these checks were recorded on the quality control forms. This was accomplished without disrupting the sampling by attaching a digital flow meter directly to the sample inlet tube to the flow controller. Sample preservation consisted of placing the Tedlar bags and stainless steel canisters in opaque shipping boxes immediately after sample collection to prevent excessive heating of the sample from exposure to sunlight.

2.5.1.2.2 Soil/Sediment

The soil/sediment samples collected during the remedial investigations were taken in rings (brass or stainless steel), glass jars, or as bulk samples in plastic bags. The samples taken in the rings were collected using either the split spoon sampling method with a drilling rig or a post hole-type driver sampler wielded by a Sanitation Districts' technician. Some of the soil cover samples were collected with a disposable trowel and placed in glass jars. The sediment samples from the South Coast Botanic Garden were collected with a sampling tube pushed to the bottom of the lake and stream at the selected sampling points, and then placed in glass jars. Bulk samples, collected in plastic bags from drill cuttings, were not preserved and were submitted for physical analyses only.

The lengths of the rings used to collect the soil/sediment samples varied from one inch to six inches. One and three inch brass rings were used to collect soil/sediment samples for physical testing. These samples for physical testing were collected with a modified split spoon sampler. These rings were then placed in a plastic bag-lined cardboard tube, capped with a snap-on plastic lid. No preservation was required for these samples.

The samples collected with the split spoon sampler for chemical analyses were taken in three inch long stainless steel rings with a diameter of 2.4 inches. The ends of the samples were covered with a Teflon sheet and then capped with a tight-fitting plastic end cap. The samples were then placed in a cooler with ice to preserve them at 4 °C. Either one or two of the three inch long rings were submitted to the laboratory for chemical analyses, depending on the required QA/QC analyses. Normally, one ring was submitted for each depth selected for analysis, but when QA/QC analyses such as field duplicates or matrix spike/matrix spike duplicates (MS/MSD) were required, two rings from a single location were submitted. In the case where two rings were submitted, adjacent rings from the split spoon sampler were selected. No field homogenization of these samples was performed because they were submitted for VOC analysis. Field homogenization, consisting of breaking up the sample and exposing it to air, would have resulted in the release of the volatile compounds prior to the sample analysis.

The samples collected with the post hole-type driver were submitted for chemical analyses. These samples were collected in six inch long stainless steel rings with a diameter of two inches. Either one or two of the six inch long rings were submitted to the laboratory for chemical analyses, depending on the required QA/QC analyses. Normally, one ring was submitted for each sampling location, but when QA/QC analyses such as field duplicates or MS/MSD were required, two rings from a single location were submitted. In the case where two rings were submitted, they were collected side by side with the sampling apparatus and then homogenized by extruding them into a stainless steel container and mixing the materials with a stainless steel spoon. Homogenization did not affect the chemical characteristics of the sample, since these samples were not analyzed for VOCs. The sample was then placed back into the tubes, the ends of the samples were covered with a Teflon sheet, and then capped with a tight-fitting plastic end cap. The samples were then placed in a cooler with ice to preserve them at 4 °C.

The soil/sediment samples collected in jars from the soil cover and the South Coast Botanic Garden lake and stream programs were submitted for chemical analyses. The jars used for the samples were provided in a certified clean condition. The samples were placed in a cooler with ice to preserve them at 4 °C after collection.

2.5.1.2.3 Water

Various sample containers and methods of preservation were used for the water samples collected during the additional remedial investigation. Typically, large volumes of water were needed for each sample to allow for all of the chemical analyses required. To assure homogeneity, samples were either composited in a plastic or stainless steel container prior to distribution to the proper sampling containers, or discharged directly into all containers from a low-flow pump. The specific containers and preservation methods used for water samples during this program are shown on Table 2.5-1.

TABLE 2.5-1

SAMPLE CONTAINERS AND PRESERVATION FOR WATER SAMPLES

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

ANALYSIS	CONTAINER	PRESERVATION
Volatile Organic Compounds	1 - 125ml[1] amber glass VOA vial (no head space)	Cool to 4°C
Semi-volatile Organic Compounds	1 - 4 l amber glass jug with Teflon lined cap	Cool to 4°C
Metals (except hexavalent Chromium)	1 - 2 l disposable HDPE bottle	Cool to 4°C 4 ml nitric acid[2]
Hexavalent Chromium	1 - 250 ml disposable HDPE bottle	Cool to 4°C 1 ml 1:1 sulfuric acid
Inorganics[3]	1 - 1 l disposable HDPE bottle	Cool to 4°Conductivity,
Inorganics plus COD and BOD[4]	1 - 4 l amber glass jug with Teflon lined cap	Cool to 4°C
Total Kjeldahl Nitrogen	1 - 1 l disposable HDPE bottle 2 ml 1:1 sulfuric acid	Cool to 4°C
Cyanides	1 - 250 ml disposable HDPE bottle	Cool to 4°C 3-4 pellets sodium hydroxide
TOC	1 - 40 ml amber glass vial	Cool to 4°C 0.5 ml 1:1 sulfuric acid
TOX	2 - 150 ml amber VOA vials	Cool to 4°C 1 ml 1:1 sulfuric acid
Hydrocarbons by Modified 8015	1 - 1 l wide mouth glass jar with Teflon lined lid	Cool to 4°C
Oil & Grease	1 - 1 l wide mouth glass jar with Teflon lined lid	Cool to 4°C
Pesticides	1 - 1 l wide mouth glass jar with Teflon lined lid	Cool to 4°C
Dioxins and Furans	2 - 1 l disposable HDPE bottles	Cool to 4°C
Gross Alpha and Gross Beta Radioactivity	1 - 2 l disposable HDPE bottle	Cool to 4°C 4 ml nitric acid

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[1] Trip blanks were taken in one 40 ml clear glass VOA vial.

[2] Rainwater runoff samples and field filtered samples were not acidified in the field.

[3] Inorganics includes pH, alkalinity, conductivity, TDS, calcium, iron, magnesium, manganese, potassium, bicarbonate, carbonate, sodium, chloride, nitrate, sulfate, and sulfide.

[4] COD and BOD are performed on regular quarterly and semi-annual ground water samples, but were not performed on the first ground water sample from new wells.

2.5.1.3 Sample Labeling

A Sanitation Districts standardized sample labeling system was used to identify all samples collected during this investigation. A sample tag was affixed to each sample container. The tags used were either self-adhesive tags or tags with a reinforced hole for securing them to the sample container. The self-adhesive tags were applied directly to the sample container, and a piece of string or a plastic strip was used to secure the non-adhesive tags to the sample container, preferably to a closed loop (such as the handle on a stainless steel air sampling canister).

Basic information was included on the sample tag, such as the date, time of sample collection, field identification, and sampler name. The field identification consisted of either a number or a physical description of the sample location. For example, field identification for the surface flux chamber samples consisted of the sample location designation followed by a sequential letter-number combination (such as SF22-A004). Similarly, subsurface soil samples were identified by the boring number and the depth at which the sample was collected.

2.5.1.4 Sample Packaging and Shipping

Following sampling, the exterior of all sample containers were wiped clean with a moist cloth. In preparation for shipment to appropriate laboratory, the following procedures were followed:

- All container caps and valves were checked to make sure they were securely tightened. The liquid levels of water samples were marked with a permanent water-proof marker if the containers were partially full.

- The sample tags were checked to make sure that all writing was legible and that the tags were securely attached to the sample containers. Plastic film tape was used to protect the tags if there was a chance they could become water logged or damaged during storage or transport. Each sample set of VOA vials was placed in a sealable plastic bag.

- The sample containers were placed in the proper shipping containers. Tedlar bags and stainless steel canisters used to collect air samples were placed in cardboard shipping boxes. Soil/sediment and water samples were placed in ice-cooled containers lined with two inches of vermiculite or equivalent non-combustible, absorbent material. Any open space in the coolers was filled with supplemental packing material to minimize sample mobility during shipping.

- The completed chain-of-custody (COC) forms were placed in the shipping container. In coolers, the COC forms were placed in sealable plastic bags and taped to the inside of the lid.

- The containers were sealed with packaging tape, including the drain port of the coolers.

- The shipping labels on the containers were checked to make sure that all addresses and other information was legible and the labels were securely attached to the containers.

- All samples for organic analysis were shipped within 24 hours of collection and inorganic samples were shipped within 48 hours of collection. All samples were delivered to the appropriate laboratories via either a courier or next-day delivery service.

2.5.1.5 Sample Tracking

Each sample collected during the additional remedial investigations was tracked by manifesting all pertinent information on a COC form. Information including, but not limited to, sample number, location, matrix, sample type (blank, duplicate), collection time and date, number of containers per sample (if more than one), analyses to be performed, sampler's name, and general comments, such as weather conditions and date shipped, were listed on the form. When possession of the samples was transferred, the individuals relinquishing and receiving signed, dated, and noted the time on the COC form in the spaces provided. Samples were packaged and shipped as described in the previous section and dispatched to the appropriate laboratory, with a separate, signed COC form enclosed in each container.

The final signature on the COC form was either the chemist or other laboratory personnel receiving the samples, along with the date, time, and condition in which the samples were received. A copy of the final signed COC form was returned to the Sanitation Districts; they are reproduced in Appendix A.

2.5.2 Equipment Decontamination

All equipment that was employed during the remedial investigation, including drilling, geophysical logging, air, soil/sediment, and water sampling, water level measuring, and field testing equipment was cleaned prior to and after each use on this project. Decontamination consisted of steam cleaning, flushing with clean media, and washing, as appropriate for the equipment and sample type. No agents other than water, ultra pure air, ultra pure nitrogen, and non-phosphate detergent were used in the field during decontamination procedures. The following sections describe the specific decontamination procedures used for various types of equipment.

2.5.2.1 Drilling and Geophysical Logging Equipment

All drilling equipment was decontaminated prior to any drilling operations and between borings. The drilling auger, bits, drill pipe, and other equipment that went into the boreholes was delivered clean to the site. Between borings and at the completion of work, the equipment was decontaminated at an on site decontamination pad using a high-pressure, hot-water washer (steam cleaner). The decontamination pads utilized during the remedial investigations were constructed on the top deck of the PVLF and included facilities to catch any water generated during the cleaning process so that it could be handled in the proper manner.

Geophysical logging equipment was decontaminated prior to and after logging operations. The cable was cleaned by washing with a disposable soap-impregnated cloth, rinsed with fresh water, and rinsed again with distilled water upon removal from each borehole to avoid cross contamination.

2.5.2.2 Well and Lysimeter Materials

Well materials, consisting of casing, wire-wrap, continuous-slot screen, and sand were decontaminated prior to delivery at the site. The casing and screen were acid and detergent washed and wrapped in plastic prior to delivery. The sand was washed and furnished clean and free of oil, acid, organic matter, or other deleterious substances.

Lysimeter materials, consisting of a ceramic cup, casing, and flexible sampling tubing were decontaminated prior to delivery at the site. The ceramic cups were acid washed and rinsed with distilled water as described in Section 2.2.8. The casing and tubing were detergent washed or otherwise decontaminated prior to delivery to the site.

2.5.2.3 Air and Landfill Gas Sampling Equipment

The Tedlar bags used to collect air and landfill gas samples were flushed a number of times with ultra pure nitrogen to remove any contamination from the manufacturing process (for new bags) or from previous samples (for used bags). The procedures used for Tedlar bag decontamination are detailed in Appendix B.1. Stainless steel canisters, used to collect additional ambient air and landfill gas samples and surface flux chamber samples were decontaminated by the laboratory per the requirements of EPA Method TO-14.

The surface flux chamber was decontaminated where contact was made with the sampling surface by wiping the chamber with a clean paper towel and water (if needed) to remove any soil or moisture. The sample lines were purged with sweep air (ultra pure air) for one to two minutes.

2.5.2.4 Soil/Sediment and Water Sampling and Measurement Equipment

The equipment used to collect soil/sediment and water samples, and take field measurements, was decontaminated by washing in a mild non-phosphate solution, followed by a rinse in clean water, and double rinses in clean distilled water. These procedures are shown on Table 2.5-2. Split spoon samplers, brass and stainless steel rings, bailers, tapes (for water level measurements), and other small field equipment were decontaminated in this manner. Ground water sampling pumps and the attached lines were decontaminated by pumping five gallons of a mild non-phosphate solution through them followed by five gallons of distilled water. The outside of the pumps and lines were steam cleaned. Field testing equipment such as pH meters, conductivity meters, and others were decontaminated according to the directions supplied by the manufacturer. Sample containers other than brass and stainless steel rings were supplied by outside companies in a certified clean condition. After samples were collected, the outside of all sample containers were decontaminated by wiping the container clean with a cloth saturated with tap water, air drying, wiping the container with a cloth saturated in distilled water, and air drying again prior to packaging for shipment.

2.5.3 Field Instrument Calibration

Real-time gas analyzers were used in the field monitoring and sample prescreening. Both a flame ionization detector instrument (an organic vapor analyzer) a photo ionization detector instrument were used during the additional remedial investigations. Both pre- and post-use multipoint calibration (two points and zero) tests were performed daily on these instruments. Since these real-time data will not be used quantitatively, no acceptance criteria are required.

2.5.4 Field Quality Assurance/Quality Control Samples

To obtain confidence that the sample handling and decontamination procedures did not induce contaminants to the samples, and to verify the laboratory's ability to reproduce results for nearly identical samples, trip blanks, equipment blanks, and field duplicates were prepared and submitted to the laboratory along with the actual field samples. These QA/QC samples are described below.

2.5.4.1 Trip Blanks

Trip blanks provide a check on contaminants which may have originated from ambient air during sample handling and transportation activities, and/or in the laboratory. During the additional remedial investigations, trip blanks were included when water samples were collected in the field. Trip blanks were prepared by the Sanitation Districts' SJCWQL using certified organic free water

TABLE 2.5-2

STANDARD DECONTAMINATION PROCEDURES

PALOS VERDES LANDFILL - REMEDIAL INVESTIGATION REPORT

STEP 1: Scrub equipment thoroughly with soft-bristle brushes in a non-phosphate detergent solution.

STEP 2: Rinse equipment with tap water by submerging and/or spraying.

STEP 3: Double rinse equipment with distilled water; the final rinse by spraying until dripping.

STEP 4: Place equipment on plastic or aluminum foil and allow to air-dry for five to ten minutes.

STEP 5: Wrap equipment in plastic or aluminum foil for handling and/or storage until next use.

placed in 40 ml glass VOA vials. The trip blank was numbered, packaged, and sealed in an identical manner as the other water samples collected for volatile organic analysis. Trip blanks were included with water samples at a rate of one per day. They were then handled and transported in the same manner as other water samples for submittal to the laboratory for analysis.

2.5.4.2 Equipment or Field Blanks

Equipment, or field, blanks provide a check on the effectiveness of sampling equipment decontamination procedures. Equipment blanks were collected for air and water samples. The methods of collection for these two media are described below.

2.5.4.2.1 Air

An equipment bland was included with every ambient air sample set, which is equivalent to a rate of at least twenty percent. Equipment blanks for Tedlar bag sampling were prepared by the field technicians. Cleaned ten-liter Tedlar bags were issued to field technicians (delivered in boxes from the laboratory to the PVLF). The cleaned Tedlar bags were flushed and filled with ultra pure nitrogen just prior to the start of ambient air sampling. The equipment blank was then placed in the sampling unit along side the field sample during the entire sampling period. It was then transported with the field samples to the analytical laboratory, and analyzed for the same suite of compounds as the field samples. Equipment blanks for stainless steel canister sampling were supplied by the laboratory. An equipment blank consisted of a six-liter stainless steel canister filled through a flow controller over 24 hours with ultra high purity air in the laboratory. At the sampling location, the blank canister was affixed in the same way as the sampling canisters. A flow controller was not connected to the blank canister during monitoring, and the canister's valve was not opened. Prior to sampling, the blank canister and flow controller went through the same cleaning and calibration procedures as those used for primary samples.

During surface flux sampling, a blank sample was obtained by placing the clean chamber on a clean Teflon surface. A Teflon surface does not emit the gas species of interest for this program. The chamber was operated as described in Section 2.2.7 and a blank sample was collected. Three blank samples were collected, for a frequency of 9.4 percent. The blank samples were spread out over the period of the surface flux chamber testing to allow determination of whether any changes occurred that could affect sample integrity. For instance, new tubing and connectors could release chemical compounds at the beginning of a sampling program, which would then decrease over time. Alternatively, chemical compounds could adsorb to the sampling apparatus surface during the first part of a program and then desorb during the last part. In the first case, the samples collected at the beginning of the program could be affected by blank contamination while in the second case the samples collected at the end of the program could be affected. For this program, the first blank sample was collected at the onset of testing (pre-use blank test), the second was collected near the middle of the program, and the last was collected at the end of testing (post-use blank test). Blank levels were used to establish the system baseline. The results of the blank testing is included in Appendix B.1.1.

2.5.4.2.2 Water

Equipment blanks for water samples were prepared in the field at the end of each sampling day or after every ten samples by pouring de-ionized water through recently decontaminated sampling equipment. The samples were then placed in 125 ml amber glass VOA vials, sealed, labeled, and stored along with all other samples in an ice-cooled container. The equipment blanks were analyzed for the same VOCs as the other water samples.

2.5.4.3 Rinsate Blanks

Rinsate blanks, prepared for water samples only, provide an additional check on the effectiveness of equipment decontamination procedures. Rinsate blanks were prepared in the field at the end of each sampling day or after every ten samples by sampling the final rinse water from its container. The samples were then placed in 125 ml amber glass VOA vials, sealed, labeled, and stored along with all other samples in an ice-cooled container. The rinsate blanks were analyzed for the same VOCs as the other water samples.

2.5.4.4 Field Duplicates

Field duplicates are collected and analyzed to check combined sampling and analytical precision. Field duplicates are collected from the same location at the same time as the actual field sample, and numbered, packaged, sealed, and analyzed in an identical manner as the field samples. Field duplicates were collected for air, soil/sediment, and water samples. The methods of collection for these media are described below.

2.5.4.4.1 Air

Duplicate ambient air samples were obtained by collecting side-by-side samples in two Tedlar bags or stainless steel canisters. Each bag was supplied through separate sampling pumps; likewise, each canister was supplied through separate flow controllers. At least one duplicate was collected during each sampling event for a frequency of at least twenty percent.

Landfill gas sample duplicates were obtained by filling two Tedlar bags or stainless steel canisters, one immediately after the other. These samples were collected from sample ports on the landfill gas headers with a frequency of 25 percent or more.

Duplicate testing for surface flux chamber sampling was performed by conducting a second measurement immediately after a previous measurement. The surface flux chamber was removed and then placed back on the same location and retested. The frequency of duplicate sample collection was 12.5 percent. Two duplicates were collected at locations over the contaminated ground water area and two to the northeast of the landfill. The criteria for acceptable field precision is plus or minus 50 percent relative percent difference (RPD). These data were used to show similarities or differences in area source emission rate data, and are shown in Appendix B.1.1.

2.5.4.4.2 Soil/Sediment

Field duplicates for soil/sediment were analyzed to check sampling and analytical precision. However, due to the innate heterogeneity of most soil matrices, sampling precision tends to be much lower than analytical precision. In many applications, sampling precision is poor due to the difficulty of obtaining two field samples with the same properties. This can be the result of a soil matrix that is difficult to mix, or because the desired analyses prevent thorough mixing (such as VOC analysis). For this reason, field duplicates from the boreholes drilled as part of the remedial investigations were not collected.

Field duplicates were collected during the additional surface soil sampling program. Two sampling tubes were used to collect samples located immediately next to each other. These samples were then extruded from the tubes, thoroughly mixed, split, and placed back in the sampling tubes. They were numbered, packaged, sealed, and analyzed in an identical manner as the other soil cover samples. Field duplicates were collected at a rate of five to ten percent of the total number of soil cover samples collected.

2.5.4.4.3 Water

Field duplicates for water samples were analyzed to check sampling and analytical precision. Field duplicates of water were collected from the same location and at the same time as the actual field sample, and numbered, packaged, sealed, and analyzed in an identical manner as the other water samples. Field duplicates were collected at a rate of five to ten percent of the total number of water samples collected.

2.5.4.5 Split Samples

Split samples, which are essentially field duplicates analyzed at different laboratories, were performed at a rate of ten percent for samples that were analyzed at Sanitation Districts laboratories. Both soil/sediment and water samples were split by the SJCWQL sample receiving personnel and sent under chain of custody protocol to certified outside laboratories. The difficulties with transferring and measuring a portion of an air sample preclude splitting these samples.

In addition, split samples were made available to DTSC at a rate of ten percent for all soil/sediment and water samples. These samples were stored on ice at the site along with the other samples collected during the program. DTSC personnel picked up a number of these samples; however, towards the end of the additional drilling program the Sanitation Districts were requested by DTSC to send this split sample to outside laboratories. The final few DTSC split samples were therefore collected and treated as another outside laboratory split sample by the Sanitation Districts. These results are included with the rest of the QA/QC results in Appendix B.

2.5.5 Laboratory Quality Assurance/Quality Control Samples

As a check on the quality and reliability of the laboratory analytical equipment and procedures, laboratory blanks and matrix spike/matrix spike duplicates were prepared and analyzed. The results from blank samples and duplicate samples were also used to assist in interpreting the field data collected. Where QA/QC results may impact the interpretation of field sample results, the appropriate QA/QC flag has been included in the analytical results found in Appendix A and in the discussion of the results in Section 3.0. The laboratory QA/QC procedures are described below.

2.5.5.1 Laboratory Blanks

Laboratory blanks are run on a regular basis to check for laboratory equipment contamination. Laboratory blanks were required for all sample media, as discussed below.

2.5.5.1.1 Air

Laboratory blanks, called method blanks or system blanks, are laboratory-generated samples which assess the degree to which laboratory operations and procedures cause false-positive analytical results for field samples. Laboratory blanks for the Tedlar bag programs are run weekly to check that the gas chromatograph system has not become contaminated. This is essentially a temperature program run performed without introduction of any material into the instrument. Laboratory blanks for stainless steel canister programs were performed at a rate of one for every batch of ten.

Compounds found at low levels in the laboratory, or method, blank tests were compared to the results from the field analyses, but were not baseline subtracted from the field data. Typically, low levels (sub-ppbv to ppbv) of compounds such as trichloroethylene, toluene, xylene, benzene, and 1,1,1-trichloroethane are observed in the laboratory blanks. The source of these VOCs is usually the Teflon tubing used in the sampling equipment or the canister. During the surface flux chamber testing, two of the eight target compounds were found in method blank analyses. These compounds were trichloroethylene and p-dichlorobenzene. It should be noted that EPA Method TO-14 allows up to 0.2 ppbv per species and 2.0 ppbv total in clean canisters.

The results from the method blanks are shown in Appendix B.1.

2.5.5.1.2 Soil/Sediment and Water

Laboratory blanks, sometimes called reagent blanks, were run to check for contamination in the laboratory equipment. Any contamination present could be indicative of improper laboratory decontamination procedures. The laboratory blanks were prepared by extracting and analyzing deionized water. Laboratory blanks were run at a rate of ten percent for both soil/sediment and water samples.

2.5.5.2 Laboratory Matrix Spike/Matrix Spike Duplicates

Since the sample matrix (air, soil/sediment, or water) may have an impact on the accuracy and precision of the laboratory results, matrix spikes were performed to evaluate the efficiency of the sample extraction and analysis procedures. A matrix spike is prepared by adding known concentrations of target compounds to an aliquot of a field sample, and then extracting and analyzing the sample to see if the known concentrations were detected. The recovered target compounds must fall within an acceptable range of their original concentrations for the results to be considered valid. Matrix spikes were run twice (duplicates) to evaluate both the precision of the laboratory procedures as well as the accuracy of the equipment. Matrix spikes/matrix spike duplicates were run at a rate of ten percent of the total number of samples for soil/sediment and water samples analyzed at the laboratory during the remedial investigations. Since it is difficult to spike an air sample with the required accuracy and precision, laboratory duplicates only were analyzed for air. These results are documented in Appendix B.1.

2.5.5.3 Canister Blanks

The confirmation of certified clean canisters was performed by blanking the canisters, that is, performing an analysis of humidified zero air after cleaning the canisters. The methodologies for this procedure are set forth in EPA Method TO-14. This blank check was performed at a rate of ten percent. The acceptance criteria for clean canisters is less than 0.2 ppbv of each target compound.