FINAL REPORT

STUDY OF POTENTIAL WATER QUALITY IMPACTS ON MALIBU CREEK AND LAGOON FROM ON-SITE SEPTIC SYSTEMS

Prepared for
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This report has been prepared by URS Greiner Woodward Clyde (URSGWC) in accordance with the City of Malibu's request for proposals dated August 5, 1996, and Woodward-Clyde's proposal to the City dated September 13, 1996 and subsequently revised December 23, 1996.

1.1 SITE BACKGROUND

As shown on Figures 1-1 and 1-2, Malibu Lagoon is bounded by the Pacific Ocean and the Malibu Colony residential area to the south, a private golf course and the Cross Creek Plaza commercial center to the west, and the Sierra Retreat residential area and the historic Adamson House to the east. Malibu Creek flows into the lagoon from the north.

In the past, the lagoon is reported to have supported a significantly larger ecosystem than the one presently found (Manion and Dillingham, 1989). With modern development during the twentieth century, the ecological condition of the lagoon declined. During this time the lagoon and adjacent land were used as a general fill site, a Caltrans dumpsite, and an area of urban development. The area of the lagoon was expanded in 1983 when the California State Department of Parks and Recreation excavated three channels and established a mud-flat on the west side of the lagoon.

In 1996, an epidemiological study (Haile, R. W. et al., 1996) found that Malibu Surfrider Beach (the beach seaward from the lagoon) was consistently polluted with fecal microorganisms present in the lagoon water discharge. The lagoon discharges to the beach when the natural sand berm barrier breaches by overflow from the lagoon. One of many potential sources of lagoon contamination is the septic tanks and leachfields adjacent to the lagoon. This report presents the results of a study that was conducted by *URSGWC* to investigate the potential for fecal microorganisms from on-site septic systems to impact Malibu Creek and lagoon.

In order to evaluate subsurface migration of septic effluent, and the potential for the effluent to enter the lagoon, two study areas and three storm drain outfalls were investigated. Figure 1-2 shows the locations of the study areas and storm drain outfalls.

The study areas identified for this assignment are the Malibu Lagoon/Colony area and the Cross Creek Plaza commercial center. These study areas were chosen because they are adjacent to the lagoon and may contribute septic effluent that could impact the lagoon. For this investigation, monitoring wells were located in both study areas to evaluate the potential for effluent and pathogenic microbes from septic systems to reach the lagoon.

The Malibu Lagoon/Colony area is to the south and southwest of the lagoon (Figure 1-2). This area was chosen for study because of its close proximity to the lagoon and density of residential septic systems in the Colony. The Colony area currently contains ten houses on the north side of Malibu Colony Drive directly adjacent to the lagoon and twenty-six houses on the south side of Malibu Colony Drive directly adjacent to the ocean but near the lagoon. Houses in the Colony have individual on-site septic systems.

The Cross Creek Plaza commercial center (Plaza) is located on the northeast corner of Pacific Coast Highway and Cross Creek Road, and is northwest of Malibu Lagoon (Figure 1-2). The Plaza was chosen for study because large discharges of septic effluent are applied to the substratum near the lagoon at this location. The Plaza consists of numerous shops and restaurants and currently produces an average of approximately 7,000 gallons per day of septic effluent (Biosolutions, pers. com.). This flow is discharged to leachfields located under the Plaza's parking areas at the locations shown on Figure 1-2. The Plaza's leachfields typically consist of approximately 1.5 to 3 feet of 1.25-inch gravel fill, overlain by a 20-inch cover of site soils and topped with asphalt.

A portion of the Plaza's wastewater system was recently upgraded with the installation of a biomechanical pretreatment system including a dosing/surge tank and a centralized remote telemetry and control system. This portion of the wastewater treatment system consists of nine soakage areas divided into 7 zones. Approximately two-thirds of the Plaza's effluent passes through the upgraded system, and designated zones are micro-dosed on an hourly basis while inactive zones are rested. A typical wastewater loading scenario would be three active zones with a micro-dosing rate of about 68 gallons per hour. The remaining third of the Plaza's septic effluent is directed to the existing leachfields in the northwest of the Plaza complex.

Three storm drains that outfall to the lagoon were also investigated. Sediment and water samples at the outfalls were obtained and analyzed for evidence of septic effluent contamination. The three storm drain outfalls are identified in Figure 1-2.

1.1.1 Previous Soil and Groundwater Studies

Soil and groundwater conditions in and near the study areas have been investigated previously by other consultants for purposes other than those identified for this study. One of the previous investigations was conducted to characterize an underground gasoline spill in the Plaza study area and in the State Parks and Recreation property immediately south of Pacific Coast Highway (W.W. Irwin Inc., 1994). That investigation included drilling 9 shallow soil borings from 7 to

15 feet deep and 5 groundwater monitoring wells approximately 30 feet deep. The investigation found that soils in the Plaza area consist mostly of silty sand, sand, and clayey sand, and that the water table was about 6 to 7 feet below ground surface. Preferential gasoline migration was identified to the east, along a storm drain that discharges to the lagoon at the southeast corner of the Plaza. The groundwater gradient was not estimated from the monitoring wells.

Apex Environmental Recovery, Inc. (1993) conducted subsurface investigations in the soils beneath the Malibu Lagoon Bridge on Pacific Coast Highway. Those investigations were conducted to characterize chemical constituents in the soils prior to construction activities. Five borings were drilled on the west bank of the lagoon beneath the bridge, three hand auger borings were advanced to approximately 4 feet below ground surface, and two groundwater monitoring wells were installed to approximately 27 feet below ground surface. Soils were found to consist of silty sands to 17 feet below ground surface, underlain by silty gravel below that depth. The groundwater gradient was not estimated from the monitoring wells.

In 1990, Dames and Moore conducted a subsurface investigation for the property at 3728 Cross Creek Road. This property is approximately 500 feet north of the Plaza site. The study was conducted to characterize an underground hydrocarbon spill at the property. Four groundwater monitoring wells were installed to 20 feet below ground surface. Soils were found to consist of sands, silty sands, clayey sands, and sandy gravels. The groundwater gradient was estimated to be toward the south-southeast.

1.2 OBJECTIVES OF STUDY

The primary objective of the study is to assess the potential for transport of septic effluent, microorganisms, and nutrients, from on-site septic systems to the lagoon. Specifically, investigations have been undertaken to:

- Characterize soil types in the study areas
- Characterize the hydrology of the study areas
- Analyze sediment and groundwater samples to evaluate indication of septic discharge from storm drain outfalls to the lagoon
- Evaluate whether on-site septic systems are hydraulically connected to the lagoon, and
- Evaluate the potential for effluent from on-site septic systems to reach groundwater and be transported to the lagoon.

1.3 APPROACH TO THIS STUDY

In order to meet the study objectives, a review of available existing information relevant to the project has been completed, and, as needed, additional field investigations have been undertaken. Work conducted for this study followed the procedures outlined in Woodward-Clyde's Project Implementation Work Plan dated August 4, 1997.

Hydrogeologic characteristics of the site materials were investigated based on existing geologic data, and by drilling 11 boreholes at the locations identified on Figure 1-2. The drilling program is described in Section 3.1 of this report. Groundwater monitoring wells were installed in each borehole and subsequently used for groundwater sampling, aquifer testing, and groundwater transport studies.

In order to establish groundwater flow directions within the study area, groundwater levels in select wells were monitored over time with pressure transducers connected to data loggers. Groundwater level data were also obtained from measurements taken periodically with an electronic water level probe. Ocean tide data was retrieved from published NOAA tidal information for Santa Monica Bay.

Slug tests were performed on selected groundwater monitoring wells to provide an estimate of the hydraulic conductivity of the water bearing strata adjacent to the slotted screen of the wells. These data are used to estimate an average rate of groundwater flow in the test areas.

Groundwater and soil samples were collected and tested for indications of anthropogenic impacts. Samples of groundwater were collected from monitoring wells and analyzed for general minerals, nutrients, indicator bacteria, and for sterols and linear alkylbenzenes (LABs) which are indicators of fecal matter and industrial contamination, respectively. Sediment samples were collected at the outfalls of three storm drains that discharge to Malibu Lagoon. These soil samples were analyzed for sterols, LABs, and pathogens.

In order to more accurately estimate groundwater transport properties in the vicinity of the Cross Creek Plaza study area, and to estimate potential virus transport rates, concentrations, and viability over time, a bromide tracer test followed by a coliphage seeding test were undertaken. The bromide tracer test involved the instantaneous injection of a known concentration of sodium bromide solution into a groundwater monitoring well, and the subsequent monitoring of bromide levels in neighboring wells. A second bromide tracer test was conducted to assess the hydraulic connection between the tested leach field and monitoring wells in the Cross Creek Plaza study

area. For this test a known concentration of sodium bromide solution was added to the septic system with subsequent monitoring for bromide in neighboring wells.

The coliphage seeding test was conducted approximately one month following the bromide tracer test in order to reduce the impact of unnaturally high salt concentrations which may affect coliphage adsorption rates. The coliphage seeding test was conducted in conjunction with Dr. Charles Gerba from the University of Arizona Microbiology & Immunology and Soil, Water & Environmental Science Department (UOA). The seeding test involved flushing a suspension of the coliphage PRD-1 into the Cross Creek Plaza effluent field through a toilet, and metering the coliphage MS-2 into a groundwater monitoring well at the southeast corner of the southern leachfield at Cross Creek Plaza. Monitoring of neighboring wells was conducted to estimate virus transport and viability in the subsurface.

Field test methods are described in Section 3 of this report. The results of the field testing are presented in Section 4. Section 5 contains a discussion of the results as they pertain to the objectives of the study along with concluding remarks. References cited in this report are included in Section 6 and supporting documentation is included in the attached Appendices.

2.1 TOPOGRAPHY

The Cross Creek Plaza and Malibu Lagoon/Colony study areas are located within the broad low-lying (less than 25 feet above mean sea level; msl) alluvial plain at the mouth of Malibu Creek. Moderately steep to steep dissected slopes border the alluvial plain to the north, east, and west. Ground surface elevations within the study area are shown on Figure 1-2, and are about 5 to 11 feet above msl across most of the site. A re-created mud flat is present south of Pacific Coast Highway that includes several small islands connected by a causeway.

The Colony study area is bounded to the north by Malibu Lagoon and to the south by the Pacific Ocean. Colony property boundaries extend to within about 60 feet from the lagoon

2.2 GEOLOGY

Dibblee (1993) indicates that Holocene-age flood plain materials consisting of alluvial gravel, sand, and clay (see Figure 2-1) underlie the study area. The Malibu Creek channel is mapped as Holocene-aged gravel and sand. Holocene-age beach sands are shown along the current foreshore, extending inland to about the boundary of Malibu Colony.

Dibblee (1993) maps the moderately steep to steep ground surrounding the alluvial plain as a mix of Tertiary-aged igneous and sedimentary materials. Several, concealed, east-west striking faults are projected below the alluvial plain to the north of the Cross Creek Plaza Study Area. Geologic observations completed during this study are consistent with the geology described by Dibblee (1993).

2.3 SURFACE AND SUBSURFACE FACILITIES

The Cross Creek Plaza area consists of retail businesses surrounded by an asphalt-surfaced parking area. Minor unsurfaced and planted areas are also present within the Plaza complex. An on-site wastewater septic system with leachfields, as described in Section 1.1, is present below the parking area. Plaza leachfields are setback from the lagoon a distance of at least 200 feet.

Underground storm drains are present at the site. Known storm drain discharges to Malibu Lagoon are shown on Figure 1-2 (OF-1, OF-2 and OF-3). The storm drains are referenced by Warshall and Williams (1992) as the Civic Center Drain (OF-1), Cross Creek Road Drain (OF-2), and the Malibu Colony Drain (OF-3). The Civic Center Drain collects runoff from much of the flood plain and the steep hill slopes between the Civic Center and Malibu Canyon Road.

The Cross Creek Drain receives runoff from the area between the Civic Center drain, PCH, and the Lagoon. The Malibu Colony Drain originates at the corner of Webb Way and Malibu Road and directs flows eastward along the northern edge of Malibu Colony under the southern edge of the golf course. Other known underground services within the Plaza area include water, electric power, and cable television.

A gasoline service station is present at the southwest corner of the Plaza. The service station maintains underground fuel storage tanks (UST's) and an underground waste-oil tank.

The Malibu Colony study area consists of large single-family houses with associated garden and recreation areas. These houses have individual on-site wastewater septic systems with leachfields. Based on existing data, Colony leachfields are setback from the lagoon a distance of at least 75 feet.

2.4 WASTE-WATER DISPOSAL

The average daily wastewater flow from the Cross Creek Plaza is approximately 7,000 gallons (Biosolutions pers. com). Effluent is discharged to leachfields located below the Plaza's parking area (as shown on Figure 1-2).

No wastewater flow data is available for homes in the Malibu Lagoon/Colony study area, however, assuming a four person occupancy and an average daily wastewater flow of 50 to 82 gpd/person (Tchobanoglous, 1979) for each of the 36 houses in the Colony study area, an effluent discharge ranging from 7,200 to 11,800 gpd is estimated for the Colony area.

3.1 DRILLING AND GROUNDWATER MONITORING WELL CONSTRUCTION

As part of the investigation 11 hollow-stem auger boreholes were drilled to depths ranging from 12.5 to 16.5 feet below ground level (bgl). The locations of the boreholes are shown on Figure 1-2. A summary of the drilling program is shown in Table 3-1. Split-spoon Standard Penetration Tests (SPT's) were performed at approximately 5-foot intervals during drilling and soil samples representing the different soil types observed were retained for laboratory analysis. A URSGWC geologist logged the boreholes during drilling. Copies of the borehole logs are in Appendix A.

Groundwater monitoring wells were installed in each of the boreholes following drilling. Construction details for the wells are shown on the borehole logs. Following construction, each well was developed in order to clear the well and filter pack of fine-grained sediments. Development consisted of vigorously bailing the wells until the quantity of suspended sediment in the bailed water had significantly reduced and at least 3 well volumes of water had been removed. The wells were surveyed by a licensed land surveyor for vertical and horizontal position.

Select soil samples were analyzed in URSGWC's soils laboratory. Analyses were undertaken to estimate the particle size distribution in accordance with ASTM D 422-63, "Standard Test Method for Particle-Size Analysis of Soils" (ASTM 1996). Results of the particle size distribution analyses are included in Appendix B.

3.2 GROUNDWATER LEVEL MEASUREMENTS

Groundwater level measurements were taken in each of the wells with an electronic water level probe following well development, and at each well prior to groundwater sampling. In addition, data loggers with pressure transducers were used in wells P-1, P-2, and P-7 for long-term groundwater level monitoring. Water levels were recorded in these three wells at hourly intervals from August 31, 1998 to December 1, 1998.

3.3 HYDRAULIC CONDUCTIVITY TESTS

Slug tests were performed on wells P-2, P-3, P-4, P-5, and P-6 in order to estimate the hydraulic conductivity of the water-bearing strata adjacent to the slotted casing in these wells, and to evaluate the variability in hydraulic conductivity between well locations. Slug testing induces a relatively instantaneous stress within the water-bearing sediments, resulting in an increase or decrease in water level. The resulting return rate in water level to static conditions enables an

estimation of hydraulic conductivity. Because the induced hydraulic stress occurs within the sediment up to several feet from the well casing, at best, the resulting hydraulic parameters are specific to the zone(s) directly adjacent to the tested well.

Rising head slug tests were performed by inserting a solid mandrel (representing a "slug" or volume of water) into the well casing such that the mandrel was immersed in the water. Prior to inserting the slug into the well casing, the depth to static water level was measured using an electronic water level probe, and a pressure transducer was placed in the well near the bottom of the well casing and connected to an data logging device. Once the water level had recovered to near static water level, the data logging device was activated and the mandrel was quickly removed from the well casing to provide an "instantaneous" drop in water level. As the water level rose, the pressure transducer provided continuous water level measurements that were recorded with the data logger. Periodic measurements of the water level in the well casing were also made manually and recorded in a field log book. Once the water level had recovered to within 80% of the initial static water level, the test was terminated.

Analysis of the slug test data was made using the empirical relationships developed by Hvorslev (1951), that describe the water-level response in an unconfined aquifer resulting from the instantaneous injection or withdrawal of water from a well. This solution assumes that the unconfined aquifer has infinite extent, both horizontally and vertically, is homogeneous, the aquifer potentiometric surface is initially horizontal, a volume of water is instantaneously discharged from the well, and that steady-state conditions are present in the aquifer.

Hydraulic conductivity is also back calculated from apparent flow velocity measurements made during the bromide tracer and coliphage seeding tests. The slug test results are compared to hydraulic conductivity estimated by back calculating flow velocity measurements. These results are used to evaluate potential pathogen transport in groundwater.

3.4 GROUNDWATER SAMPLING FOR WATER QUALITY INDICATORS

During the course of this study groundwater samples were collected from each well, except well P-8, and analyzed for selected indicator bacteria, nutrients and general minerals. These samples were collected with either a dedicated PVC bailer, or a down-hole submersible pump that had been decontaminated prior to placement in the well. Before being sampled, the wells were purged by removing at least three well volumes of water from the well. Purged groundwater was monitored for pH, electrolytic conductivity, and temperature. Groundwater sampling and chain-of-custody procedures followed the protocols presented in Woodward-Clyde's Project

Implementation Work Plan (1997). Groundwater samples were also collected from wells P-2 through P-5, P-8 and P-9 during the bromide tracer and coliphage seeding tests as described below in Sections 3.6 and 3.7.

3.5 SEDIMENT SAMPLING

Sediment samples were collected from storm drain outfalls OF-1, OF-2, and OF-3 (Figure 1-2). Two sediment samples were collected at the mouth of each outfall. Samples were collected using a California-modified sampler and a trowel. One sediment sample collected from each of the outfalls was submitted to Dr. Indira Venkatesan at the University of California-Los Angeles (UCLA) for analyses of sterols and LABs using gas chromatography/mass spectrometry (gc/ms). The second sample was submitted to an accredited laboratory for microbial assays.

3.6 BROMIDE TRACER TESTS

URSGWC staff initiated a bromide tracer test on September 16, 1998. The test procedures can be summarized as follows:

Water level measurements and baseline water quality samples were collected from wells P-2, P-3, P-4, and P-5 prior to commencing the test. A submersible electric pump was installed near the base of well P-4 to induce a hydraulic gradient between wells P-2 and P-4, and to facilitate groundwater sampling. This gradient was intended to apply additional stress to the natural groundwater flow potential towards Malibu Lagoon. A pressure transducer was installed near the base of well P-2 and attached to a data logger in order to monitor the water level in this well.

At the start of the test, the pump in well P-4 and the data logger in well P-2 were activated and 4 liters of sodium bromide solution were added to well P-2. Groundwater samples were collected at specified times from wells P-2 using a dedicated PVC bailer and P-4 directly from the pump discharge until completion of the test (approximately 20 hours).

Groundwater level measurements were taken periodically in wells P-2, P-3, P-4, and P-5 during the test with an electronic water level probe. The rate of pumping at well P-4 was periodically measured with a bucket and stopwatch. At the completion of the test the submersible pump was disconnected and removed from well P-4.

Collected samples were chilled and dispatched to the analytical laboratory under standard URSGWC chain-of-custody procedures. Samples were analyzed at the laboratory for bromide concentration.

A second bromide tracer test was initiated on March 16, 1999 and continued to April 23, 1999. This test was conducted to assess the hydraulic connection between the Cross Creek Plaza wastewater disposal system, the test leach field and nearby monitoring well P-2.

At the start of the test, a known concentration of sodium bromide was added directly to the wastewater disposal system's septic tank. The system was operated in a manner that directed the flow from the septic tank to the test leach field. Groundwater samples were collected at specified times from wells P-2 and P-4 using a dedicated PVC bailer. Collected groundwater samples were chilled and delivered to the analytical laboratory for bromide analysis. Standard URSGWC chain-of-custody procedures were followed for the handling of the collected samples.

3.7 COLIPHAGE SEEDING TEST

The coliphage seeding test was conducted by URSGWC, in conjunction with Dr. Charles Gerba from UOA. The test was initiated on October 26, 1998 and continued until December 1, 1998. The test methodology was developed in conjunction with UOA.

Water level measurements and baseline water quality samples were collected from wells P-2, P-3, P-4, and P-5 prior to commencing the test. A peristaltic pump was installed near P-2 to enable controlled dosing of the coliphage MS-2 into this well. A submersible electric pump was installed near the base of well P-4 to induce a gradient between wells P-2 and P-4 as in the bromide tracer test. An initial concentration of $1x10^{14}$ MS-2 was added to 2 liters of water from well P-2.

At the start of the test, the pumps associated with wells P-2 and P-4 were activated and MS-2 dosing commenced at a rate of 10 ml/min. for 3 hours for a total addition of 1.8 liters. Five minutes after the commencement of the test, 1 liter of water with $2x10^{10}$ PRD-1 was flushed down a toilet in a restaurant located approximately 150 feet north of well P-2. Wastewater from this toilet was conveyed to the Cross Creek Plaza wastewater disposal system where it discharged to the test leach field.

Groundwater samples were collected at specified times from wells P-2, P-3, and P-5 using a dedicated PVC bailer and from P-4 at the pump discharge. A known volume of Tryptacase Soy

Broth, supplied by UOA, was added to the samples as a preservative. After approximately 51 hours, the pump in well P-4 was removed. Groundwater sampling continued using dedicated PVC bailers until December 1, 1998, at which time sampling ceased.

Collected samples were chilled and express mailed to UOA's analytical laboratory in accordance with standard URSGWC chain-of-custody procedures. Samples were received at UOA's laboratory in a chilled state within 72 hours of collection.

4.1 HYDROGEOLOGIC CHARACTERISTICS

Detailed logs for the boreholes are included in Appendix A. Field investigations indicate minor amounts of fill soil in the areas investigated up to depths of 2.5 feet bgl. Where observed, the fill soils typically consist of reworked sandy silt, silty sand, and sandy gravel underlying an asphalt surface. A layer of clayey or sandy silt is typically present across the study area to depths ranging from 4.0 to 9.0 feet bgl (the exception was location P-1 where silty and sandy gravel is present to a depth of 16.5 feet bgl). Beneath the silt layer, coarser grained silty sand and sandy gravel soils are present to the maximum depths drilled (between 12.5 and 16.5 feet bgl). Cobbles up to 4 inches in diameter were observed from this lower zone. These observations are consistent with the published data for the area (Dibble, 1993; Apex Environmental Recovery, Inc., 1993; W. W. Irwin Inc., 1994; and Dames and Moore, 1990).

Based on the recorded blow counts from SPT testing, the granular soils encountered range from loose to dense, and the cohesive soils range from medium stiff to very stiff (U.S. Bureau of Reclamation, 1960; see boring logs in Appendix A). Particle grain size analyses indicate the materials sampled range from silty sand to well graded sands with silt and gravel (Appendix B).

At depths of about 6 to 10 feet bgl, groundwater was observed during drilling and the soils became wet. Groundwater levels measured in the monitoring wells indicate piezometric levels approximately 5 to 7 feet bgl.

Rising-head slug tests indicate the saturated soils tested range in hydraulic conductivity from 0.6 feet/day to 4.1 feet/day. Results of the hydraulic conductivity tests are shown in Table 4-1. Slug test data are presented in Appendix C.

4.2 GROUNDWATER LEVEL

Groundwater levels measured in the monitoring wells installed during the course of this investigation indicate piezometric levels at the site in the order of 5 to 7 feet bgl (Table 4-2). Data from pressure transducers and data loggers installed in several of the wells during the study indicate a tidal influence on groundwater levels (Figure 4-1). Monitoring wells P-2 and P-7, located near the lagoon, show maximum water level amplitudes in the order of 0.5 feet during tidal cycles. The tidal influence appears somewhat attenuated at monitoring well P-1, located upgradient from the Cross Creek Plaza and further from the lagoon, with a maximum water level amplitude in the order of 0.25 feet. The water level data indicate peak tide levels above those recorded at P-2 and P-7, however, P-2 consistently maintains a higher water level than P-7

suggesting groundwater flow towards the lagoon is maintained throughout these periods. (Note: Well P-2 is screened below the edge of a Plaza leachfield, which is dosed at hourly intervals when on-line. Water level data collected at P-2 during this investigation did not show rises in water level due to periodic recharge of wastewater.) The amplitude of variations in observed water levels also corresponds to lunar phase with a maximum of 1.3 feet difference occurring between the highest high tide and the lowest low tide observed during the monitoring period (Figure 4-1).

Water level measurements from the wells installed in the Plaza study area indicate a groundwater gradient between wells P-1 and P-3 of 0.0015 ft/ft (i.e. 0.45 feet of drop per 100 yards) and between P-3 and P-6 of 0.0014 ft/ft (i.e. 0.42 feet of drop per 100 yards). Long-term monitoring of water levels indicates an overall groundwater gradient during high tides of 0.002 ft/ft (i.e. approximately 0.6 feet of drop per 100 yards) to the southeast. At low tides the gradient steepens slightly to 0.003 ft/ft (i.e. 0.9 feet of drop per 100 yards) and the flow direction shifts to the east-southeast.

Groundwater flow along the northern portion of the Colony study area, based on water level data at C-1 and C-2 and concurrent lagoon level, is to the north with a hydraulic gradient of about 0.017 ft/ft (i.e. 5.1 feet of drop per 100 yards). This hydraulic gradient is anticipated to steepen with ebbing tides and flatten with waxing tides.

4.3 GROUNDWATER CHEMISTRY (GENERAL MINERALS)

General mineral analyses from collected groundwater samples are summarized in Table 4-3 and shown on a Piper tri-linear diagram in Figure 4-2. Laboratory results reports are contained in Appendix D.

Groundwater from well C-1, located approximately 60 feet from Malibu Lagoon, has a relatively elevated sodium and chloride concentration compared to the other sampled groundwater. Groundwater from well P-1, located upgradient of the Plaza effluent disposal system and approximately 500 feet from the lagoon, is enriched in magnesium sulfate. Groundwater from well P-6, located near the storm drain identified as OF-2 and its tidal channel, contains slightly elevated sodium and chloride concentrations. In the remainder of the samples analyzed no cation/anion relationship was dominant.

4.4 ANTHROPOGENIC INDICATORS IN SEDIMENT AND GROUNDWATER

The laboratory report tables in Appendix D present the results of sediment samples collected at the storm drain outfalls. These samples were analyzed for sterols, LABs, and selected indicator bacteria. Seven (7) sterols were analyzed including coprostanol and epicoprostanol which are sterols derived from fecal matter. These results are shown on Table 4-4a. Coprostanol was detected in the sediment samples at concentrations ranging from 0.22 micrograms per gram (µg/g) to 0.4 µg/g of dry soil with the highest concentration detected in the sample at the outfall of the Cross Creek Road Drain (OF-2). Epicoprostanol was detected in the sediment samples at concentrations ranging from trace levels to 0.18 µg/g of dry soil. The highest concentration of epicoprostanol detected, was also in sample OF-2 from the Cross Creek Road Drain.

Twenty-one (21) LABs were analyzed and the results include the ratio of internal to external substituted LAB isomers (I/E Ratio). LAB concentrations ranged from not detected to 0.16 nanograms per gram (ng/g) of dry soil in the sample from the Civic Center Drain (OF-1). The I/E ratio for this sample is 0.0. The sample from the Cross Creek Road Drain Outfall (OF-2) contained LAB concentrations that ranged from not detected to 21.36 ng/g of dry soil with an I/E ratio of 0.85. Sample OF-3 from the Malibu Colony Drain outfall contained LAB concentrations that ranged from not detected to 5.45 ng/g of dry soil. The I/E ratio for this sample is 0.0. The LAB results are presented on Table 4-4b.

Microbial analyses were conducted to estimate enterococcus, fecal coliform, and total coliform concentrations. Enterococcus was detected in the sediment samples at concentrations ranging from 43 MPN/g (most probable number per gram) to 430 MPN/g with the sample from the Cross Creek Road Drain Outfall (OF-2) containing the highest concentration. Fecal coliform were below the detection limit in the sediment samples while total coliform ranged from 160 MPN/g to 11,000 MPN/g. The highest concentration of total coliform was detected in the sample from the Malibu Colony Drain Outfall (OF-3). Results of the microbial analyses are shown on Table 4-4c.

Groundwater samples collected from wells P-1, P-6, P-7, C-1 and C-2 were analyzed for microbial content and nutrient concentrations. Microbial analyses were conducted by VOC Analytical to estimate enterococcus, fecal coliform, and total coliform concentrations in the groundwater samples from these wells. Enterococcus ranged from less than 2 MPN/0.1L to greater than 1,600 MPN/0.1L in the water samples collected from wells and the lagoon. Fecal coliform detected in the water samples ranged from 23 MPN/0.1L to greater than 1,600 MPN/0.1L. Total coliform was detected in the water samples ranging from 80 MPN/0.1L to

greater than 1,600 MPN/0.1L. The lagoon sample collected near the Malibu Colony Drain Outfall (OF-3) contained the highest concentrations of the indicator bacteria. The water sample from well C-1 contained the highest concentrations of indicator bacteria for samples collected from monitoring wells. The results of the indicator bacteria testing are shown on Table 4-5.

Nutrient analyses were completed at UCLA for nitrate, total nitrogen and total phosphate. Detected nitrate concentrations ranged from not detected to 9.37 mg/L. Total nitrogen concentrations detected in the water samples ranged from 1.57 mg/L to 11.87 mg/L. Total phosphate concentrations detected in the water samples ranged from not detected to 0.77 mg/L. The higher concentrations of nitrate and total nitrogen were detected in the samples from well P-1. The highest concentration of total phosphate was detected in a sample from well C-2. The results of these analyses are presented on Table 4-3.

4.5 BROMIDE TRACER TESTS

The bromide breakthrough curve for well P-4 is shown in Figure 4-3. Well P-4 is 11.5 feet from well P-2. The breakthrough curve indicates peak bromide concentrations occurred at P-4 between 10 and 18 hours after injection (Figure 4-3; Table 4-6). A 4-percent bromide solution was injected in P-2 at the start of the test. The peak bromide concentration recorded in P-4 was 2 percent of the concentration at the point of injection at the start of the test. The bromide velocity between P-2 and P-4 induced by the pumping of well P-4 was between 15 and 28 feet/day.

A second bromide tracer test was conducted to test the hydraulic connection between the Cross Creek Plaza wastewater disposal system, the test leachfield, and well P-2. Sodium bromide was added to the system's septic tank on March 16, 1999 and water samples were collected from well P-2, one, three, and 38 days later. The samples collected one and three days following seeding of the septic tank contained bromide concentrations of 0.35 mg/L and 0.56 mg/L, respectively. These values are comparable with other background levels detected in the study area at different times and in different wells. The sample collected 38 days after the bromide test was initiated contained 10.3 mg/L bromide which is well above identified background levels.

4.6 COLIPHAGE SEEDING TEST

The coliphage seeding test allowed estimation of the coliphage transport rate between the injected well and adjacent wells. The well dosed with MS-2 coliphage (P-2) was first sampled approximately 16 hours after injection and reported an MS-2 count of 3×10^8 plaque-forming

units (pfu) which is 0.19 percent of the original injectate concentration (Figures 4-4 and 4-5; Table 4-6). Subsequent sampling showed a steady decline in MS-2 counts with a non-detect recorded 37 days following injection.

MS-2 breakthrough curves for wells P-3, P-4, and P-5 are shown in Figures 4-4, and 4-5. The highest MS-2 concentrations reported in the observation wells were detected at P-4 (the pumping well) which reported a peak concentration of 8×10^4 pfu approximately 22 hours after injection. This is 0.005 percent of the concentration injected at well P-2. At P-5, peak MS-2 concentrations were reported at about the same time (21 hours after injection) as P-4, although at much lower levels (maximum 476 pfu; less than 0.001 percent of the input value). The MS-2 peak breakthrough at P-3 was reported approximately 2 days and 4 hours after injection, with an MS-2 count of 2,000 pfu which is less than 0.001 percent of the initial input concentration at P-2. The maximum velocity for the coliphage induced in the groundwater between P-2 and P-4 for this test was approximately 13 feet/day.

A second peak of MS-2 coliphage was detected in wells P-3, P-4, and P-5, after the MS-2 concentration in each well had reduced to non-detectable levels (Figure 4-4). These secondary peaks occurred at varying times between 14 days 14 hours to 22 days 22 hours after the start of the test. The coliphage was not detected in wells P-8 and P-9 during or following the test.

Periodic water level measurements during the pumping phase of the coliphage seeding test indicate a maximum hydraulic gradient from P-2 to P-4 of 0.02 ft/ft (i.e. a drop of 0.25 feet over the 11.5-foot separation between the two wells). A reversal of gradients back towards P-2 occurred about 18 hours after the start of the test (Table 4-6). The reversal was apparently due to a higher than usual tide.

The coliphage PRD-1, which was dosed into a toilet feeding into the septic system, was not detected in any of the wells during the course of the investigation.

Assessment of the potential for transport of effluent from septic systems to the Malibu Lagoon area requires understanding of the following:

- Wastewater disposal practice
- Evidence for septic effluent in groundwater and sediments
- Groundwater flow characteristics
- Microbial transport properties

The results of this study are used in an attempt to address the question: What is the potential for septic effluent, microorganisms, and nutrients to migrate from on-site septic systems to the lagoon?

The two areas investigated for this study included the area between the northern edge of Malibu Colony and the lagoon and the Cross Creek Plaza commercial center. Soil and groundwater data were collected for the Colony/lagoon area and site specific soil, groundwater and transport data were obtained for the Plaza area. Estimates of wastewater from on-site septic systems in the Colony area may be as high as 11,800 gpd. The closest Colony leachfield to the lagoon is separated by a distance of at least 75 feet. The Plaza discharges up to 7,000 gpd of wastewater from its on-site septic system. Recent retrofitting of the septic system utilizes micro-dosing of wastewater to the leachfields to limit mounding in the fields and to maintain the efficacy of the underlying unsaturated soils. The closest Plaza leachfield to the lagoon is separated by a distance of at least 200 feet.

5.1 INDICATION OF ANTHROPOGENIC IMPACTS

Anthropogenic impacts observed in Malibu Lagoon could be derived from many sources throughout the Malibu Creek drainage (Manion and Dillingham, 1989). This study evaluates impacts using several indicator methods. Results of selected bacteria analyses are used to indicate the presence of human or animal fecal contamination. Nutrient concentrations are used as indicators of water quality and organic pollution. Sterol analyses provide an indication of human and animal fecal contamination, and LAB results indicate a source of wastewater contamination. While any one of these indicators is not able to pin-point the source of an impact, collectively, they can be used to narrow possible sources.

5.1.1 Water Sampling

Water samples collected from the lagoon area south of Pacific Coast Highway, contained indicator bacteria at levels greater than samples from north of Pacific Coast Highway. The highest concentration of indicator bacteria detected was in the sample collected from the lagoon at OF-3. This sample contained enterococcus, fecal coliform, and total coliform concentrations all greater than 1,600 MPN/0.1L. These concentrations of indicator bacteria exceed the standards set by the state and federal governments for these coliforms.

Total coliform may undergo aftergrowth in nutrient-enriched water. Coupled with fecal coliform, these two indicators can be used to differentiate between fecal and non-fecal contamination (Bashar et al., 1988). Groundwater samples from wells P-1 and C-2 indicate coliform contributions are from non-fecal sources in addition to coliforms derived from fecal matter at these locations.

Nutrient concentrations detected in groundwater samples collected from wells indicate the presence of nitrate-nitrogen and total nitrogen with the highest concentration in the sample from well P-1. The detected concentrations of nitrate-nitrogen are at or below the state and federal standards for this compound (45 mg/L and 10 mg/L, respectively).

5.1.2 Storm Drain Sediment Sampling

Detected levels of indicator bacteria in sediment samples collected at the three storm drain outlets, indicate concentrations of enterococcus ranging from 43 to 430 MPN/g, fecal coliform less than 10 MPN/g, and total coliform ranging from 160 to 11,000 MPN/g. These results suggest that the coliforms are only partially derived from fecal sources as indicated by the detected enterococcus concentrations. The absence of fecal coliforms in the sediment samples may be due to early die-off, and are not an absolute indication for the lack of fecal sources. The highest concentration of total coliform was from the outfall of the Malibu Colony Drain, OF-3, south of Pacific Coast Highway, which is consistent with the findings from the water analyses. Indicator bacteria concentrations in the sediment sample from the outfall of the Civic Center Drain, OF-1, which is near the inlet to the lagoon, is less than a factor of 10 compared to results for OF-2 and OF-3. This result indicates a preferential source for the indicator bacteria that is downstream from OF-1. State or federal numerical standards for enterococcus or coliforms in soil were not identified.

Research conducted by UCLA, and others, have shown that human fecal matter can be detected with a high degree of confidence by measuring the levels of the sterol, coprostanol (Venkatesan, 1994). The breakdown of cholesterol, which is present in all animals, yields several compounds. The sediment sampling results provide data on the concentrations of two of these compounds, coprostanol and epicoprostanol, as well as other sterols. Coprostanol is enriched about 10 to 100-fold in human feces compared to feces from animals. Outside the body, coprostanol has been found to degrade to coprostanone in a one-to-one ratio. In other words, one molecule of coprostanol yields one molecule of coprostanone. Therefore, the combination of coprostanol and coprostanone (correcting for molecular weight differences) yields the total quantity of coprostanol initially present in the excreted fecal matter. Coprostanol and epicoprostanol are present in the fecal matter of all mammals (Venkatesan, 1994). Ferezou et al, analyzed 133 specimen of human feces and found some to have the ratio of coprostanol to epicoprostanol vary from 21 to 25. Venkatesan found in her study, that this ratio may vary from over 60 for humans and cats to less than about 15 for other animal sources.

Coprostanol was detected in the three storm drain sediment samples with concentrations ranging from 0.22 to 0.4 μg/gm. Epicoprostanol was detected in the sediment samples at concentrations ranging from trace levels to 0.18 μg/gm. Coprostanone was not detected in the collected sediment samples. The ratio of detected coprostanol to epicoprostanol ranges from 1.6 to about 22 (assuming trace levels are equivalent to 0.01 μg/gm). The concentrations of coprostanol and epicoprostanol detected in the outfall sediment samples are high suggesting the presence of fecal sterols. The sediment sample OF-2 from the Cross Creek Road storm drain outfall contains the highest concentration of coprostanol and epicoprostanol suggesting that this storm drain has the highest relative inputs of fecal matter. The concentrations and ratios of the sterols in the sediment samples suggest the sources for the fecal matter are probably from both human and animals. Additional sampling, though, would be necessary to confirm this conclusion.

LABs are a class of anionic surfactant compounds (i.e. cleaning detergent) that, when detected in the environment, provide an indication of wastewater discharges containing detergents. The LABs with external substituted isomers (e.g., a methyl group attached at the 2nd, 3rd, or 4th position in the molecule's chain of carbon atoms) are more readily biodegraded than the internal substituted isomers (at the 5th and 6th position). The ratio of the internal to external isomers provides an indication of the rate of biodegradation with values less than 1 indicating no or little degradation. Ratios greater than 1 indicate the compounds are degraded.

The LABs detected in sediment samples collected at the Civic Center and Malibu Colony storm drain outfalls OF-1 and OF-3 ranged from not detected to 0.16 ng/g. The LABs detected in these two samples were all external isomers. The LABs detected in the sediment sample collected at the Cross Creek Road storm drain outfall OF-2, ranged from not detected to 21.36 ng/g. The LABs detected in all three samples are enriched in external isomers (I/E ratios of 0 and 0.85). These results indicate that discharges of anionic surfactant compounds detected in the three samples tested have undergone little, if any, biodegradation. Therefore, the results suggest that there are ongoing contributions of these compounds from the storm drains to the creek and lagoon sediments, with the greatest mass of these compounds occurring at the Cross Creek Road storm drain outfall, OF-2.

Possible septic overflows to drains or movement of septic system discharges to storm drains through shallow soils are a concern as the effluent may reach and contaminate the lagoon. The results of the water and sediment sampling indicates impacts from fecal matter and wastewater discharges at the storm drain outfalls. The results, however, do not specifically identify on-site septic systems as a source.

5.2 GROUNDWATER FLOW SYSTEM

The drilling investigation results indicate the principal water-bearing unit at the site is composed of silty sand to sandy gravel. The upper surface of this coarse-grained water-bearing unit ranges from ground surface to 9.0 feet bgl and extends to below the base of the borings drilled for this study. Groundwater flow is likely to occur preferentially within this unit under unconfined to semi-confined conditions.

Based on water level elevation data, a shallow groundwater gradient ranging from 0.002 ft/ft to the southeast, to 0.003 ft/ft to the east-southeast, is estimated across the area northwest of the lagoon. The gradient is influenced by tides and steepens during low tides. The gradients indicate that groundwater flow and solute/microbe transport would be from the Plaza towards the lagoon at an estimated rate ranging from 1 to 4 feet per day. However, a reversal in gradient occurs during high tides that likely causes water from the lagoon to recharge adjacent sediments. Analysis of tidal and groundwater level charts indicates that the groundwater flow direction is reversed up to a distance of 100 feet inland from the lagoon, and possibly more during high spring tides.

Mixing of upgradient groundwater with brackish water from the lagoon is also indicated in the general mineral analyses for wells within 200 feet of the lagoon. Groundwater samples from

wells P-6 and P-7, located near the northern edge of the lagoon, contain a general mineral assemblage that is enriched in sodium and chloride. Well P-1, at the upgradient margin of the study area, contains general minerals that are more representative of sediments derived from bedrock in the area. Within the zone where lagoon-influenced groundwater appears to mix with upgradient groundwater, the general minerals appear to be an equally distributed mixture of anions and cations. Water from this mixed zone also contains carbonate and bicarbonate levels above the concentrations detected in the upgradient well and these elevated parameters may, in part, be from wastewater discharges.

Groundwater flow along the northern portion of the Colony study area south of the lagoon, based on water level data at wells C-1, C-2, and in the lagoon, is to the north with a hydraulic gradient of about 0.017 ft/ft. Considering the nature of the sediments encountered in C-1 and C-2, and the presence of tidal influences to the north and south of the Colony area, an east-west trending groundwater mound is likely present beneath the Malibu Lagoon/Colony study area. The hydraulic gradients across this part of the study area are also likely to flatten and steepen in response to tidal influence with flow rates in excess of 10 feet per day possible. Additional well points and groundwater level monitoring would be required, however, to confirm a mound and its orientation with time.

Under normal lagoon levels, approximately 1.5 to 4 feet of separation exists between the groundwater surface and the base of the Cross Creek Plaza leachfields. In the Colony, the separation between the groundwater surface and the base of the leachfields is not known, however, these fields are reportedly inundated when the lagoon level rises over 3.5 feet above msl (Gold et al., 1992).

5.3 MICROBIAL TRANSPORT PROPERTIES

Processes that control microbial migration in the subsurface include inactivation or dying off, advection, dispersion, adsorption and desorption, and filtration. These processes are both physical and chemical in nature and are important elements in evaluating microbial transport (Mathess et al., 1988; and Bales et al., 1995). The use of chemical tracers and microbial indicators provides a means for evaluating the transport properties of microbes in the subsurface.

For this study, bromide was used as a conservative tracer (i.e. bromide does not react with the saturated sediments) and was used to evaluate advection and dispersion during groundwater transport. Coliphages, which are non-pathogenic viruses that infect coliform bacteria, have been proposed and used reliably by others as indicators of enteric virus behavior in the subsurface

(Kott et al., 1974; IAWPRC, 1991; U.S. EPA, 1994; Wentsel et al., 1982; DeBorde et al., 1998; and Bales et al., 1995). For this study, the coliphages PRD-1 and MS-2 were used to evaluate filtration efficacy of unsaturated and saturated sediments beneath the leachfields in the Cross Creek Plaza study area (Figure 5-1), estimate virus transport rates, and assess attenuation relative to bromide (reactive versus non-reactive solutes).

The coliphage PRD-1 was flushed down a toilet that drains to the test leachfield within the Cross Creek Plaza study area (Figure 5-2). PRD-1 was not detected in groundwater samples collected from wells located either directly beneath the leachfield or downgradient of the leachfield. During a similar test using a bromide tracer, the bromide was detected in the groundwater sample from the well screened beneath the leachfield. This suggests that unsaturated soils beneath the leachfield (approximately 2 feet of separation existed between the bottom of the leachfield and groundwater during the test) are effective at removing microbes from wastewater through filtering and adsorption.

During high spring tides, or during periods when the lagoon is sealed and full, the subsequent rise in groundwater level would diminish the effectiveness of the unsaturated sediments to remove microbes. The diminished effectiveness would result from possible inundation of the leachfield, whereby, septic effluent would move directly into the groundwater or by a decrease in the thickness of the remaining unsaturated sediment such that the wastewater is not sufficiently filtered of microbes prior to reaching the groundwater. It should be noted that during the test period, the lagoon was kept open by the heavy flows down Malibu Creek and groundwater levels fluctuated in direct response to tidal influence.

Hydraulic conductivity provides a measure for assessing groundwater movement through sediments. This parameter has been estimated from slug test results for the Cross Creek Plaza study area and bromide tracer and coliphage seeding test results have been used to directly estimate groundwater flow and solute/microbe transport velocities. The measured groundwater flow velocities are used to calculate an estimated hydraulic conductivity using its relationship with seepage velocity:

$$v = K*I/n$$

where;

v is seepage velocity (length per time [L/t])

K is hydraulic conductivity [L/t]

I is groundwater gradient [L/L], and
n is effective sediment porosity [dimensionless].

Hydraulic conductivity estimates for the Cross Creek Plaza study area ranged from approximately 200 to 400 feet/day using this approach. These results are considerably higher than estimates completed using the slug test approach.

Slug test results represent an average or "bulk" hydraulic conductivity measured over a volume of soil that is within several feet of the screened interval of the tested well. Using slug test results to estimate the rate of groundwater movement in heterogeneous sediments often underestimate observed groundwater velocities. Previous studies investigating groundwater flow in heterogeneous sediments have found that methods that result in a "bulk" hydraulic conductivity value tend to average out or diminish the significance that thin, highly permeable layers have on groundwater flow and solute transport rates (Thorbjarnarson, et al., 1997; Pickens and Grisak, 1981; Mas-Pla, et al., 1992; and Young, 1995). Flow velocities resulting from bromide tracer and coliphage seeding tests, however, tend to reflect groundwater movement through the more permeable saturated strata screened by the test wells.

Bromide and MS-2 were dosed directly to groundwater in P-2 to evaluate pathogen transport potential when high groundwater levels inundate leachfields. Water was pumped from P-4 during the test to develop a hydraulic gradient from the leachfield comparable to the groundwater flow condition that develops when the sand berm breaches and the lagoon rapidly drains to the ocean.

The results indicate initial coliphage breakthrough at P-4 is comparable to that reported for the bromide tracer test, considering the sampling frequency and hydraulic gradients (Figure 4-6). The coliphage concentration curves show slower die-off following breakthrough compared to the bromide tracer test. The persistence of higher MS-2 levels in the well after the main mass has passed the well indicates that the coliphage is being adsorbed and desorbed to the sediment through which it is passing. This process tends to spread out the mass of the solute or microbes in groundwater, causing the "tailing effect" that is observed during monitoring of the well.

A greater relative concentration of bromide was detected in the downgradient monitoring well P-4 than for the coliphage MS-2, as shown in Figure 4-6. The lower relative concentration of coliphage detected, indicates that the coliphage is likely to have been attenuated as it moves with groundwater through the sediment, whereas, bromide is not. The continued attenuation of the

Secondary coliphage peaks occur in each monitoring well after at least one non-detect sample had been collected. This could be due to a reversal in the groundwater gradient between P-2 and the adjacent monitoring wells, resulting in remobilizing the coliphage back toward the monitoring wells. However, apart from a water level recorded in P-4 that was lower than for the nearby monitoring wells during this time period, there is no direct evidence to support this and the cause of the secondary peaks is not known.

The flow rate induced by the pumping for the bromide tracer and coliphage seeding tests is estimated to be between 13 and 28 feet/day. Based on velocities obtained from the bromide tracer and coliphage seeding tests and measured natural gradients, the groundwater flow rate in the Cross Creek Plaza Study area under "normal conditions" is estimated between 1 and 4 feet/day. During periods when the lagoon is full, and the sand berm breeches causing rapid fall in lagoon level, a steep groundwater gradient up to 0.03 ft/ft (i.e., a drop of 6 feet between the Cross Creek Plaza area test field and the lagoon) likely exists towards the lagoon. This would induce estimated groundwater flow rates up to 20 to 40 feet per day toward the lagoon. This increased flow rate would result in increased stress within the saturated zone, causing an increase in groundwater transport, and potentially remobilizing microbes that were otherwise inactivated.

The following conclusions from the study of potential water quality impacts on Malibu Creek and Lagoon from on-site septic systems are based on the findings discussed in this report:

Storm Drain Sediment Sampling

- Sediment sampling at the three major storm drain outfalls found levels of bacteria and sterols indicative of impact by fecal matter. The results suggest that the fecal matter sources are probably from both human and animals and the greatest inputs occur at the Cross Creek Road drain that outlets into Malibu Creek immediately north of the PCH bridge. This result suggests a possible source may be from septic overflows to drains or movement of septic system discharges to storm drains through shallow soils. However, additional testing would be required to confirm this conclusion.

- Testing of sediments for linear alkyl benzene compounds (i.e., anionic surfactants commonly found in detergents) at the three major storm drain outfalls indicates on-going contamination from detergents. The highest concentrations were detected at the Cross Creek Road drain outfall. Parking lot washing, restaurant washing, and gray-water systems are the most likely sources needing further investigation.

Groundwater Testing

- Groundwater levels were found to be within 5 to 7 feet below ground surface throughout the study period. This means there was 1.5 to 4 feet of unsaturated soils between the bottom of the leachfield and groundwater. This must be qualified by the fact that the heavy rainfall year kept the lagoon open to the ocean throughout the test period. Further monitoring will be necessary to assess impacts to groundwater levels during extended periods of lagoon closure and subsequent high water levels.

- Nutrient testing of groundwater found nitrate and phosphate levels below 10 mg/L. This result leads to the conclusion that the nutrients are being effectively removed from the effluent as it passes through the unsaturated soils beneath the septic leachfields. While more study may be necessary to confirm this, it appears that septic systems in the Civic Center are not adding to the high concentrations of nutrients found in Malibu Lagoon.

- Based on the low hydraulic gradient (less than 1 foot of drop in 100 yards) measured for the groundwater in the Civic Center commercial area, the groundwater flow rate is estimated at approximately 1 to 4 feet per day. To increase this flow rate, and mimic a worst case condition, the tracer and microbial transport testing was done using a pump that induced a gradient of over 6 feet of drop in 100 yards. This provided a gradient comparable to what would be anticipated during a lagoon breaching event.

Microbial Transport

- A very large dose of the non-pathogenic biophage PRD-1, mimicking an enteric virus, was introduced into the test septic system through a toilet. Groundwater was sampled immediately below the test leachfield and at distances of approximately 10 feet, 80 feet and 150 feet from the edge of the leachfield. PRD-1 was not detected in the groundwater at any of the sampling locations throughout the testing period. Similar testing with a bromide tracer detected bromide breakthrough at the sampling point below the leachfield thus confirming a hydraulic connection.

- A similar large dose of the non-pathogenic biophage MS-2, which also mimics an enteric virus, was introduced directly into the groundwater below the test leachfield. MS-2 was detected a distance of 10 feet away within 24 hours indicating a transport rate between 13 and 28 feet/day under "worst case" hydraulic conditions. Sampling was then performed at 80-feet away with no detection at that point. Bromide tracer testing showed similar results. Further study will be necessary to estimate the actual distance the biophage can travel before being fully attenuated.

In summary, the study results provide the following main conclusions:

- Provided that adequate unsaturated soil exists between the bottom of the leachfield and groundwater (at least 2 feet for the fine-grained soil identified in the Civic Center commercial area), there is minimal concern for pathogen transport to the Creek or Lagoon through subsurface pathways.

- If groundwater levels rise to the bottom of the leachfield there is concern that pathogens could be transported to the Creek or Lagoon. This study found that pathogens were transported at least 10 feet from the edge of the leachfield under "worst case" hydraulic conditions. However, because neither bromide nor MS-2 were detected in samples from P-8 or P-9 at 80 and 150 feet from the test field, the maximum distance that nutrients and pathogens may travel cannot be estimated.

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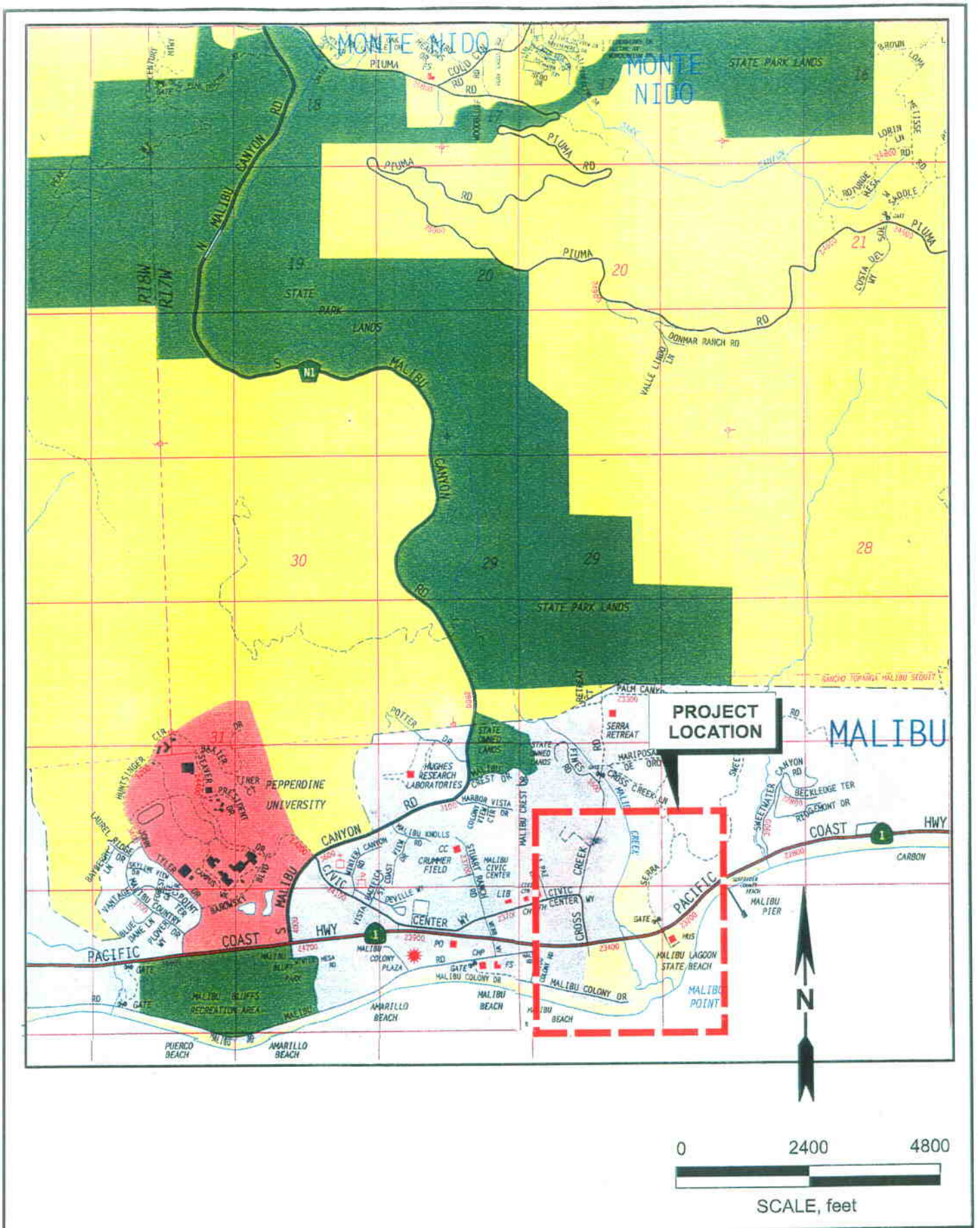

SITE LOCATION MAP

Project No.: 964P170	Date: JANUARY 1999	Project: MALIBU LAGOON	Fig. 1-1

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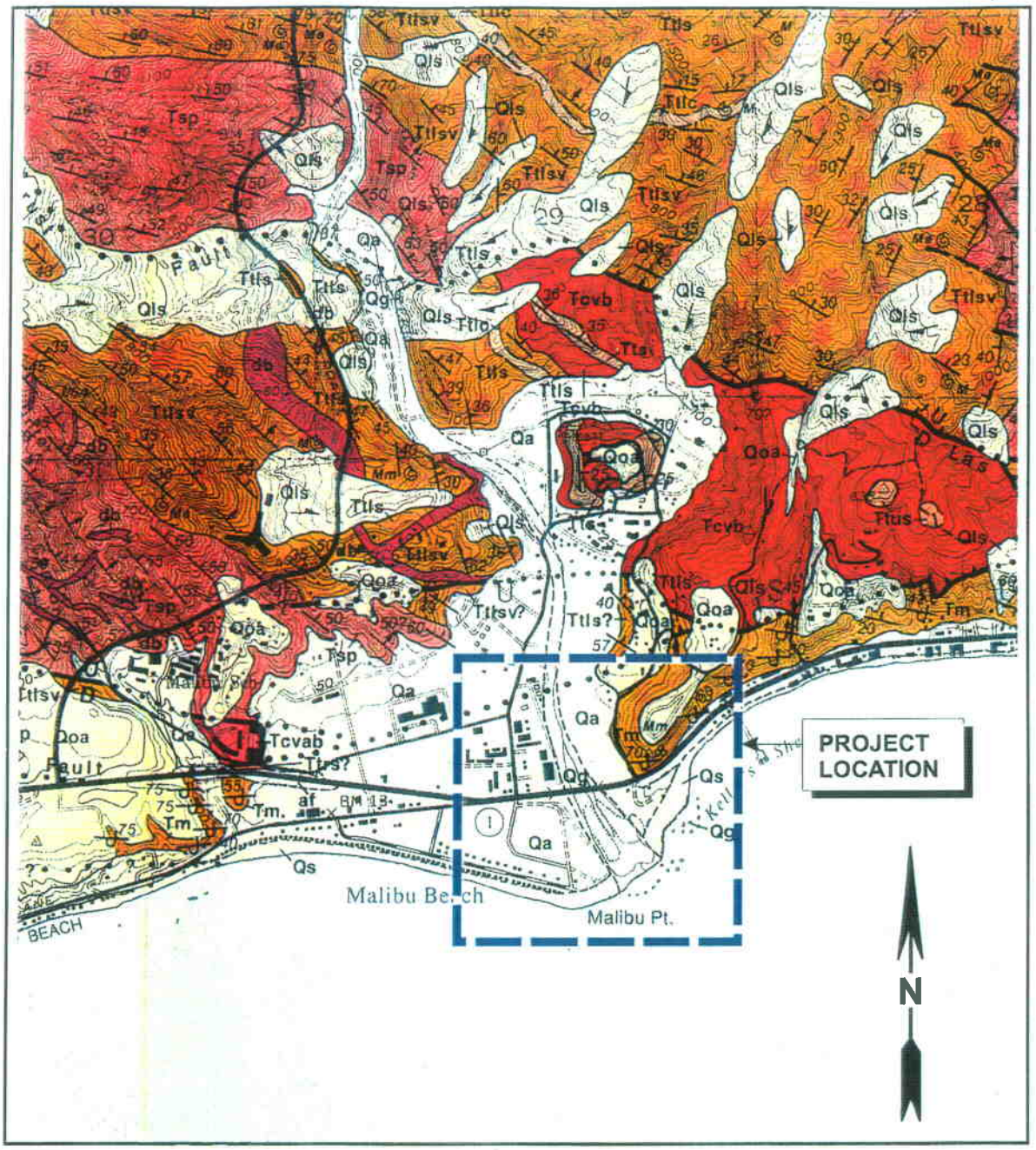
URS Greiner Woodward Clyde



LEGEND

Quaternary

- **af** - **Artifical Fill**
- **Qa** - **Flood Plan Alluvial Clay, Sand, Gravel**
- **Qs** - **Beach Sand**
- **Qg** - **Stream Channel Gravel & Sand**
- **Qls** - **Landslide Debris**
- **Qoa** - **Older Alluvium**

Tertiary

- **Tm** - **Thin Bedded Siliceous Shale** ***(Monterey Fm)***
- **Tcvb** - **Basaltic Flows & Breccias** ***(Conejo Volcanics)***
- **db** - **Diabase or Basalt**
- **Ttls** - **Thick Bedded Coherent Sandstone** ***(Lower Topanga Fm)***
- **Tsp** - **Thick Bedded Resistant Sandstone** ***(Sespe Fm)***

0 2000 4000

SCALE, feet

Note: Base map taken from Geologic Map of the Malibu Beach Quadrangle. Los Angeles, CA. By Thomas W. Dibblee Jr., 1993.

GEOLOGIC SITE LOCATION MAP

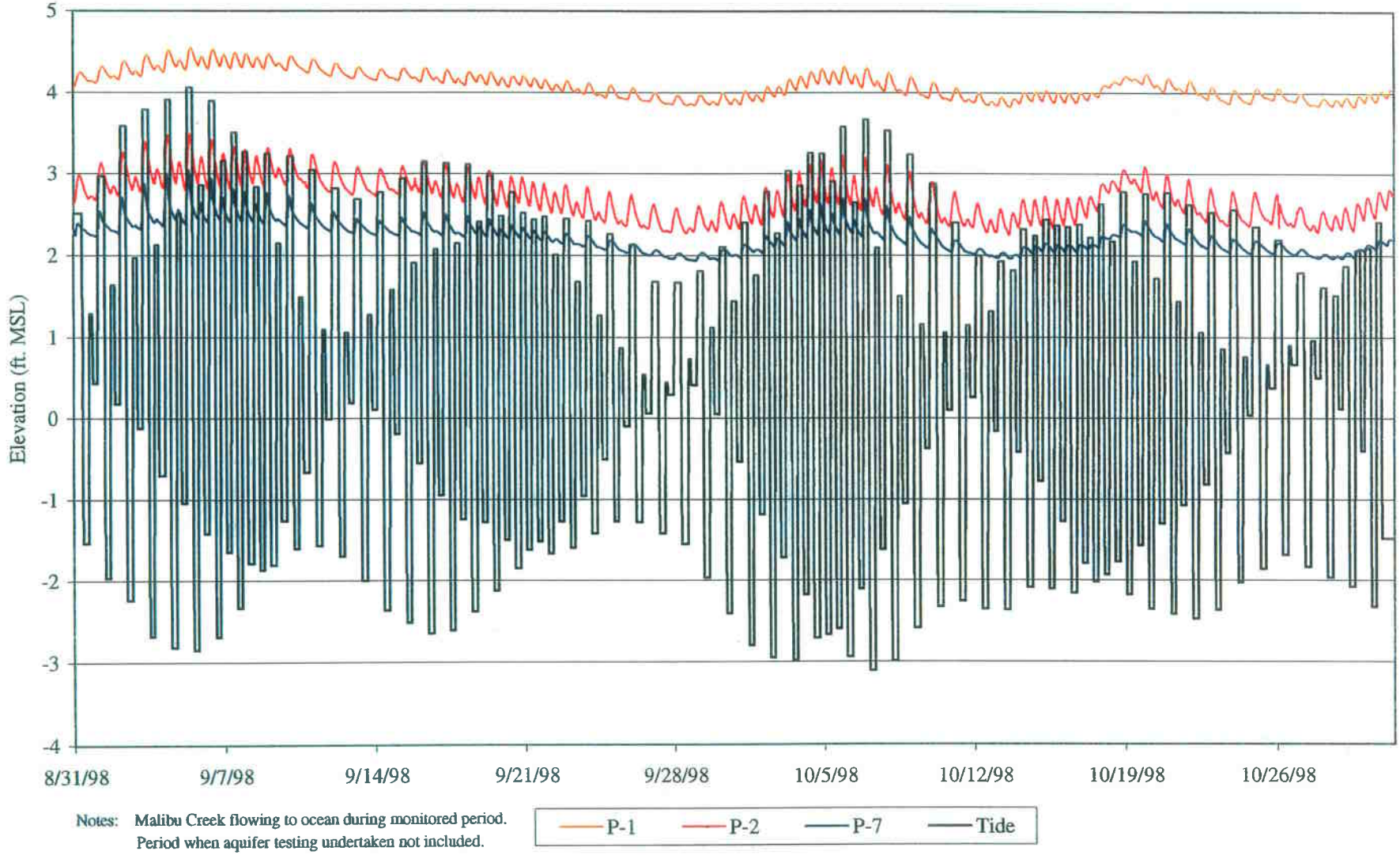
Project No.: 964P170	Date: JANUARY 1999	Project: MALIBU LAGOON	Fig. 2-1

I:\ADMIN\MALIBU2-1.CDR

URS Greiner Woodward Clyde

Figure 4-1

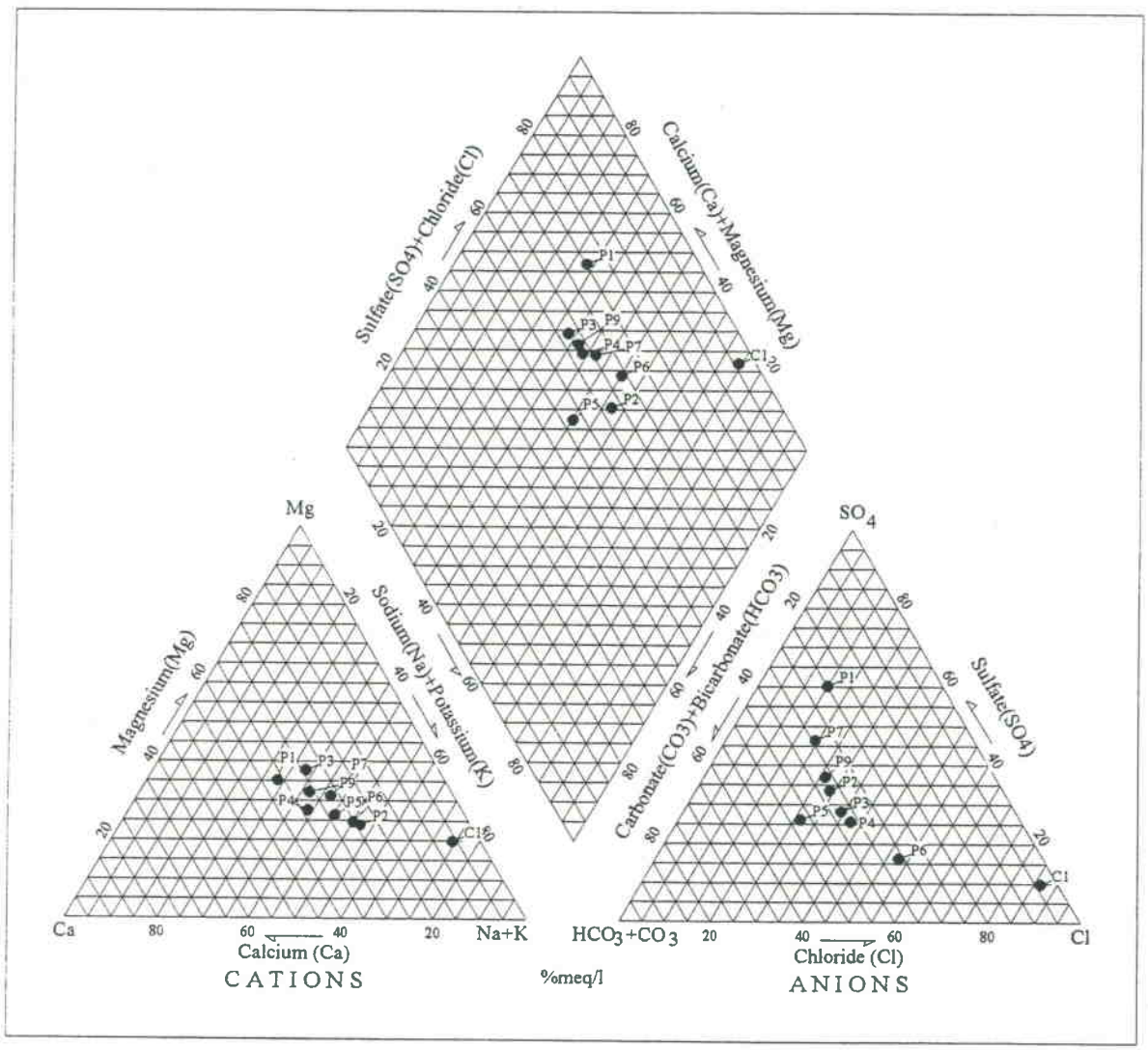
Groundwater Level Data



Notes: Malibu Creek flowing to ocean during monitored period.
Period when aquifer testing undertaken not included.

Figure 4-2

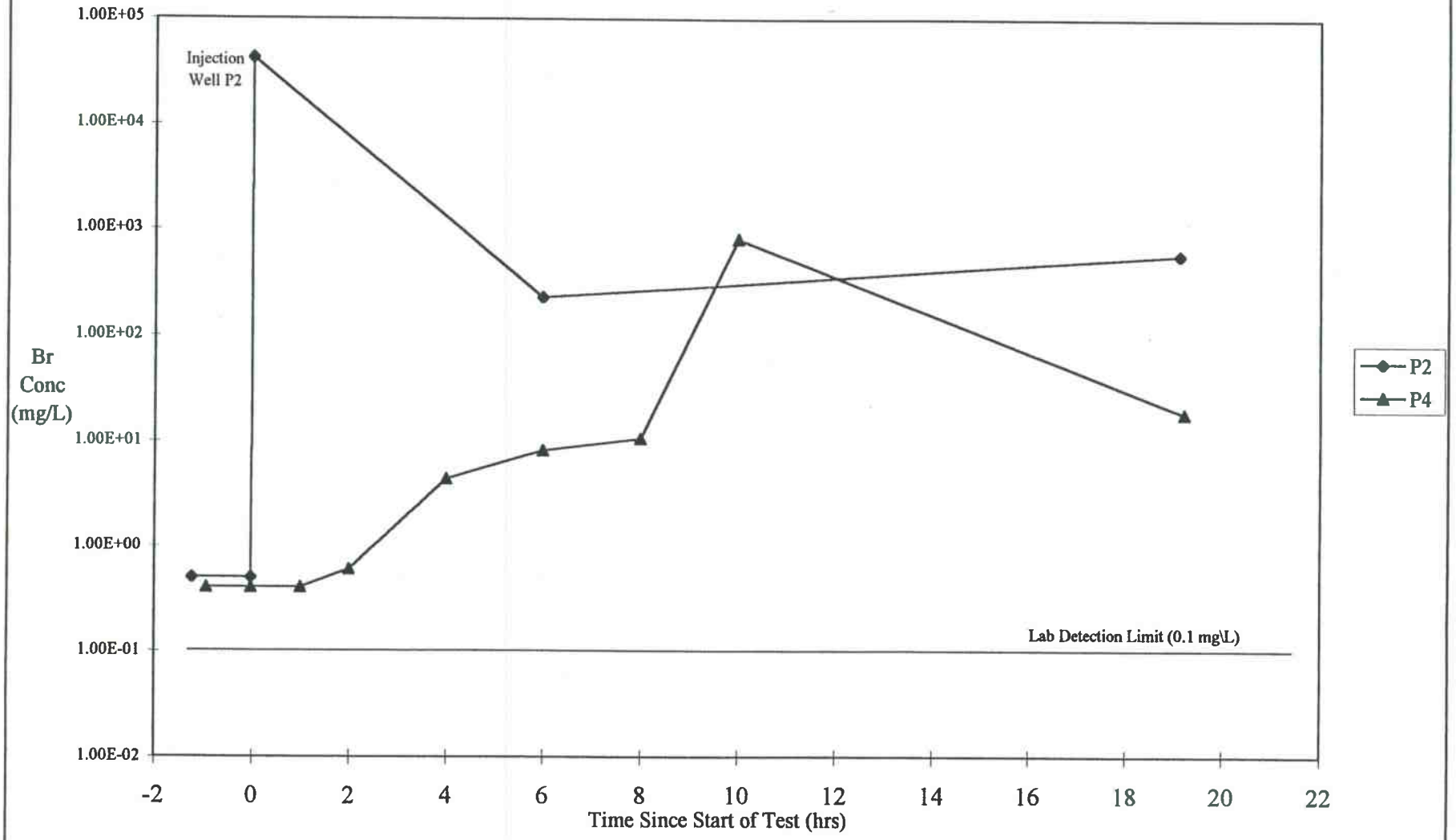
Piper Tri-liner Diagram[1]



Note: [1] Groundwater samples from P2, P3, P4, and P5 collected on 10.26.98. Groundwater samples from C1, P1, P6, P7, and P9 collected on 12.1.98

Figure 4-3

Bromide Tracer Test: Bromide Concentration vs Time



Notes: Bromide concentration immediately prior to test assumed to be the same as those measured approximately 1 hour before test.
P-2 bromide concentration in at t=0 calculated from quantity of bromide added to well.

Figure 4-4

Coliphage Seeding Test: MS-2 Count vs Time

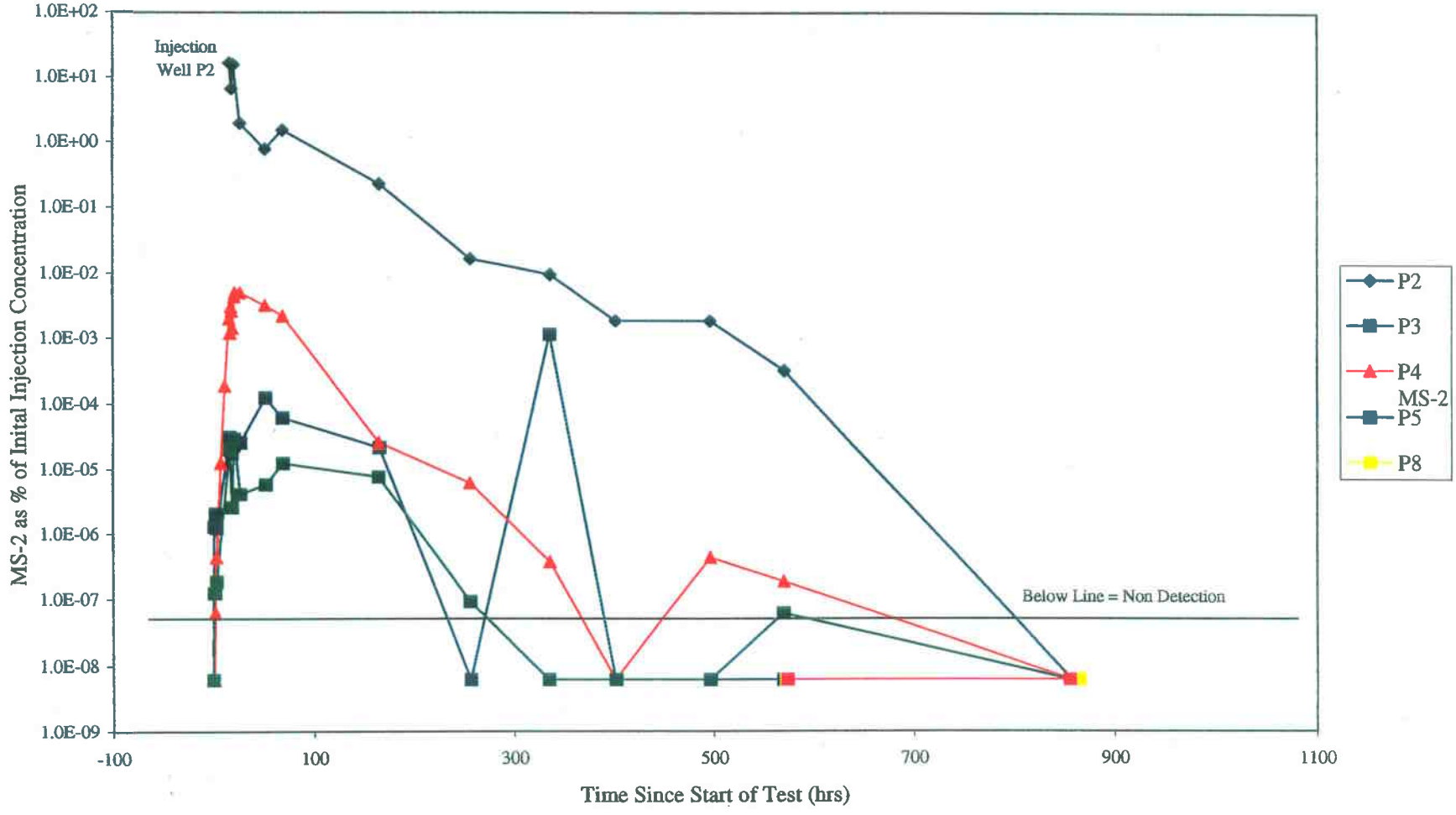


Figure 4-5

Coliphage Seeding Test: MS-2 Count vs Time (3-Day Plot)

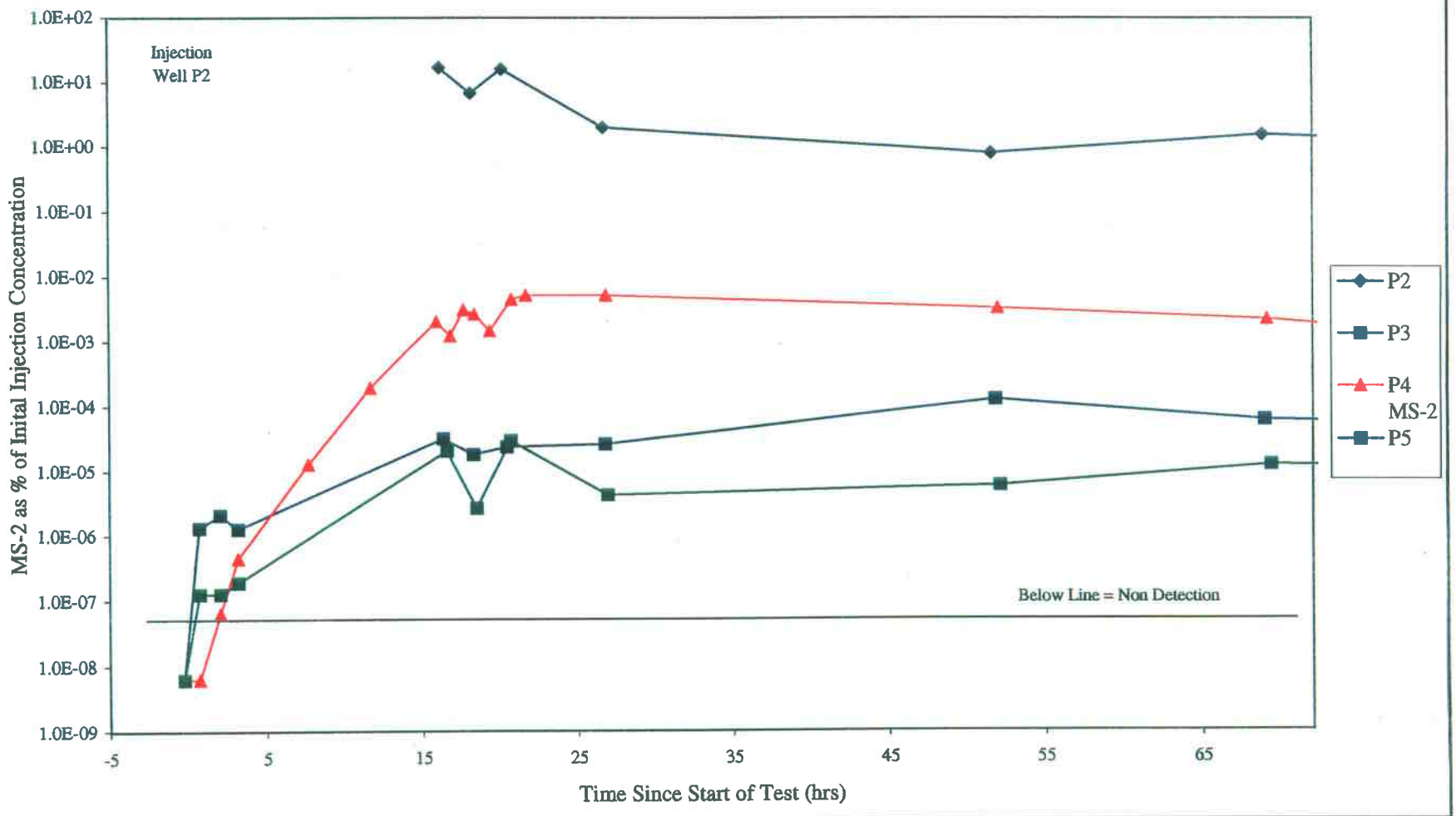
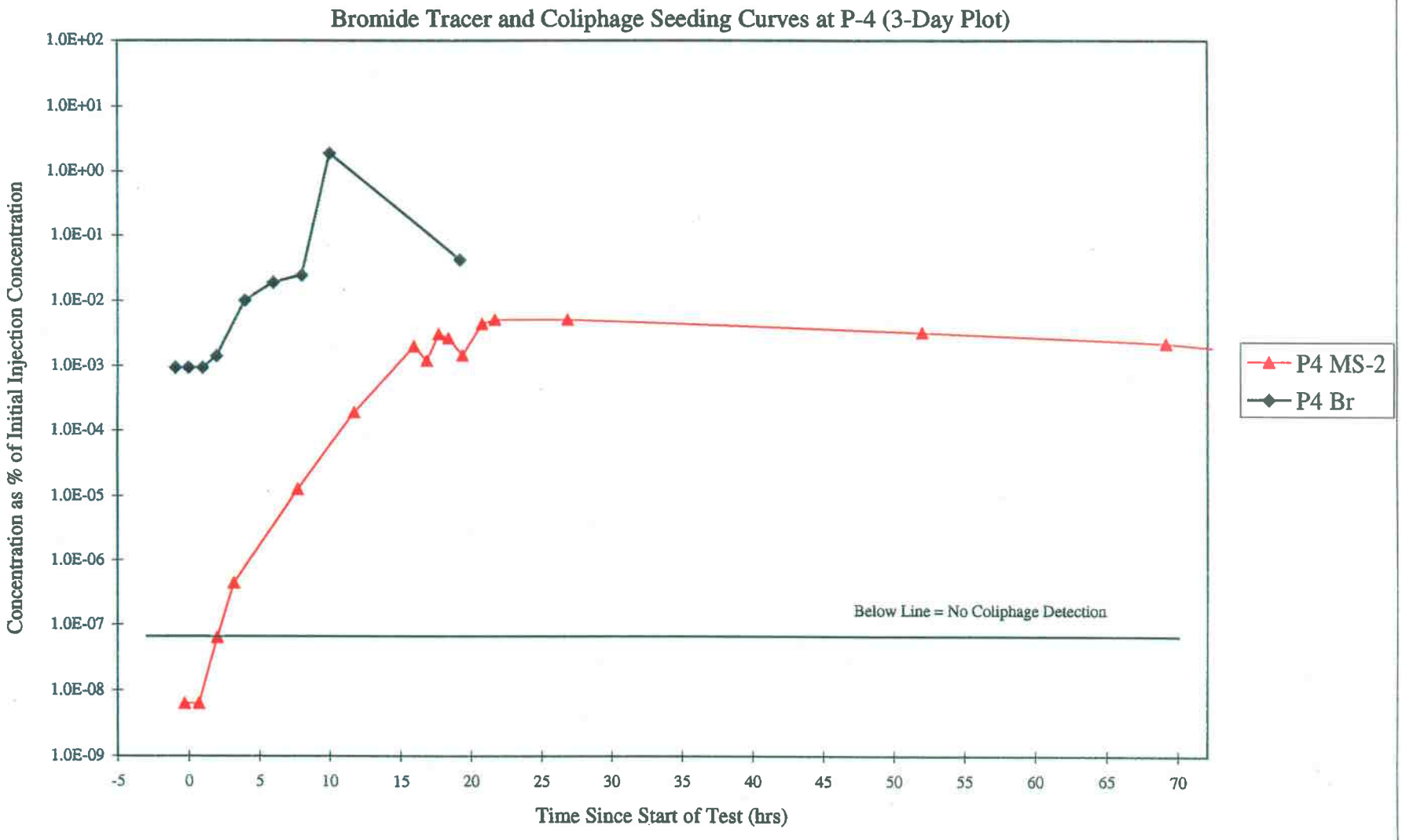
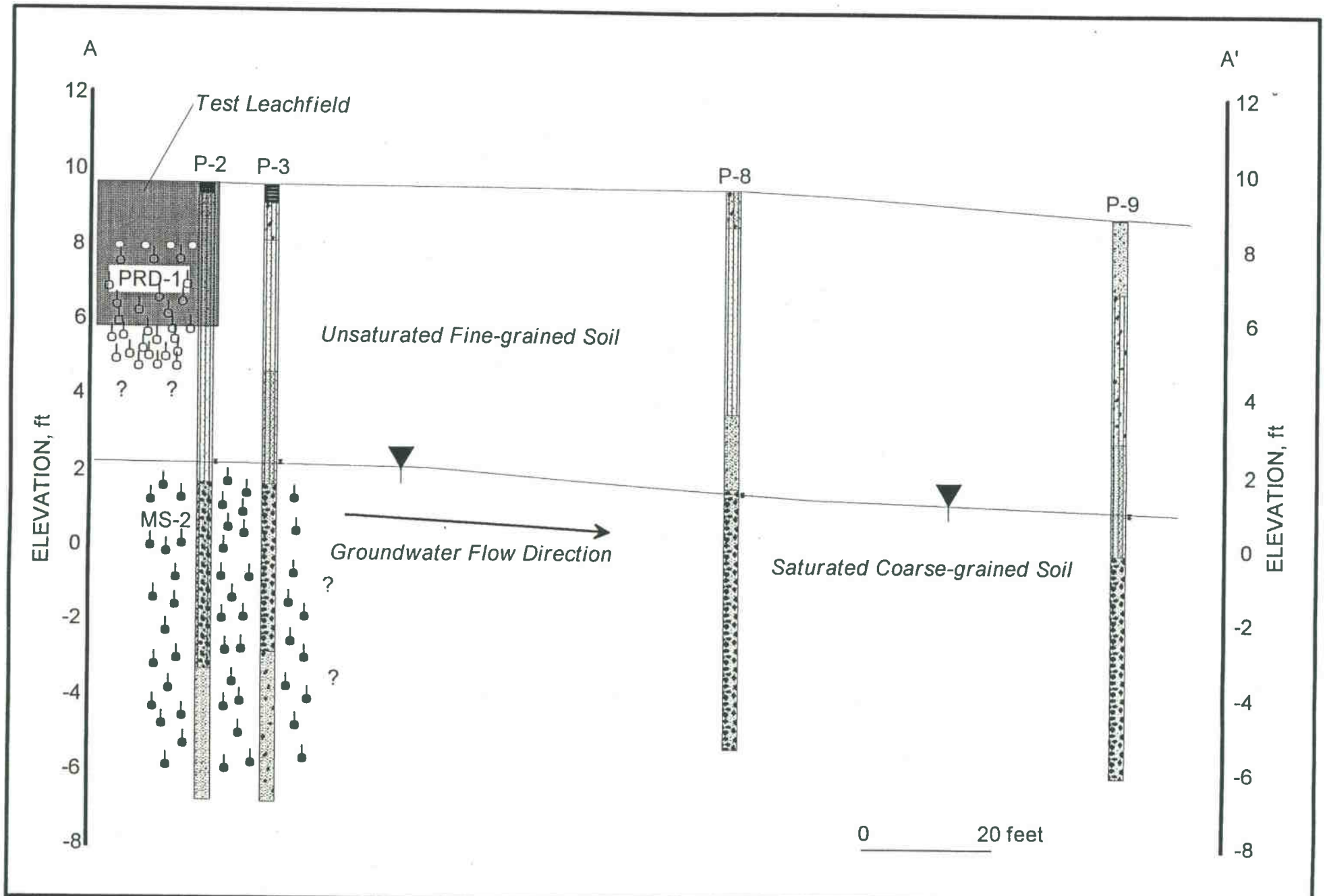


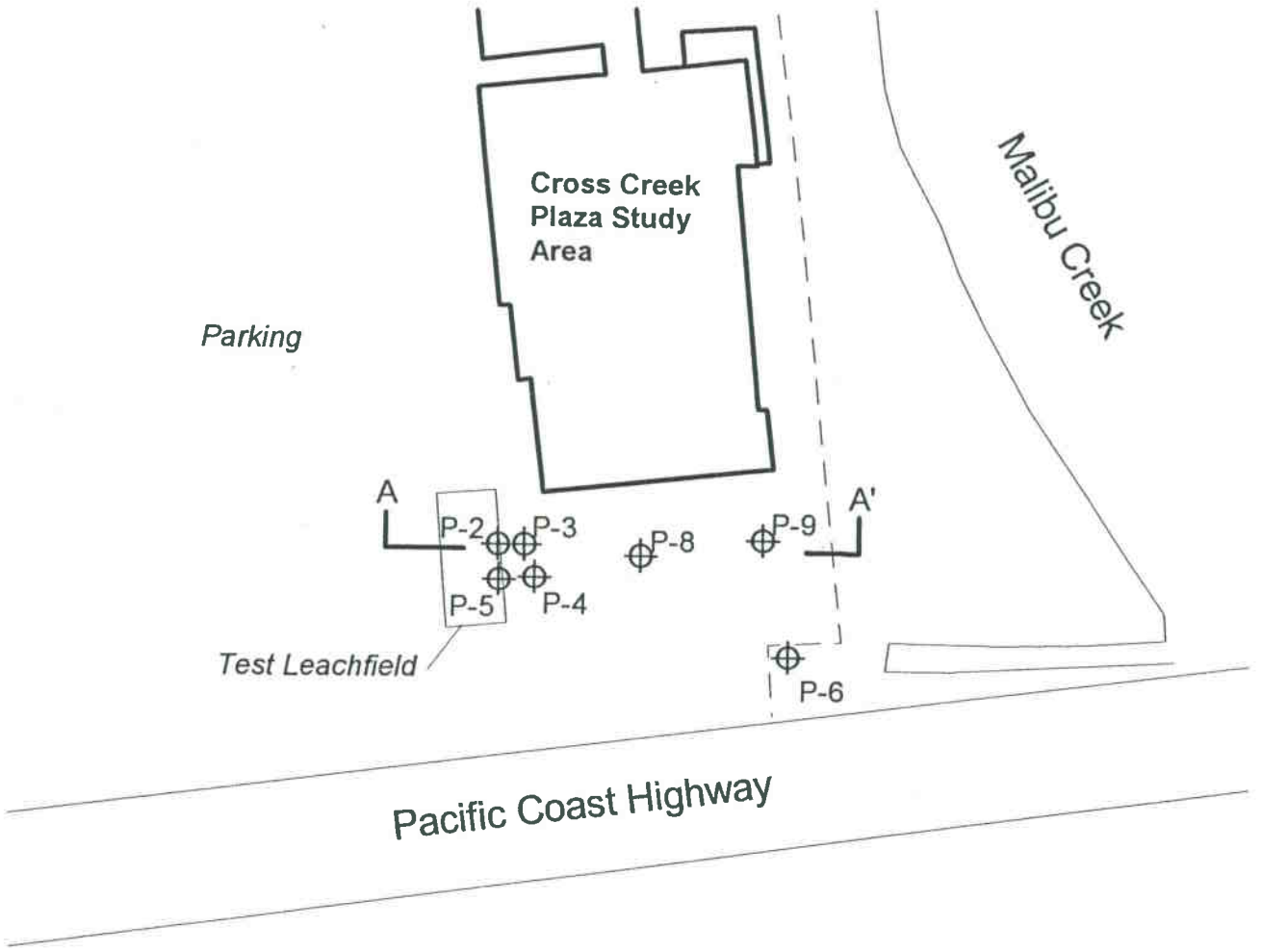
Figure 4-6


Bromide Tracer and Coliphage Seeding Curves at P-4 (3-Day Plot)
Concentration as % of Initial Injection Concentration
1.0E+02
1.0E+01
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-08
1.0E-09
-5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Time Since Start of Test (hrs)
Below Line = No Coliphage Detection
P4 MS-2
P4 Br



PROFILE A-A' CROSS CREEK PLAZA STUDY AREA

Project No.: 57094P170	Date: May 1999	Project: City of Malibu	Figure 5-2



CROSS CREEK PLAZA STUDY AREA

Project No.: 570964P170	Date: May 1999	Project: City of Malibu	Fig. 5-1

Table 3-1

Summary of Drilling Activities

Borehole	Date Drilled	GD RL (ft amsl)	Total Depth (ft bgl)	Screened Interval (ft bgl)
C-1	8.14.97	9.5	15.0	4.0 - 14.5
C-2	8.14.97	9.3	15.0	4.0 - 14.5
P-1	8.14.97	11.6	16.5	4.0 - 14.5
P-6	8.14.97	9.0	16.5	4.0 - 14.5
P-7	8.14.97	8.9	15.0	4.0 - 14.5
P-2	8.25.98	9.8	16.5	3.5 - 13.5
P-3	8.25.98	9.8	16.5	4.7 - 14.7
P-4	8.25.98	10.2	12.5	4.0 - 12.5
P-5	8.25.98	10.2	16.5	4.9 - 14.9
P-8	11.18.98	TBD(2)	15.0	3.6 - 13.6
P-9	11.18.98	TBD(2)	15.0	4.3 - 14.3

Notes: (1) Date and time of measurement in brackets
(2) TBD = To Be Determined

Table 4-1

Summary of Rising Head Slug Test Results[1]

Well	Induced Excess Head (ft)	Hydraulic Conductivity (ft/day)
P-2	2.29	0.60
P-3	2.41	0.69
P-4	1.45	4.06
P-5	1.51	2.80
P-6	2.44	1.22

Note: [1] Analysis following Horslev (1951)

Table 4-2

Groundwater Level Measurements Taken With Electronic Water Level Probe

Well	P-1		P-2		P-3		P-4		P-5		P-6		P-7		P-8		P-9		C-1		C-2	
Ground RL[1]	11.60		9.80		9.80		10.20		10.20		9.00		8.90		9.80(3)		9.80(3)		9.50		9.30	
Date	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]	Time	WL RL[2]
8.13.98	1720	5.25	...	...	...	...	...	...	...	...	1325	3.09	1500	3.52	...	...	...	...	1530	3.25	...	...
8.25.98	...	...	1306[4]	2.25	1408[4]	2.39	1500[4]	2.00	1530[4]	2.52	...	...	...	...	...	...	...	...	...	...	...	...
8.28.98	...	...	1200[4]	2.21	1155[4]	2.27	1202[4]	2.25	1201[4]	2.28	1622	2.33	...	...	...	...	...	...	...	...	...	...
8.31.98	...	...	0850	2.30	0849	2.36	0851	2.35	0852	2.36	...	...	1346	2.29	...	...	...	...	...	...	...	...
9.16.98	0831	3.63	0855	2.51	0857	2.58	0859	2.57	0901	2.59	0843	2.35	...	...	...	...	...	...	...	...	...	...
10.26.98	...	...	0855	2.12	0857	2.18	0859	2.17	0903	2.18	0930	1.95	...	...	...	...	...	...	...	...	...	...
10.29.98	...	...	1356	1.92	1345	1.99	1359	1.98	1401	1.99	...	...	...	...	...	...	...	...	...	...	...	...
11.9.98	...	...	1535	2.39	1537	2.45	1537	2.45	1538	2.45	...	...	...	...	...	...	...	...	...	...	...	...
11.12.98	...	...	1010	2.06	1005	2.13	1007	1.82	1009	2.12	...	...	...	...	...	...	...	...	...	...	...	...
11.16.98	...	...	0918	2.54	0916	2.61	0917	2.60	0915	2.59	...	...	...	...	...	...	...	...	...	...	...	...
11.19.98	...	...	1023	2.80	1021	2.85	1022	2.85	1020	2.84	1505	2.65	...	...	...	...	...	...	...	...	...	...
12.1.98	...	...	0814	3.03	0811	3.11	0813	3.10	0812	3.09	0808	3.01	...	...	0810	2.18	0805	2.91	...	...	...	...
12.2.98	0850	3.95	...	...	...	...	...	...	...	...	...	...	1005	3.03	...	...	...	...	1049	3.07	1042	3.14

Notes: Water levels taken during development, slug testing, and aquifer testing not included
See Figure 4-1 for continuously monitored water levels in select wells

(1) ft above mean sea level

(2) Water level RL

(3) Approximate (not yet surveyed)

(4) Water level prior to development

Table 4-3

Summary of Analytical Results for General Minerals - Groundwater Samples

Well	Date	Sample No.	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	HCO_3^-	CO_3^{2-}	SO_4^{2-}	Br^-	NO_3^--N	Total-N	Total-P
P1	10.28.97	P1	...	...	...	...	...	...	...	...	...	9.37	11.87	ND
	11.5.97	P1	...	...	...	...	...	...	...	...	...	6.08	8.08	ND
	12.2.98	SET34-P1-12/1-0945	141	5.13	162	94.6	98	282	ND	537	...	...	...	...
P2	9.16.98	P2916-1015	...	...	...	...	...	...	...	...	0.5	...	...	...
	10.26.98	P21026-1037	327	11.6	134	80.7	212	472	ND	333	283	...	...	...
P3	10.26.98	P31026-1057	211	15.1	168	133	266	504	ND	298	3.9	...	...	...
P4	9.16.98	P4916-1035	...	...	...	...	...	...	...	...	0.4	...	...	...
	10.26.98	P41026-1305	223	9.11	172	86.1	307	520	ND	284	1.6	...	...	...
P5	10.26.98	P51026-1122	238	8.82	133	75.1	181	560	ND	242	0.7	...	...	...
P6	10.28.97	P6	...	...	...	...	...	...	...	...	...	0.25	5.35	ND
	11.5.97	P6	...	...	...	...	...	...	...	...	...	ND	5.1	ND
	12.1.98	SET23-P6-12/1-0915	789	23.8	353	209	1100	1120	ND	458		...	...	...
P7	10.28.97	P7	...	...	...	...	...	...	...	...	...	0.18	3.58	ND
	11.5.97	P7	...	...	...	...	...	...	...	...	...	0.27	1.57	0.22
	12.2.98	SET34-P7-12/2-1030	223	12.1	129	91.1	145	444	ND	472	...	...	...	...
P8	12.1.98	SET26-98-12/1-1326	...	...	...	...	...	...	...	...	0.7	...	...	...
P9	12.1.98	SET23-P9-12/1-0840	181	8.3	137	86.2	168	406	ND	323	0.6	...	...	...
C1	10.28.97	C1	...	...	...	...	...	...	...	...	...	0.11	7.18	ND
	11.5.97	C1	...	...	...	...	...	...	...	...	...	ND	9.2	ND
	12.2.98	SET34-C1-12/2-1100	2600	129	188	379	4530	350	ND	695	...	...	...	...
C2	10.28.97	C2	...	...	...	...	...	...	...	...	...	0.15	2.15	ND
	11.5.97	C2	...	...	...	...	...	...	...	...	...	0.53	2.33	0.77

Notes: All concentrations in mg/L (ppm)

ND = Not detected

... = Not sampled

Table 4-4a

Sterol Results - Soil Samples[1]

Sterols	090597-OF1-1	090597-OF1-1[2]	090597-OF2-1	090597-OF3-1
Coprostanol	0.22	0.28	0.4	0.24
Epicoprostanol	TR	TR	0.18	0.15
Coprostanone	ND	ND	ND	ND
Cholesterol	0.22	0.25	0.76	1.11
Cholestanol	ND	0.07	0.44	0.32
Campesterol	0.75	1.08	0.83	0.14
β-Sitosterol	5.41	5.87	5.23	7.62
5α-Androstanol(sur) % Recovered	83.45	81.47	73.6	94.9

Notes: [1] Sterols in microgram/g dry soil (Data not corrected for surrogate recovery)

[2] Replicate analysis by gas chromatography

TR = Trace

ND = Not Detect

Table 4-4b

Linear Alkyl Benzene (LAB) Results - Soil Samples[1]

LAB Type	090597-OF1-1	090597-OF2-1	090597-OF3-1
55-11	ND	9.92	ND
64-11	ND	21.36	ND
73-11	ND	18.97	ND
82-11	ND	15.92	ND
91-11	0.14	9.21	0.18
65-12	ND	15.83	ND
74-12	ND	16.68	ND
83-12	ND	15.17	ND
92-12	ND	11.80	ND
101-12	0.16	11.47	0.14
66/75-13	ND	7.96	1.90
84-13	ND	4.87	ND
93-13	ND	4.00	ND
102-13	ND	3.61	ND
111-13	ND	3.43	0.74
76-14	ND	2.27	ND
85-14	ND	ND	0.75
94-14	ND	1.57	ND
103-14	ND	0.83	5.45
112-14	ND	0.95	ND
121-14	0.05	1.06	0.13
Total LAB's	**0.35**	**176.88**	**9.29**
I/E Ratio[2]	**0.00**	**0.85**	**0.00**

Notes: [1] Results in ng/g dry soil

[2] I/E Ratio = $6\text{-}C_{12}+5\text{-}C_{12}/4\text{-}C_{12}+3\text{-}C_{12}+2\text{-}C_{12}$

ND = Non Detect

Table 4-4c

Results of Selected Indicator Bacteria - Soil Samples

Sample Location	Sample Number	Date Sampled	Sample Matrix	Enterococcus (MPN[1]/G)[2]	Fecal Coliform (MPN/G)[3]	Total Coliform (MPN/G)[4]
OF-1	090597-OF1-2	09/05/97	Soil	43	<10	160
OF-2	090597-OF2-2	09/05/97	Soil	430	<10	2800
OF-3	090597-OF3-2	09/05/97	Soil	230	<10	11000

Notes:
1 MPN = most probable number
2 In accordance with SM9230
3 In accordance with FDA Biological Analytical Manual
4 In accordance with FDA Biological Analytical Manual

Table 4-5

Results of Selected Indicator Bacteria - Water Samples

Sample Location	Sample Number	Date Sampled	Sample Matrix	Enterococcus (MPN[1]/0.1L)[2]	Fecal Coliform (MPN/0.1L)[3]	Total Coliform (MPN/0.1L)[4]
P-1	082997-P1	08/29/97	Groundwater	2	23	130
P-6	082997-P6	08/29/97	Groundwater	<2	80	80
P-7	082997-P7	08/29/97	Groundwater	8	>1600	>1600
C-1	082997-C1	08/29/97	Groundwater	900	1600	1600
C-2	082997-C2	08/29/97	Groundwater	4	80	130
OF-3	090597-OF3-3	09/05/97	Surface Water	>1600	>1600	>1600

Notes:
1 MPN = most probable number
2 In accordance with FDA Biological Analytical Manual
3 In accordance with EPA Method 908C
4 In accordance with EPA Method 908A

Table 4-6

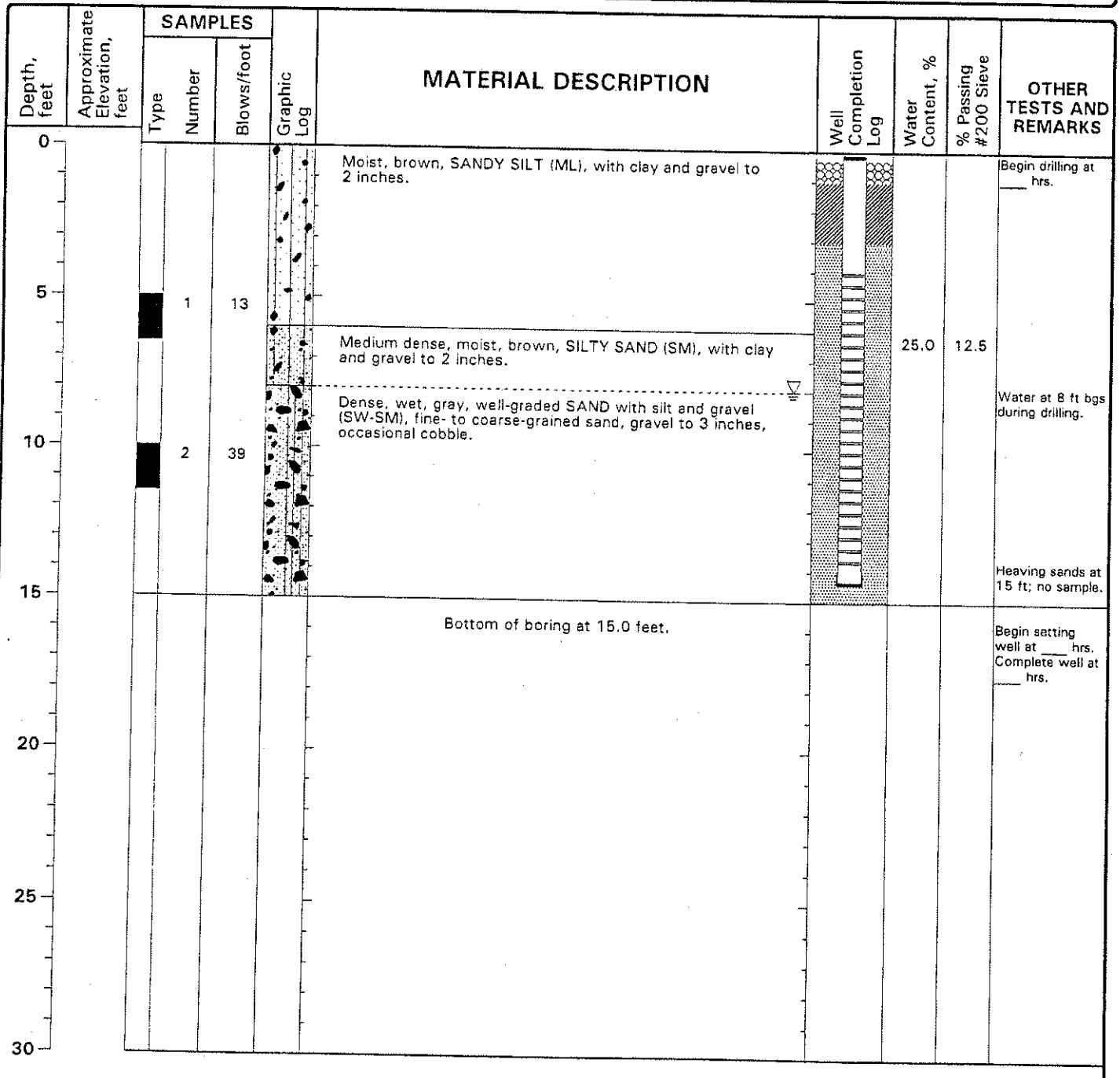
Relative Bromide and Coliphage Concentrations

Bromide Tracer Test P-4 Results		
Time Since Start of Test (hrs)	Conc. (mg/L Br)	Conc. (as % of Injection Conc.)
-0.93	0.4	9.4E-04
-0.02	0.4	9.4E-04
0.00	0.4	9.4E-04
1.00	0.4	9.4E-04
2.00	0.6	1.4E-03
4.00	4.4	1.0E-02
6.00	8.2	1.9E-02
8.00	10.7	2.5E-02
10.00	816	1.9E+00
19.22	18.5	4.4E-02

Coliphage Seeding Test P-4 Results		
Time Since Start of Test (hrs)	Conc. (pfu of MS-2)	Conc. (as % of Injection Conc.)
-0.28	0.0	0.0E+00
0.72	0.0	0.0E+00
2.05	1.0	6.3E-08
3.22	7.0	4.4E-07
7.72	200.0	1.3E-05
11.72	3000.0	1.9E-04
15.97	32000.0	2.0E-03
16.88	19000.0	1.2E-03
17.72	49000.0	3.1E-03
18.43	42000.0	2.6E-03
19.43	23000.0	1.4E-03
20.80	71000.0	4.4E-03
21.72	82000.0	5.1E-03
26.88	82000.0	5.1E-03
52.00	52000.0	3.3E-03
69.13	35000.0	2.2E-03
165.13	416.0	2.6E-05
256.35	98.0	6.1E-06
335.92	6.0	3.8E-07
401.78	0.0	0.0E+00
496.63	7.0	4.4E-07
570.05	3.0	1.9E-07
857.08	0.0	0.0E+00

Project: Malibu Creek and Lagoon Project Location: Malibu, California Project Number: 964P170	Log of Boring P-7 Sheet 1 of 1

Date(s) Drilled	8/14/97	Logged By	E. Fordham	Checked By	
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth Drilled (feet)	15.0
Drill Rig Type	Mobile B-80	Drilling Contractor	Budger Drilling	Surface Elevation	
Groundwater Level		Date Measured		Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	11 Diameter of Well (inches) 4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	#2/12 Lonestar sand	Type/Depth of Seal(s)	Bentonite 3 feet to 1 foot bgs		
Comments	See site map for location.				



Project: Malibu Lagoon Investigation Project Location: Cross Creek Plaza, Malibu, California Project Number: 964P170	**Log of Boring P-8** Sheet 1 of 1

Date(s) Drilled	11/18/98	Logged By	P. Salter	Checked By	
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth of Boring	15.0 feet
Drill Rig Type	Mobile Drill B-80	Drilling Contractor	Badger Drilling	Approximate Surface Elevation	Not available
Groundwater Level(s) and Date(s) Measured	7.70 feet below top of PVC casing on 11/19/98 at 1515 hrs			Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	10	Diameter of Well (inches)	4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	2/12 Lonestar sand	Type/Depth of Seal(s)	Bentonite pellets 2.6 feet bgs to ground surface		
Comments	See site map for location. Top of PVC casing at 0.45 foot bgs.				

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0						Medium dense, moist, brown, silty SAND (SM), fine- to medium-grained, organic, with gravel- to cobble-size concrete fragments (up to 8 inches diameter) [Fill].				
						Medium stiff to stiff, moist, dark brown, sandy SILT (ML), medium- to coarse-grained sand, with rare lenses to 2 inches thick of loose, dry, brown, silty medium- to coarse-grained sand.				
5			1	11						SPT samples retained.
						Medium dense, dry, gray-brown, poorly graded SAND (SP), medium- to coarse-grained, quartz-rich [beach sand?].				
						Dense, wet, gray-brown, sandy GRAVEL (GP); medium- to coarse-grained quartz sand, cemented sandstone gravel to 1-1/2 inches diameter.				Water at about 8 ft bgs during drilling.
10			2	39						
15						Bottom of boring at 15.0 feet.				
20										
25										

Project: Malibu Lagoon Investigation **Project Location:** Cross Creek Plaza, Malibu, California **Project Number:** 964P170	**Log of Boring P-9** Sheet 1 of 1

Date(s) Drilled	11/18/98	Logged By	P. Salter	Checked By	
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth of Boring	15.0 feet
Drill Rig Type	Mobile Drill B-80	Drilling Contractor	Badger Drilling	Approximate Surface Elevation	Not available
Groundwater Level(s) and Date(s) Measured	7.40 feet below top of PVC casing on 11/19/98 at 1509 hrs			Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	10	Diameter of Well (inches)	4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	2/12 Lonestar sand	Type/Depth of Seal(s)	Bentonite pellets 2.6 feet bgs to ground surface		
Comments	See site map for location. Top of PVC casing at 0.52 foot bgs.				

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0						Loose, moist, yellow-brown, poorly graded SAND (SP), medium- to coarse-grained, quartz-rich, organic.				
						Medium stiff, moist, gray-black, sandy SILT, medium- to coarse-grained sand, some subangular gravel consisting of strong, yellow quartzite, trace organics.				
5			1	7						SPT samples retained(?).
						Loose, moist, brown-yellow, silty SAND (SM), medium-grained.				
						▽				
10			2	32		Dense, wet, yellow-gray, sandy GRAVEL (GP); medium- to coarse-grained sand, quartzite gravel to 1-1/2 inches diameter.				Water at about 9 ft bgs during drilling.
15						Bottom of boring at 15.0 feet.				
20										
25										

APPENDIX A

BOREHOLE LOGS

Project: Malibu Creek and Lagoon Project Location: Malibu, California Project Number: 964P170	Key to Log of Boring Sheet 1 of 2

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
						Dense, moist, brown, SILTY SAND (SM).				
						[solid line denotes observed contact between strata or abrupt change in soil type]				
						[dashed line denotes inferred contact between strata or gradational change]				
										Gravelly zone.
						SAMPLING METHOD				
			1	22		Sample collected in 2-inch-OD split barrel drive sampler with 1-3/4-inch brass liner tubes and advanced using 140-lb hammer dropped 30 inches		13.0	28	Strong odor.
						Water encountered at time of drilling ▽				
						Static water level measured in well				
1	2	3	4	5	6	7	8	9	10	11

COLUMN DESCRIPTIONS

1	Depth:	Distance in feet below the ground surface.
2	Elevation:	Elevation in feet with respect to mean sea level (MSL) or assumed datum.
3	Sample Type:	Type of sample collected at depth interval shown; symbols explained above.
4	Sample Number:	Sample identification number.
5	Sample Blows/foot:	Number of blows required to advance driven sampler 1 foot, or distance indicated, using a 140-lb hammer with a 30-inch drop. " * " indicates blow count for initial 6-inch seating interval of sampling only.
6	Graphic Log:	Graphic depiction of subsurface material encountered; symbols explained on Sheet 2 of Key.
7	Material Description:	Description of subsurface material encountered, including USCS soil designation.
8	Well Completion Log:	Graphic depiction of well construction; symbols explained on Sheet 2 of Key.
9	Water Content:	Water content of soil specimen as percentage of dry soil weight.
10	% Passing #200 Sieve:	Percentage of total dry soil weight passing #200 sieve.
11	Other Tests and Remarks:	Results of other laboratory testing and/or comments or observations regarding drilling/sampling made by driller or Woodward-Clyde Consultants' field personnel.

GENERAL NOTES

1. Soil classifications are based on the Unified Soil Classification System (USCS) and include relative density/consistency (where standard blow count correlation is possible), moisture, and color. Field descriptions may have been modified to reflect results of laboratory tests.

2. Descriptions on this boring log apply only at the specific boring location and at the time the boring was advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

Project: Malibu Creek and Lagoon
Project Location: Malibu, California
Project Number: 964P170

Key to Log of Boring

Depth, feet	Approximate Elevation, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS

UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL AND ROCK TYPE NAME VERSUS CORRESPONDING GRAPHIC LOG

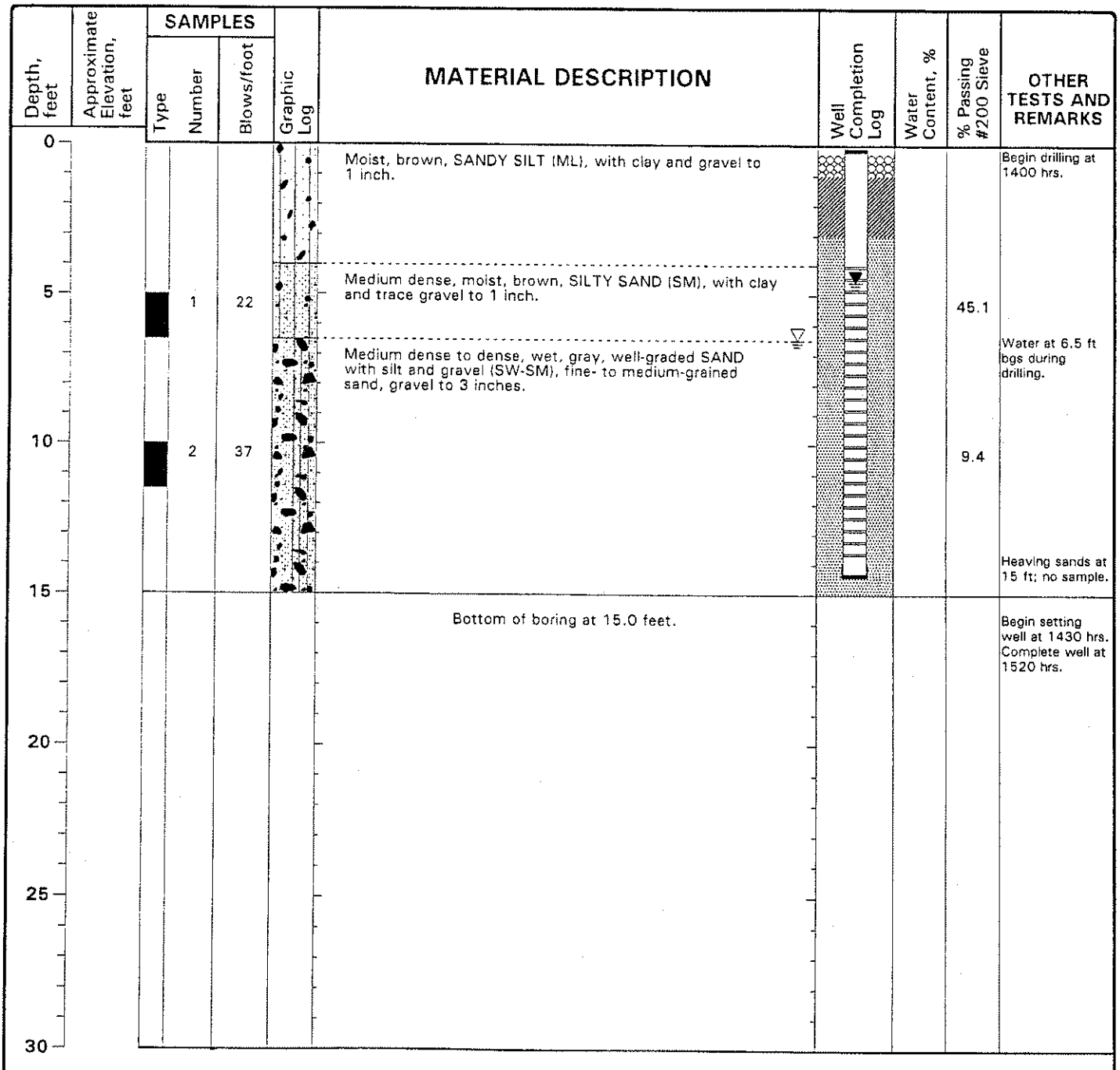
- SILT - ML
- Lean (low-plasticity) CLAY - CL
- Elastic SILT - MH
- Fat (high-plasticity) CLAY - CH
- SILTY CLAY (CL)
- CLAYEY SILT (ML)
- Well-graded GRAVEL - GW
- Poorly graded GRAVEL - GP
- CLAYEY GRAVEL - GC
- SILTY GRAVEL - GM
- Well-graded SAND - SW
- Poorly graded SAND - SP
- CLAYEY SAND - SC
- SILTY SAND - SM
- Well-graded GRAVEL with CLAY - GW-GC
- Well-graded GRAVEL with SILT - GW-GM
- Poorly graded GRAVEL with CLAY - GP-GC
- Poorly graded GRAVEL with SILT - GP-GM
- SILTY, CLAYEY GRAVEL - GC-GM
- Well-graded SAND with CLAY - SW-SC
- Well-graded SAND with SILT - SW-SM
- Poorly graded SAND with CLAY - SP-SC
- Poorly graded SAND with SILT - SP-SM
- SILTY, CLAYEY SAND - SC-SM
- Topsoil
- SAPROLITE or WEATHERED ROCK
- SCHIST
- SHALE
- CLAYSTONE
- SILTSTONE

SYMBOLS USED IN WELL COMPLETION LOG

- PIPE IN CONCRETE
- PIPE IN CEMENT-BENTONITE GROUT
- PIPE IN SAND-BENTONITE MIXTURE
- PIPE IN BENTONITE CHIPS
- PIPE IN BENTONITE PELLETS
- PIPE IN SAND PACK
- SLOTTED PIPE IN SAND PACK
- PIPE END CAP
- SAND PACK
- CEMENT-BENTONITE BACKFILL

Project: Malibu Creek and Lagoon Project Location: Malibu, California Project Number: 964P170	**Log of Boring C-1** Sheet 1 of 1

Date(s) Drilled	8/14/97	Logged By	E. Fordham	Checked By	
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth Drilled (feet)	15.0
Drill Rig Type	Mobile B-80	Drilling Contractor	Budger Drilling	Surface Elevation	
Groundwater Level	4.57 feet below ground surface	Date Measured	8/14/97 at 1620 hrs	Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	11 Diameter of Well (inches) 4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	#2/12 Lonestar sand	Type/Depth of Seal(s)	Bentonite 3 feet to 1 foot bgs		
Comments	See site map for location.				



Project: Malibu Creek and Lagoon
Project Location: Malibu, California
Project Number: 964P170

Log of Boring C-2

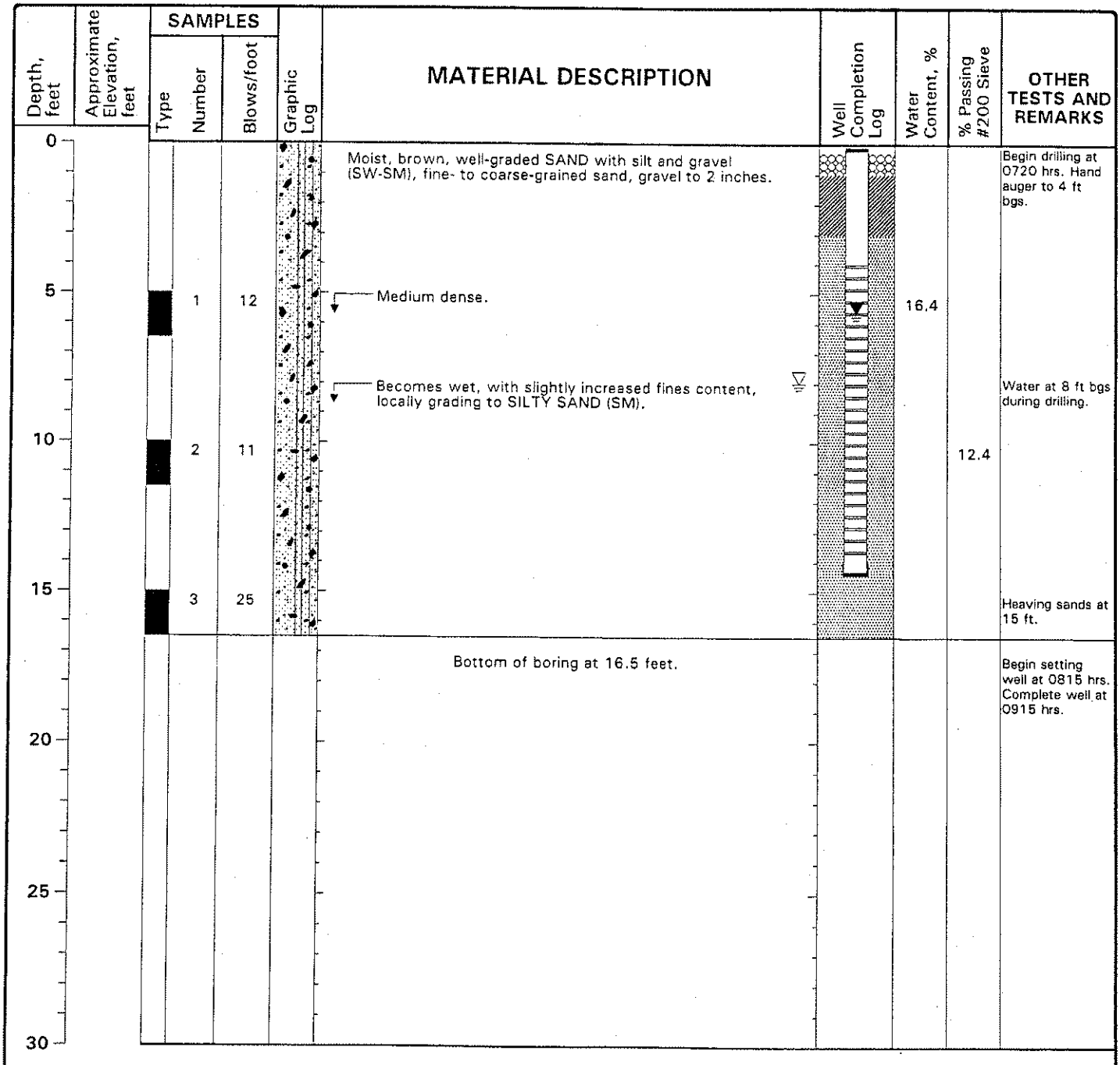
Sheet 1 of 1

Date(s) Drilled	8/14/97	Logged By	E. Fordham	Checked By	
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth Drilled (feet)	15.0
Drill Rig Type	Mobile B-80	Drilling Contractor	Budger Drilling	Surface Elevation	
Groundwater Level	4.24 feet below ground surface	Date Measured	8/14/97 at 1630 hrs	Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	11 Diameter of Well (inches) 4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	#2/12 Lonestar sand	Type/Depth of Seal(s)	Bentonite 3 feet to 1 foot bgs		
Comments	See site map for location.				

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0						Moist, brown, CLAYEY SILT (ML), with sand, occasional gravel to 1/2 inch.				Begin drilling at 1215 hrs.
5			1	17		Very stiff, moist, brown, SANDY SILT (ML), with clay, occasional gravel to 1/2 inch.		21.3		
						Dense, wet, gray, well-graded SAND with silt and gravel (SW-SM), fine- to medium-grained sand, gravel to 3 inches.				Water at 8 ft bgs during drilling.
10			2	36		increasing gravel.				Heaving sands at 10 ft.
15						Bottom of boring at 15.0 feet.				No sample at 15 ft due to heaving sands and gravel. Begin setting well at 1300 hrs. Complete well at 1340 hrs.
20										
25										
30										

Project: Malibu Creek and Lagoon Project Location: Malibu, California Project Number: 964P170	**Log of Boring P-1** Sheet 1 of 1

Date(s) Drilled	8/14/97	Logged By	E. Fordham	Checked By	
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth Drilled (feet)	16.5
Drill Rig Type	Mobile B-80	Drilling Contractor	Budger Drilling	Surface Elevation	
Groundwater Level	5.65 feet below top of casing	Date Measured	8/14/97 at 1735 hrs	Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	11 Diameter of Well (inches) 4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	#2/12 Lonestar sand	Type/Depth of Seal(s)	Bentonite 3 feet to 1 foot bgs		
Comments	See site map for location.				



Project: Malibu Lagoon Investigation Project Location: Cross Creek Plaza, Malibu, California Project Number: 964P170	**Log of Boring P-2** Sheet 1 of 1

Date(s) Drilled	8/25/98	Logged By	P. Salter	Checked By	E. Fordham
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth of Boring	16.5 feet
Drill Rig Type	Mobile Drill B-80	Drilling Contractor	Badger Drilling	Approximate Surface Elevation	9.8 feet MSL
Groundwater Level(s) and Date(s) Measured	7.16 feet below top of PVC casing on 8/31/98 at 0850 hrs			Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	10	Diameter of Well (inches)	4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	Monterey 2/12 sand	Type/Depth of Seal(s)	Bentonite pellets 3 feet to 1 foot bgs		
Comments	See site map for location. Top of PVC casing at 0.34 foot bgs.				

Depth, feet	Approx. Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0						Asphalt				
						Medium dense, moist, dark brown, silty SAND (SM), medium-grained (Fill).				
						Medium stiff, moist, dark brown, sandy SILT, medium, predominantly quartz sand grains.				
5	5		1	4						
						Loose, moist to wet, gray-brown, silty GRAVEL with sand (GM), subangular to rounded gravel to 1-1/2 inches consisting of slightly weathered, strong, dark gray graywacke and slightly weathered, very strong, green-gray granite.				
10	0		2	50/2"*						SPT sampler wet at about 10 ft. *Blow count for seating interval.
						Medium dense, wet, dark gray-brown, poorly graded SAND (SP), medium quartz and mafic grains, trace silt, rare strong, brown sandstone gravel to 1 inch.				
15	-5		3	22		Wet, gray, coarse-grained sand layer 0.2 foot thick				
						Bottom of boring at 16.5 feet.				
20	-10									
25	-15									

Project: Malibu Lagoon Investigation Project Location: Cross Creek Plaza, Malibu, California Project Number: 964P170	**Log of Boring P-3** Sheet 1 of 1

Date(s) Drilled	8/25/98	Logged By	P. Salter	Checked By	E. Fordham
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth of Boring	16.5 feet
Drill Rig Type	Mobile Drill B-80	Drilling Contractor	Badger Drilling	Approximate Surface Elevation	9.8 feet MSL
Groundwater Level(s) and Date(s) Measured	7.03 feet below top of PVC casing on 8/31/98 at 0849 hrs			Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	10	Diameter of Well (inches)	4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	Monterey 2/12 sand	Type/Depth of Seal(s)	Bentonite pellets 3.7 feet to 1 foot bgs		
Comments	See site map for location. Top of PVC casing at 0.41 foot bgs.				

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0						Asphalt				
						Medium stiff, moist, mottled black-gray, sandy SILT (ML) with asphalt fragments to 2-1/2 inches (Fill).				
						Stiff, moist, dark brown, sandy SILT, medium-grained sand.				
5	5		1	7		Loose, moist, light brown, silty SAND (SM), medium, predominantly quartz grains, rare highly weathered, weak, light brown sandstone gravel to 1 inch.				SPT sampler dry at 6.5 ft.
10	0		2	22		Medium dense, moist to wet, gray, sandy GRAVEL (GP), gravel and cobbles to 4 inches consisting of moderately weathered, strong, gray sandstone and slightly weathered, strong, brown conglomerate.				SPT sampler wet at about 10.5 ft. Hydrocarbon odor below 10.5 ft.
						Becomes wet ▽				
15	-5		3	40		Dense, wet, dark gray, poorly graded SAND (SP), medium- to coarse-grained, with fine gravel; gravel content decreases with depth.				
						Bottom of boring at 16.5 feet.				
20	-10									
25	-15									

Project: Malibu Lagoon Investigation	Log of Boring P-4
Project Location: Cross Creek Plaza, Malibu, California	Sheet 1 of 1
Project Number: 964P170	

Date(s) Drilled	8/25/98	Logged By	P. Salter	Checked By	E. Fordham
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth of Boring	12.5 feet
Drill Rig Type	Mobile Drill B-80	Drilling Contractor	Badger Drilling	Approximate Surface Elevation	10.2 feet MSL
Groundwater Level(s) and Date(s) Measured	7.40 feet below top of PVC casing on 8/31/98 at 0851 hrs			Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	10	Diameter of Well (inches)	4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	Monterey 2/12 sand	Type/Depth of Seal(s)	Bentonite pellets 3 feet to 1 foot bgs		
Comments	Encountered steel pipe at 4.5 feet (undamaged); moved hole 1 foot south and redrilled. See site map for location.				

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0	10					Soft, moist, dark brown, sandy SILT (ML) with organics [Topsoil/Fill].				Top of PVC casing 0.45 ft below ground level.
						Medium stiff, moist, dark gray-brown, sandy SILT (ML) with concrete fragments to 4 inches [Fill].				
						Medium stiff, moist, dark brown, sandy SILT, medium-grained sand.				
5	5		1	8		Loose, moist, light brown, silty SAND (SM), medium-grained, with rare subangular quartz gravel to 1 inch.				
10	0		2	34		Dense, moist to wet, dark gray, sandy GRAVEL (GP), gravel and cobbles consisting of slightly weathered, strong, green-gray granite. Becomes wet				SPT sampler wet at about 10.5 ft. Hydrocarbon odor below 10.5 ft.
						Boring terminated at 12.5 feet due to refusal on cobbles.				
15	-5									
20	-10									
25										

Project: Malibu Lagoon Investigation Project Location: Cross Creek Plaza, Malibu, California Project Number: 964P170	**Log of Boring P-5** Sheet 1 of 1

Date(s) Drilled	8/25/98	Logged By	P. Salter	Checked By	E. Fordham
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth of Boring	16.5 feet
Drill Rig Type	Mobile Drill B-80	Drilling Contractor	Badger Drilling	Approximate Surface Elevation	10.2 feet MSL
Groundwater Level(s) and Date(s) Measured	7.33 feet below top of PVC casing on 8/31/98 at 0852 hrs			Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	10	Diameter of Well (inches)	4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	Monterey 2/12 sand	Type/Depth of Seal(s)	Bentonite pellets 3.9 feet to 1 foot bgs		
Comments	See site map for location. Top of PVC casing at 0.51 foot bgs.				

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0	10					Medium stiff, moist, dark brown, sandy SILT (ML) with organics [Topsoil/Fill].				
						Medium dense, dry, yellow-brown, sandy GRAVEL (GP) with asphalt fragments [Fill].				
						Very stiff, moist, dark gray, sandy SILT (ML), medium-grained sand.				
5	5		1	6		Loose, moist, dark brown, silty SAND (SM), medium-grained.				
10	0		2	41		Dense, wet, gray, sandy GRAVEL (GP), subangular to rounded clasts to 1 inch consisting of slightly weathered, strong, gray sandstone and yellow granite.				SPT sampler wet at about 10 ft. Hydrocarbon odor below 10 ft.
15	-5		3	33		Dense, wet, gray, poorly graded SAND (SP), coarse, predominantly quartz grains, rare sandstone gravel to 1 inch.				
						Bottom of boring at 16.5 feet.				
20	-10									
25										

Project: Malibu Creek and Lagoon	Log of Boring P-6
Project Location: Malibu, California	Sheet 1 of 1
Project Number: 964P170	

Date(s) Drilled	8/14/97	Logged By	E. Fordham	Checked By	
Drilling Method	Hollow-Stem Auger	Drill Bit Size/Type	10-inch-OD auger	Total Depth Drilled (feet)	16.5
Drill Rig Type	Mobile B-80	Drilling Contractor	Budger Drilling	Surface Elevation	
Groundwater Level	3.41 feet below top of casing	Date Measured	8/14/97 at 1730 hrs	Hammer Weight/ Drop (lbs/in.)	140 / 30
Diameter of Hole (inches)	11 Diameter of Well (inches) 4	Type of Well Casing	Schedule 40 PVC	Screen Perforation	0.020-inch slot
Type of Sand Pack	#2/12 Lonestar sand	Type/Depth of Seal(s)	Bentonite 3 feet to 1 foot bgs		
Comments	See site map for location.				

Depth, feet	Approximate Elevation, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows/foot	Graphic Log	MATERIAL DESCRIPTION	Well Completion Log	Water Content, %	% Passing #200 Sieve	OTHER TESTS AND REMARKS
0						Soft to medium stiff, moist, dark brown, SANDY SILT (ML), with clay and gravel to 1/2 inch.				Begin drilling at 0950 hrs.
5			1	5						Hydrocarbon odor 5-10 ft. No recovery in sample at 5 ft. Water at 6 ft bgs during drilling.
			2	9		Becomes medium stiff to stiff, wet.		19.1		
10			3	15		Medium dense, wet, brown, well-graded SAND with silt and gravel (SW-SM), fine- to coarse-grained, gravel to 2 inches. Increasing gravel. Decreasing gravel.			11.7	
15			4	17						Heaving sands at 15 ft.
						Bottom of boring at 16.5 feet.				Begin setting well at 1030 hrs. Complete well at 1130 hrs.
20										
25										
30										

APPENDIX B

GEOTECHNICAL LABORATORY TEST DATA

LABORATORY WATER CONTENT: AS - RECEIVED CONDITION

ASTM D 2216 - 92

Project Number: 964P170 Task Number: 9005

Project Name: MALIBU CREEK Assignment Number:

Project Engineer: EF Authorized by:

Exploration No.	C-2		P-1		P-6			
Sample No.	1		1		2			
Depth (ft.)	5		5		6.5~7'			
Container No.	M-10		M-6		M-60			
Mass of Container and Wet Specimen, M1 (g)	423.88		353.20		380.28			
Mass Container and Dry Specimen, M2 (g)	365.10		316.75		334.00			
Mass Container, M3 (g)	89.70		90.62		91.78			
Water Content, w (%)	21.34		16.38		19.11			
Unified Soil Classification Group Symbol (Visual)	SM		SP-SM		ML			
Circle Approximate Maximum Grain Size (Visual)	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10
Oven Temp. if Other Than 110 °C								

Exploration No.								
Sample No.								
Depth (ft.)								
Container No.								
Mass of Container and Wet Specimen, M1 (g)								
Mass Container and Dry Specimen, M2 (g)								
Mass Container, M3 (g)								
Water Content, w (%)								
Unified Soil Classification Group Symbol (Visual)								
Circle Approximate Maximum Grain Size(Visual)	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10	3", 11/2", 3/4", 3/8" #4, #10, <#10
Oven Temp. if Other Than 110 °C								

Remarks:

w = ((M1 - M2)/ (M2 - M3)) * 100

TESTED BY: TD DATE: 8/25/97

DRY MASS BY: TD

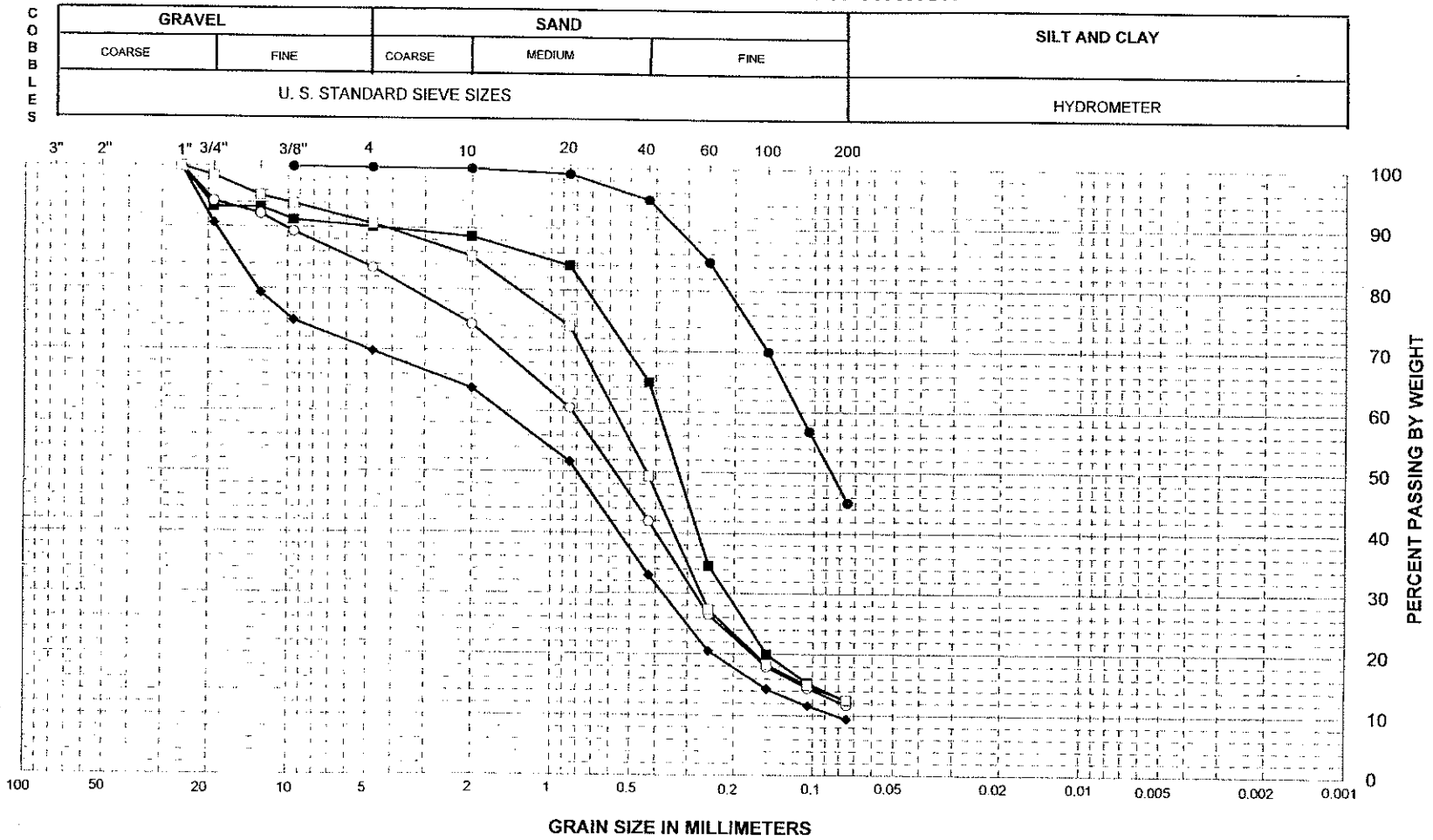
CALCULATED BY: TD

CHECKED BY:

SPOT CHECKED BY:

REVIEWED BY:

UNIFIED SOIL CLASSIFICATION



Exploration No.	Sample No.	Depth (ft)	SYMBOL	Wn (%)	LL	PI	CF	Description and Classification	D_{60}	D_{30}	D_{10}	Cu	Cc
C-1	1	5.0	●	NT	NT	NT	NT	Grayish brown silty SAND (SM)					
C-1	2	10.0	◆	NT	NT	NT	NT	Dark gray well-graded SAND with silt and gravel (SW-SM)	1.7	0.38	0.08	21.3	1.1
P-1	2	10.0	■	NT	NT	NT	NT	Brown silty SAND (SM)					
P-6	3	10.0	○	NT	NT	NT	NT	Gray well-graded SAND with silt (SW-SM)	0.83	0.29	0.06	13.8	1.7
P-7	1	5.0	□	25.0	NT	NT	NT	Dark brown silty SAND (SM)					

PROJECT NAME: Malibu Creek

PROJECT NUMBER: 964P170

PARTICLE-SIZE DISTRIBUTION CURVES

Figure:

PARTICLE-SIZE ANALYSIS : by Sieving using Soil Sieve Sizes & with Water Content

ASTM D 422 - 63 (1990), C 136 - 92, C 117 - 90 and D 2216 - 92

Project Number: 964P170 Task Number: 9005 Exploration No.: C-1

Project Name: MALIBU CREEK Assignment No ____ Sample No.: 1

Project Engineer: EF Depth (ft): 5

Initial Visual Description: ☐ See Visual Description Form (S-103) or Grayish brown silty Sand (SM)

SPECIMEN: Tested From: Bulk Sample ☐, SPT Sample ☐, Mod Calif Sample ☒, Other ____; Thin-Walled Tube ☐, Engr. Property Test ☐, Specimen's WC ☐

Selection Method: X Sieves (1) - whole sample used; ____ Sieves (1) - partial sample used & selected by Method(s) &; ____ Sieves (1) - partial sample used & selected by Method(s) &

Methods: (a) Splitter, (use for dry soils or that which will segregate) (b) Quartering, (use for dry soils or that which will segregate) (c) Representative scoop after mixing, or slice of intact sample. (use for moist soils or that which will not segregate)

☐ See Bulk Sample Processing Information Form (S-106)

Preparation:

Sample/Specimen: Oven-Dried ☐, Air Dried ☐, As-Received State ☒

Oven-Dried Soil Broken Up Before: Selecting partial sample. No ☒ ; Yes ☐; Sieving 1st Sieve Series: No ☐ ; Yes ☐; Sieving 2nd Sieve Series: No ☐ ; Yes ☐; Sieving 3rd Sieve Series: No ☐ ; Yes ☐

By: Mortar & Pestle ☐, Pulverizer ☐, Hand ☐, Other ____

Remarks ____

Washing:

	No	Yes
Whole Specimen Washed on No. 200 sieve ?		☒ and Soil Soaked for 6 hrs.
Retained Fraction: 1st Split Washed ?		☒ , 2nd Split Washed ? No ☐ ; Yes ☐
Fine Fraction Washed on No. 200 sieve ?		and Soil Soaked for ____ hrs.

MASS OF TEST SPECIMEN (g)

	Total Test Specimen	Partial Test Specimen 1st Split	Partial Test Specimen 2nd Split	Soil Retained (after washing) 2nd Split	Soil Retained (after washing) +200	Water Content As Recieved or	
Min.sieve size in sieving sequence (1)	200						
Container Number	M-1				M-1	Container No	
Mass of Container and Dry Soil, (g)	366.05				248.54	Wet, M1 (g)	
Mass of Container, (g)	92.06				92.06	Dry, M2 (g)	
Dry Soil, Ws (g)	273.99				156.48	Cont.,M3 (g)	
Mass of Dry Soil from Hydrometer, Ws (g)						Water Content (%)	

SIEVING RESULTS

See (2)	Sieve No.	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
	3"			
	2"			
	1 1/2"			
	1"			
	3/4"			
	1/2"			
	3/8"			
	4			
	Pan		XXXXXXXX	XXXXXXXXXX

Req. Mass of Test Spec. for 1% (kg)
3"= 70
1 1/2"=10
3/4"= 1.1
3/8"= 0.25
#4 = 0.1
#10 = 0.1

Sieve No. / (3)	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
3/8"	0.00		100.0
4 / 325	0.37		99.9
10 / 180	0.55		99.8
20 / 115	2.87		99.0
40 / 75	14.18		94.8
60 / 60	42.01		84.7
100*/ 40	82.17		70.0
140 / 30	118.22		56.9
200 / 20	150.48		45.1
Pan	156.69	XXXXXXXX	XXXXXXXXXX

Mica Noted: No ☒ ; Yes ☐ Amount Adjective: ____

Notes: (1) Sieve size given, denotes min. sieve size used in the appropriate sieving sequence

(2) X in box denotes sieve on which split was made (3) Proposed alowable amount of soil retained on 8" sieve.

SUMMARY: Shape, Filter, & etc. Parameters

% COBBLES ____ D60 ____ D85 ____

% GRAVEL 0.1 D30 ____ D15 ____

% SAND 54.8 D10 ____ D50 ____

% FINES 45.1 Cu = ____ Cc = ____

Remarks: ____

Coefficient of Uniformity, Cu = D60 / D10 Coefficient of Curvature, Cc = D30^2 / (D60 * D10)

Note: The above values D## denotes particle size (mm) at the corresponding percent passing. * Denotes sieve added to better define gradation curve

	SET-UP BY:	DRY MASS BY:	WASHED BY:	CALCULATED BY:
COARSE FRACTION:				
FINE FRACTION:	TO	TO	IAT	CHECKED BY:
DATE:	8/25/97	8/26/97	8/26/97	SPOT CHECKED BY:
				REVIEWED BY:

S-104 (10/94) (SNA) SIEV_S_H.XLS 4/7/97 WOODWARD-CLYDE CONSULTANTS

PARTICLE-SIZE ANALYSIS : by Sieving using Soil Sieve Sizes & with Water Content

ASTM D 422 - 63 (1990), C 136 - 92, C 117 - 90 and D 2216 - 92

Project Number 964P170 Task Number 9005 Exploration No.: C-1

Project Name MALIBU CREEK Assignment No ____ Sample No.: 2

Project Engineer EF Depth (ft): 10

Initial Visual Description ☐ See Visual Description Form (S-103) or Dark gray poorly-graded Sand with silt and gravel (SP-SM) (SW-SM)

SPECIMEN: Tested From: Bulk Sample ☐, SPT Sample ☐, Mod Calif Sample ☒, Other ____; Thin-Walled Tube ☐, Engr Property Test ☐, Specimen's WC ☐

☐ See Bulk Sample Processing Information Form (S-106)

Selection Method:
- X Sieves (1) - whole sample used
- ____ Sieves (1) - partial sample used & selected by Method(s) ____ &
- ____ Sieves (1) - partial sample used & selected by Method(s) ____ &

Methods: (a). Splitter, (use for dry soils or that which will segregate); (b) Quartering, (use for dry soils or that which will segregate); (c) Representative scoop after mixing, or slice of intact sample. (use for moist soils or that which will not segregate)

Preparation:
Sample/Specimen: Oven-Dried ☐, Air Dried ☐, As-Received State ☒
Oven-Dried Soil Broken Up Before: Selecting partial sample: No ☒, Yes ☐; Sieving 1st Sieve Series: No ☐, Yes ☐; Sieving 2nd Sieve Series: No ☐, Yes ☐; Sieving 3rd Sieve Series: No ☐, Yes ☐
By: Mortar & Pestle ☐, Pulverizer ☐, Hand ☐, Other ____
Remarks ____

Washing:
Whole Specimen Washed on No. 200 sieve ? No ☐ Yes ☒ and Soil Soaked for ____ hrs.
Retained Fraction: 1st Split Washed ? ☐ ☐
Fine Fraction Washed on No. 200 sieve ? ☐ ☐ , 2nd Split Washed ? No ☐ ;Yes ☐ and Soil Soaked for ____ hrs.

MASS OF TEST SPECIMEN (g)

	Total Test Specimen	Partial Test Specimen 1st Split	Partial Test Specimen 2nd Split	Soil Retained (after washing) 2nd Split	Soil Retained (after washing) +200
Min.sieve size in sieving sequence (1)	200				
Container Number	M-62				M1-62
Mass of Container and Dry Soil, (g)	377.41				351.74
Mass of Container, (g)	92.01				92.01
Dry Soil, Ws (g)	285.40				259.94
Mass of Dry Soil from Hydrometer, Ws (g)					

Water Content As Recieved or

Container No	
Wet, M1 (g)	
Dry, M2 (g)	
Cont.,M3 (g)	
Water Content (%)	

SIEVING RESULTS

See (2)	Sieve No.	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
	3"			
	2"			
	1 1/2"			
	1"	0.00		100.0
	3/4"	26.82		90.6
	1/2"	59.07		79.3
	3/8"	71.81		74.8
	4	86.13		69.8
	Pan		XXXXXXXX	XXXXXXXXXX

Req. Mass of Test Spec for 1% (kg)
3"= 70
1 1/2"=10
3/4"= 1.1
3/8"= 0.25
#4 = 0.1
#10 = 0.1

Sieve No. / (3)	Cum Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
3/8"			
4 / 325			
10 / 180	103.26		63.8
20 / 115	137.82		51.7
40 / 75	191.23		33.0
60 / 60	226.99		20.5
100*/ 40	244.72		14.3
140 / 30	252.37		11.6
200 / 20	258.62		9.4
Pan	260.05	XXXXXXXX	XXXXXXXXXX

Notes: (1) Sieve size given, denotes min. sieve size used in the appropriate sieving sequence

(2) X in box denotes sieve on which split was made (3) Proposed alowable amount of soil retained on 8" sieve.

SUMMARY: Shape, Filter, & etc. Parameters

% COBBLES ____ D60 1.7 D85 ____

% GRAVEL 30.2 D30 0.38 D15 ____

% SAND 60.4 D10 0.08 D50 ____

% FINES 9.4 Cu = 21.3 Cc = 1.1

Note: The above values D## denotes particle size (mm) at the corresponding percent passing.

Mica Noted: No ☒ ; Yes ☐ Amount Adjective: ____

Remarks: ____

Coefficient of Uniformity, Cu = D60 / D10 Coefficient of Curvature, Cc = D30^2 / (D60 * D10)

* Denotes sieve added to better define gradation curve

	SET-UP BY:	DRY MASS BY:	WASHED BY:
COARSE FRACTION:			
FINE FRACTION:	TO	TO	HH
DATE:	8/25/97	8/26/97	8/26/97

CALCULATED BY: TO

CHECKED BY: ____

SPOT CHECKED BY: ____

REVIEWED BY: ____

PARTICLE-SIZE ANALYSIS : by Sieving using Soil Sieve Sizes & with Water Content

ASTM D 422 - 63 (1990), C 136 - 92, C 117 - 90 and D 2216 - 92

Project Number 964P170 Task Number 9005 Exploration No.: P-1
Project Name MALIBU CREEK Assignment No _____ Sample No.: 2
Project Engineer EF Depth (ft): 10

Initial Visual Description ☐ See Visual Description Form (S-103) or Brown silty Sand (SM)

SPECIMEN: Tested From:
Bulk Sample ☐ Thin Walled Tube ☐
SPT Sample ☐ Engr. Property Test
Mod Calif. Sample ☒ Specimen's WC ☐
Other _____

☐ See Bulk Sample Processing Information Form (S-106)

Selection Method:
X Sieves (1) - whole sample used
_____ Sieves (1) - partial sample used & selected by Method(s) _____ &
_____ Sieves (1) - partial sample used & selected by Method(s) _____ &

Methods: (a) Splitter; (use for dry soils or that which will segregate)
(b) Quartering, (use for dry soils or that which will segregate)
(c) Representative scoop after mixing, or slice of intact sample. (use for moist soils or that which will not segregate)

Preparation:
Sample/Specimen: Oven-Dried ☐ Air Dried ☐ As-Received State ☒
Oven-Dried Soil Broken Up Before: Selecting partial sample. No ☒ ; Yes ☐
Sieving 1st Sieve Series: No ☐ ; Yes ☐
Sieving 2nd Sieve Series: No ☐ ; Yes ☐
Sieving 3rd Sieve Series: No ☐ ; Yes ☐
By: Mortar & Pestle ☐ Pulverizer ☐ Hand ☐ Other _____
Remarks _____

Washing:

	No	Yes
Whole Specimen Washed on No. 200 sieve ?	☐	☒
Retained Fraction: 1st Split Washed ?	☐	☐
Fine Fraction Washed on No. 200 sieve ?	☐	☐

and Soil Soaked for _____ hrs.
, 2nd Split Washed ? No ☐ ; Yes ☐
and Soil Soaked for _____ hrs.

MASS OF TEST SPECIMEN (g)

	Total Test Specimen	Partial Test Specimen 1st Split	Partial Test Specimen 2nd Split	Soil Retained (after washing) 2nd Split	Soil Retained (after washing) +200
Min.sieve size in sieving sequence (1)	200				
Container Number	M-7				M7-7
Mass of Container and Dry Soil, (g)	326.77				298.56
Mass of Container, (g)	91.39				91.39
Dry Soil, Ws (g)	235.38				207.17
Mass of Dry Soil from Hydrometer, Ws (g)					

Water Content

	As Recieved or
Container No	
Wet, M1 (g)	
Dry, M2 (g)	
Cont ,M3 (g)	
Water Content (%)	

SIEVING RESULTS

See (2)	Sieve No.	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
	3"			
	2"			
	1 1/2"			
	1"	0.00		100.0
	3/4"	15.79		93.3
	1/2"	15.79		93.3
	3/8"	20.64		91.2
	4	23.42		90.1
	Pan		XXXXXXXX	XXXXXXXXXX

Req Mass of Test Spec for 1% (kg)
3"= 70
1 1/2"=10
3/4"= 1.1
3/8"= 0.25
#4 = 0.1
#10 = 0.1

Sieve No. / (3)	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
3/8"			
4 / 325			
10 / 180	26.87		88.6
20 / 115	37.55		84.0
40 / 75	82.67		64.9
60 / 60	154.05		34.6
100*/ 40	188.33		20.0
140 / 30	199.42		15.3
200 / 20	206.25		12.4
Pan	207.64	XXXXXXXX	XXXXXXXXXX

Notes: (1) Sieve size given, denotes min. sieve size used in the appropriate sieving sequence.
(2) X in box denotes sieve on which split was made (3) Proposed alowable amount of soil retained on 8" sieve.

SUMMARY: Shape, Filter, & etc. Parameters

% COBBLES _____ D60 _____ D85 _____
% GRAVEL 9.9 D30 _____ D15 _____
% SAND 77.7 D10 _____ D50 _____
% FINES 12.4 Cu = _____ Cc = _____

Mica Noted: No ☒ ; Yes ☐ Amount Adjective: _____

Remarks: _____

Note: The above values D## denotes particle size (mm) at the corresponding percent passing.
Coefficient of Uniformily, Cu = D60 / D10 Coefficient of Curvature, Cc = D30^2 / (D60 * D10)
* Denotes sieve added to better define gradation curve

	SET-UP BY:	DRY MASS BY:	WASHED BY:
COARSE FRACTION:			
FINE FRACTION:	TO	TO	HTT
DATE:	8/25/97	8/26/97	8/26/97

CALCULATED BY: TO
CHECKED BY: _____
SPOT CHECKED BY: _____
REVIEWED BY: _____

PARTICLE-SIZE ANALYSIS : by Sieving using Soil Sieve Sizes & with Water Content

ASTM D 422 - 63 (1990), C 136 - 92, C 117 - 90 and D 2216 - 92

Project Number 964P170 Task Number: 9005 Exploration No.: P-6

Project Name MALIBU CREEK Assignment No ____ Sample No.: 3

Project Engineer FEI Depth (ft): 10

Initial Visual Description ☐ See Visual Description Form (S-103) or Grey poorly-graded Sand with silt (SP-SM) (SW-SM)

SPECIMEN: Tested From:

Bulk Sample ☐ Thin-Walled Tube ☐

SPT Sample ☐ Engr. Property Test

Mod Calif Sample ☒ Specimen's WC ☐

Other ____

☐ See Bulk Sample Processing Information Form (S-106)

Selection Method:

X Sieves (1) - whole sample used

____ Sieves (1) - partial sample used & selected by Method(s) &

____ Sieves (1) - partial sample used & selected by Method(s) &

Methods: (a) Splitter, (use for dry soils or that which will segregate)

(b) Quartering, (use for dry soils or that which will segregate)

(c) Representative scoop after mixing, or slice of intact sample. (use for moist soils or that which will not segregate)

Preparation:

Sample/Specimen: Oven-Dried ☐ Air Dried ☐ As-Received State ☒

Oven-Dried Soil Broken Up Before: Selecting partial sample: No ☒, Yes ☐; Sieving 1st Sieve Series: No ☐, Yes ☐; Sieving 2nd Sieve Series: No ☐, Yes ☐; Sieving 3rd Sieve Series: No ☐, Yes ☐

By: Mortar & Pestle ☐ Pulverizer ☐ Hand ☐ Other ____

Remarks ____

Washing:

	No	Yes	
Whole Specimen Washed on No. 200 sieve ?	☐	☒	and Soil Soaked for ____ hrs.
Retained Fraction: 1st Split Washed ?	☐	☐	, 2nd Split Washed ? No ☐ ;Yes ☐
Fine Fraction Washed on No. 200 sieve ?	☐	☐	and Soil Soaked for ____ hrs.

MASS OF TEST SPECIMEN (g)

	Total Test Specimen	Partial Test Specimen 1st Split	Partial Test Specimen 2nd Split	Soil Retained (after washing) 2nd Split	Soil Retained (after washing) +200
Min.sieve size in sieving sequence (1)	200				
Container Number	M-3				M-3
Mass of Container and Dry Soil, (g)	339.35				311.71
Mass of Container, (g)	90.14				90.14
Dry Soil, Ws (g)	249.21				221.57
Mass of Dry Soil from Hydrometer, Ws (g)					

Water Content As Recieved or

Container No	
Wet, M1 (g)	
Dry, M2 (g)	
Cont.,M3 (g)	
Water Content (%)	

SIEVING RESULTS

See (2)	Sieve No.	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
	3"			
	2"			
	1 1/2"			
	1"	0.00		100.0
	3/4"	14.53		94.2
	1/2"	19.47		92.2
	3/8"	26.64		89.3
	4	41.23		83.5
	Pan		XXXXXXXX	XXXXXXXXXX

Req. Mass of Test Spec for 1% (kg)
3"= 70
1 1/2"=10
3/4"= 1.1
3/8"= 0.25
#4 = 0.1
#10 = 0.1

Sieve No. / (3)	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
3/8"			
4 / 325			
10 / 180	64.13		74.3
20 / 115	98.09		60.6
40 / 75	144.52		42.0
60 / 60	183.28		26.5
100*/ 40	204.54		17.9
140 / 30	213.14		14.5
200 / 20	220.16		11.7
Pan	221.88	XXXXXXXX	XXXXXXXXXX

Notes: (1) Sieve size given, denotes min. sieve size used in the appropriate sieving sequence.

(2) X in box denotes sieve on which split was made (3) Proposed alowable amount of soil retained on 8" sieve.

Mica Noted: No ☒ ; Yes ☐ Amount Adjective: ____

SUMMARY: Shape, Filter, & etc. Parameters

% COBBLES ____ D60 0.83 D85 ____

% GRAVEL 16.5 D30 0.29 D15 ____

% SAND 71.8 D10 20.06 D50 ____

% FINES 11.7 Cu = 13.8 Cc = 1.7

Remarks: ____

Coefficient of Uniformity, Cu = D60 / D10 Coefficient of Curvature, Cc = D30^2 / (D60 * D10)

Note: The above values D## denotes particle size (mm) at the corresponding percent passing. * Denotes sieve added to better define gradation curve

	SET-UP BY:	DRY MASS BY:	WASHED BY:	CALCULATED BY:
COARSE FRACTION:				
FINE FRACTION:	TO	TO	TO	CHECKED BY:
DATE:	8/25/97	8/26/97	8/26/97	SPOT CHECKED BY:
				REVIEWED BY:

S-104 (10/94) (SNA) SIEV_S_H.XLS 4/7/97 WOODWARD-CLYDE CONSULTANTS

PARTICLE-SIZE ANALYSIS : by Sieving using Soil Sieve Sizes & with Water Content

ASTM D 422 - 63 (1990), C 136 - 92, C 117 - 90 and D 2216 - 92

Project Number 964P170 Task Number: 9005 Exploration No.: P-7

Project Name MALIBU CREEK Assignment No ____ Sample No.: 1

Project Engineer EF Depth (ft): 5

Initial Visual Description: ☐ See Visual Description Form (S-103) or Dark brown silty Sand (SM)

SPECIMEN: Tested From:

Bulk Sample ☐ Thin Walled Tube ☐

SPT Sample ☐ Engr. Property Test

Mod Calif Sample ☒ Specimen's WC ☐

Other ____

☐ See Bulk Sample Processing Information Form (S-106)

Selection Method:

X Sieves (1) - whole sample used

___ Sieves (1) - partial sample used & selected by Method(s) &

___ Sieves (1) - partial sample used & selected by Method(s) &

Methods: (a). Splitter; (use for dry soils or that which will segregate)

(b) Quartering, (use for dry soils or that which will segregate)

(c) Representative scoop after mixing, or slice of intact sample. (use for moist soils or that which will not segregate)

Preparation:

Sample/Specimen: Oven-Dried ☐ Air Dried ☐ As-Received State ☒

Oven-Dried Soil Broken Up Before: Selecting partial sample: No ☒; Yes ☐ Sieving 1st Sieve Series: No ☐; Yes ☐ Sieving 2nd Sieve Series: No ☐; Yes ☐ Sieving 3rd Sieve Series: No ☐; Yes ☐

By: Mortar & Pestle ☐ Pulverizer ☐ Hand ☐ Other ____

Remarks ____

Washing:

	No	Yes
Whole Specimen Washed on No. 200 sieve ?		X
Retained Fraction: 1st Split Washed ?		
Fine Fraction Washed on No. 200 sieve ?		

and Soil Soaked for 6 hrs.

, 2nd Split Washed ? No ☐ ;Yes ☐

and Soil Soaked for ____ hrs.

MASS OF TEST SPECIMEN (g)

	Total Test Specimen	Partial Test Specimen 1st Split	Partial Test Specimen 2nd Split	Soil Retained (after washing) 2nd Split	Soil Retained (after washing) +200
Min.sieve size in sieving sequence (1)	200				
Container Number	FJ-10				FJ-10
Mass of Container and Dry Soil, (g)	327.09				301.00
Mass of Container, (g)	111.56				115.56
Dry Soil, Ws (g)	215.53				185.44
Mass of Dry Soil from Hydrometer, Ws (g)					

Water Content

As Recieved or	
Container No	FJ-10
Wet, M1 (g)	380.94
Dry, M2 (g)	327.09
Cont.,M3 (g)	111.56
Water Content (%)	24.98

SIEVING RESULTS

See (2)	Sieve No.	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
	3"			
	2"			
	1 1/2"			
	1"	0.00		100.0
	3/4"	3.50		98.4
	1/2"	10.24		95.2
	3/8"	13.23		93.9
	4	20.23		90.6
	Pan		XXXXXXXX	XXXXXXXXXX

Req. Mass of Test Spec for 1% (kg)
3"= 70
1 1/2"=10
3/4"= 1.1
3/8"= 0.25
#4 = 0.1
#10 = 0.1

Sieve No. / (3)	Cum. Mass Retained (g)	% Finer than Sieve ____	Total Specimen % Finer N'
3/8"			
4 / 325			
10 / 180	31.46		85.4
20 / 115	56.09		74.0
40 / 75	109.33		49.3
60 / 60	156.69		27.3
100*/ 40	176.05		18.3
140 / 30	183.32		14.9
200 / 20	188.56		12.5
Pan	189.72	XXXXXXXX	XXXXXXXXXX

Notes: (1) Sieve size given, denotes min. sieve size used in the appropriate sieving sequence

(2) X in box denotes sieve on which split was made (3) Proposed alowable amount of soil retained on 8" sieve.

SUMMARY: Shape, Filter, & etc. Parameters

% COBBLES ____	D60 ____	D85 ____	
% GRAVEL 9.4	D30 ____	D15 ____	
% SAND 78.1	D10 ____	D50 ____	
% FINES 12.5	Cu = ____	Cc = ____	

Mica Noted: No ☒ ; Yes ☐ Amount Adjective: ____

Remarks: ____

Coefficient of Uniformity, Cu = D60 / D10 Coefficient of Curvature, Cc = D30^2 / (D60 * D10)

Note: The above values D## denotes particle size (mm) at the corresponding percent passing. * Denotes sieve added to better define gradation curve

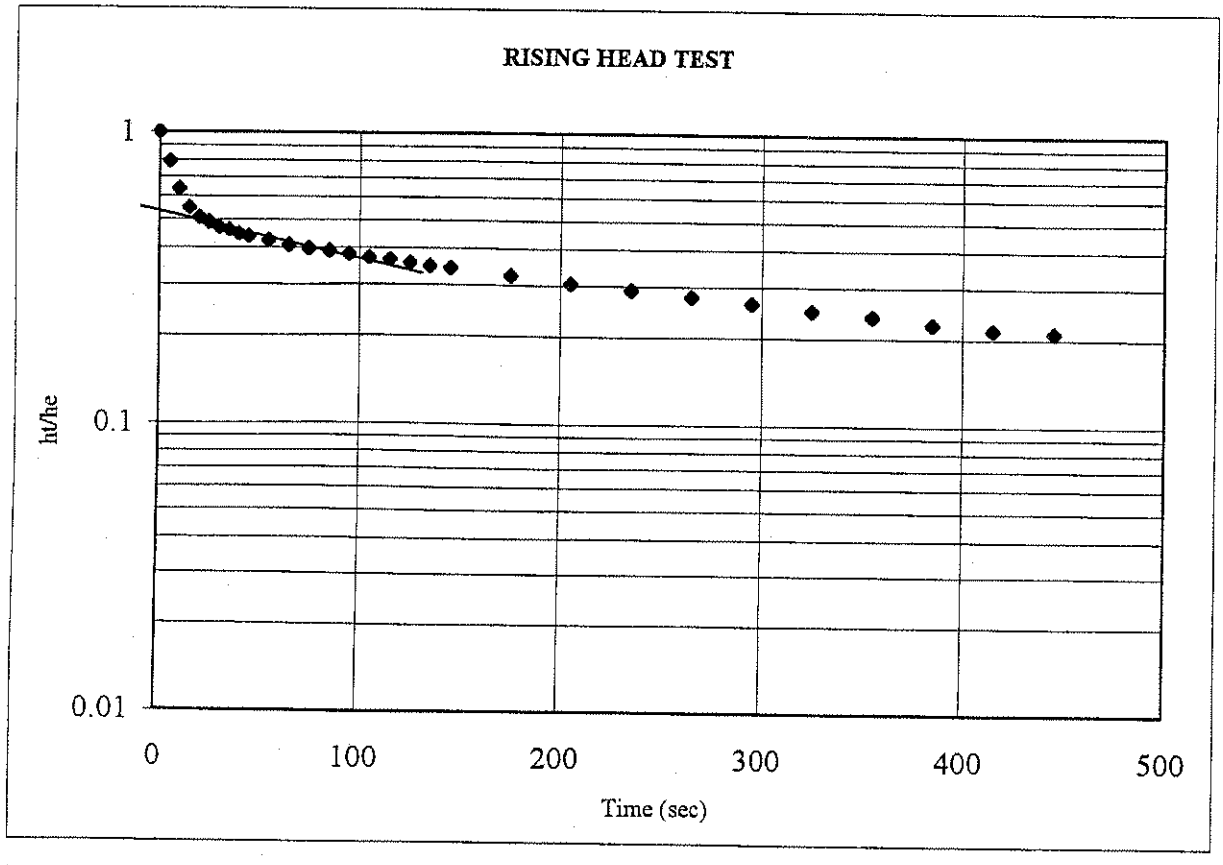
	SET-UP BY:	DRY MASS BY:	WASHED BY:	CALCULATED BY:
COARSE FRACTION:				
FINE FRACTION:	TO	TO	HTT	CHECKED BY:
DATE:	8/25/97	8/26/97	8/26/97	SPOT CHECKED BY:
				REVIEWED BY:

CALCULATED BY: TO

APPENDIX C

SLUG TEST DATA

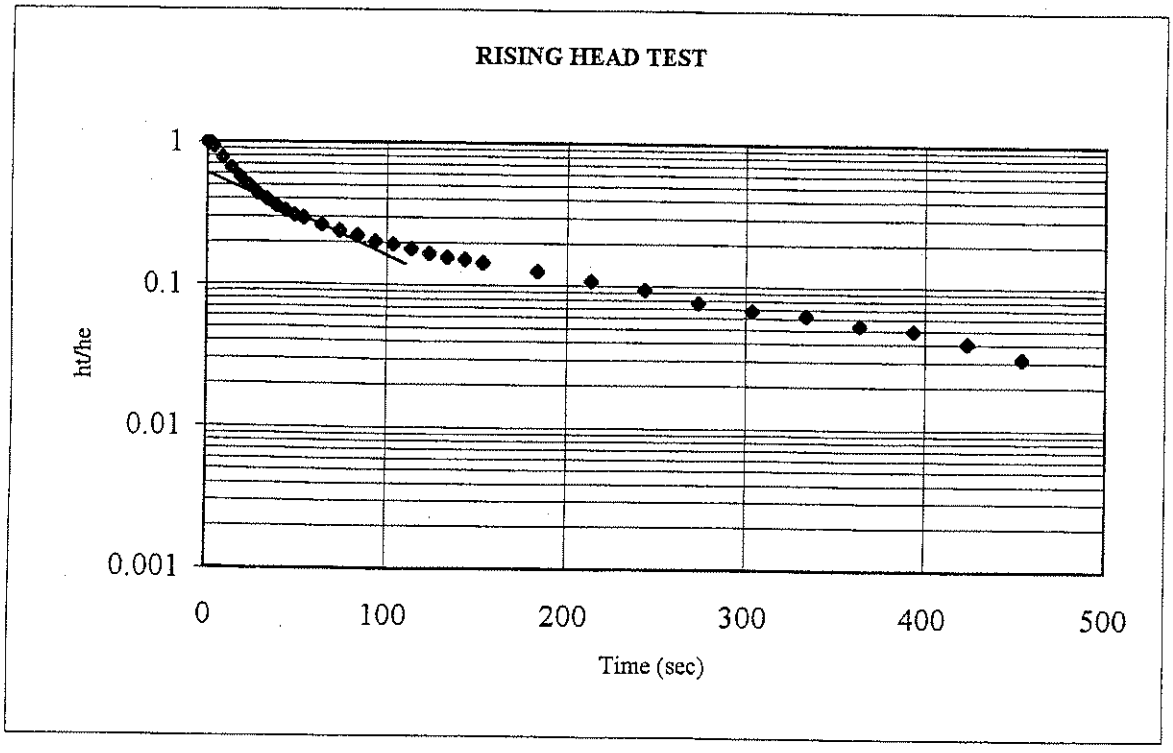
RISING HEAD TEST		MALIBU LAGOON INVESTIGATION	
Borehole	P-2	Date	8.31.98
Project No.	964P170	Engineer	PAS
All depths are vertical depths		Collar Elevation (ft)	9.46
Top of test section (d1) (ft)	7.17	Base of test section (ft)	13.55
Depth to SWL, Hw (ft)	7.17	Borehole rad. r (ft)	0.417
Head excess, He (ft)	2.29	Casing rad r(c) (ft)	0.167



Slope (S) =	0.01190
Hydraulic conductivity K (ft/d) =	0.133S[(r(c)^2)/L]
K =	5.98E-01

WOODWARD-CLYDE CONSULTANTS

RISING HEAD TEST		MALIBU LAGOON INVESTIGATION	
Borehole	P-3	Date	8.31.98
Project No.	964P170	Engineer	PAS
All depths are vertical depths		Collar Elevation (ft)	9.39
Top of test section (d1) (ft)	7.07	Base of test section (ft)	14.44
Depth to SWL, Hw (ft)	7.07	Borehole rad. r (ft)	0.417
Head excess, He (ft)	2.41	Casing rad r(c) (ft)	0.167



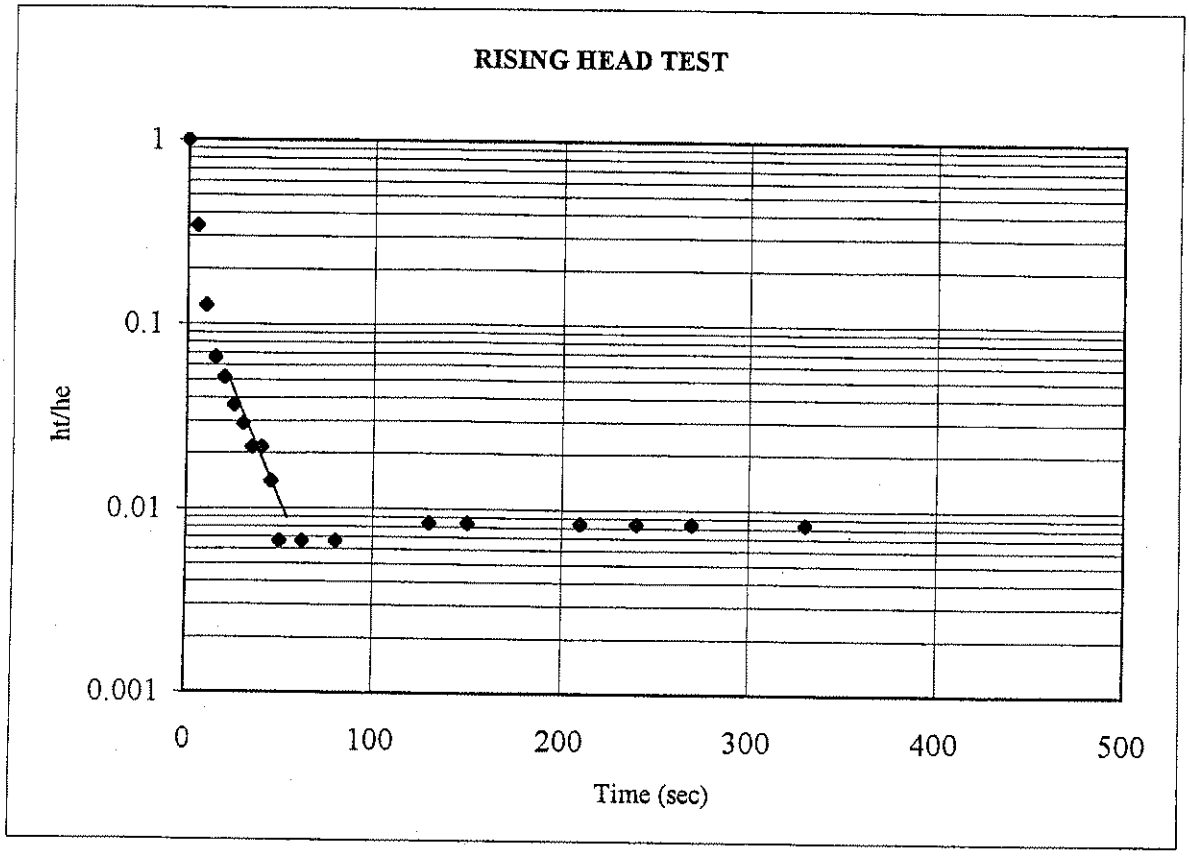
Slope (S) = 0.01580

Hydraulic conductivity K (ft/d) = 0.133S[(r(c)^2)/L]

K = 6.87E-01

WOODWARD-CLYDE CONSULTANTS

RISING HEAD TEST		MALIBU LAGOON INVESTIGATION	
Borehole	P-4	Date	8.31.98
Project No.	964P170	Engineer	PAS
All depths are vertical depths		Collar Elevation (ft)	9.75
Top of test section (d1) (ft)	7.44	Base of test section (ft)	11.95
Depth to SWL, Hw (ft)	7.44	Borehole rad. r (ft)	0.417
Head excess, He (ft)	1.45	Casing rad r(c) (ft)	0.167



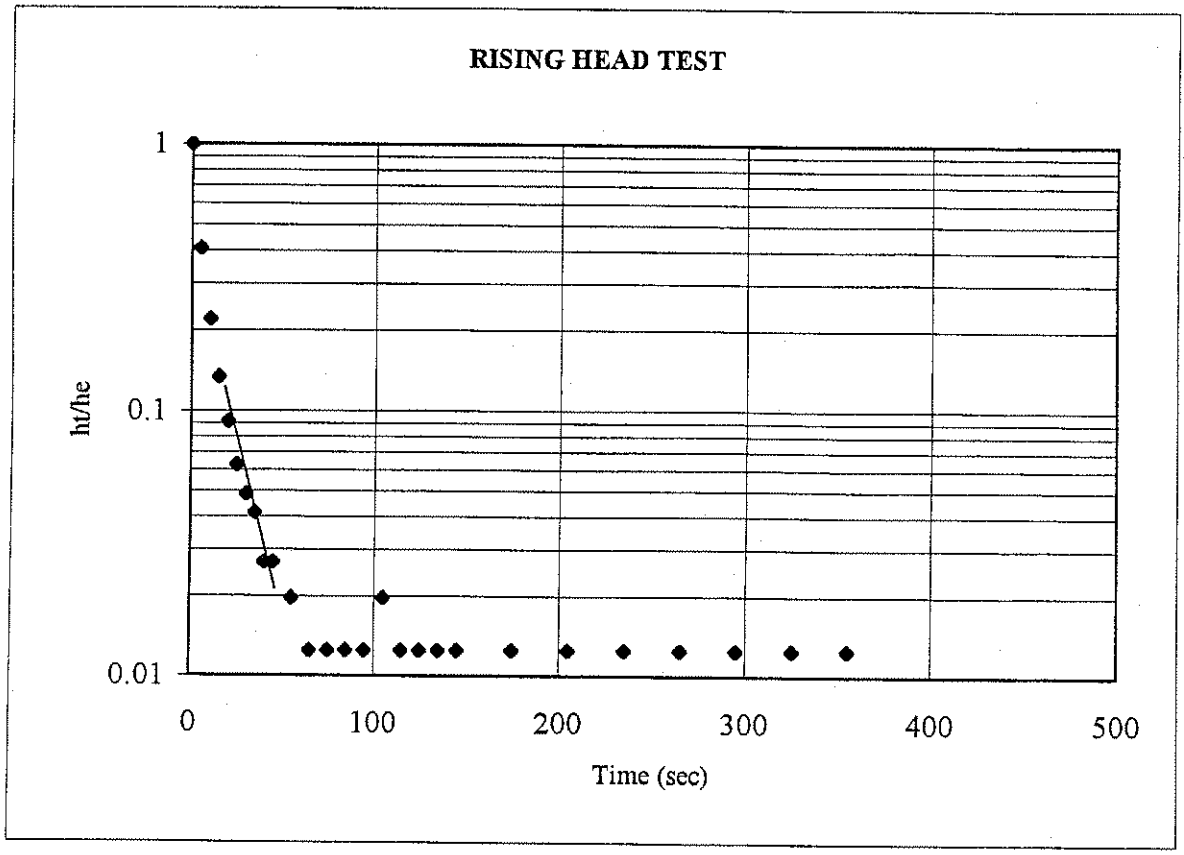
Slope (S) = 0.05710

Hydraulic conductivity K (ft/d) = 0.133S[(r(c)^2)/L]

K = 4.06E+00

WOODWARD-CLYDE CONSULTANTS

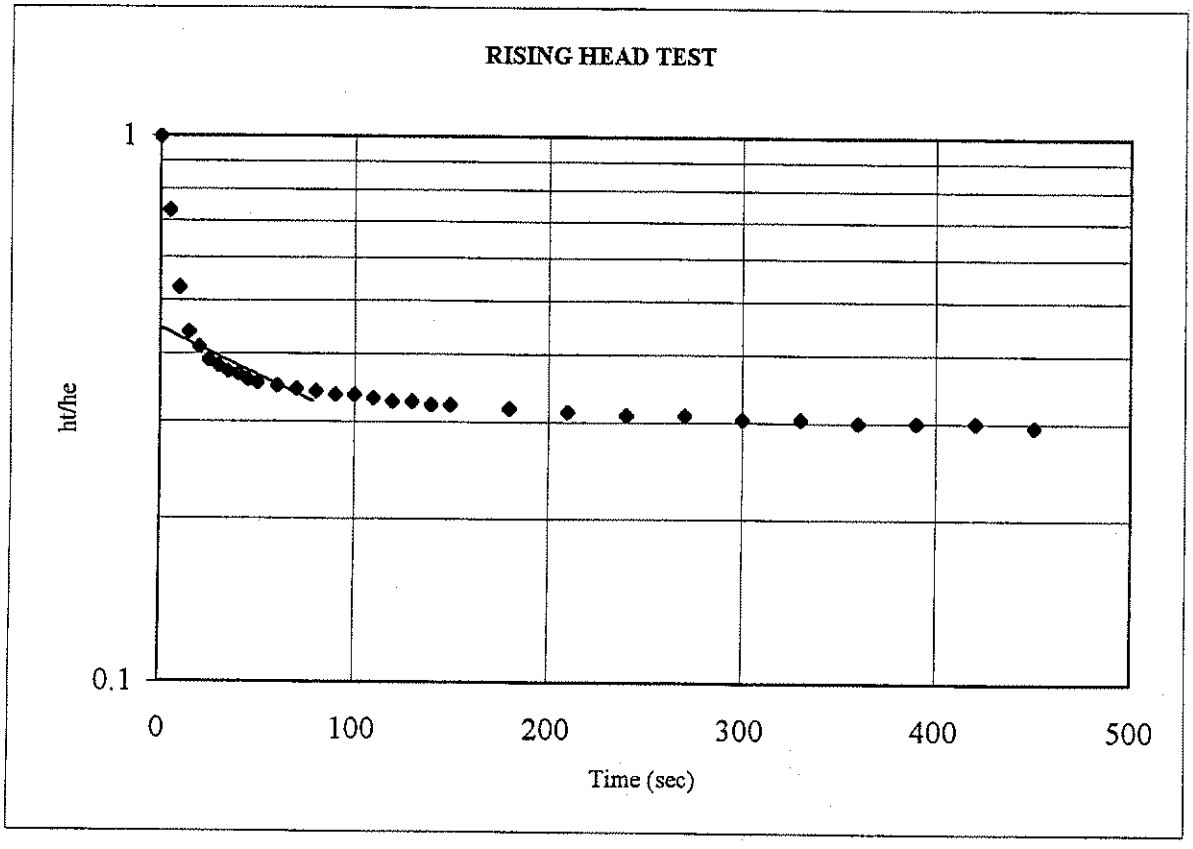
RISING HEAD TEST		MALIBU LAGOON INVESTIGATION	
Borehole	P-5	Date	8.31.98
Project No.	964P170	Engineer	PAS
All depths are vertical depths		Collar Elevation (ft)	9.69
Top of test section (d1) (ft)	7.34	Base of test section (ft)	14.14
Depth to SWL, Hw (ft)	7.34	Borehole rad. r (ft)	0.417
Head excess, He (ft)	1.51	Casing rad r(c) (ft)	0.167



Slope (S) =	0.05950
Hydraulic conductivity K (ft/d) =	0.133S[(r(c)^2)/L]
K =	2.80E+00

WOODWARD-CLYDE CONSULTANTS

RISING HEAD TEST		MALIBU LAGOON INVESTIGATION	
Borehole	P-6	Date	8.28.98
Project No.	964P170	Engineer	PAS
All depths are vertical depths		Collar Elevation (ft)	8.63
Top of test section (d1) (ft)	5.75	Base of test section (ft)	13.66
Depth to SWL, Hw (ft)	5.75	Borehole rad. r (ft)	0.417
Head excess, He (ft)	2.44	Casing rad r(c) (ft)	0.167



Slope (S) =	0.03010
Hydraulic conductivity K (ft/d) =	0.133S[(r(c)^2)/L]
K =	1.22E+00

WOODWARD-CLYDE CONSULTANTS

APPENDIX D

ENVIRONMENTAL LABORATORY DATA

Calscience Environmental Laboratories, Inc.

October 29, 1998

Paul Salter
Woodward-Clyde Consultants
2020 East 1st Street, Suite 400
Santa Ana, CA 92705

Subject: **Calscience Work Order Number: 98-10-0664**
Client Reference: Malibu Lagoon

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 10/27/98 and analyzed in accordance with the attached chain-of-custody.

The results in this analytical report are limited to the samples tested, and any reproduction of this report must be made in its entirety.

If you have any questions regarding this report, require sampling supplies or field services, or information on our analytical services, please feel free to call me at (714) 895-5494.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Marycarol Valenzuela
Project Manager

William H. Christensen
Deliverables Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants		Date Sampled:	10/26/98
2020 East 1st Street, Suite 400		Date Received:	10/27/98
Santa Ana, CA 92705		Date Analyzed:	10/27/98
		Work Order No.:	98-10-0664
Attn: Paul Salter		Method:	SM 2320B
RE: Malibu Lagoon		Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number	Bicarbonate Concentration	Carbonate Concentration	Reporting Limit
P21026-1037	472	ND	5
P31026-1057	504	ND	5
P51026-1122	560	ND	5
P41026-1305	520	ND	5

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants		Date Sampled:	10/26/98
2020 East 1st Street, Suite 400		Date Received:	10/27/98
Santa Ana, CA 92705		Date Analyzed:	10/27/98
		Work Order No.:	98-10-0664
Attn: Paul Salter		Method:	EPA 300.0
RE: Malibu Lagoon		Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number: P21026-1037

Bromide	283	10.0
Chloride	212	100
Sulfate	333	100

Sample Number: P31026-1057

Bromide	3.9	0.1
Chloride	266	100
Sulfate	298	100

Sample Number: P51026-1122

Bromide	0.7	0.1
Chloride	181	100
Sulfate	242	100

Sample Number: P41026-1305

Bromide	1.6	0.1
Chloride	307	100
Sulfate	284	100

Sample Number: Method Blank

Bromide	ND	0.1
Chloride	ND	1
Sulfate	ND	1

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

EPA 6010B ICP Metals, TTLC

Client Name:	Woodward-Clyde Consultants		
Project ID:	Malibu Lagoon		
Work Order Number:	98-10-0664		
QC Batch ID:	981028lcs2	Date Collected:	10/26/98
Matrix:	Aqueous	Date Received:	10/27/98
Preparation:	Total Digestion	Date Prepared:	10/28/98
Method:	EPA 6010B	Date Analyzed:	10/29/98

Client Sample Number: **P21026-1037**
Lab Sample Number: 98-10-0664-1

Parameter	Result	RL	Qualifiers	Units
Calcium	134	0.100		mg/L
Magnesium	80.7	0.100		mg/L
Potassium	11.6	0.500		mg/L
Sodium	327	0.500		mg/L

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

EPA 6010B ICP Metals, TTLC

Client Name:	Woodward-Clyde Consultants		
Project ID:	Malibu Lagoon		
Work Order Number:	98-10-0664		
QC Batch ID:	981028lcs2	Date Collected:	10/26/98
Matrix:	Aqueous	Date Received:	10/27/98
Preparation:	Total Digestion	Date Prepared:	10/28/98
Method:	EPA 6010B	Date Analyzed:	10/29/98

Client Sample Number: **P31026-1057**
Lab Sample Number: 98-10-0664-2

Parameter	Result	RL	Qualifiers	Units
Calcium	168	0.100		mg/L
Magnesium	133	0.100		mg/L
Potassium	15.1	0.500		mg/L
Sodium	211	0.500		mg/L

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

EPA 6010B ICP Metals, TTLC

Client Name:	Woodward-Clyde Consultants		
Project ID:	Malibu Lagoon		
Work Order Number:	98-10-0664		
QC Batch ID:	981028lcs2	Date Collected:	10/26/98
Matrix:	Aqueous	Date Received:	10/27/98
Preparation:	Total Digestion	Date Prepared:	10/28/98
Method:	EPA 6010B	Date Analyzed:	10/29/98

Client Sample Number: **P51026-1122**
Lab Sample Number: 98-10-0664-3

Parameter	Result	RL	Qualifiers	Units
Calcium	133	0.100		mg/L
Magnesium	75.1	0.100		mg/L
Potassium	8.82	0.500		mg/L
Sodium	238	0.500		mg/L

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

EPA 6010B ICP Metals, TTLC

Client Name:	Woodward-Clyde Consultants		
Project ID:	Malibu Lagoon		
Work Order Number:	98-10-0664		
QC Batch ID:	981028lcs2	Date Collected:	10/26/98
Matrix:	Aqueous	Date Received:	10/27/98
Preparation:	Total Digestion	Date Prepared:	10/28/98
Method:	EPA 6010B	Date Analyzed:	10/29/98

Client Sample Number: **P41026-1305**
Lab Sample Number: 98-10-0664-4

Parameter	Result	RL	Qualifiers	Units
Calcium	172	0.100		mg/L
Magnesium	86.1	0.100		mg/L
Potassium	9.11	0.500		mg/L
Sodium	223	0.500		mg/L

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

EPA 6010B ICP Metals, TTLC

Client Name:	Woodward-Clyde Consultants		
Project ID:	Malibu Lagoon		
Work Order Number:	98-10-0664		
QC Batch ID:	981028lcs2	Date Collected:	N/A
Matrix:	Aqueous	Date Received:	N/A
Preparation:	Total Digestion	Date Prepared:	10/28/98
Method:	EPA 6010B	Date Analyzed:	10/29/98

Client Sample Number: **Method Blank**
Lab Sample Number: 097-01-003-588

Parameter	Result	RL	Qualifiers	Units
Calcium	ND	0.100		mg/L
Magnesium	ND	0.100		mg/L
Potassium	ND	0.500		mg/L
Sodium	ND	0.500		mg/L

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

Method EPA 300.0

Woodward-Clyde Consultants		Work Order No.:	98-10-0664
Page 1 of 1		Date Analyzed:	10/27/98

Matrix Spike/Matrix Spike Duplicate

Sample Spiked: 98-10-0650-4

Analyte	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Bromide	101	102	50 - 150	0	0 - 25
Chloride	98	98	50 - 150	0	0 - 25
Sulfate	100	100	50 - 150	0	0 - 25

Calscience Environmental Laboratories, Inc.

Quality Control - Spike/Spike Duplicate

EPA 6010B ICP Metals, TTLC

MS/MSD Batch Number:	102898ms2	Instrument:	ICP 2000
Matrix:	Aqueous	Date Extracted:	10/28/98
Method:	EPA 6010B	Date Analyzed:	10/29/98

Spiked Sample ID: P41026-1305

Parameter	MS %REC	MSD %REC	%REC CL	RPD	RPD CL	Qualifiers
Calcium	4X	4X	80-120	4X	0-20	Q
Magnesium	4X	4X	80-120	4X	0-20	Q
Potassium	99	96	80-120	2	0-20	
Sodium	4X	4X	80-120	4X	0-20	Q

Calscience Environmental Laboratories, Inc.

Quality Control - Laboratory Control Sample

EPA 6010B ICP Metals, TTLC

LCS Batch Number:	981028lcs2		
Lab File ID:	981028-L		
Matrix:	Aqueous	Instrument:	ICP 2000
Method:	EPA 6010B	Date Analyzed:	10/29/98

LCS Sample Number: 097-01-003-588

Parameter	Conc Added	Conc Recovered	%Rec	%Rec CL	Qualifiers
Calcium	1.00	0.991	99	80-120	
Magnesium	1.00	1.01	101	80-120	
Potassium	10	9.86	99	80-120	
Sodium	1.00	0.983	98	80-120	

Calscience Environmental Laboratories, Inc.

GLOSSARY OF TERMS AND QUALIFIERS

Work Order Number: 98-10-0664

Qualifier	Definition
ND	Not detected at indicated reporting limit.
Q	Spike recovery and RPD control limits do not apply resulting from the sample concentration exceeding the spike concentration by a factor of four or greater.

0664

Woodward-Clyde Consultants

SHIPMENT NO.: _____

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

DATE 10/26/98

PROJECT NAME: MALIBU LAGOON

PROJECT NO.: 964p170.200

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp	Chemical	
P21026-1037	P-2	WATER	BAIL	1L PLASTIC	4°C		BROMIDE
P31026-1057	P-3	WATER	BAIL	↓	↓		GENERAL
P51026-1122	P-5	WATER	BAIL				MINERALS
P41026-1305	P-4	WATER	PUMP				(Na, K, Ca, Mg, carbonate, bicarbonate, chloride, sulfate)

Total Number of Samples Shipped: 4 | Sampler's Signature: Paul Salter/EL-TOC

Relinquished By: Signature Printed Name Eric S. Fordham Company Woodward-Clyde Reason Delivery to Lab.	Received By: Signature Printed Name ALEX ENRIQUEZ Company CEL	Date 10/27/98 Time 15:40
Relinquished By: Signature Printed Name ~~ALEX ENRIQUEZ~~ Company CEL Reason	Received By: Signature Printed Name Company	Date / / Time
Relinquished By: Signature Printed Name Company Reason	Received By: Signature Printed Name Company	Date / / Time
Relinquished By: Signature Printed Name ALEX ENRIQUEZ Company CEL Reason DELIVERY TO LAB.	Received By: Signature Printed Name S. NOWAK Company CALSCIENCE	Date 10/27/98 Time 1635

Special Shipment / Handling / Storage Requirements:

* Note — This does not constitute authorization to proceed with analysis

Calscience Environmental Laboratories, Inc.

December 10, 1998

Paul Salter
Woodward-Clyde Consultants
2020 East 1st Street, Suite 400
Santa Ana, CA 92705

Subject: **Calscience Work Order Number:** **98-12-0104**
Client Reference: **Malibu Lagoon/964P170-600**

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 12/03/98 and analyzed in accordance with the attached chain-of-custody.

The results in this analytical report are limited to the samples tested, and any reproduction of this report must be made in its entirety.

If you have any questions regarding this report, require sampling supplies or field services, or information on our analytical services, please feel free to call me at (714) 895-5494.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Marycarol Valenzuela
Project Manager

William H. Christensen
Quality Assurance Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants		Date Sampled:	12/02/98
2020 East 1st Street, Suite 400		Date Received:	12/03/98
Santa Ana, CA 92705		Date Analyzed:	12/04/98
		Work Order No.:	98-12-0104
Attn: Paul Salter		Method:	EPA 300.0
RE: Malibu Lagoon/964P170-600		Page 1 of 2	

All concentrations are reported in mg/L (ppm).

Analyte	Concentration	Reporting Limit
Sample Number: Set 23-P9-12/1-0840		
Bromide	0.6	0.1
Chloride	168	100
Sulfate	323	100
Sample Number: Set 23-P6-12/1-0915		
Chloride	1100	200
Sulfate	458	100
Sample Number: Set 34-P1-12/2-0945		
Chloride	98	25
Sulfate	537	100
Sample Number: Set 34-P7-12/2-1030		
Chloride	145	100
Sulfate	472	100

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants		Date Sampled:	12/02/98
2020 East 1st Street, Suite 400		Date Received:	12/03/98
Santa Ana, CA 92705		Date Analyzed:	12/03-04/98
		Work Order No.:	98-12-0104
Attn: Paul Salter		Method:	EPA 300.0
RE: Malibu Lagoon/964P170-600		Page 2 of 2	

All concentrations are reported in mg/L (ppm).

Sample Number: Set 34-C1-12/2-1100

Chloride	4530	500
Sulfate	695	100

Sample Number: Set 26-P8-12/1-1326

Bromide	0.7	0.1

Sample Number: Method Blank

Bromide	ND	0.1
Chloride	ND	1
Sulfate	ND	1

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants	Date Sampled:	12/02/98
2020 East 1st Street, Suite 400	Date Received:	12/03/98
Santa Ana, CA 92705	Date Analyzed:	12/03/98
	Work Order No.:	98-12-0104
Attn: Paul Salter	Method:	SM 2320B
RE: Malibu Lagoon/964P170-600	Page 1 of 1	

All concentrations are reported in mg/L (ppm).

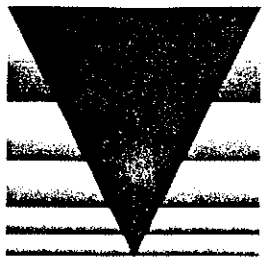
Sample Number	Bicarbonate Concentration	Reporting Limit
Set 23-P9-12/1-0840	406	5
Set 23-P6-12/1-0915	1120	10
Set 34-P1-12/2-0945	282	5
Set 34-P7-12/2-1030	444	5
Set 34-C1-12/2-1100	350	5

QA/QC

Sample Number	Sample Conc.	Duplicate Conc.	%RPD	Control Limits (%)
Set 23-P9-12/1-0840	406	408	0	0 - 25

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.



Our Quality Control Is Your Quality Assurance

October 1, 1997

LOG NO.: G97-09-087

Woodward Clyde Consultants
Attn: Mr. Eric Fordham
2020 E. First St. 4th Floor
Santa Ana, CA 92705

Reference: Client Project #964P170, Malibu Septic Study.

Dear Mr. Fordham,

Enclosed is the analytical report for the chemical testing of samples collected in support of the above-referenced project. Samples are identified and tracked in the BCA/VOC system as log number **G97-09-087**. When making inquiries about this report, please provide the log number.

The contents of this package are based on the requirements specified in the BC Analytical, A Division of V.O.C. Analytical Laboratories, Inc. "Quality Assurance Management Plan". The case narrative addresses batch specific quality control as it pertains to this document.

If you have any questions, please do not hesitate to call me at (714) 978-0113.

Sincerely,

Patty Mata
Project Manager

Report from UCLA to Woodward-Clyde
LABs in ng/g dry soil
March 17, 1998

UCLA ID	OF1-1(0-3cm)	OF2-1(0-3cm)	OF3-1(0-3cm)
WC Sample No	090597-OF1-1	090597-OF2-1	090597-OF3-1
LABs			
55-11	nd	9.92	nd
64-11	nd	21.36	nd
73-11	nd	18.97	nd
82-11	nd	15.92	nd
91-11	0.14	9.21	0.18
65-12	nd	15.83	nd
74-12	nd	16.68	nd
83-12	nd	15.17	nd
92-12	nd	11.80	nd
101-12	0.16	11.47	0.14
66/75-13	nd	7.96	1.90
84-13	nd	4.87	nd
93-13	nd	4.00	nd
102-13	nd	3.61	nd
111-13	nd	3.43	0.74
76-14	nd	2.27	nd
85-14	nd	nd	0.75
94-14	nd	1.57	nd
103-14	nd	0.83	5.45
112-14	nd	0.95	nd
121-14	0.05	1.06	0.13
Total LABS	0.35	176.88	9.29
I/E Ratio*	0	0.85	0

*$6\text{-}C_{12} + 5\text{-}C_{12}/4\text{-}C_{12} + 3\text{-}C_{12} + 2\text{-}C_{12}$

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants	Date Sampled:	12/02/98
2020 East 1st Street, Suite 400	Date Received:	12/03/98
Santa Ana, CA 92705	Date Analyzed:	12/03/98
	Work Order No.:	98-12-0104
Attn: Paul Salter	Method:	SM 2320B
RE: Malibu Lagoon/964P170-600	Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number	Carbonate Concentration	Reporting Limit
Set 23-P9-12/1-0840	ND	5
Set 23-P6-12/1-0915	ND	10
Set 34-P1-12/2-0945	ND	5
Set 34-P7-12/2-1030	ND	5
Set 34-C1-12/2-1100	ND	5

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants		Date Sampled:	12/02/98
2020 East 1st Street, Suite 400		Date Received:	12/03/98
Santa Ana, CA 92705		Date Digested:	12/02-04/98
		Date Analyzed:	12/07/98
		Work Order No.:	98-12-0104
Attn: Paul Salter			
RE: Malibu Lagoon/964P170-600		Page 1 of 2	

All concentrations are reported in mg/L (ppm). Analyses for metals were conducted on a total digestion.

Analyte	Method	Concentration	Reporting Limit
Sample Number: Set 23-P9-12/1-0840			
Calcium	EPA 6010B	137	0.100
Magnesium	EPA 6010B	86.2	0.100
Potassium	EPA 6010B	8.30	0.500
Sodium	EPA 6010B	181	0.500
Sample Number: Set-23-P6-12/1-0915			
Calcium	EPA 6010B	353	0.100
Magnesium	EPA 6010B	209	0.100
Potassium	EPA 6010B	23.8	0.500
Sodium	EPA 6010B	789	0.500
Sample Number: Set 34-P1-12/2-0945			
Calcium	EPA 6010B	162	0.100
Magnesium	EPA 6010B	94.6	0.100
Potassium	EPA 6010B	5.13	0.500
Sodium	EPA 6010B	141	0.500

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants	Date Sampled:	12/02/98
2020 East 1st Street, Suite 400	Date Received:	12/03/98
Santa Ana, CA 92705	Date Digested:	12/02-04/98
	Date Analyzed:	12/07/98
	Work Order No.:	98-12-0104
Attn: Paul Salter		
RE: Malibu Lagoon/964P170-600	Page 2 of 2	

All concentrations are reported in mg/L (ppm). Analyses for metals were conducted on a total digestion.

Analyte	Method	Concentration	Reporting Limit
Sample Number: Set 34-P7-12/2-1030			
Calcium	EPA 6010B	129	0.100
Magnesium	EPA 6010B	91.1	0.100
Potassium	EPA 6010B	12.1	0.500
Sodium	EPA 6010B	223	0.500
Sample Number: Set 34-C1-12/2-1100			
Calcium	EPA 6010B	188	0.100
Magnesium	EPA 6010B	379	0.100
Potassium	EPA 6010B	129	0.500
Sodium	EPA 6010B	2600	5.00
Sample Number: Method Blank			
Calcium	EPA 6010B	ND	0.100
Magnesium	EPA 6010B	ND	0.100
Potassium	EPA 6010B	ND	0.500
Sodium	EPA 6010B	ND	0.500

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

EPA 300.0

Woodward-Clyde Consultants		Work Order No.:	98-12-0104
Page 1 of 1		Date Analyzed:	12/03/98

Matrix Spike/Matrix Spike Duplicate

Sample Spiked: Set23-P9-12/1-0840

Analyte	Method	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Bromide	EPA 300.0	93	94	50 - 150	1	0 - 25
Chloride	EPA 300.0	104	104	50 - 150	0	0 - 25
Sulfate	EPA 300.0	102	102	50 - 150	0	0 - 25

Laboratory Control Sample

Analyte	Conc. Added	Conc. Rec.	%REC	Control Limits
Bromide	2.00	1.92	96	80 - 120
Chloride	4.00	3.77	94	80 - 120
Sulfate	4.00	4.00	100	80 - 120

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

ICP / GF Metals (Solids)

Woodward-Clyde Consultants	Work Order No.: 98-12-0104
Page 1 of 1	Date Analyzed: 12/07/98

Matrix Spike/Matrix Spike Duplicate

Sample Spiked: 98-12-0081-1

Analyte	Method	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Calcium	EPA 6010B	4X	4X	80 - 120	4X	0 - 20
Magnesium	EPA 6010B	4X	4X	80 - 120	4X	0 - 20
Potassium	EPA 6010B	91	109	80 - 120	14	0 - 20
Sodium	EPA 6010B	4X	4X	80 - 120	4X	0 - 20

Laboratory Control Sample

Analyte	Method	Conc. Added	Conc. Rec.	%REC	Control Limits
Calcium	EPA 6010B	1.00	0.960	96	80 - 120
Magnesium	EPA 6010B	1.00	0.962	96	80 - 120
Potassium	EPA 6010B	10.0	9.47	95	80 - 120
Sodium	EPA 6010B	1.00	0.938	94	80 - 120

4X: Spike recovery and RPD control limits do not apply resulting from the sample concentration exceeding the spike concentration by a factor of four or greater.

104

Woodward-Clyde Consultants

SHIPMENT NO.: _____

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

PROJECT NAME: MALIBU LAGOON

DATE 12/2/98

PROJECT NO.: 964P170.600

Sample Number	Location	Type of Sample: Material	Type of Sample: Method	Type of Container	Type of Preservation: Temp	Type of Preservation: Chemical	Analysis Required*
SET 23-P9-12/1-0846	P9	GW	BAIL	1L GLASS	4°C	—	TO BE ADVISED
SET 23-P6-12/1-0915	P6						
SET 23-P8-12/1-0945	P8						
SET 34-P1-12/2-0945	P1						
SET 34-P7-12/2-1030	P7						
SET 34-C1-12/2-1100	C1						
SET 26-P8-12/1-1326	P8	GW	PUMP	50 mL PLASTIC	4°C	5 DROPS SOY BROTH	P9, P6, P8, P1, P7, C1 ANALYSIS FOR GENERAL MINERALS (Na, K, Ca, Mg, Carbonate, Bicarbonate, Cl, SO_4) (5 SAMPLES)
							P8, P9 ADDITIONAL ANALYSIS FOR BROMIDE TO ≤ 0.1 mg/L DETECTION LIMIT. (2 SAMPLES)

Total Number of Samples Shipped: 6 | Sampler's Signature: Paul Salter

Relinquished By: Signature: Paul Salter; Printed Name: PAUL SALTER; Company: URS GREINER WOODWARD CLYDE; Reason: SHIPMENT.	Received By: Signature: S. Nowak; Printed Name: S. NOWAK; Company: CEL	Date: 12/3/98; Time: 1000
Relinquished By: Signature: ; Printed Name: ; Company: ; Reason:	Received By: Signature: ; Printed Name: ; Company:	Date: / / ; Time:
Relinquished By: Signature: ; Printed Name: ; Company: ; Reason:	Received By: Signature: ; Printed Name: ; Company:	Date: / / ; Time:
Relinquished By: Signature: ; Printed Name: ; Company: ; Reason:	Received By: Signature: ; Printed Name: ; Company:	Date: / / ; Time:

Special Shipment / Handling / Storage Requirements:

~~Mary Grant~~, I am awaiting confirmation of analytes. I will fax ~~instructions~~ ASAP.

P. L. Salter

* Note — This does not constitute authorization to proceed with analysis

UNIVERSITY OF CALIFORNIA, LOS ANGELES UCLA

BERKELEY · DAVIS · IRVINE · LOS ANGELES · RIVERSIDE · SAN DIEGO · SAN FRANCISCO SANTA BARBARA · SANTA CRUZ

INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
3845 SLICHTER HALL
BOX 951567
LOS ANGELES, CALIFORNIA 90095-1567
FAX: (310) 206-3051

April 8, 19978

Ph: 310-206-2561

Dr. Eric Fordham
Woodward- Clyde Consultants
2020 E. First Street Suite 400
Santa Ana, CA 92705

FAX 714-667-7147

Re: Analysis of sterols and linear alkylbenzenes in sediments and water from Malibu Lagoon and vicinity

Dear Eric:

Enclosed below are the data of sterols and linear alkylbenzenes in the 0-3 cm section from the three sediment cores you had provided from Malibu Lagoon and vicinity (two Tables). As I had explained to you earlier, I had to wait for the GC/MS analysis of some samples for confirmation of the identification of the compounds and hence this delay. The original tables and the chain of custody record sheet are being mailed to you.

I believe an invoice for the service has already been sent to you from UCLA. Thanks for giving me this opportunity to work with a prestigious organization like yours. Please do not hesitate to call me if you ever need such services from my laboratory. I can be reached at the above ph. no. should you have any questions regarding the data. With best wishes,

Sincerely,

M. I. Venkatesan

M. I. Venkatesan
Research Geochemist

MIV/EF
Enclosures (Tables)

Report from UCLA to Woodward Clyde
Sterols in microgram/g dry soil*
March 17, 1998

UCLA ID	OF1-1(0-3cm)	OF1-1(0-3cm)(R)**	OF2-1(0-3cm)	OF3-1(0-3cm)
WC Sample No	090597-OF1-1	090597-OF1-1	090597-OF2-1	090597-OF3-1
Sterols				
Coprostanol	0.22	0.28	0.4	0.24
Epicoprostanol	Tr	Tr	0.18	0.15
Coprostanone	nd	nd	nd	nd
Cholesterol	0.22	0.25	0.76	1.11
Cholestanol	nd	0.07	0.44	0.32
Campesterol	0.75	1.08	0.83	0.14
β-Sitosterol	5.41	5.87	5.23	7.62
5α-Androstanol(sur)				
% Recovered	83.45	81.47	73.6	94.9

*Data not corrected for surrogate recovery
** Replicate analysis by gas chromatography
Tr-Trace amounts
nd- Not detected

LOG NO.: G97-09-087

CASE NARRATIVE

The following narrative addresses all project specific data quality objectives with respect to: holding times, method blanks, lab control standards, matrix spike and duplicate samples. Analytical anomalies encountered during sample analysis are also discussed as necessary.

Sample receipt:
Samples were received under COC at VOC's Glendale lab on 9/5/97. All containers were received intact and properly preserved.
All analyses were performed by DFL Labs in Modesto, CA. The method referenced for Coliform refers to the FDA Biological Analytical Manual.

No anomalies were encountered during the analysis of the project.

VOC Analytical Laboratories, Inc.
1212 East Katella Avenue, Anaheim CA 92805 - **Phone:** (714) 978-0113 - **Fax:** (714) 978-9284

ACRONYMS AND FLAG DEFINITIONS

Flag Definitions:

*	Replicate values. Used when replicate results are entered into the MS/MSD column of the QC report.
B	Blank contamination. Used when associated method blank concentration is greater than the PQL.
J	Estimated value. Used for sample results greater than or equal to MDL, but less than the PQL.
NC	Not calculated. Used when sample result is greater than two times the spike amount added, or when extracted surrogates were diluted below detectable levels.
Q	Quality objectives were not met. Used for Method Blank, Laboratory Control Samples, Matrix Spikes, Matrix Duplicates and Surrogates.

Acronyms:

COC	Chain of Custody
FLG	Flag
LC	Actual LCS/LCSD concentration recovered
LCL	Lower Control Limit
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LT	True LCS/LCSD concentration
MB	Method Blank
MS	Matrix Spike
MSD	Matrix Spike Duplicate
R1	Unspiked sample concentration
RDL	Reporting Detection Limit
%REC	Percent Recovery
Rep.	Surrogate Reported value
RPD	Relative Percent Difference
S1	Actual MS concentration
S2	Actual MSD concentration
T	True concentration of MS/MSD
Theo.	Surrogate Theoretical value
UCL	Upper Control Limit

ANALYTICAL REPORT

Our Quality Control Is Your Quality Assurance

LOG NO: G97-09-087

Received: 05 SEP 97

Mailed: 9/27

Mr. Eric Fordham
Woodward-Clyde Consultants
2020 E. First St. 4th Floor
Santa Ana, CA 92705

Project: 964P170/MALIBU

REPORT OF ANALYTICAL RESULTS

LOG NO	09-087-1	09-087-2	09-087-3
DATE SAMPLED	05 SEP 97	05 SEP 97	05 SEP 97
SAMPLE DESCRIPTION	090597-0F1-2	090597-0F2-2	090597-0F3-2
NON-AQUEOUS			
Enterococcus (SM9230), MPN/G	43	430	230
Fecal Coliform (FDA BAM), /G	<10	<10	<10
Total Coliform (FDA BAM), /G	160	2800	11000

VOC Analytical Laboratories, Inc.
1212 East Katella Avenue, Anaheim CA 92805 - **Phone:** (714) 978-0113 - **Fax:** (714) 978-9284

Our Quality Control Is Your Quality Assurance

LOG NO: G97-09-087

Received: 05 SEP 97

Mr. Eric Fordham
Woodward-Clyde Consultants
2020 E. First St. 4th Floor
Santa Ana, CA 92705

Project: 964P170/MALIBU

REPORT OF ANALYTICAL RESULTS

LOG NO	09-087-4
DATE SAMPLED	05 SEP 97
SAMPLE DESCRIPTION	090597-0F3-3
AQUEOUS	
Enterococcus (FDA BAM), MPN/0.1L	>1600
Fecal Coliform (908C), MPN/0.1L	>1600
Total Coliform (908A), MPN/0.1L	>1600

Greta Galoustian, Laboratory Director

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.....	DATE..... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
9709087*1	090597-0F1-2	ENTEROCOCCUS	09.06.97	SM9230			
		COLI,F	09.06.97	FDA BAM			
		COLI,T	09.06.97	FDA BAM			
9709087*2	090597-0F2-2	ENTEROCOCCUS	09.06.97	SM9230			
		COLI,F	09.06.97	FDA BAM			
		COLI,T	09.09.97	FDA BAM			
9709087*3	090597-0F3-2	ENTEROCOCCUS	09.06.97	SM9230			
		COLI,F	09.06.97	FDA BAM			
		COLI,T	09.06.97	FDA BAM			
9709087*4	090597-0F3-3	ENTEROCOCCUS	09.06.97	FDA BAM			
		COLI,F	09.06.97	908C			
		COLI,T	09.06.97	908A			

***

Notes: Equipment = VOC Analytical identification number for a particular piece of analytical equipment.

ID.NO = VOC Analytical employee identification number of analyst.

Woodward-Clyde Consultants

SHIPMENT NO.: 1

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

DATE 12/15/97

PROJECT NAME: MALIBU SEPTIC STUDY

PROJECT NO.: 91418170

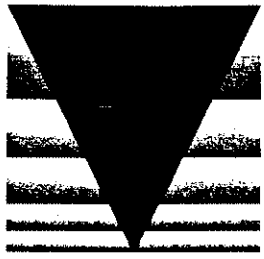
Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp	Chemical	
[illegible]-SS-2	SS-1	SOIL	GRAB	~~1 GLASS~~ ~~GLASS~~ 1	ICE	N-IE	TOTAL NITROGEN
[illegible]-DF-2	DF-2	〃	〃	BRASS TUBE	〃	〃	TOTAL NITROGEN
[illegible]-SS-3	SS-3	〃	〃	1 GLASS	〃	〃	TOTAL NITROGEN
[illegible]-SS-2	SS-3	WATER	BAILER	1 L PLASTIC	〃	THIOSULFATE	〃

Total Number of Samples Shipped: 4 Sampler's Signature: [signature]

Relinquished By:	Received By:	Date / Time
Signature [signature]	Signature [signature]	Date 12/15/97
Printed Name [illegible]	Printed Name	Time 2:45
Company [illegible]	Company	
Reason		
Relinquished By:	Received By:	Date / Time
Signature	Signature	Date / /
Printed Name	Printed Name	Time
Company	Company	
Reason		
Relinquished By:	Received By:	Date / Time
Signature	Signature	Date / /
Printed Name	Printed Name	Time
Company	Company	
Reason		
Relinquished By:	Received By:	Date / Time
Signature	Signature	Date / /
Printed Name	Printed Name	Time
Company	Company	
Reason		

Special Shipment / Handling / Storage Requirements:

* Note — This does not constitute authorization to proceed with analysis



Our Quality Control Is Your Quality Assurance

October 1, 1997 LOG NO.: G97-08-582

Woodward Clyde Consultants
Attn: Mr. Eric Fordham
2020 E. First St. 4th Floor
Santa Ana, CA 92705

Reference: Client Project #964P170, Malibu Septic Study

Dear Mr. Fordham,

Enclosed is the analytical report for the chemical testing of samples collected in support of the above-referenced project. Samples are identified and tracked in the BCA/VOC system as log number **G97-08-582**. When making inquiries about this report, please provide the log number.

The contents of this package are based on the requirements specified in the BC Analytical, A Division of V.O.C. Analytical Laboratories, Inc. "Quality Assurance Management Plan". The case narrative addresses batch specific quality control as it pertains to this document.

If you have any questions, please do not hesitate to call me at (714) 978-0113.

Sincerely,

Patty Mata
Project Manager

LOG NO.: G97-08-582

CASE NARRATIVE

The following narrative addresses all project specific data quality objectives with respect to: holding times, method blanks, lab control standards, matrix spike and duplicate samples. Analytical anomalies encountered during sample analysis are also discussed as necessary.

Sample receipt:
Samples were received under COC at VOC's Glendale lab on 8/29/97. All containers were received intact and properly preserved.

Coliform and Enterococcus analyses were performed by DFL Labs, a subcontractor to VOC Analytical.

No anomalies were encountered during the analysis of the project.

ACRONYMS AND FLAG DEFINITIONS

Flag Definitions:

*	Replicate values. Used when replicate results are entered into the MS/MSD column of the QC report.
B	Blank contamination. Used when associated method blank concentration is greater than the PQL.
J	Estimated value. Used for sample results greater than or equal to MDL, but less than the PQL.
NC	Not calculated. Used when sample result is greater than two times the spike amount added, or when extracted surrogates were diluted below detectable levels.
Q	Quality objectives were not met. Used for Method Blank, Laboratory Control Samples, Matrix Spikes, Matrix Duplicates and Surrogates.

Acronyms:

COC	Chain of Custody
FLG	Flag
LC	Actual LCS/LCSD concentration recovered
LCL	Lower Control Limit
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LT	True LCS/LCSD concentration
MB	Method Blank
MS	Matrix Spike
MSD	Matrix Spike Duplicate
R1	Unspiked sample concentration
RDL	Reporting Detection Limit
%REC	Percent Recovery
Rep.	Surrogate Reported value
RPD	Relative Percent Difference
S1	Actual MS concentration
S2	Actual MSD concentration
SUB	Subcontracted Analysis
T	True concentration of MS/MSD
Theo.	Surrogate Theoretical value
UCL	Upper Control Limit

ANALYTICAL REPORT

Our Quality Control Is Your Quality Assurance

LOG NO: G97-08-582

Received: 29 AUG 97

Mailed: OCT

Mr. Eric Fordham
Woodward-Clyde Consultants
2020 E. First St. 4th Floor
Santa Ana, CA 92705

Project: 964P170/MALIBU

REPORT OF ANALYTICAL RESULTS

LOG NO	08-582-1	08-582-2	08-582-3
DATE SAMPLED	29 AUG 97	29 AUG 97	29 AUG 97
SAMPLE DESCRIPTION	082997-P1	082997-P6	082997-P7
AQUEOUS			
Enterococcus (FDA BAM), MPN/0.1L	2	<2	8
Fecal Coliform (908C), MPN/0.1L	23	80	>1600
Total Coliform (908A), MPN/0.1L	130	80	>1600

VOC Analytical Laboratories, Inc.
1212 East Katella Avenue, Anaheim CA 92805 - **Phone:** (714) 978-0113 - **Fax:** (714) 978-9284

LOG NO: G97-08-582

Received: 29 AUG 97

Mr. Eric Fordham
Woodward-Clyde Consultants
2020 E. First St. 4th Floor
Santa Ana, CA 92705

Project: 964P170/MALIBU

REPORT OF ANALYTICAL RESULTS

LOG NO	08-582-4	08-582-5
DATE SAMPLED	29 AUG 97	29 AUG 97
SAMPLE DESCRIPTION	082997-C1	082997-C2
AQUEOUS		
Enterococcus (FDA BAM), MPN/0.1L	900	4
Fecal Coliform (908C), MPN/0.1L	1600	80
Total Coliform (908A), MPN/0.1L	1600	130

Greta Galoustian, Laboratory Director

: ORDER PLACED FOR CLIENT: Woodward-Clyde Consultants 9708582 :
: VOC ANALYTICAL : GLEN LAB : 16:34:28 10 OCT 1997 - P. 1 :

SAMPLES...	SAMPLE DESCRIPTION..	DETERM.....	DATE..... ANALYZED	METHOD.....	EQUIP.	BATCH..	ID.NO
9708582*1	082997-P1	ENTEROCOCCUS	08.30.97	FDA BAM			
		COLI,F	08.30.97	908C			
		COLI,T	08.30.97	908A			
9708582*2	082997-P6	ENTEROCOCCUS	08.30.97	FDA BAM			
		COLI,F	08.30.97	908C			
		COLI,T	08.30.97	908A			
9708582*3	082997-P7	ENTEROCOCCUS	08.30.97	FDA BAM			
		COLI,F	08.30.97	908C			
		COLI,T	08.30.97	908A			
9708582*4	082997-C1	ENTEROCOCCUS	08.30.97	FDA BAM			
		COLI,F	08.30.97	908C			
		COLI,T	08.30.97	908A			
9708582*5	082997-C2	ENTEROCOCCUS	08.30.97	FDA BAM			
		COLI,F	08.30.97	908C			
		COLI,T	08.30.97	908A			

***

Notes: Equipment = VOC Analytical identification number for a particular piece of analytical equipment.

ID.NO = VOC Analytical employee identification number of analyst.

Author: ssheehan@ucla.edu at Internet
Date: 10/9/98 11:49 AM
Priority: Normal
BCC: ESFORDH0 at WC-LA_METRO
TO: esfordh0@wcc.com at INTERNET
Subject: Re: Re[2]: well sampling ofr indira
---------- Message Contents ----------

eric-

i am wondering if you got my phone message a couple weeks ago. two things from there. one, i wanted to pick you brain sometime soon regarding future sampling of the wells and where they are/will be located.

two, i can give you results from my sampling and here they are:

first set oct 28, 1997 (in mg/L)

	nitrate/N	total N	total P
p7:	0.18	3.58	nd
c2:	0.15	2.15	nd
c1:	0.11	7.18	nd
p1:	9.37	11.87	nd
p6:	0.25	5.35	nd

second set nov 5, 1997

p1:	6.08	8.08	nd
c2:	0.53	2.33	0.77
p7:	0.27	1.57	0.22
c1:	nd	9.2	nd
p6:	nd	5.1	nd

Calscience
Environmental
Laboratories, Inc.

September 23, 1998

Paul Salter
Woodward-Clyde Consultants
2020 East 1st Street, Suite 400
Santa Ana, CA 92705

Subject: **Calscience Work Order Number:** **98-09-0502**
Client Reference: **Malibu Lagoon Investigation/ 964P170**

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 09/17/98 and analyzed in accordance with the attached chain-of-custody.

The results in this analytical report are limited to the samples tested, and any reproduction of this report must be made in its entirety.

If you have any questions regarding this report, require sampling supplies or field services, or information on our analytical services, please feel free to call me at (714) 895-5494.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Marycarol Valenzuela
Project Manager

William H. Christensen
Deliverables Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

Woodward-Clyde Consultants	Date Sampled:	09/17/98
2020 East 1st Street, Suite 400	Date Received:	09/17/98
Santa Ana, CA 92705	Date Analyzed:	09/18/98
	Work Order No.:	98-09-0502
Attn: Paul Salter	Method:	EPA 300.0
RE: Malibu Lagoon Investigation/ 964P170	Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number	Bromide Concentration	Reporting Limit
P2916-1015	0.5	0.1
P2916-1731	229	5.0
P2916-2131	11.0	1.0
P4916-1035	0.4	0.1
P4916-1231	0.4	0.1
P4916-1331	0.6	0.1
P4916-1531	4.4	0.1
P4916-1731	8.2	1.0
P4916-1931	10.7	1.0
P4916-2131	816	50
P2917-0638	580	50
P4917-0644	18.5	1.0
Method Blank	ND	0.1

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

Method EPA 300.0

Woodward-Clyde Consultants		Work Order No.:	98-09-0502
Page 1 of 1		Date Analyzed:	09/18/98

Matrix Spike/Matrix Spike Duplicate

Sample Spiked: P2916-1015

Analyte	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Bromide	96	96	50 - 150	0	0 - 25

582

Woodward-Clyde Consultants

SHIPMENT NO.: _____

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

PROJECT NAME: MALIBU LAGOON INVESTIGATION DATE 9/17/98

PROJECT NO.: 964P170

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp	Chemical	
P2916-1015	P2	WATER	BAIL	PLASTIC BOTTLE	4°C	—	BROMIDE TO ≤ 0.1 mg/L DETECTION LIMIT
P2916-1731	P2		BAIL				
P2916-2131	P2		BAIL				
P4916-1035	P4		BAIL				
P4916-1231	P4		PUMP				
P4916-1331	P4		PUMP				
P4916-1531	P4		PUMP				
P4916-1731	P4		PUMP				
P4916-1931	P4		PUMP				
P4916-2131	P4		PUMP				
P2917-0638	P2		BAIL				
P4917-0644	P4		PUMP				

Total Number of Samples Shipped: 12 | Sampler's Signature: Paul Salter

Relinquished By: Signature: Paul Salter Printed Name: PAUL SALTER Company: WCC Reason: DELIVERY TO LABORATORY	Received By: Signature: Printed Name: VIRENDRA PATEL Company: C.E.L.	Date: 9/17/98 Time: 12:05p
Relinquished By: Signature: Printed Name: Company: Reason:	Received By: Signature: Printed Name: Company:	Date: / / Time:
Relinquished By: Signature: Printed Name: Company: Reason:	Received By: Signature: Printed Name: Company:	Date: / / Time:
Relinquished By: Signature: Printed Name: VIRENDRA R. PATEL Company: CALSCIENCE Reason:	Received By: Signature: Printed Name: Company:	Date: 9/17/98 Time: 1715

Special Shipment / Handling / Storage Requirements:

PLEASE RETAIN SAMPLES UNTIL FURTHER INSTRUCTION FOLLOWING ANALYSIS.

* Note – This does not constitute authorization to proceed with analysis

Calscience Environmental Laboratories, Inc.

March 09, 1999

Paul Salter
URS Greiner Woodward Clyde
2020 East 1st Street, Suite 400
Santa Ana, CA 92705

Subject: **Calscience Work Order No.: 99-03-0227**
Client Reference: Malibu/57-0964P17000-00700

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 03/05/99 and analyzed in accordance with the attached chain-of-custody.

The results in this analytical report are limited to the samples tested and any reproduction of this report must be made in its entirety.

If you have any questions regarding this report, require sampling supplies or field services, or information on our analytical services, please feel free to call me at (714) 895-5494.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Marycarol Valenzuela
Project Manager

William H. Christensen
Quality Assurance Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

URS Greiner Woodward Clyde	Date Sampled:	03/05/99
2020 East 1st Street, Suite 400	Date Received:	03/05/99
Santa Ana, CA 92705	Date Analyzed:	03/09/99
	Work Order No.:	99-03-0227
Attn: Paul Salter	Method:	EPA 300.0
RE: Malibu/57-0964P17000-00700	Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number	Bromide Concentration	Reporting Limit
P435-0853	0.27	0.05
P235-0933	0.61	0.05
Method Blank	ND	0.05

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

Method EPA 300.0

URS Greiner Woodward Clyde — Work Order No.: 99-03-0227
Page 1 of 1 — Date Analyzed: 03/09/99

Matrix Spike/Matrix Spike Duplicate

Sample Spiked: 99-03-0244-1

Analyte	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Bromide	94	95	50 - 150	1	0 - 25

Laboratory Control Sample

Analyte	Conc. Added	Conc. Rec.	%REC	Control Limits
Bromide	2.00	1.93	96	80 - 120

7440 Lincoln Way, Garden Grove, CA 92841-1432 • TEL: (714) 895-5494 • FAX: (714) 894-7501

(0227)

Woodward-Clyde Consultants

SHIPMENT NO.: _____

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

DATE 3/5/99

PROJECT NAME: MALIBU

PROJECT NO.: 57-0964P17000-00700

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp	Chemical	
P435-0853	P4		GRAB	PLASTIC	4°C	—	BROMIDE
P235-0933	P2		GRAB	PLASTIC	4°C	—	BROMIDE
							(TO ≤ 0.1 mg/L)

Total Number of Samples Shipped: 2 | Sampler's Signature: Paul Salter

Relinquished By: Signature: Paul Salter Printed Name: PAUL SALTER Company: URSGNC Reason: SHIPMENT	Received By: Signature: [signature] Printed Name: Y. PATEL Company: C.E.L	Date: 3/5/99 Time: 1845
Relinquished By: Signature / Printed Name / Company / Reason	Received By: Signature / Printed Name / Company	Date: / / Time
Relinquished By: Signature / Printed Name / Company / Reason	Received By: Signature / Printed Name / Company	Date: / / Time
Relinquished By: Signature / Printed Name / Company / Reason	Received By: Signature / Printed Name / Company	Date: / / Time

Special Shipment / Handling / Storage Requirements:

48 hr TURN AROUND REQUIRED

* Note — This does not constitute authorization to proceed with analysis

Calscience Environmental Laboratories, Inc.

March 19, 1999

Paul Salter
URS Greiner Woodward Clyde
2020 East 1st Street, Suite 400
Santa Ana, CA 92705

Subject: **Calscience Work Order No.: 99-03-0567**
Client Reference: Malibu / 964P170-600

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 03/18/99 and analyzed in accordance with the attached chain-of-custody.

The results in this analytical report are limited to the samples tested and any reproduction of this report must be made in its entirety.

If you have any questions regarding this report, require sampling supplies or field services, or information on our analytical services, please feel free to call me at (714) 895-5494.

Sincerely,

Calscience Environmental Laboratories, Inc.
Marycarol Valenzuela
Project Manager

William H. Christensen
Quality Assurance Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

URS Greiner Woodward Clyde	Date Sampled:	03/17/99
2020 East 1st Street, Suite 400	Date Received:	03/18/99
Santa Ana, CA 92705	Date Analyzed:	03/18/99
	Work Order No.:	99-03-0567
Attn: Paul Salter	Method:	EPA 300.0
RE: Malibu / 964P170-7000	Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number	Bromide Concentration	Reporting Limit
P2-317-1417	0.35	0.05
Method Blank	ND	0.05

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

IC - EPA 300.0 (Aqueous)

URS Greiner Woodward Clyde
Page 1 of 1

Work Order No.: 99-03-0567
Date Analyzed: 03/18/99

Matrix Spike/Matrix Spike Duplicate

Sample Spiked:

Analyte	Method	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Bromide	EPA 300.0	95	95	50 - 130	0	0 - 25

0567

Woodward-Clyde Consultants

CHAIN OF CUSTODY RECORD

SHIPMENT NO.: _____

PAGE 1 OF 1

DATE 1 1

PROJECT NAME: MALIBU

PROJECT NO.: 964P170.7000

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp	Chemical	
P2-317-1417	P2	GW	GRAB	PLASTIC	Chill	—	BR ≤ 0.1 ppm DETECTION LIMIT

Total Number of Samples Shipped: | Sampler's Signature:

Relinquished By: Signature / Printed Name: Andrew Rasmussen / Company: Secor Int'l, Inc. / Reason: Shipment	Received By: Signature / Printed Name / Company	Date: 1 1 / Time:
Relinquished By: Signature / Printed Name: Jule Geraty / Company: Foley / Reason:	Received By: Signature / Printed Name: J. S. Neupe / Company: Calscience	Date: 3/8/95 / Time: 1015
Relinquished By: Signature / Printed Name / Company / Reason	Received By: Signature / Printed Name / Company	Date: 1 1 / Time:
Relinquished By: Signature / Printed Name / Company / Reason	Received By: Signature / Printed Name / Company	Date: 1 1 / Time:

Special Shipment / Handling / Storage Requirements:

24 HR. TURN AROUND REQUIRED

* Note — This does not constitute authorization to proceed with analysis

Calscience
Environmental
Laboratories, Inc.

March 23, 1999

Paul Salter
URS Greiner Woodward Clyde
2020 East 1st Street, Suite 400
Santa Ana, CA 92705

Subject: **Calscience Work Order No.: 99-03-0686**
Client Reference: Malibu Lagoon/964P170-0700

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 03/22/99 and analyzed in accordance with the attached chain-of-custody.

The results in this analytical report are limited to the samples tested and any reproduction of this report must be made in its entirety.

If you have any questions regarding this report, require sampling supplies or field services, or information on our analytical services, please feel free to call me at (714) 895-5494.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Marycarol Valenzuela
Project Manager

William H. Christensen
Quality Assurance Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

URS Greiner Woodward Clyde	Date Sampled:	03/19/99
2020 East 1st Street, Suite 400	Date Received:	03/22/99
Santa Ana, CA 92705	Date Analyzed:	03/22/99
	Work Order No.:	99-03-0686
Attn: Paul Salter	Method:	EPA 300.0
RE: Malibu Lagoon/964P170-0700	Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number	Bromide Concentration	Reporting Limit
P2-319-1830	0.56	0.05
Method Blank	ND	0.05

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

Method EPA 300.0

URS Greiner Woodward Clyde — Work Order No.: 99-03-0686
Page 1 of 1 — Date Analyzed: 03/22/99

Matrix Spike/Matrix Spike Duplicate

Sample Spiked: 99-03-0680-1

Analyte	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Bromide	94	94	50 - 150	0	0 - 25

Laboratory Control Sample

Analyte	Conc. Added	Conc. Rec.	%REC	Control Limits
Bromide	2.00	1.95	98	80 - 120

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1686

Woodward-Clyde Consultants

SHIPMENT NO.: _____

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

PROJECT NAME: MALIBU

DATE 3/19/99

PROJECT NO.: 964P170-0700

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp	Chemical	
P2-319-1550	P2	GW	GRAB	PLASTIC	CHILL	—	BR ≤ 0.1 ppm DETECTION LIMIT

PAS.

Total Number of Samples Shipped: 1 | Sampler's Signature: Paul Salter

Relinquished By: Signature: Paul Salter Printed Name: [illegible] Company: [illegible] Reason: Shipment	Received By: Signature: [signature] Printed Name: V. PATEL Company: CALSCIENCE	Date: 3/22/99 Time: 15:00
Relinquished By: Signature: [signature] Printed Name: V. PATEL Company: CALSCIENCE Reason:	Received By: Signature: Printed Name: Company:	Date: 3/22/99 Time: 16:30
Relinquished By: Signature: Printed Name: Company: Reason:	Received By: Signature: Printed Name: Company:	Date: / / Time:
Relinquished By: Signature: Printed Name: Company: Reason:	Received By: Signature: Printed Name: Company:	Date: / / Time:

Special Shipment / Handling / Storage Requirements:

PAS: 24 hrs TURN AROUND REQUIRED

* Note – This does not constitute authorization to proceed with analysis

Calscience Environmental Laboratories, Inc.

April 29, 1999

Paul Salter
URS Greiner Woodward Clyde
2020 East 1st Street, Suite 400
Santa Ana, CA 92705

Subject: **Calscience Work Order No.: 99-04-0759**
Client Reference: Malibu Creek Septic Testing

Dear Client:

Enclosed is an analytical report for the above-referenced project. The samples included in this report were received 04/23/99 and analyzed in accordance with the attached chain-of-custody.

The results in this analytical report are limited to the samples tested and any reproduction of this report must be made in its entirety.

If you have any questions regarding this report, require sampling supplies or field services, or information on our analytical services, please feel free to call me at (714) 895-5494.

Sincerely,

Calscience Environmental
Laboratories, Inc.
Marycarol Valenzuela
Project Manager

William H. Christensen
Quality Assurance Manager

Calscience Environmental Laboratories, Inc.

ANALYTICAL REPORT

URS Greiner Woodward Clyde	Date Sampled:	04/23/99
2020 East 1st Street, Suite 400	Date Received:	04/23/99
Santa Ana, CA 92705	Date Analyzed:	04/27/99
	Work Order No.:	99-04-0759
Attn: Paul Salter	Method:	300.0
RE: Malibu Creek Septic Testing	Page 1 of 1	

All concentrations are reported in mg/L (ppm).

Sample Number	Bromide Concentration	Reporting Limit
P2-1	10.3	1.0
Method Blank	ND	0.1

ND denotes not detected at indicated reportable limit.

Each sample was received by CEL chilled, intact, and with chain-of-custody attached.

Calscience Environmental Laboratories, Inc.

QUALITY ASSURANCE SUMMARY

Method EPA 300.0

URS Greiner Woodward Clyde
Page 1 of 1

Work Order No.: 99-04-0759
Date Analyzed: 04/27/99

Matrix Spike/Matrix Spike Duplicate

Sample Spiked: P2-1

Analyte	MS%REC	MSD%REC	Control Limits	%RPD	Control Limits
Bromide	95	96	50 - 130	0	0 - 25

Laboratory Control Sample

Analyte	Conc. Added	Conc. Rec.	%REC	Control Limits
Bromide	2.00	1.91	96	80 - 120

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0759

Woodward-Clyde Consultants

SHIPMENT NO.:_____

CHAIN OF CUSTODY RECORD

PAGE 1 OF 1

PROJECT NAME: Malibu Creek Septic Testing DATE 4 12 94

PROJECT NO.: 570964 P17C

Sample Number	Location	Type of Sample		Type of Container	Type of Preservation		Analysis Required*
		Material	Method		Temp	Chemical	
PZ-1	P2	Liquid	~~Bailer~~	Plastic	None		Bromide
PZ-2	P2	Liquid	—	Plastic	None		Bromide

Total Number of Samples Shipped: 2 Sampler's Signature: [signature]

Relinquished By: Signature [signature] Printed Name [illegible] Company [illegible] Reason _____	Received By: Signature _____ Printed Name _____ Company _____	Date / / Time _____
Relinquished By: Signature [signature] Printed Name _____ Company _____ Reason _____	Received By: Signature _____ Printed Name _____ Company _____	Date / / Time _____
Relinquished By: Signature _____ Printed Name _____ Company _____ Reason _____	Received By: Signature _____ Printed Name _____ Company _____	Date / / Time _____
Relinquished By: Signature _____ Printed Name _____ Company _____ Reason _____	Received By: Signature [signature] Printed Name JAY PATEL Company CLC	Date 4/26/94 Time 1000

Special Shipment / Handling / Storage Requirements:

* Note – This does not constitute authorization to proceed with analysis

MALIBU TRACER STUDY
MS-2 AND PRD-1

DATE	HOUR	SET	P2	P3	P4	P5
10/26	0	1	NS	0	0	0
10/26	5:30 P.M.	2	NS	21	0	2
10/26	6:30 P.M.	3	NS	33	1	2
10/26	8:30 P.M.	4	NS	20	7	3
10/27	1:00 A.M.	5	NS	NS	200	NS
10/27	5:00 A.M.	6	NS	NS	$3.00X10^3$	NS
10/27	9:30 A.M.	7	$2.70X10^8$	512	$3.20x10^4$	328
10/27	10:10 A.M.	8	NS	NS	$1.90x10^4$	NS
10/27	11:00 A.M.	9	NS	NS	$4.90x10^4$	NS
10/27	11:30 A.M.	10	$1.09x10^8$	289	$4.20x10^4$	42
10/27	1:00 P.M.	11	NS	NS	$2.30x10^4$	NS
10/27	1:30 P.M.	12	$2.56x10^8$	378	$7.10x10^4$	476
10/27	3:00 P.M.	13	NS	NS	$8.20x10^4$	NS
10/27	8:00 P.M.	14	$3.20x10^7$	416	$8.20x10^4$	67
10/28	9:25 P.M.	15	$1.28x10^7$	$2.00x10^3$	$5.20x10^4$	94
10/29	2:40 P.M.	16	$2.48x10^7$	$1.00x10^3$	$3.50x10^4$	200
11/02	2:12 P.M.	17	$3.70x10^6$	352	416	124

NO PRD-1 IN ANY OF THE SAMPLES. BACKGROUND SAMPLES WERE COLLECTED FOR ALL WELLS(ALL NEGATIVE)

MALIBU TRACER STUDY
MS-2 AND PRD-1

DATE	HOUR	SET	P2	P3	P4	P5
11/6	N/A	18	2.73×10^5	0	98	1.5
11/9	3:59 P.M.	19	1.55×10^5	1.85×10^4	6	0
11/12	10:50 A.M.	20	3.00×10^4	0	0	0
11/16	9:45 A.M.	21	3.00×10^5	0	7	0
11/19	11:10 A.M.	22	5.20×10^3	0	3	1

P8 (11/19, 13:45)= 0
P9 (11/19, 14:50)= 0

No PRD was found in any of the samples.

To: Eric Fordham
714-667-7147

From: Jaime Naranjo
520-626-4849

TO: Paul Salter
Eric Fordham

MALIBU TRACER STUDY
SAMPLES FROM 12/02/98
RESULTS ARE GIVEN AS PLAQUE FORMING UNIT PER ML

SAMPLE No.	MS-2	PRD-1
SET 23-P9-12/1/-0840	0	N/A
SET 23-P6-12/1-0915	0	N/A
SET 23-P8-12/1-0945	0	N/A
SET 23-P3-12/1-1005	0	0
SET 23-P5-12/1-1012	0	0
SET 23 P4-12/1-1022	0	0
SET 23-P2-12/1-1030	0	0
SET 25-P8-12/1-1226	0	N/A
SET 30-P8-12/1-1726	0	N/A
SET 33-P8-12/1-2026	0	N/A

TO: Eric Fordham
Paul Salter
Fax: 714-667-7147

FROM: Jaime Naranjo
520-626-4849