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Report of Hydrogeologic Services Supplemental Ground Water Contamination Study

Unocal Bulk Plant 0138
Coupeville, Washington

July 12, 1995

For
Unocal CERT - Northern Region

describes in detail the hydrologic properties and characteristics of the perched aquifer

GeoEngineers

July 12, 1995

Consulting Engineers and Geoscientists
Offices in Washington, Oregon, and Alaska

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Attention: Dr. Mark Brearley, R.G.

We are submitting three copies of our "Report of Hydrogeologic Services, Supplemental Ground Water Contamination Study" for the site of former Unocal Bulk Plant 0138 in Coupeville, Washington. The services summarized in this report were conducted between February and May 1995. Contractual terms for our services are included in blanket contract number CTB1982G.

We appreciate the opportunity to be of continued service to Unocal. Please call if you have questions regarding this report.

Yours very truly,

GeoEngineers, Inc.

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Principal

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REPORT OF HYDROGEOLOGIC SERVICES
SUPPLEMENTAL GROUND WATER CONTAMINATION STUDY
UNOCAL BULK PLANT 0138
COUPEVILLE, WASHINGTON
FOR
UNOCAL CERT - NORTHERN REGION

INTRODUCTION AND BACKGROUND

This report summarizes GeoEngineers' hydrogeologic services at the site of former Unocal Bulk Plant 0138. The activities discussed in this report were conducted between February and May 1995. The site is located southwest of the intersection between Coveland Street and Alexander Street in Coupeville, Washington. The site location is shown relative to surrounding physical features in Figure 1. The former bulk plant site is shown relative to nearby streets and the Town of Coupeville Water Supply Well No. 1 (Well No. 1) in Figure 2. A detailed site plan of the property showing the approximate locations of on-site wells is presented in Figure 3.

GeoEngineers conducted subsurface explorations and monitored remediation activities at the site in 1990 and 1991. The results of these studies are presented in past reports and are summarized in Appendix A.

The town of Coupeville sent a letter to Unocal dated January 26, 1995 regarding problems with Well No. 1. Well No. 1 is located approximately 250 feet north-northeast of the former Unocal Bulk Plant site (Figure 2). The town of Coupeville treats its water supply by electrodialysis. This process uses closely spaced semipermeable membranes that aid in the removal of anions and cations from water. The treatment process typically is used to make potable water from brackish water. The Town contends that the water treatment membranes are clogged by bacteria that originate from Well No. 1 when it is used as a supplemental water supply source. A high percentage of the bacteria appear to be pseudomonas, some of which are known to be a type of aerobic bacteria capable of degrading petroleum hydrocarbons. The town of Coupeville's letter references a 130-foot-deep well (PW-1) as a possible source of the bacteria that are causing problems in Well No. 1.

The purpose of our services is to help determine whether PW-1 has contributed to the bacteria problem observed in Well No. 1. GeoEngineers' scope of services completed for this phase of study at the site is listed in Appendix B.

GEOLOGIC/HYDROGEOLOGIC SETTING

GENERAL

Our interpretation of surface and subsurface geologic/hydrogeologic conditions in the vicinity of the site is based on the following.

- A review of available published literature regarding regional geologic/hydrogeologic conditions on Whidbey Island.

- A review of Ecology (Washington State Department of Ecology) water well reports for 22 water wells located in the vicinity of the site.
- A review of two reports, one prepared by Applied Geotechnology, Inc. (1993) and one by John E. Schaefer (1991).
- One short-term aquifer test conducted in PW-1.
- Our experience and observations of subsurface conditions at Unocal's former bulk plant site.

GEOLOGIC SETTING

A review of the available information indicates the geologic/hydrogeologic conditions in the Coupeville area are the result of several episodes of interglacial erosion, scour by the glaciers, deposition of glacial and nonglacial sediments, and postglacial deposition and erosion. The Fraser Glaciation is the most recent glaciation of western Washington and includes two periods of glacial advance (the Sumas and Vashon stades) separated by an interglacial period (the Everson interstade). Erosion and deposition during and following the Fraser Glaciation have resulted in the modern topography of the Coupeville area. Deposits associated with the Vashon stade present in the vicinity of the site include advance outwash, till and recessional outwash. Deposits associated with the Everson interstade include the Everson glaciomarine drift. A generalized hydrogeologic cross section of the area in the vicinity of the site is presented in Figure 4.

The advance outwash deposit consists primarily of sand and gravel with interbedded silt and clay lenses; these sediments were deposited by meltwater streams in front of the advancing glacier. The advance outwash was overridden by several thousand feet of glacial ice. The advance outwash deposit appears to be at least 50 feet (15 m) thick in the vicinity of the site. The advance outwash unit is overlain by Vashon till, a dense, nonsorted, nonstratified deposit of silt, sand, gravel and cobbles that also has been compacted by the weight of several thousand feet of glacial ice. The Vashon till is locally covered with a layer of glaciomarine drift deposited during the Everson interstade of the Fraser Glaciation. The glaciomarine drift is primarily composed of silt and clay material that was deposited in a marine environment beneath floating/melting glacial ice. The till and glaciomarine drift can be up to 150 feet (46 m) thick in the vicinity of the site (Figure 4). Recessional outwash sand and gravel deposits mantle the upland areas located southeast and southwest of Coupeville.

HYDROGEOLOGIC SETTING

At least two aquifer systems appear to be present in the vicinity of the site: (1) a perched aquifer located in more permeable sand and gravel lenses within the upper portion of the till/glaciomarine drift, and (2) a confined aquifer located in the advance outwash deposits.

Perched Aquifer

The following are our observations related to the perched aquifer:

- The shallow perched aquifer occurs within a local isolated lens of relatively permeable sand and gravel located in the upper portion of the till/glaciomarine drift.
- The perched aquifer is generally located at a depth of approximately 20 feet (6.1 m) to 40 feet (12.2 m) and appears to slope downward to the north, roughly paralleling topography (Figure 4). The thickness of the aquifer is influenced by relief on the underlying less permeable till/glaciomarine drift. The perched aquifer is characterized by significant by horizontal and vertical variations in permeability.
- All of the existing monitoring wells at and near the bulk plant property appear to be completed within the perched aquifer.
- The perched aquifer generally is unconfined (an unsaturated zone exists between the water level in the aquifer and ground surface) beneath the bulk plant.
- The aquifer appears to exhibit slight confining conditions in the downgradient portion of the aquifer near MW-13 (Figure 4).
- Soil heterogeneities within the perched aquifer unit and variations in monitoring well screen depths/lengths result in a problematic determination of ground water flow direction and hydraulic gradient (slope). However, based on water levels observed in the on- and off-site monitoring wells and the surface topography in the vicinity of the site, we estimate that ground water flow within the perched aquifer is generally to the north in the immediate vicinity of the bulk plant site.
- Recharge to the aquifer is from the downward infiltration of precipitation through the overlying till/glaciomarine drift unit and/or directly from precipitation in areas where the sand and gravel lens extends to the ground surface.
- The perched aquifer appears to discharge vertically and horizontally into the surrounding till/glaciomarine drift.

Advance Outwash Aquifer

The following are our observations related to the advance outwash aquifer:

- The advance outwash aquifer consists of stratified sand and gravel deposits that are interbedded with relatively low-permeability zones of silt and clay.
- The top of the aquifer appears to slope downward to the north and is located at a depth of approximately 120 feet (36.5 m) to 140 feet (42.7 m) below ground surface in the vicinity of the site (Figure 4).
- The total thickness of the confined aquifer is unknown but appears to be at least 50 feet (15.2 m) in the vicinity of the site.
- The town of Coupeville Well No. 1 and PW-1 appear to be completed within the advance outwash aquifer.

- PW-1 and Well No. 1 appear to penetrate only the upper portion of the advance outwash aquifer.
- The advance outwash aquifer is confined (static water levels within PW-1 and Well No. 1 are significantly higher than the upper surface of the aquifer unit) by the overlying till/glaciomarine unit.
- Static water levels within PW-1 and Well No. 1 are near mean sea level and exhibit rhythmic fluctuations in response to tidal action in Penn Cove.
- Ground water within the confined aquifer appears to flow generally north toward Penn Cove. However, short-term localized reversals in ground water flow may occur in the immediate vicinity of Well No. 1 because of tidal influences on ground water levels within the advance outwash aquifer.
- Recharge to the confined aquifer is from the infiltration of precipitation through the overlying till/glaciomarine drift.
- The confined aquifer appears to discharge to Penn Cove.

WELL DEVELOPMENT AND INSPECTION

Well PW-1 was inspected and developed on April 4, 1995 using equipment owned and operated by Holt Drilling, Inc. The inner portion of the well casing was scrubbed to the base of the casing using a wire brush for approximately 2 hours followed by approximately 2 hours of water bailing. The development water was placed in a 20,000-gallon Baker tank located on site. After well development was completed, the condition of PW-1 was explored using a down-boring video camera owned and operated by Mr. Doug Dow. The results of the well development and inspection are as follows.

- Approximately 50 gallons of sediment and development water were removed from the well during the development procedure.
- Minor amounts of organic material were observed in the well development water.
- PW-1 is completed as a 7-inch-diameter casing to a depth of 131 feet.
- The well casing joints appear to be threaded.
- The well was completed as an open-end boring. No well screen or perforations were observed in the well.
- The well casing appeared to be in good condition with minor pitting of the casing walls. No cracks or holes indicative of deteriorated casing were observed.

AQUIFER TEST AND ANALYSIS

GENERAL

A stepped-rate aquifer test was attempted in PW-1 on April 11, 1995. The well was pumped initially for approximately 20 minutes at a rate of approximately 15 gpm (gallons per minute). The discharge rate was determined using an in-line flow meter. Minor amounts of sediment, natural organic detritus and casing-scale debris were observed in the discharge water.

The sediment, natural organic detritus and scale debris in the discharge water clogged and eventually prevented the in-line meter from operating properly after approximately 15 minutes of testing. Consequently, the stepped-rate test was halted and the in-line meter was removed. An attempt was made to restart the stepped-rate test following the removal of the flow meter. However, the submersible pump installed in PW-1 would not operate and had to be replaced.

A constant rate pumping aquifer test was conducted in PW-1 on April 12, 1995. PW-1 was pumped at a constant rate of 75 gpm (0.29 m^3/min) for 8 hours. Ground water levels in PW-1, Well No. 1, MW-5, MW-6, MW-8, MW-10 and MW-11 were monitored prior to, during and after the test for response to the pumping test. The test was performed to determine pertinent aquifer and well characteristics. Details of the aquifer testing procedures and field data sheets are presented in Appendix C.

WELL EFFICIENCY

Wells that are completed as open-end casing, such as PW-1, are generally very inefficient. Well inefficiencies cause the pumping water level in the well casing to be lower than the actual water level in the aquifer adjacent to the well. Based on our experience, we estimate that PW-1 has an approximate well efficiency of 30 percent. Therefore, the actual water level drawdown in the aquifer adjacent to the well is approximately 30 percent of the water level drawdown observed inside the well casing.

TIDAL EFFECTS

General

Aquifers hydraulically connected to nearby water bodies that experience tidal fluctuations are subject to fluctuation in water levels. The degree to which the aquifer responds to tidal fluctuations is referred to as the aquifer tidal efficiency. The amplitude of the tidally induced fluctuations deceases with increased distance from the shoreline. Furthermore, the time lag between the tidal fluctuation in the surface water and the induced fluctuation in the aquifer increases as a function of distance from the shoreline. Tidally induced water level fluctuations need to be quantified and factored out of aquifer test data to allow an accurate estimation of aquifer parameters. Information concerning tidal fluctuations in Penn Cove during and after the PW-1 aquifer test was obtained from tide tables for Seattle and Port Townsend.

Well No. 1

Tidal fluctuations were observed in Well No. 1 during and after the PW-1 aquifer test on April 12, 1995. Furthermore, the town of Coupeville conducted a constant rate drawdown test on Well No. 1 for approximately 214 hours between August 7 and 20, 1990. A description of the aquifer test is presented in Schaefer (1991). The limited water level drawdown and tidal information presented in Schaefer (1991) indicates that a tidal fluctuation of approximately 11.1

feet resulted in a water level fluctuation of approximately 6.6 feet in PW-1, indicating a tidal efficiency of approximately 59 percent.

The theoretical tidally induced fluctuation within an aquifer can be estimated for wells that are screened through a high percentage of the aquifer using the methodology outlined in Fetter (1994), as shown in the following formula.

$$H_x = H_o \, e^{(- x(\pi S / to T)^{1/2})}$$

Where:

H_x = Amplitude of tidally induced fluctuation.

H_o = Amplitude of tidal change (3.1 ft / 0.95 m).

x = Distance from the well to the contact between the aquifer and seawater body (750 ft/ 229 m).

π = 3.1416

S = Aquifer storativity (1.01×10^{-4}).

to = Time for tide to go from one extreme to another (0.25 day).

T = Aquifer transmissivity (2,640 ft²/d / 245 m²/d).

Preliminary values of transmissivity and storativity for the confined aquifer were estimated from the constant-rate aquifer test using the distance drawdown method outlined in Fetter (1994). Water level drawdown versus distance for PW-1 (corrected for well efficiency losses) and Well No. 1 are shown in Figure 5. Using the above analysis, a tidal fluctuation of 3.1 ft (0.95 m) would induce a tidal fluctuation in the confined aquifer of 1.8 ft (0.55 m). Therefore, the theoretical tidal efficiency of the confined aquifer is approximately 58 percent (1.8 ft / 3.1 ft = 0.58). This compares well with the tidal efficiency estimated from the limited aquifer testing data presented in Schaefer (1991). For the purposes of this report, an average tidal efficiency of approximately 60 percent was assumed for Well No. 1.

PW-1

Tidally induced fluctuations were observed in PW-1 during and after the April 12 aquifer test. However, the limited time duration of the test made the estimation of tidal efficiency problematic. Furthermore, the theoretical methodology described previously for Well No. 1 is not applicable to PW-1 because the well is not screened through a substantial portion of the aquifer. Based on the water level fluctuations observed during the PW-1 aquifer test and the distance inland from Well No. 1, we estimate that the aquifer has a tidal efficiency ranging from approximately 10 to 30 percent in the vicinity of PW-1.

Ground Water Monitoring Wells

Tidally induced water level fluctuations were not observed in MW-5, MW-6, MW-8, MW-10 and MW-11 prior to, during or after the 8-hour constant rate aquifer test performed in PW-1.

AQUIFER TEST RESULTS

General

Plots of water level elevations versus time for PW-1, Well No. 1 and the monitoring wells (MW-5, MW-6, MW-8, MW-10 and MW-11) during and after the 8-hour PW-1 aquifer test are shown in Figure 6. The PW-1 water level data shown in Figure 6 were corrected to account for well efficiency losses. The drawdown data shown in Figure 6 were not corrected for tidal effects.

The time-drawdown data indicated that near steady-state conditions were achieved in PW-1 and Well No. 1 after approximately 100 minutes of the test at a constant pumping rate of 75 gpm. Tidally induced fluctuations in PW-1 and Well No. 1 are apparent in the water level data obtained after approximately 100 minutes into the test (Figure 6). Water level drawdown was not observed in the monitoring wells during the PW-1 aquifer test. Total water level drawdowns of approximately 6.5 feet (2.0 m) and 2.8 feet (0.85 m) below the static water levels were observed in PW-1 and Well No. 1, respectively.

Water level recovery was recorded in PW-1, Well No. 1 and the monitoring wells for approximately 60 minutes following the constant rate test. The water levels had recovered to static or near-static conditions in both wells within the 60-minute time period (Appendix C).

Aquifer Transmissivity, Hydraulic Conductivity and Specific Storage

Transmissivity is a measure of the amount of water that can be transmitted horizontally by the full saturated thickness of the aquifer under a hydraulic gradient (slope) of 1. Transmissivity values for the aquifer were calculated using the Jacob Distance-Drawdown (Figure 5) and Papadopulos-Cooper methods for confined aquifers as outlined in Fetter (1994). The drawdown data were corrected for well losses and tidal effects, as described in previous sections of this report. Water level drawdown data observed in PW-1 and Well No. 1 during the constant rate test were used as input for the calculations. Based on the results of the aquifer test, the calculated transmissivity of the confined aquifer ranges from approximately 2,640 ft^2/d (square feet per day) (245 m^2/d) to 2,900 ft^2/d (270 m^2/d). A plot of water level drawdown versus time for Well No. 1, corrected for tidally induced fluctuations, is presented in Figure 7.

Hydraulic conductivity is a measure of the rate at which water can move through an aquifer and is equal to the transmissivity divided by the saturated thickness of the unit. As discussed previously, the thickness of the confined aquifer is unknown. However, the aquifer appears to be at least 50 feet (15.2 m) thick in the vicinity of the site. Based on an estimated aquifer thickness of 50 feet, the transmissivity values correspond to a hydraulic conductivity ranging from approximately 53 ft/day (feet per day) (16.2 m/d) to 58 ft/day (17.7 m/d). These values are typical of relatively permeable sand aquifers.

Specific storage is the amount of water per unit volume of a saturated formation that is expelled from storage as a result of compression of the aquifer and expansion of water when the aquifer is pumped. Specific storage is dimensionless and for confined aquifers generally ranges

from 10^{-5} to 10^{-3}. Specific storage for the confined aquifer as estimated from the PW-1 pumping test data is approximately 1.01×10^{-4}.

Well Radius of Influence

The radius of influence (cone of water level depression) for PW-1 can be estimated by analyzing total drawdowns (corrected for well inefficiency and tidal induced fluctuations) for PW-1 and Well No. 1 at the conclusion of the constant rate pumping test. We estimate that the measurable radius of influence for PW-1 at a pumping rate of 75 gpm is approximately 4,400 feet (1,340 m), as shown on Figure 5.

GROUND WATER QUALITY

FIELD GROUND WATER QUALITY PARAMETERS

A representative of GeoEngineers measured temperature, pH, electrical conductance, salinity and dissolved oxygen in water samples obtained from PW-1 during the 8-hour aquifer test. Details of the water quality monitoring program are presented in Appendix C. The water quality parameter data are presented in Table 1. A general summary of the data follows.

- Water temperature increased slightly during the test and ranged from 11.4 degrees C (Celsius) to 11.7 degrees C.
- Ground water pH was a relatively constant 7.9 during the aquifer test.
- Electrical conductance increased slightly during the test from 637 μmhos/cm (micromhos per centimeter) to 645 μmhos/cm.
- Salinity remained constant at 0.4 ppt (parts per thousand) during the aquifer test.
- Dissolved oxygen generally decreased during the test and ranged from 2.0 mg/l (milligrams per liter) to 0.3 mg/l. The dissolved oxygen concentrations detected in the water samples obtained throughout the aquifer test were generally low for typical ground water.

GROUND WATER CHEMISTRY

A representative of GeoEngineers obtained water samples from the PW-1 discharge water (PW-1) near the end of the 8-hour aquifer test for chemical analysis. A water sample (Deep Well-1) was also obtained from the purge/development water for disposal characterization. The chemical analytical results for ground water sample PW-1 are summarized in Table 2 and described below. Laboratory data sheets are presented in Appendix D.

- The samples were tested for dissolved petroleum products, chloride (Cl), total dissolved solids (TDS) and total organic carbon (TOC) using the testing methods listed in Table 2 and Appendix D.
- Petroleum-range hydrocarbons either were not detected or were detected at concentrations less than Model Toxics Control Act (MTCA) cleanup levels in the water sample obtained from the purge/development water (Deep Well-1).

- Petroleum-related compounds were not detected in the water sample (PW-1) obtained near the end of the aquifer test.
- Concentrations of TDS, Cl and TOC either were less than the secondary maximum contaminate levels or were not detected in water sample obtained PW-1.

MICROBIAL TESTING

A representative of GeoEngineers obtained one water sample (BAC-1) during the aborted stepped-rate aquifer test conducted on April 11 and three water samples (BAC-2, BAC-3 and BAC-4) during the 8-hour aquifer test conducted on April 12. Water sample BAC-1 was collected after PW-1 had been pumped approximately 20 minutes on April 11. Water samples BAC-2 through BAC-4 were collected after approximately 45, 225 and 465 minutes, respectively, of pumping in PW-1 on April 12. The water samples were submitted to RETEC for microbial counts, including total aerobic heterotrophs and specific hexadecane and diesel degraders. Details of the microbial testing are presented in RETEC's report dated May 18, 1995, included as Appendix E. A summary of the testing results follows.

- The microbial numbers in the field samples represent reasonable numbers for an uncontaminated aquifer.
- Total heterotrophic numbers decreased significantly during continued pumping of the well.
- Hexadecane and diesel degraders also decreased significantly during continued pumping of the well.
- Microorganisms capable of growth on wood chip filtrate decreased significantly to nondetectable levels during the test.

CONCLUSIONS

Based on the results of our aquifer testing and ground water sampling activities, microbial testing by RETEC, and the results of our previous studies and remediation at the site, GeoEngineers makes the following conclusions and recommendations.

- The former Unocal Bulk Plant site is underlain by at least two aquifers: (1) a perched aquifer and (2) a confined aquifer.
- The town of Coupeville Well No. 1 is completed in the same confined aquifer as PW-1.
- Monitoring wells MW-2 and MW-5 through MW-13 are completed within the shallow perched aquifer.
- The confined aquifer is at least 50 ft (15.2 m) thick and appears to be regionally extensive in the vicinity of the town of Coupeville.
- The confined aquifer has a transmissivity ranging between 2,640 ft^2/d (245 m^2/d) and 2,900 ft^2/d (270 m^2/d), hydraulic conductivity ranging between 53 ft^2/d (16.2 m^2/d) and 58 ft^2/d (17.7 m^2/d), and a storativity of 1.01×10^{-4} in the vicinity of the former bulk plant.
- Ground water within the perched and confined aquifers generally flows toward Penn Cove.

- The tidally induced ground water fluctuations in PW-1 and Well No. 1 indicate that the confined aquifer is likely in hydraulic continuity with Penn Cove.
- Pumping-induced water level drawdowns and tidally induced fluctuations were not observed in the monitoring wells, indicating that the perched aquifer is not in hydraulic continuity with either Penn Cove or the lower confined aquifer.
- Video inspection of PW-1 indicates that the casing is undamaged to the completion depth of the well.
- Petroleum-related ground water contamination was not detected in a water sample obtained from PW-1 during the 8-hour aquifer test, indicating that ground water contamination present in local areas of the perched aquifer is not migrating along the PW-1 casing or through the underlying silt and clay unit into the lower confined aquifer.
- The microbial numbers in the water samples obtained from PW-1 represent reasonable numbers for an uncontaminated aquifer and are similar to the concentrations reported by AGI (1993) for water samples obtained during the initial 4 weeks of a pumping test performed on Well No. 1.
- RETEC's microbiological testing indicated that the addition of oxygen increased the number of total heterotrophs and specific degraders in all samples except the initial sample (BAC-1), suggesting that the growth of bacteria in the confined aquifer is oxygen-limited.
- The presence of specific diesel and hexadecane degraders did not directly correlate with the presence of petroleum hydrocarbon contamination.
- RETEC's report indicates that the largest number of total heterotroph colonies detected in BAC-3 would require roughly 2 mg/l of natural organic carbon (Appendix E). This is consistent with the concentration of 2.3 mg/l TOC detected in water sample PW-1.
- The aerobic microbiologic activity in the confined aquifer, combined with the presence of significant TOC in the aquifer, is the likely cause of the low concentrations of dissolved oxygen in the water samples obtained from PW-1.
- The shallow soil and ground water contamination present at the former Unocal Bulk Plant site is not affecting water quality in the lower confined aquifer.
- The water treatment plant problem reported by the town of Coupeville occurred when water from Well No. 1 was mixed with water from other wells operated by the town. In our opinion, these problems are not related to the conditions of Unocal's bulk plant property or to the presence of PW-1.

RECOMMENDATIONS

- We recommend that PW-1 be abandoned in accordance with WAC 173-160.

LIMITATIONS

We have prepared this report for use by Unocal. This report may be made available to regulatory agencies and prospective buyers of the property. This report is not intended for use by others and the information contained herein is not applicable to other sites.

Our interpretations of subsurface conditions are based on GeoEngineers' field observations, one relatively short-term aquifer test and chemical analytical data for ground water samples from relatively widely spaced sampling locations at and near the site.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

We appreciate the opportunity to be of service on this project. Please call if you have questions regarding this report.

Respectfully submitted,

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Document ID: 0161205R.GW

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TABLES

TABLE 1
SUMMARY OF WATER QUALITY PARAMETERS

Time	Temperature[1] (°C)	pH[2]	Electrical[1] Conductance (μmhos/cm)	Salinity[1] (°/oo)	Dissolved[3] Oxyden (mg/l)
0845	11.4	7.9	637	0.4	2.0
0852	11.4	7.8	637	0.4	1.0
0938	11.4	7.9	637	0.4	1.0
1010	11.5	7.9	639	0.4	0.6
1057	11.5	7.9	640	0.4	0.3
1205	11.7	7.9	643	0.4	1.0
1259	11.6	7.9	642	0.4	0.6
1400	11.7	7.9	644	0.4	0.5
1500	11.7	7.9	644	0.4	0.6
1558	11.7	7.9	645	0.4	0.7

Note:

[1]Measurements obtained using a YSI Model 30 SCT meter.

[2]Measurements obtained using a PHTESTER meter.

[3]Measurements obtained using a YSI DO meter.

C^{o} = degrees Centigrade

μmhos/cm = micromhos per centimeter

°/oo = parts per thousand

mg/l = milligrams per liter

TABLE 2
SUMMARY OF GROUND WATER CHEMICAL ANALYTICAL DATA[1]

Sample Number	Date Sampled	WTPH-G[2] (µg/l)	WTPH-D[3] (mg/l)		TPH[4] (mg/l)			Volatile Organic Compounds[5] (µg/l)				Cl[6] (mg/l)	TDS[7] (mg/l)	TOC[8] (mg/l)
			Diesel Range	Heavy-Oil Range	Total	Non-Polar	Polar	B	E	T	X			
PW-1	4/11/95	<50	<0.25	<0.75	<1.0	<1.0	<1.0	<0.5	<0.5	<0.5	<1.0	65	450	2.3

Notes:

[1]Chemical Analysis conducted by North Creek Analytical. Laboratory Data Sheets are presented in Appendix E.

[2]Washington State Total Petroleum Hydrocarbons-Gasoline Method.

[3]Washington State Total Petroleum Hydrocarbons-Diesel Extended Method.

[4]Total Petroleum Hydrocarbons by EPA Methods 418.1 (Non-Polar) and 413.2 (Polar).

[5]B = benzene, E = ethylbenzene, T = toluene, X = total xylenes by EPA Method 8020.

[6]Chloride by EPA Method 300.0.

[7]Total Dissolved Solids by EPA Method 160.1.

[8]Total Organic Carbon by EPA Method 415.1.

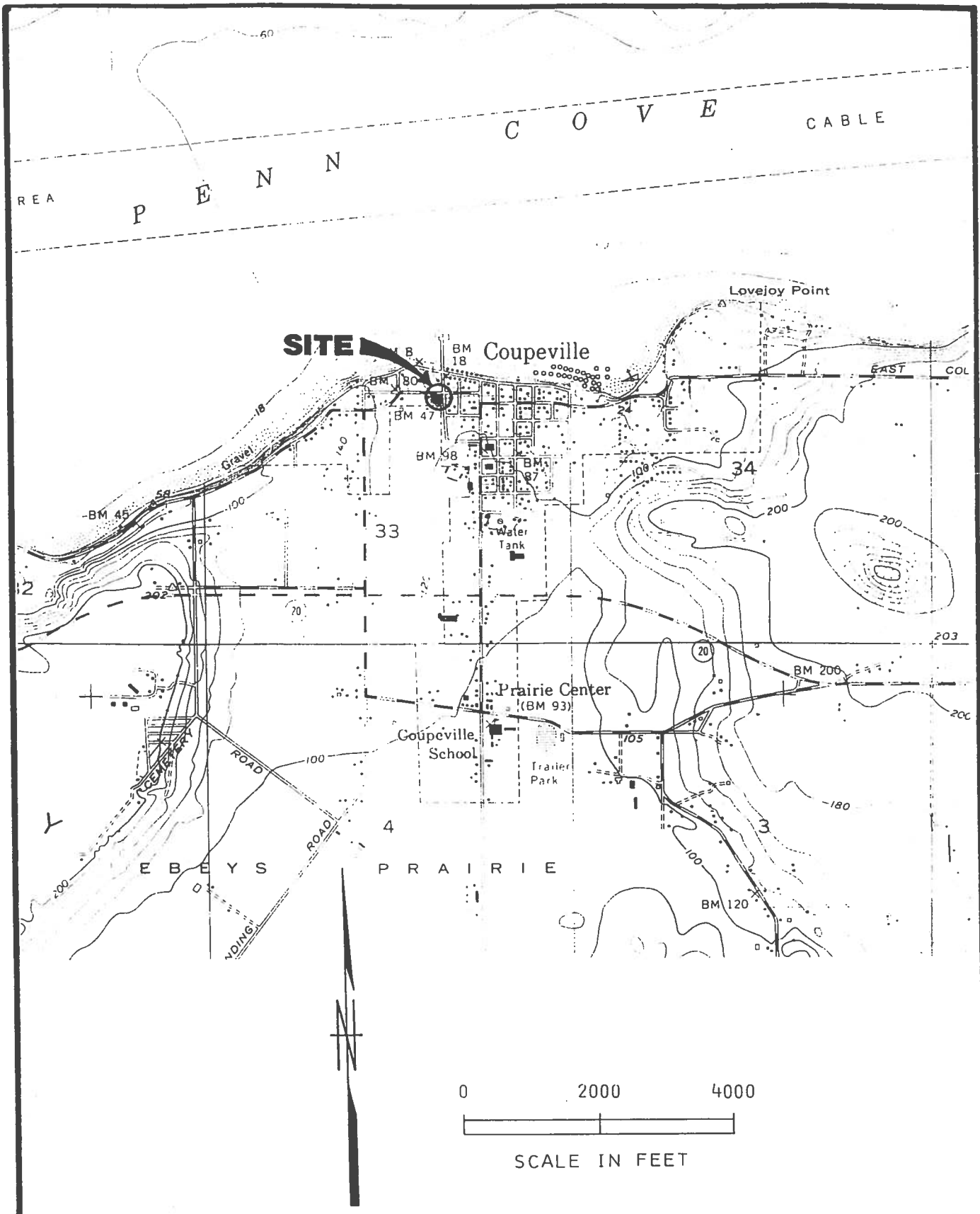
< = less than

µg/l = micrograms per liter

mg/l = milligrams per liter

"–" = not tested

FIGURES



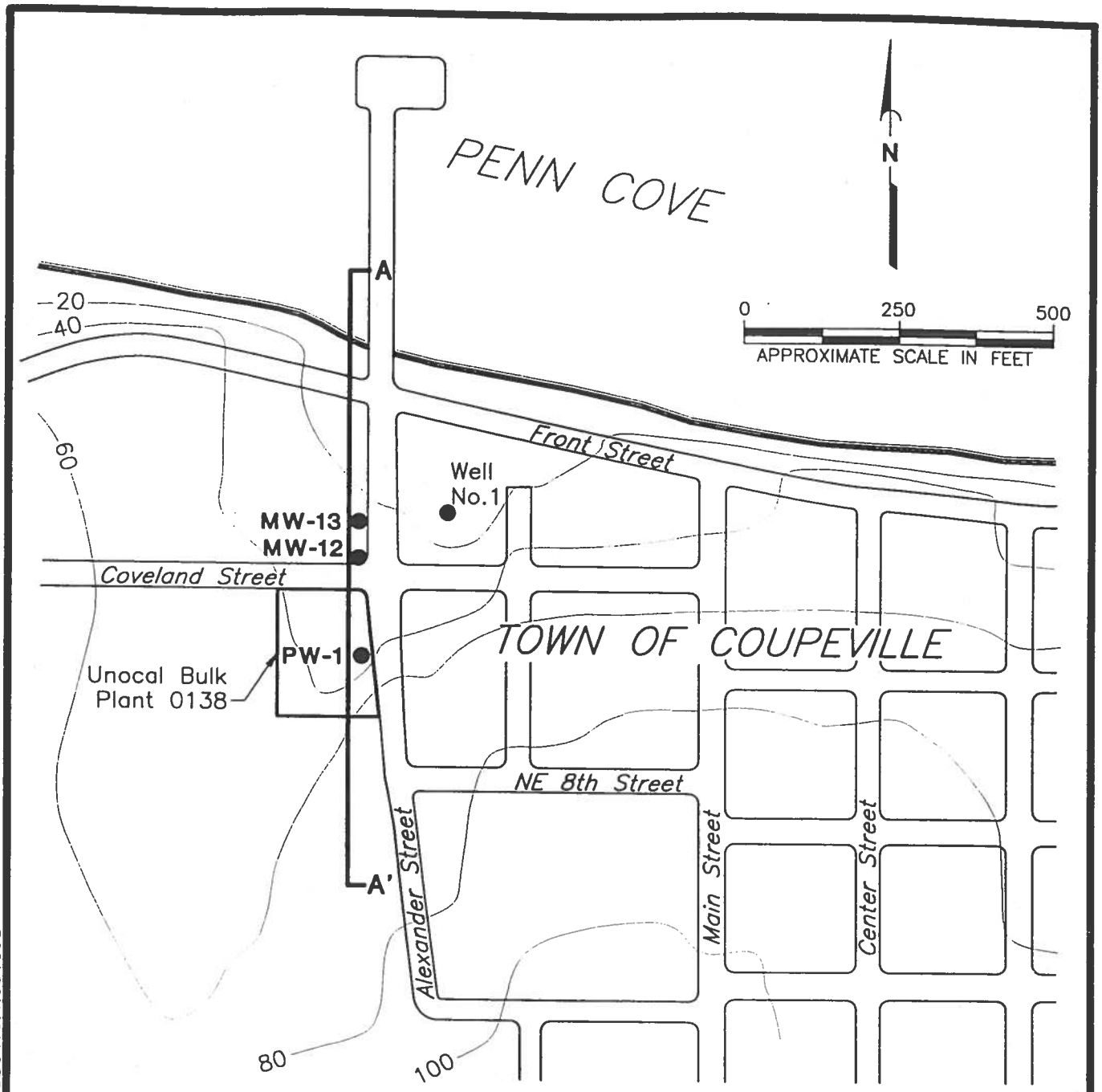
REFERENCE: USGS 7.5' TOPOGRAPHIC QUADRANGLE MAP "COUPEVILLE, WASH."

Geo Engineers

VICINITY MAP

FIGURE 1

0161-205-804 WH:KKI 9.11.09



EXPLANATION:

MW-13 ● WELL NUMBER AND APPROXIMATE LOCATION

100 GROUND SURFACE CONTOUR AND ELEVATION

A / A' HYDROGEOLOGIC CROSS SECTION LOCATION

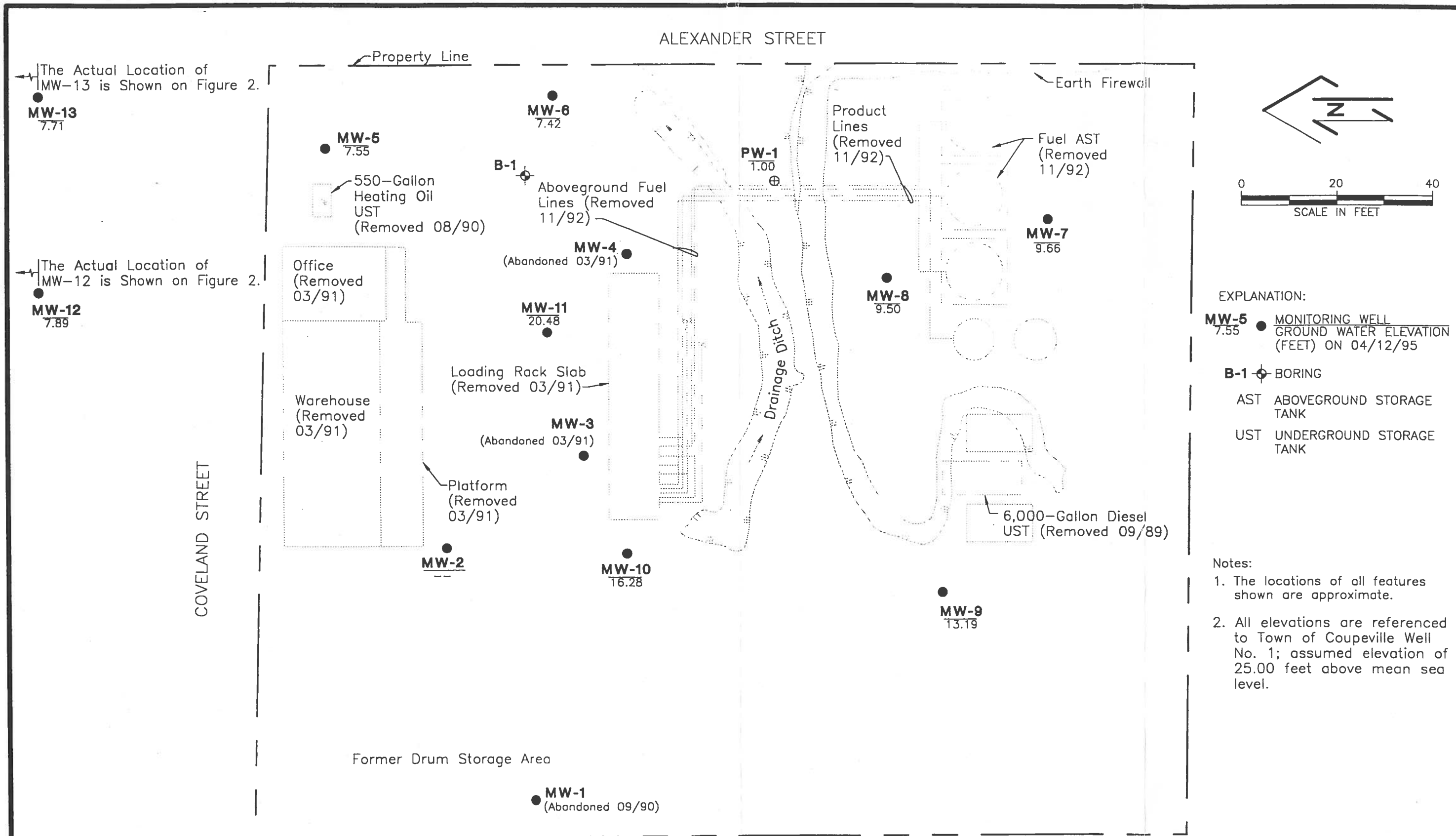
Reference: Information from USGS topographic quadrangle map.

Geo Engineers

PROJECT LOCATION MAP

FIGURE 2

CSL:SPS 01/61205.DWG 01/61205B04T6.4:051095



Notes:

1. The locations of all features shown are approximate.
2. All elevations are referenced to Town of Coupeville Well No. 1; assumed elevation of 25.00 feet above mean sea level.

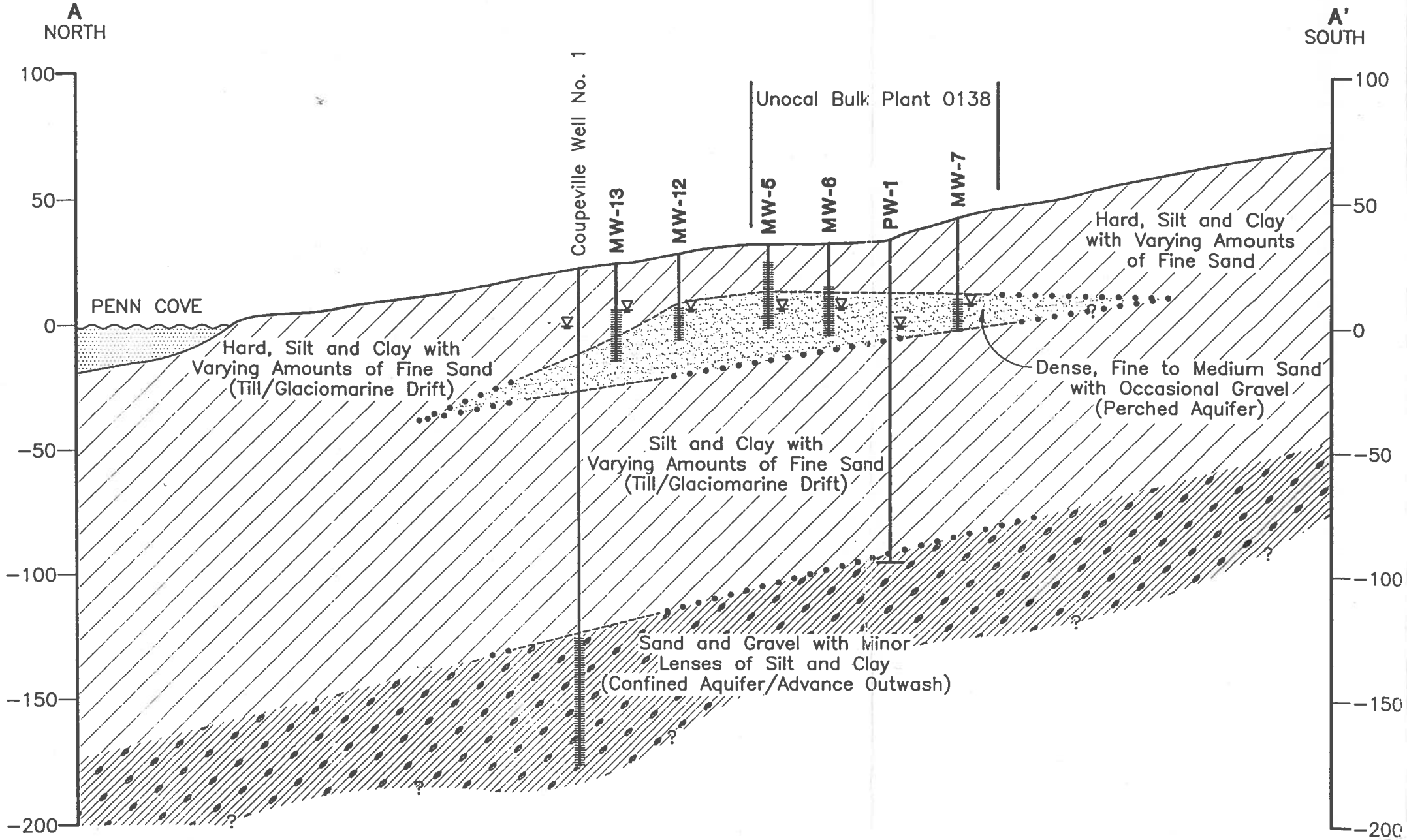
Reference: Drawing entitled "Coupeville, Washington, Coveland and Alexander Streets, Bulk Plant, General Arrangement," by Unocal, dated 04/22/81.

Geo Engineers

SITE PLAN AND GROUND WATER ELEVATIONS 04/12/95

FIGURE 3

05/11/95 CSL:BDH G:\0161\205\0161205B.DWG



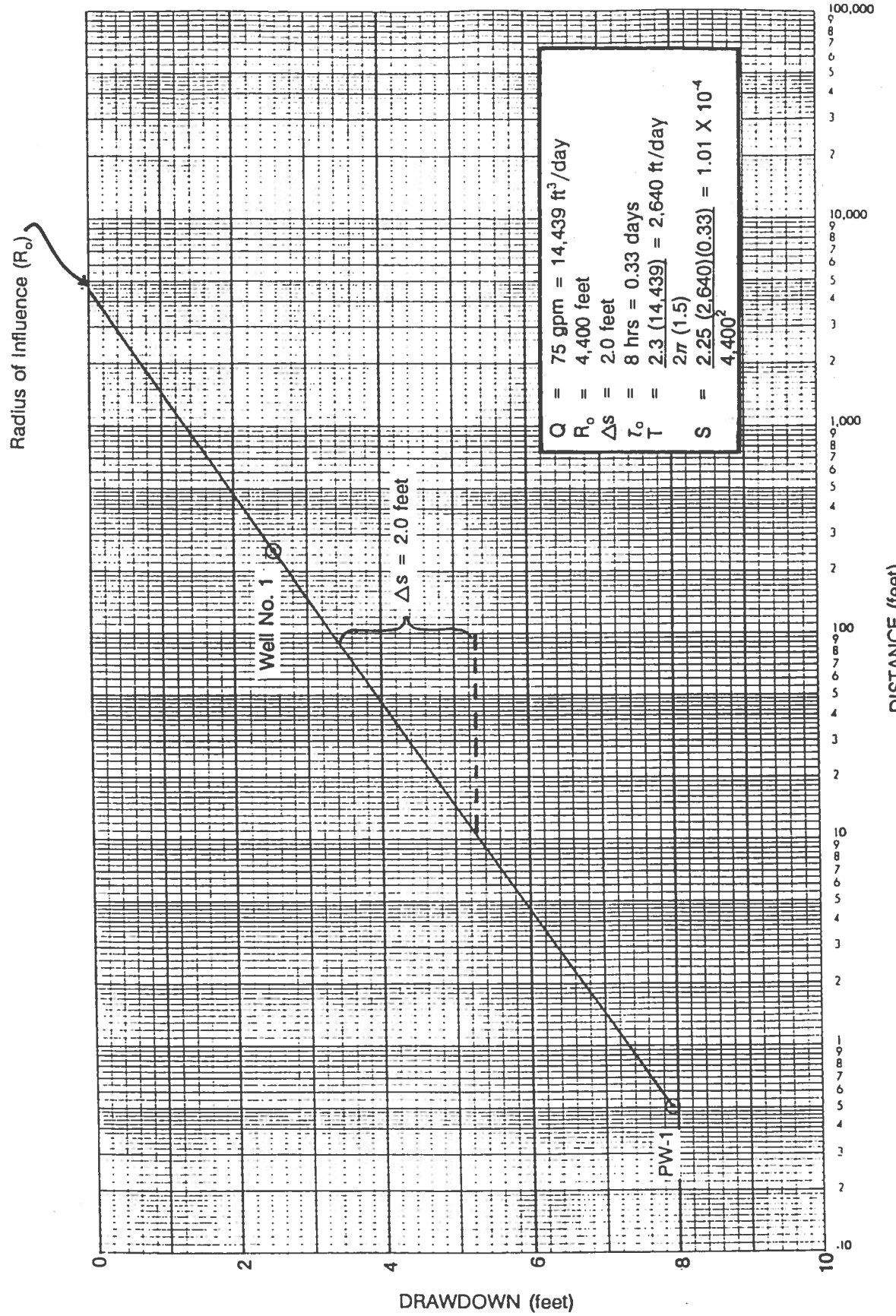
0161205B.DWG 0161205B04T6.4:051195

CSL:SPS

Geo Engineers

GENERALIZED HYDROGEOLOGIC CROSS SECTION A-A'

FIGURE 4

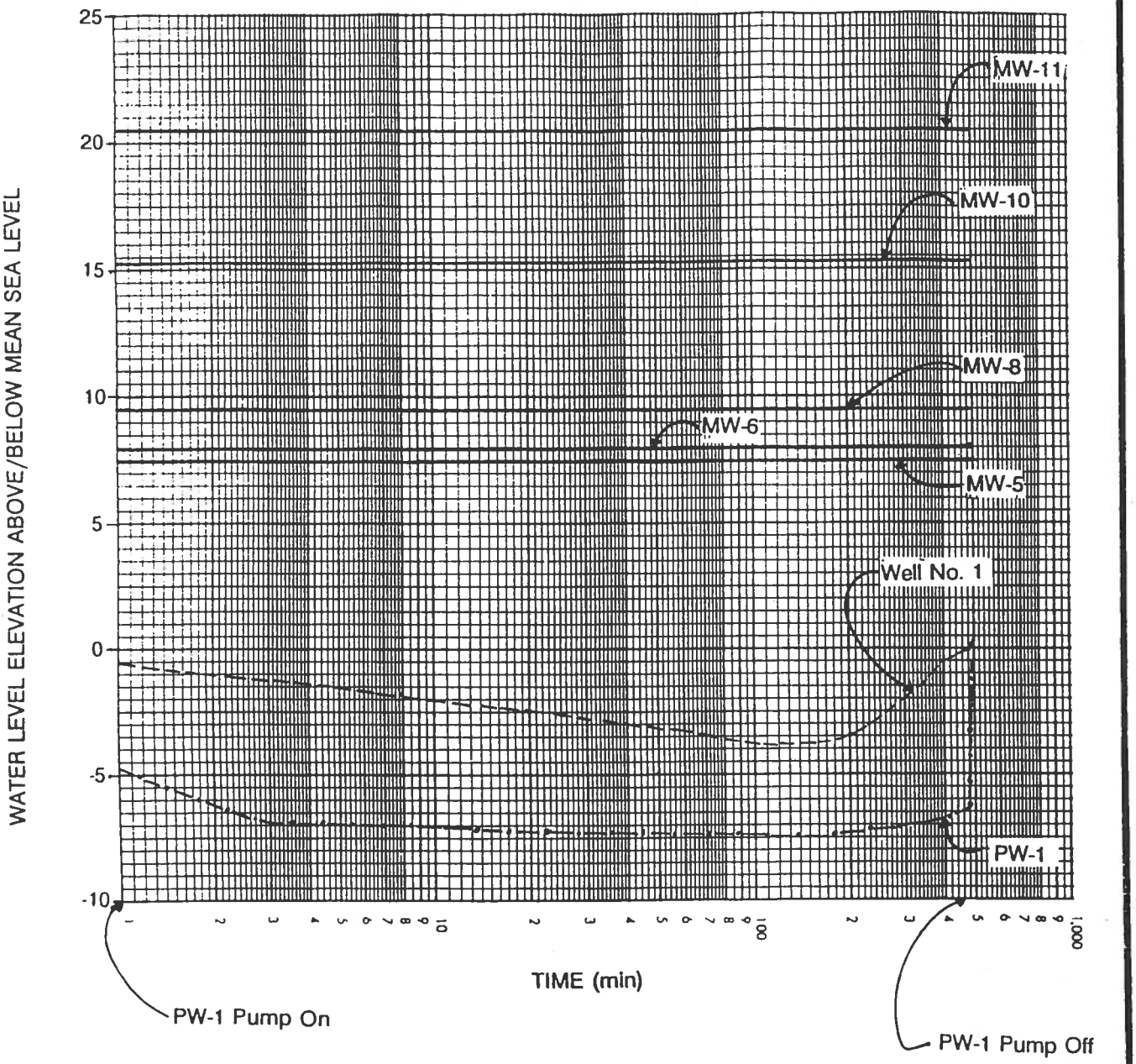


Geo Engineers

DISTANCE-DRAWDOWN PLOT

FIGURE 5

#0161-205-B0416.4 CSL:dam 05/24/95



MONITOR WELLS

WELL NO. 1

PW-1

NOTE: Elevations are referenced to Well No. 1 casing rim @ an assumed elevation of 25.0 feet (7.6m) above mean sea level.

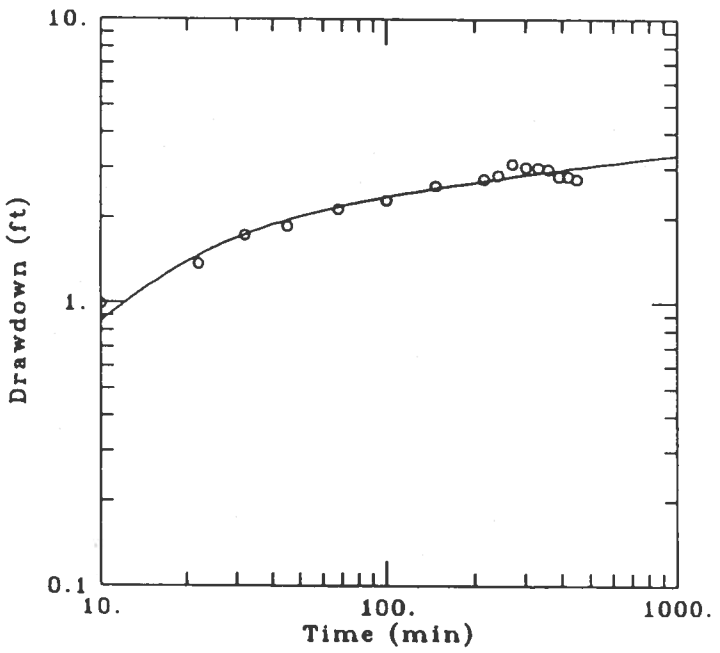
Geo Engineers

WATER LEVEL DRAWDOWN VERSUS TIME

FIGURE 6

GeoEngineers, Inc.	Client Unocal
Project No 0161-205-B04/Task 6.0	Location Coupeville, Washington

Well No 1 Drawdown vs Time



DATA SET
0161w1.dat
05/22/95

AQUIFER TYPE
Confined
SOLUTION METHOD
Papadopulos-Cooper
TEST DATE:
April 12, 1995
TEST WELL:
PW-1
OBS WELL:
Well No 1

ESTIMATED PARAMETERS:
T = 2.014 ft^2/min
S = 1.5821E-05
a = 8.8954E-07

TEST DATA:
Q = 10.03 ft^3/min
r = 250 ft
rc = 0.29 ft
rw = 0.5 ft

Geo Engineers

WELL NO. 1, DRAWDOWN VERSUS TIME

FIGURE 7

APPENDIX A

APPENDIX A

SUMMARY OF PAST SITE ACTIVITIES BY GEOENGINEERS

GeoEngineers has conducted environmental studies at the site since 1989. The results of our previous studies are presented in the following reports:

- "Report of Geotechnical Services" dated October 6, 1989.
- "Report of Geotechnical Services" dated January 30, 1990.
- "Project Status Report" dated November 2, 1990.
- "Report of Geoenvironmental Services" dated March 18, 1992.
- "Results of Ground Water Sampling" dated August 17, 1992.
- "Results of Ground Water and Soil Stockpile Sampling" dated January 22, 1993.
- "Results of Ground Water Sampling" dated December 29, 1993.
- "Results of Ground Water Sampling" dated August 3, 1994.

The following is a summary of GeoEngineers' activities and findings during the previous studies:

- Observed the removal of one semiburied 6,000-gallon diesel storage tank from the site in September 1989.
- Explored subsurface conditions at the site in November 1989 by drilling six exploratory borings and excavating three test pits. Ground water monitoring wells (MW-1 through MW-6) were completed in the exploratory borings at the approximate locations shown in Figure 3.
- Observed the removal of one 550-gallon heating oil tank and associated product lines, and the completion of five remedial excavations at the site in August and October 1990.
- Observed the completion one boring (B-1), five on-site monitoring wells (MW-7 through MW-11) and two off-site monitoring wells (MW-12 and MW-13), and the excavation of approximately 850 cubic yards of contaminated soil at the site between March and July 1991.
- The results of our previous site studies indicate that soil contamination remains at depth in areas near MW-5, MW-11, north of the former abovegrade storage tanks, north of the former loading rack and east of the former office building. It appears that most of the shallow subsurface soil contamination was removed during remedial excavation activities at the site in 1990 and 1991.
- Quarterly ground water sampling was completed at the site through June 1994. Based on our observations and review of the laboratory data, the concentrations of ground water contaminants in monitoring wells MW-5, MW-9 and MW-11 are generally decreasing over time.

APPENDIX B

APPENDIX B

SCOPE

The purpose of our most recent services was to evaluate the condition of PW-1 as it relates to ground water conditions encountered in Well No. 1. The purpose of our services was to help determine whether PW-1 has contributed to the bacteria problem observed in Well No. 1. Our specific scope of services completed for this study is listed below.

1. Subcontract Holt (Holt Drilling, Inc) to remove sediment and rust from the well and to "develop" the well casing perforations by mechanical surging, scrubbing and jetting.
2. Mobilize a 20,000-gallon Baker tank to the site for temporary storage of water and sediment removed from the well during well development.
3. At the end of the well development process, purge the well of at least three well casing volumes and obtain a series of water samples for analytical testing as follows:
   - Analysis of BETX (benzene, ethylbenzene, toluene and xylenes) by EPA Method 8020, gasoline-range hydrocarbons by Ecology (Washington State Department of Ecology) Method WTPH-G, and diesel- and heavy oil-range hydrocarbons by Ecology Method WTPH-D extended. The results of these analyses will be used to determine the disposal method of water generated during well development and the subsequent pumping test.
   - Submit a bulk water sample to RETEC for bacteriological analysis of total heterotroph counts and hydrocarbon degrader counts.
4. Subcontract a video survey of PW-1 to determine well perforation interval(s) and evaluate casing integrity.
5. Conduct an 8-hour constant rate pumping test on PW-1. The pumping test was performed in general accordance with the guidelines provided in the Ecology WRIS Bulletin No. 30 Aquifer Testing Procedures.
6. Measure and record drawdown in the pumping well (PW-1), Coupeville's Well No. 1 and five monitoring wells at the Unocal site during the constant rate pumping test.
7. Monitor the temperature, pH, electrical conductivity and dissolved oxygen of water pumped from PW-1 during the pumping test.
8. Obtain water samples at intervals of 1, 4 and 8 hours after start of the constant rate pumping test for bacteriological testing by RETEC.
9. Near the conclusion of the pumping test, collect ground water samples from PW-1 for analysis of gasoline-range hydrocarbons by Ecology Method WTPH-G, diesel- and heavy oil-range hydrocarbons by WTPH-D extended, volatile aromatic hydrocarbons by EPA Method 8020, chloride by EPA Method 300.0, total organic carbon by EPA Method 415.1 and total dissolved solids by EPA Method 160.1.

10. Measure and record water level recovery data in PW-1, Well No. 1 and the monitoring wells following the constant rate pumping test. Recovery data were measured until near-static water levels were recorded.
11. Analyze the pumping test data to estimate aquifer hydraulic conductivity, transmissivity, radius of influence and storage coefficient.
12. Evaluate the data with respect to the claim by the town of Coupeville.
13. Attend one meeting with the town of Coupeville to present the results of our investigations and testing.

APPENDIX C

APPENDIX C

FIELD PROCEDURES

WELL DEVELOPMENT AND INSPECTION

Well PW-1 was cleaned and developed on April 4, 1995 using equipment owned and operated by Holt Testing, Inc. The inside portion of the well casing initially was scrubbed using a 7-inch-diameter wire brush. Sediment and debris were removed from the well casing using a steel bailer after the casing had been scrubbed for approximately 2 hours. Approximately 5 gallons of water and sediment were removed from the casing during the development procedure. The water/sediment was stored in a 20,000-gallon Baker tank located on site pending disposal.

The condition of PW-1 was explored using a down-boring video camera owned and operated by Mr. Doug Dow. The video indicated that the casing was completed as an open-end boring at a depth of approximately 131 feet below ground surface. The casing joints appear to be threaded and no cracks or holes in the casing were observed.

AQUIFER TESTS

The aquifer tests were completed in PW-1 using a submersible pump installed at a depth of approximately 110 feet below the casing rim. The aquifer tests were conducted on April 11 and 12, 1995.

A stepped-rate aquifer test was attempted in PW-1 on April 11. PW-1 was pumped at a rate of 15 gpm (gallons per minute). Flow was determined using an in-line flow meter. Discharge from the well was initially turbid, with minor amounts of organic debris. Approximately 20 minutes into the test, the sediment and organic material in the discharge water stopped the in-line flow meter from functioning. The stepped-rate test was immediately terminated and the in-line flow meter was removed. An attempt was made to restart the stepped-rate test shortly after the in-line meter was removed. However, the submersible pump became sand locked and had to be removed and replaced.

The constant rate aquifer test was conducted in PW-1 on April 12, 1995. PW-1 was pumped at a rate of approximately 75 gpm throughout the 8-hour test period. Flow rates were determined using a calibrated 5-gallon bucket and stop watch. Ground water pumped from PW-1 during the aquifer tests was discharged to a storm drain located on the northern property boundary. The storm drain discharged directly to Penn Cove.

GROUND WATER ELEVATIONS

The ground water elevations in PW-1 and the town of Coupeville Well No. 1 were measured during and after the aquifer test using a manual electronic water level indicator. Ground water elevations were estimated relative to the casing rims of the wells. Static water levels in PW-1 and Well No. 1 were at depths of approximately 41 and 27 feet below ground surface, respectively, prior to the 8-hour test.

Water levels were monitored in MW-5, MW-6, MW-8, MW-10 and MW-11 during and after the aquifer test using in-boring pressure transducers connected to an eight-channel data logger. Ground water elevations shown on Figure 3 on the text are relative to an assumed elevation of 25 above mean sea level for Well No. 1.

FIELD GROUND WATER QUALITY PARAMETERS

The ground water quality data are summarized in Table 1. The temperature, salinity and electrical conductance of ground water from PW-1 were measured with a YSI (Yellow Springs Instrument) SCT Meter. Dissolved oxygen in the discharge water was measured using a YSI DO meter. The pH of the ground water from PW-1 was measured using a PHTESTR meter. The PHTESTR meter was calibrated to pH 4.0 and 7.0 solutions prior to obtaining the field measurements.

GROUND WATER SAMPLING

Ground water samples were obtained from PW-1 on April 4 and 11. The April 4 water sample was obtained from well development water using a clean, disposable polyethylene bailer. The water samples obtained on April 11 were obtained from PW-1 periodically during the 8-hour constant rate test. The water samples were transferred to appropriate containers in the field and placed in a cooler with Blue Ice. The samples were kept cool during transport to the testing laboratory. Hydrochloric acid (a preservative) was present in the bottles used for collection of water samples for analysis of BETX and gasoline-range hydrocarbons. Chain-of-custody procedures were observed during transport of the water samples to the analytical laboratory.

0161-205-B04
TASK

AQUIFER TEST DATA

r Unocal Address Coupeville County Island State WA

Company performing test ~~GeoEngineers~~, Inc. / Holt Measured by CSL + RNM

lo. PW-1 Distance from pumping well _____ Type of test Constant Rate Test No. _____

uring equipment GEI-B3 Electric Tape / Data Logger, Channel 1, 15 psi Tranducer 150027

Time Data
mp on: Date 4/12 Time 0830 (la)
mp off: Date 4/12 Time 1630 (la)
ion of aquifer test:
mping _____ Recovery _____

Water Level Data
Static water level 41.35
Measuring point Top of PVC
Elevation of measuring point _____

Discharge Data
How Q measured 5-gal Bucket
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	I/R		Data Logger Water level measurement	Electric Tape Correction or Conversion	Water level	Water level change s or s'	25% well eff (correct)	Discharge measurement	Rate	(ppt) Sal	(°C) T	(µS) Cond	pH	(mg/l) DO	(mbar) Bar	Comments
	0830	0.5					52.22		10.88	2.72	5gal/45sec	75							Static @ 41.35 below
	0831	1.0					51.75		15.40	3.85									PVC casing Rim
	0831	1.5					60.95		19.60	4.90									Data Logger set
	0832	2.0					62.91		21.56	5.39									@ 53.65'
	0832	2.5					64.01		22.66	5.67									Stick up = 3.29 ft
	0833	3.0					64.50		23.15	5.79	5gal/4	75gpm							above 7-in casing Pvt
	0835	5.0					65.15		23.80	5.95									Elevation measuring pt
	0837	7.0					65.27		23.92	5.98									= 106.17 GEI Datum
	0840	10.0					65.43		24.08	6.02									
	0845	15.0					65.65		24.30	6.08			0.4	11.4	860/637	7.9	2.0		
	0852	22.0					66.02		24.67	6.17	5g/4s	75gpm	0.4	11.4	859/637	7.8	1.0		
	0902	32.0					66.35		25.00	6.25									
	0917	47.0					66.78		25.43	6.36									Water Sample BAC-2 obtained
	0938	68.0					67.10		25.75	6.44			0.4	11.4	860/637	7.9	1.0		
	1010	100					67.39		26.04	6.51			0.4	11.5	84/639	7.9	0.6	1033	
	1057	147					67.48		26.15	6.54			0.4	11.5	862/640	7.9	0.3	1032	
	1205	215					67.05		25.70	6.43			0.4	11.7	861/643	7.9	1.0	1031	
	1229	239					66.86		25.51	6.38									
	1259	269					66.46		25.11	6.28	5gal/4sec.	75gpm	0.4	11.6	862/642	7.9	0.6	102	
	1329	299					66.06		24.71	6.18									
	1400	330					65.65		24.30	6.08			0.4	11.7	862/644	7.9	0.5	102	
	1428	358					65.24		23.89	5.96									
	1500	390					64.79		23.44	5.86			0.4	11.7	864/644	7.9	0.6	102	
	1528	418					64.52		23.17	5.79	5gal/4sec.	75gpm							
	1558	448					64.39		23.04	5.76			0.4	11.7	864/645	7.9	0.7	102	
	1630	480					64.45		23.10	5.78									pump turned off
	1630		0.25			8.67													
	"		0.50			2.97													Full Recovery in
	"		0.75			0													45 sec.

0161-205-B04
TASK

AQUIFER TEST DATA

Unocal Address Coupeville County Island State WA

Company performing test GeoEngineers, Inc. / Holt Measured by CSL + RNM

o. 1 Distance from pumping well 250' Type of test Constant Rate Test No.

ring equipment Electric Tape (GEI-B2)

Time Data
mp on: Date 4/12 Time 0830 (t₀)
mp off: Date 4/12 Time 1630 (t'₀)
on of aquifer test:
nping 8 Recovery

Water Level Data
Static water level 27.32
Measuring point CE
Elevation of measuring point 83.21

Discharge Data
How Q measured 5gal bucket + watch
Depth of pump/air line ~95
Previous pumping? Yes No
Duration End

Comments on factors affecting test data

Clock time	Time since pump started t	Time since pump stopped t'	t/t'	Water level measurement	Tidal Correction or Conversion	Water level	Water level change s or s'	Current 60%	Discharge measurement	Rate
	0.5			--						
	1.0			--						
	1.5			--						
	2.0			--						
	2.5			--						
	3.0			--						
	5.0			--						
	7.0			--						
0840	10			28.37	-0.05	1.05		0.99		
0845	15			--		--				
0852	22			28.88	-0.16	1.56		1.37		
0902	32			29.30	-0.21	1.98		1.73		
0915	45			29.56	-0.32	2.24		1.86		
0938	68			29.90	-0.37	2.58		2.14		
1010	100			30.12	-0.42	2.80		2.30		
1057	147			30.16	-0.21	2.84		2.59		
1205	215			29.56	+.42	2.24		2.74		
1231	241			29.14	+.85	1.82		2.83		
1300	270			28.91	1.27	1.59		3.10		
1331	301			28.32	1.7	1.00		3.02		
1402	332			27.94	2.01	1.62		3.01		
1430	360			27.52	2.33	0.20		2.97		
1501	391			27.10	2.54	-0.22		2.80		
1530	420			26.84	2.76	-0.48		2.80		
1600	450			26.72	+2.81	-0.60		2.74		

Static: @ 26.77 0751
@ 27.27 0815
@ 27.32 0825

AQTESOLV
0161WI.DAT
HPGL File
0161WI.CJ Coupon
0161WI.TH Theis
0161WI.PC

AQUIFER TEST DATA

0161-205-B04

er Unocal Address Coupeville County Island State WA

Company performing test GEI/Holt Measured by RNM

No. 1 Distance from pumping well ____ Type of test recovery Test No. ____

Measuring equipment elec. tape (GEI-B2)

Time Data
Pump on: Date 4/12/95 Time 0830 (hr)
Pump off: Date 4/12/95 Time 1630 (hr)
Duration of aquifer test:
Pumping 8hrs. Recovery ____

Water Level Data
Static water level 27.32'
Measuring point top of casing
Elevation of measuring point ____

Discharge Data
How Q measured 5 gal bucket + watch
Depth of pump/air line ~95'
Previous pumping? Yes ____ No ____
Duration ____ End ____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate	Comments
4/12/95	1630		0		26.72			-0.60			
			1/2		26.71			-0.61			
	1631		1		26.66			-0.66			
			1 1/2		26.57			-0.75			
	1632		2		26.51			-0.81			
	1633		3		26.42			-0.90			
	1634		4		26.34			-0.98			
	1635		5		26.29			-1.03			
	1636		6		26.24			-1.08			
	1638		8		26.15			-1.17			
	1640		10		26.08			-1.24			
	1642		12		25.99			-1.33			
	1645		15		25.92			-1.40			
	1650		20		25.85			-1.47			
	1655		25		25.77			-1.55			
	1700		30		25.71			-1.61			
	1715		45		25.63			-1.69			
	1733		63		25.62			-1.70			1025 mbar
	1752		82		25.72			-1.60			
	1828		118		26.07			-1.25			1025 mbar

APPENDIX D

APPENDIX D

CHEMICAL ANALYTICAL PROGRAM

ANALYTICAL METHODS

Chain-of-custody procedures were followed during the transport of the field samples to the analytical laboratory. The samples were held in cold storage pending extraction and/or analysis. The analytical results, analytical methods reference and laboratory QA/QC (quality assurance/quality control) records are included in this appendix. The analytical results also are summarized in the text and tables of this report.

ANALYTICAL DATA REVIEW

The laboratory maintains an internal quality assurance program as documented in its laboratory quality assurance manual. The laboratory uses a combination of blanks, surrogate recoveries, duplicates, matrix spike recoveries, matrix spike duplicate recoveries, blank spike recoveries and blank spike duplicate recoveries to evaluate the validity of the analytical results. The laboratory also uses data quality goals for individual chemicals or groups of chemicals based on the long-term performance of the test methods. The data quality goals were included in the laboratory reports. The laboratory compared each group of samples with the existing data quality goals and noted any exceptions in the laboratory report. The laboratory QA/QC and data quality exceptions documented by the laboratory were reviewed by GeoEngineers using the applicable data validation guidelines from the following documents: "National Functional Guidelines for Organic Data Review," draft dated 1991, and "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses," dated 1988.

ANALYTICAL DATA REVIEW SUMMARY

No significant data quality exceptions were noted in the laboratory report or during our review. Based on our data quality review, it is our opinion that the analytical data are of acceptable quality for their intended use.

NORTH CREEK ANALYTICAL

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East 11115 Montgomery, Suite B • Spokane, WA 99206-4776 (509) 924-9200 • FAX 924-9290
9405 S.W. Nimbus Avenue • Beaverton, OR 97008-7132 (503) 643-9200 • FAX 644-2202

Dear Consultant:

Enclosed please find your UNOCAL project and chain of custody. To help better serve you and UNOCAL, Inc., we would appreciate your cooperation in taking a few moments to fill in the "Final Report Approval" section of the Chain of Custody (bottom right hand corner) and faxing it back to North Creek Analytical, at (206) 485-2992 Attention: Bethany White. This allows us to proceed with invoicing to UNOCAL.

We appreciate your assistance in helping us with this request.

NORTH CREEK ANALYTICAL, Inc.

Administrative Department

NORTH CREEK ANALYTICAL

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Project Name: UNOCAL #0138
Client Project #: #0161-205-B04

NCA Project #: B504183

Received: Apr 13, 1995
Reported: Apr 20, 1995

PROJECT SUMMARY PAGE

Laboratory Sample Number	Sample Description	Sample Matrix	Date Sampled
B504183-01	PW-1	Water	4/12/95

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

NORTH CREEK ANALYTICAL

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: Total FOG: 413.2; Non-Polar: 418.1
First Sample #: B504183-01

Sampled: Apr 12, 1995
Received: Apr 13, 1995
Extracted: Apr 17, 1995
Analyzed: Apr 17, 1995
Reported: Apr 20, 1995

FATS OIL & GREASE

Sample Number	Sample Description	Total FOG Result mg/L (ppm)	Non-Polar Result mg/L (ppm)	Polar Result mg/L (ppm)
B504183-01	PW-1	N.D.	N.D.	N.D.
BLK041795	Method Blank	N.D.	N.D.	N.D.
Reporting Limit:		1.0	1.0	1.0

Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton
Project Manager

NORTH CREEK ANALYTICAL

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: EPA 413.2 (I.R.)
Units: mg/L (ppm)

Analyst: T.Rubalcava

Extracted: Apr 17, 1995
Analyzed: Apr 17, 1995
Reported: Apr 20, 1995

HYDROCARBON QUALITY CONTROL DATA REPORT

ACCURACY ASSESSMENT
Laboratory Control Sample

Oil and Grease

Spike Conc. Added:	4.2
Spike Result:	4.3
% Recovery:	102
Upper Control Limit %:	136
Lower Control Limit %:	54

PRECISION ASSESSMENT
Sample Duplicate

Oil and Grease

Sample Number:	B504183-01
Original Result:	N.D.
Duplicate Result:	N.D.
Relative % Difference:	Relative Percent Difference values are not reported at sample concentration levels less than ten times the Detection Limit.
Maximum RPD:	28

NORTH CREEK ANALYTICAL Inc.

Laura Dutton
Project Manager

% Recovery: $\frac{\text{Spike Result}}{\text{Spike Concentration Added}} \times 100$

Relative % Difference: $\frac{\text{Original Result - Duplicate Result}}{(\text{Original Result + Duplicate Result}) / 2} \times 100$

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: WTPH-418.1
Units: mg/L (ppm)

Analyst: T.Rubalcava

Extracted: Apr 17, 1995
Analyzed: Apr 17, 1995
Reported: Apr 20, 1995

HYDROCARBON QUALITY CONTROL DATA REPORT

ACCURACY ASSESSMENT
Laboratory Control Sample

Petroleum Oil	
Spike Conc. Added:	4.2
Spike Result:	4.3
% Recovery:	102
Upper Control Limit %:	134
Lower Control Limit %:	63

PRECISION ASSESSMENT
Sample Duplicate

Petroleum Oil	
Sample Number:	B504183-01
Original Result:	N.D.
Duplicate Result:	N.D.
Relative % Difference:	Relative Percent Difference values are not reported at sample concentration levels less than ten times the Detection Limit.
Maximum RPD:	44

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Laura Dutton

Laura Dutton
Project Manager

% Recovery: $\frac{\text{Spike Result}}{\text{Spike Concentration Added}} \times 100$

Relative % Difference: $\frac{\text{Original Result - Duplicate Result}}{(\text{Original Result + Duplicate Result}) / 2} \times 100$

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: WTPH-G
First Sample #: B504183-01

Sampled: Apr 12, 1995
Received: Apr 13, 1995
Analyzed: Apr 21, 1995
Reported: Apr 24, 1995

TOTAL PETROLEUM HYDROCARBONS-GASOLINE RANGE

Sample Number	Sample Description	Sample Result µg/L (ppb)	Surrogate Recovery %
B504183-01	PW-1	N.D.	80
BLK042195	Method Blank	N.D.	89

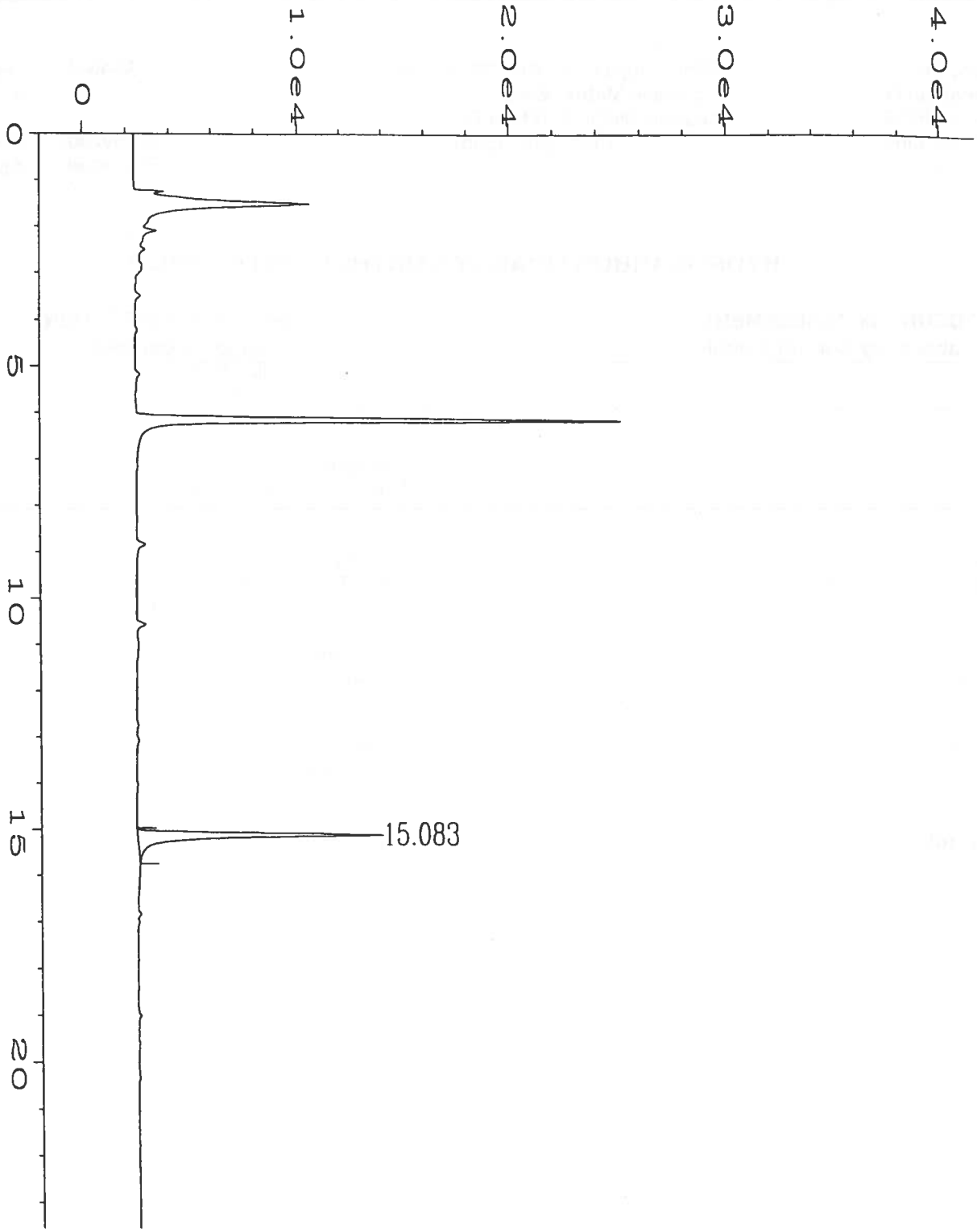
Reporting Limit:	50

4-Bromofluorobenzene surrogate recovery control limits are 50 - 150 %.
Volatile Total Petroleum Hydrocarbons are quantitated as Gasoline Range Organics (toluene - dodecane).
Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager



Data File Name : C:\HPCHEM\1\DATA\042195\004F0101.D
Operator :
Instrument : GC#8
Sample Name : b504183-01
Run Time Bar Code:
Acquired on : 21 Apr 95 10:41 AM
Report Created on: 21 Apr 95 11:05 AM
Sample Info : 5 ml

Page Number : 1
Vial Number : 4
Injection Number : 1
Sequence Line : 1
Instrument Method: WA-WATER.MTH
Analysis Method : WA-WATER.MTH

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: WTPH-G
Units: µg/L (ppb)

Analyst: R. Hager, B. Christlieb
Analyzed: Apr 21, 1995
Reported: Apr 24, 1995

HYDROCARBON QUALITY CONTROL DATA REPORT

ACCURACY ASSESSMENT
Laboratory Control Sample

Gasoline	
Spike Conc. Added:	100
Spike Result:	103
% Recovery:	103
Upper Control Limit %:	132
Lower Control Limit %:	56

PRECISION ASSESSMENT
Sample Duplicate

Gasoline Range Organics	
Sample Number:	B504273-01
Original Result:	980
Duplicate Result:	1,200
Relative % Difference:	20
Maximum RPD:	50

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Laura Dutton

Laura Dutton
Project Manager

% Recovery: $\frac{\text{Spike Result}}{\text{Spike Concentration Added}} \times 100$

Relative % Difference: $\frac{\text{Original Result - Duplicate Result}}{(\text{Original Result + Duplicate Result}) / 2} \times 100$

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: EPA 8020
First Sample #: B504183-01

Sampled: Apr 12, 1995
Received: Apr 13, 1995
Analyzed: Apr 21, 1995
Reported: Apr 24, 1995

BTEX DISTINCTION

Sample Number	Sample Description	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Xylenes µg/L (ppb)	Surrogate Recovery %
B504183-01	PW-1	N.D.	N.D.	N.D.	N.D.	66
BLK042195	Method Blank	N.D.	N.D.	N.D.	N.D.	70
Reporting Limits:		**0.50**	**0.50**	**0.50**	**1.0**	

4-Bromofluorobenzene surrogate recovery control limits are 59 - 144 %.
Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton
Project Manager

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: EPA 8020
Units: µg/L (ppb)
QC Sample #: B504209-02

Analyst: R. Hager, B. Christlieb
Analyzed: Apr 21, 1995
Reported: Apr 24, 1995

MATRIX SPIKE QUALITY CONTROL DATA REPORT

ANALYTE	Benzene	Toluene	Ethyl Benzene	Xylenes
Sample Result:	N.D.	N.D.	N.D.	N.D.
Spike Conc. Added:	20.0	20.0	20.0	60.0
Spike Result:	18.9	17.8	19.1	57.5
Spike % Recovery:	95%	89%	96%	96%
Spike Dup. Result:	19.7	18.6	19.7	58.7
Spike Duplicate % Recovery:	99%	93%	99%	98%
Upper Control Limit %:	115	116	122	122
Lower Control Limit %:	82	81	85	85
Relative % Difference:	4.1%	4.4%	3.1%	2.1%
Maximum RPD:	16	16	16	17

NORTH CREEK ANALYTICAL Inc.

Laura Dutton
Project Manager

% Recovery: $\frac{\text{Spike Result - Sample Result}}{\text{Spike Conc. Added}} \times 100$

Relative % Difference: $\frac{\text{Spike Result - Spike Dup. Result}}{\text{(Spike Result + Spike Dup. Result) / 2}} \times 100$

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: WTPH-D Extended
First Sample #: B504183-01

Sampled: Apr 12, 1995
Received: Apr 13, 1995
Extracted: Apr 14, 1995
Analyzed: Apr 18, 1995
Reported: Apr 20, 1995

TOTAL PETROLEUM HYDROCARBONS - DIESEL RANGE EXTENDED

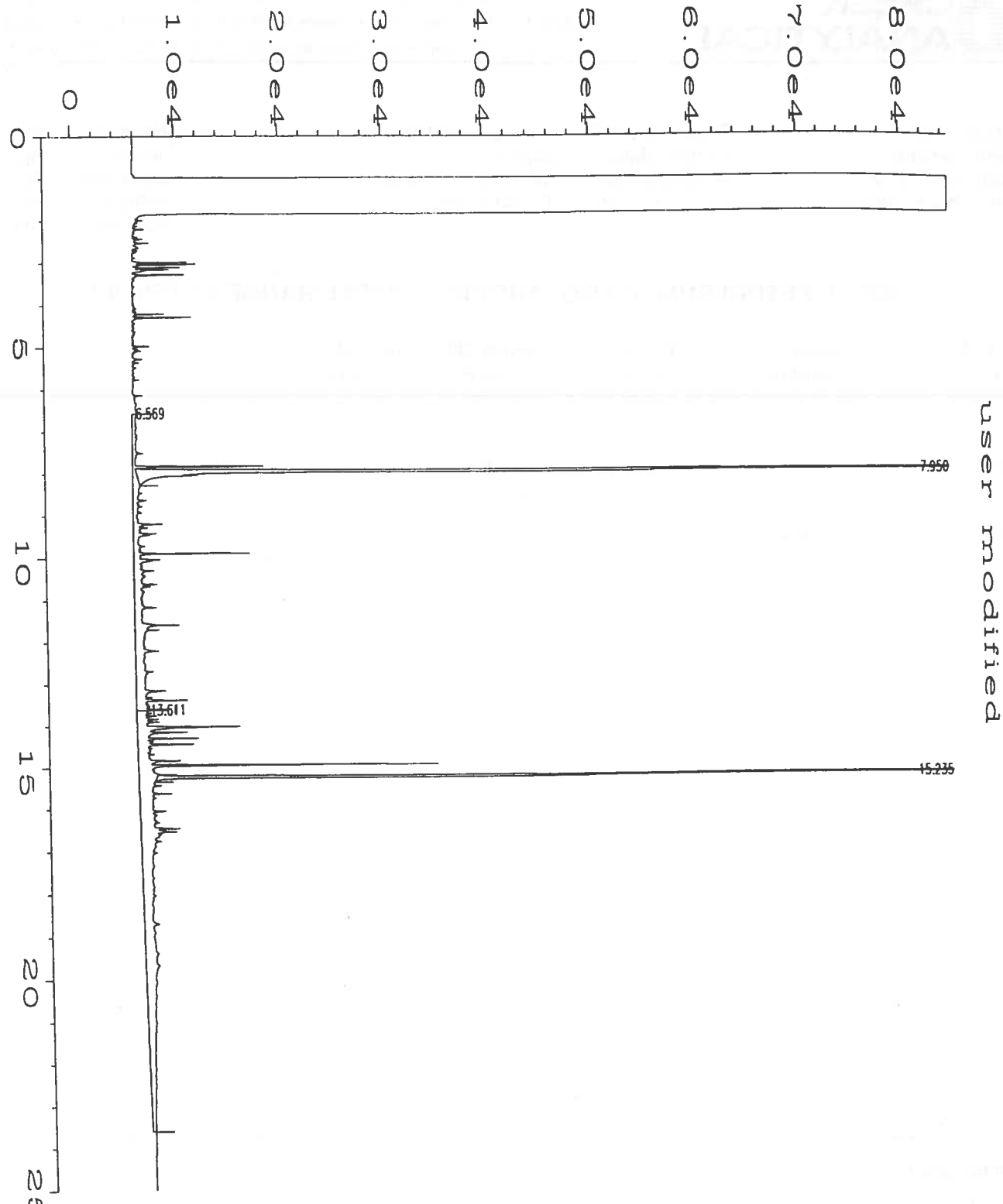
Sample Number	Sample Description	Diesel Result mg/L (ppm)	Heavy Oil Result mg/L (ppm)	Surrogate Recovery %
B504183-01	PW-1	N.D.	N.D.	87
BLK041495	Method Blank	N.D.	N.D.	91
Reporting Limit:		**0.25**	**0.75**	

2-Fluorobiphenyl surrogate recovery control limits are 50 - 150%.
Extractable Hydrocarbons are quantitated as Diesel Range Organics (C12 - C24) and Heavy Oil Range Organics (>C24).
Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager



Data File Name : C:\HPCHEM\1\DATA\APR17\074R1601.D
Operator : TF
Instrument : PHIL
Sample Name : 504183-01W
Run Time Bar Code:
Acquired on : 18 Apr 95 05:15 AM
Report Created on: 18 Apr 95 08:08 AM

Page Number : 1
Vial Number : 74
Injection Number : 1
Sequence Line : 16
Instrument Method: NEW1F.MTH
Analysis Method : NEW1F.MTH

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix: Water
Analysis Method: WTPH-D
Units: mg/L (ppm)

Analyst: T. Fitzgibbon

Extracted: Apr 14, 1995
Analyzed: Apr 18, 1995
Reported: Apr 20, 1995

HYDROCARBON QUALITY CONTROL DATA REPORT

ACCURACY ASSESSMENT
Laboratory Control Sample

Diesel

Spike Conc. Added:	2.1
Spike Result:	2.2
% Recovery:	105
Upper Control Limit %:	119
Lower Control Limit %:	74

PRECISION ASSESSMENT
Sample Duplicate

Diesel Range Organics

Sample Number:	B504204-01
Original Result:	0.40
Duplicate Result:	0.55
Relative % Difference:	Relative Percent Difference values are not reported at sample concentration levels less than 10 times the Detection Limit.
Maximum RPD:	44

NORTH CREEK ANALYTICAL Inc.

Laura Dutton
Project Manager

% Recovery: $\frac{\text{Spike Result}}{\text{Spike Concentration Added}} \times 100$

Relative % Difference: $\frac{\text{Original Result - Duplicate Result}}{(\text{Original Result + Duplicate Result}) / 2} \times 100$

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GeoEngineers

JUN 06 1995

GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Descript: PW-1
Sample Matrix: Water
Sample Number: B504183-01

Routing: CSL File

Sampled: Apr 12, 1995
Received: Apr 13, 1995
Analyzed: Apr 17-25, 1995
Reported: Apr 27, 1995

LABORATORY ANALYSIS

Analyte	EPA Method	Reporting Limit mg/L (ppm)	Sample Results mg/L (ppm)
Chloride	300.0	0.20	65
Total Dissolved Solids	160.1	10	450
Total Organic Carbon	415.1	1.0	2.3

Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

Please Note:
Report was amended on June 2, 1995.

504183.GEO <11>

NORTH CREEK ANALYTICAL

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Descript: Method Blank
Sample Matrix: Water
Sample Number: BLK041795

Analyzed: Apr 17-25, 1995
Reported: Apr 27, 1995

LABORATORY ANALYSIS

Analyte	EPA Method	Reporting Limit mg/L (ppm)	Sample Results mg/L (ppm)
Chloride	300.0	0.20	N.D.
Total Dissolved Solids	160.1	10	N.D.
Total Organic Carbon	415.1	5.0	N.D.

Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

NORTH CREEK ANALYTICAL

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL #0138
Sample Matrix : Water
Units: mg/L (ppm)

Analyst: R. Wood
J. Wright

Reported: Apr 27, 1995

INORGANIC QUALITY CONTROL DATA REPORT

ANALYTE	Total Organic Carbon	Chloride
EPA Method:	415.1	300
Date Analyzed:	Apr 17, 1995	Apr 20, 1995

ACCURACY ASSESSMENT

LCS Spike Conc. Added:	200	2.0
LCS Spike Result:	206	1.9
LCS Spike % Recovery:	103	95
Upper Control Limit:	125	106
Lower Control Limit:	75	71

PRECISION ASSESSMENT

Sample #:	B504158-01	B504158-01
Original:	N.D.	1.2
Duplicate:	N.D.	1.2
Relative % Difference:	Q-6	0
Maximum RPD:	25	33

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

Please Note:
Q-6 = RPD values are not reported at sample concentrations <5 X the Reporting Limit.

504183.GEO <13>

NORTH CREEK ANALYTICAL
East 11115 Montgomery, Suite B, Spokane, WA 99206-4779 (509) 924-9200 FAX 924-9290
9405 S.W. Nimbus Avenue, Beaverton, OR 97008-7132 (503) 643-9200 FAX 644-2202

UNOCAL CHAIN OF CUSTODY REPORT

UNOCAL INFORMATION

Facility Number: SS# 0138
Site Address:
City, State, ZIP:
Site Release Number:
Unocal Manager:
CERT INFO: (check one) o Evaluation o Remediation
o Detection o Demolition o Closure o Miscellaneous

CONSULTANT INFORMATION

Firm: GeoEngineers, Inc. Project Number: 0161-205-B04
Address: 801 West Orchard Drive, Suite 2
Bellingham, WA 98225
Phone: (206) 647-1510 Fax: (206) 647-5044
Project Manager: Chuck Lindsay
Sample Collection by: Robert Miyahira

Chain of Custody Record #:

Quality Assurance Data Level: A [X] B
A: Standard Summary
B: Standard + Chromatograms

Laboratory Turnaround Days: [X] 10 | 5 | 3 | 2 | 1

o Oregon [X] Washington Hydrocarbon Methods

SAMPLE IDENTIFICATION	SAMPLING DATE / TIME	MATRIX (W,S,O)	# OF CONTAINERS	TPH-HCID	TPH-Gas	BTEX (EPA 8020 Mod.)	TPH-Gas + BTEX	TPH-Diesel	TPH-Diesel Extended	TPH-418.1	Halogen Volatiles (EPA 8010)	Aromatic Volatiles (EPA 8020)	Pesticides/PCBs or PCBs Only	GC/MS Volatiles (EPA 8240/8260)	GC/MS SemiVols (EPA 8270)	PAHs by HPLC (EPA 8310)	Lead Total or Dissolved	TCLP Metals (8)	Chloride	Total Organic Carbon	Total Dissolved Solids	NCA SAMPLE NUMBER
1. PW-1	04/12/95 1615	W	9		X				X	X		X							X	X	X	B504183-01
2.																						
3.																						
4.																						
5.																						
6.																						
7.																						
8.																						
9.																						
10.																						

D-18

Relinquished by:	Firm:	Date & Time	Received by:	Firm:	Date & Time
1. Robert Miyahira	GeoEngineers, Inc.	04/12/95 2130	Pete	NCA	4/13/95 1215
2.					
3.					

Final Report Approval

Were all requested results provided? yes [X] no Define
Were results within requested turnaround? yes [X] no "No" on back
Final Approval Signature
Firm Date

Page 1 of 1
Rev 2 2, 11/94

Comments
Please perform 418.1 with and without silica gel cleanup

Distribution White Laboratory Yellow - Consultant Photocopy - Unocal

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Project Name: UNOCAL Coupeville
Client Project #: #0161-205-R04

NCA Project #: B504063

Received: Apr 5, 1995
Reported: Apr 7, 1995

PROJECT SUMMARY PAGE

Laboratory Sample Number	Sample Description	Sample Matrix	Date Sampled
B504063-01	DEEP WELL-1	Water	4/5/95

GeoEngineers
APR 14 1995
Route: PSL
File

The results in this report apply to the samples analyzed in accordance with the chain of custody document.
This analytical report must be reproduced in its entirety.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

NORTH CREEK ANALYTICAL

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GeoEngineers, Inc.
410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL Coupeville
Sample Matrix: Water
Analysis Method: WTPH-G
First Sample #: B504063-01

Sampled: Apr 5, 1995
Received: Apr 5, 1995
Analyzed: Apr 7, 1995
Reported: Apr 7, 1995

TOTAL PETROLEUM HYDROCARBONS-GASOLINE RANGE

Sample Number	Sample Description	Sample Result µg/L (ppb)	Surrogate Recovery %
B504063-01	DEEP WELL-1	N.D.	113
BLK040795	Method Blank	N.D.	111

Reporting Limit:	50

4-Bromofluorobenzene surrogate recovery control limits are 50 - 150 %.
Volatile Total Petroleum Hydrocarbons are quantitated as Gasoline Range Organics (toluene - dodecane).
Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton
Project Manager

504063.GEO <2>

NORTH CREEK ANALYTICAL

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL Coupeville
Sample Matrix: Water
Analysis Method: WTPH-G
Units: µg/L (ppb)

Analyst: R. Hager, B. Christlieb
Analyzed: Apr 7, 1995
Reported: Apr 7, 1995

HYDROCARBON QUALITY CONTROL DATA REPORT

ACCURACY ASSESSMENT
Laboratory Control Sample

Gasoline

Spike Conc. Added:	100
Spike Result:	103
% Recovery:	103
Upper Control Limit %:	132
Lower Control Limit %:	56

PRECISION ASSESSMENT
Sample Duplicate

Gasoline Range Organics

Sample Number:	B504063-01
Original Result:	N.D.
Duplicate Result:	N.D.
Relative % Difference:	Relative Percent Difference values are not reported at sample concentration levels less than 10 times the Detection Limit.
Maximum RPD:	50

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

% Recovery: $\frac{\text{Spike Result}}{\text{Spike Concentration Added}} \times 100$

Relative % Difference: $\frac{\text{Original Result - Duplicate Result}}{(\text{Original Result + Duplicate Result}) / 2} \times 100$

NORTH CREEK ANALYTICAL

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9405 S.W. Nimbus Avenue • Beaverton, OR 97008-7132 (503) 643-9200 • FAX 644-2202

GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL Coupeville
Sample Matrix: Water
Analysis Method: EPA 8020
First Sample #: B504063-01

Sampled: Apr 5, 1995
Received: Apr 5, 1995
Analyzed: Apr 7, 1995
Reported: Apr 7, 1995

BTEX DISTINCTION

Sample Number	Sample Description	Benzene µg/L (ppb)	Toluene µg/L (ppb)	Ethyl Benzene µg/L (ppb)	Xylenes µg/L (ppb)	Surrogate Recovery %
B504063-01	DEEP WELL-1	N.D.	N.D.	N.D.	N.D.	94
BLK040795	Method Blank	N.D.	N.D.	N.D.	N.D.	105
Reporting Limits:		0.50	0.50	0.50	1.0	

4-Bromofluorobenzene surrogate recovery control limits are 59 - 144 %.
Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

NORTH CREEK ANALYTICAL

18939 120th Avenue N.E., Suite 101 • Bothell, WA 98011-9508 (206) 481-9200 • FAX 485-2992
East 11115 Montgomery, Suite B • Spokane, WA 99206-4776 (509) 924-9200 • FAX 924-9290
9405 S.W. Nimbus Avenue • Beaverton, OR 97008-7132 (503) 643-9200 • FAX 644-2202

GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL Coupeville
Sample Matrix: Water
Analysis Method: EPA 8020
Units: µg/L (ppb)
QC Sample #: B503517-07

Analyst: R. Hager, B. Christlieb
Analyzed: Apr 7, 1995
Reported: Apr 7, 1995

MATRIX SPIKE QUALITY CONTROL DATA REPORT

ANALYTE	Benzene	Toluene	Ethyl Benzene	Xylenes
Sample Result:	N.D.	N.D.	N.D.	N.D.
Spike Conc. Added:	10.0	10.0	10.0	30.0
Spike Result:	9.2	9.6	10.0	30.6
Spike % Recovery:	92%	96%	100%	102%
Spike Dup. Result:	8.9	9.3	9.8	29.6
Spike Duplicate % Recovery:	89%	93%	98%	99%
Upper Control Limit %:	115	116	122	122
Lower Control Limit %:	82	81	85	85
Relative % Difference:	3.3%	3.2%	2.0%	3.3%
Maximum RPD:	16	16	16	17

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Laura Dutton

Laura Dutton
Project Manager

$$\%\ \text{Recovery:} \quad \frac{\text{Spike Result - Sample Result}}{\text{Spike Conc. Added}} \times 100$$

$$\text{Relative \% Difference:} \quad \frac{\text{Spike Result - Spike Dup. Result}}{\text{(Spike Result + Spike Dup. Result) / 2}} \times 100$$

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL Coupeville
Sample Matrix: Water
Analysis Method: WTPH-D Extended
First Sample #: B504063-01

Sampled: Apr 5, 1995
Received: Apr 5, 1995
Extracted: Apr 6, 1995
Analyzed: Apr 7, 1995
Reported: Apr 7, 1995

TOTAL PETROLEUM HYDROCARBONS - DIESEL RANGE EXTENDED

Sample Number	Sample Description	Diesel Result mg/L (ppm)	Heavy Oil Result mg/L (ppm)	Surrogate Recovery %
B504063-01	DEEP WELL-1	0.29	N.D.	90
BLK040695	Method Blank	N.D.	N.D.	91
Reporting Limit:		**0.25**	**0.75**	

2-Fluorobiphenyl surrogate recovery control limits are 50 - 150%.
Extractable Hydrocarbons are quantitated as Diesel Range Organics (C12 - C24) and Heavy Oil Range Organics (>C24).
Analytes reported as N.D. were not detected above the stated Reporting Limit.

NORTH CREEK ANALYTICAL Inc.

Laura Dutton

Laura Dutton
Project Manager

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GeoEngineers, Inc.
8410 154th Avenue N.E.
Redmond, WA 98052
Attention: Chuck Lindsay

Client Project ID: UNOCAL Coupeville
Sample Matrix: Water
Analysis Method: WTPH-D
Units: mg/L (ppm)

Analyst: T. Fitzgibbon

Extracted: Apr 6, 1995
Analyzed: Apr 7, 1995
Reported: Apr 7, 1995

HYDROCARBON QUALITY CONTROL DATA REPORT

ACCURACY ASSESSMENT
Laboratory Control Sample

Diesel

Spike Conc. Added:	2.1
Spike Result:	2.0
% Recovery:	95
Upper Control Limit %:	119
Lower Control Limit %:	74

PRECISION ASSESSMENT
Sample Duplicate

Diesel Range Organics

Sample Number:	B504063-01
Original Result:	N.D.
Duplicate Result:	N.D.
Relative % Difference:	Relative Percent Difference values are not reported at sample concentration levels less than 10 times the Detection Limit.
Maximum RPD:	44

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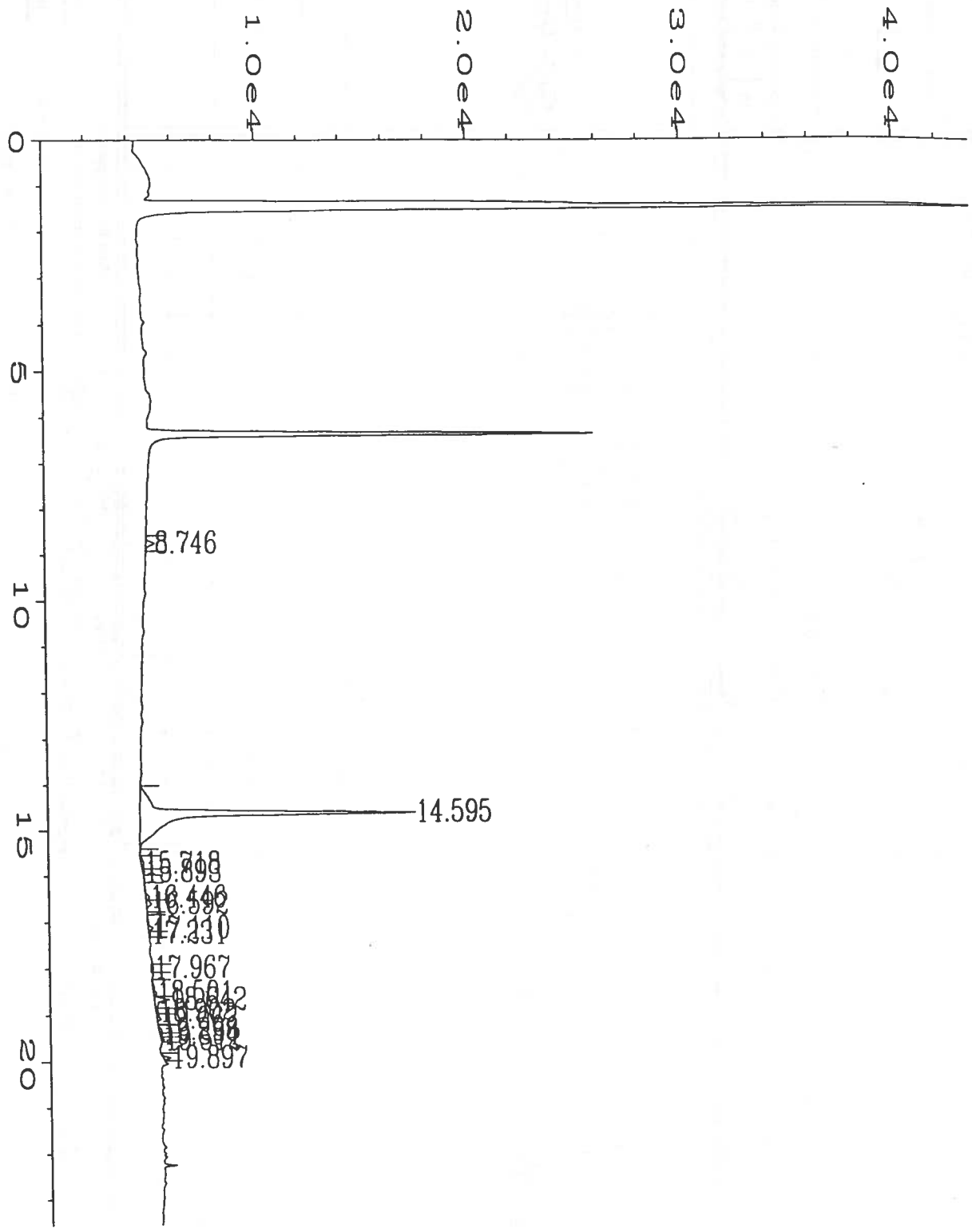
Laura Dutton
Project Manager

% Recovery: $\frac{\text{Spike Result}}{\text{Spike Concentration Added}} \times 100$

Relative % Difference: $\frac{\text{Original Result - Duplicate Result}}{(\text{Original Result + Duplicate Result}) / 2} \times 100$



Data File Name : C:\HPCHEM\3\DATA\040795\020F0901.D
Operator :
Instrument : GC#2
Sample Name : b504063-01
Run Time Bar Code:
Acquired on : 07 Apr 95 02:41 PM
Report Created on: 07 Apr 95 03:05 PM
Sample Info : 5 ml

Page Number : 1
Vial Number : 20
Injection Number : 1
Sequence Line : 9
Instrument Method: WA-WATER.MTH
Analysis Method : WA-WATER.MTH

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9405 S.W. Nimbus Avenue, Beaverton, OR 97008-7132 (503) 643-9200 FAX 644-2202

UNOCAL CHAIN OF CUSTODY REPORT

UNOCAL INFORMATION

Facility Number:
Site Address: SW Corner of Alexander & Cleveland St.
City, State, ZIP: Cowpeville, WA
Site Release Number:
Unocal Manager: Dr. Mark Brearley
CERT INFO: (check one) o Evaluation o Remediation
o Detection o Demolition o Closure o Miscellaneous

CONSULTANT INFORMATION

Firm: GeoEngineers Project Number: 0161-205-R04
Address: 8410 - 154th Avenue NE
Redmond, WA 98052
Phone: (206) 861-6000 Fax: 861-6050
Project Manager: Chuck Lindsey
Sample Collection by: Amy Kilgore

Chain of Custody Record #:

Quality Assurance Data Level: A B
A: Standard Summary
B: Standard + Chromatograms
Laboratory Turnaround Days: 10 5 3 (2) 1

o Oregon o Washington Hydrocarbon Methods

SAMPLE IDENTIFICATION	SAMPLING DATE / TIME	MATRIX (W,S,O)	# OF CONTAINERS	TPH-HCID	TPH-Gas	BTEX (EPA 8020 Mod.)	TPH-Gas + BTEX	TPH-Diesel	TPH-Diesel Extended	TPH-418.1	Halogen. Volatiles (EPA 8010)	Aromatic Volatiles (EPA 8020)	Pesticides/PCBs or PCBs Only	GC/MS Volatiles (EPA 8240/8260)	GC/MS SemiVols (EPA 8270)	PAHs by HPLC (EPA 8310)	Lead: Total or Dissolved	TCLP Metals (8)	NCA SAMPLE NUMBER
1. Unocal Deep Well-1	4/5/95 9:40	W.	3				X		X										B504063-01
2.																			
3.																			
4.																			
5.																			
6.																			
7.																			
8.																			
9.																			
10.																			

D-27

	Relinquished by:	Firm:	Date & Time	Received by:	Firm:	Date & Time
1.	[signature]	GEI	4/5/95 15:50	[signature]	NCA	4/5/95 1550
2.						
3.						

Final Report Approval

Were all requested results provided? yes no Define
Were results within requested turnaround? yes no "No" on back
Final Approval Signature:
Firm Date

Page ____ of ____
Rev 2.2, 11/94

Comments:

Distribution White - Laboratory Yellow - Consultant Photocopy - Unocal

APPENDIX E

GeoEngineers

MAY 25 1995

ROUTING CSL ☐ ☐

☐ ☐ ☐

FILE#

RETEC

May 24, 1995

1011 S W Klickitat Way
Suite 207
Seattle WA 98134
(206) 624 9349
FAX (206) 624 2839

Mr. Chuck Lindsay
GeoEngineers, Inc.
801 W. Orchard Drive, Suite #2
Bellingham, Washington 98225

Dear Mr. Lindsay:

The following letter describes the work that RETEC performed on water samples collected from the Unocal site in Coupeville, Washington. The methods used, the results of the testing, and a brief list of conclusions are presented in the following sections.

1.0 SAMPLES COLLECTION/RECEIPT

Water samples were collected by GeoEngineers from the Unocal, Coupeville site on April 11 and 12, 1995, for microbial counts. A pump test was performed on a selected well on Unocal's site, and water samples were collected at four different time intervals. The samples were identified as BAC-1 (collected on April 11), and BAC-2, BAC-3, and BAC-4 (collected on April 12). Sample BAC-1 represents the initial sample and was collected after 15 minutes of pumping. Samples BAC-2, BAC-3, and BAC-4 were collected after 45, 225, and 465 minutes of pumping, respectively. Microbial counts were performed on the day after the samples were collected. The samples were refrigerated prior to analysis.

2.0 EXPERIMENTAL PROCEDURE

Microbial counts included total aerobic heterotrophs as well as specific hexadecane and diesel degraders. An additional plate count analysis was performed using filtrate from wood chips (washed with deionized water). This wood chip filtrate, which was solidified with agar, was included because visual observations indicated the presence of organic materials in the groundwater (i.e., "peat-like" suspended solids). Additional testing was performed on the groundwater samples to determine the effect of aeration on the microbial population. An aliquot of each water sample was placed in a flask and aerated for 72 hours, then microbial counts were performed.

3.0 RESULTS

The results of microbial counts of the site groundwater samples are summarized in Table 1. Total heterotrophic numbers decreased by roughly 1,000 times after 45 minutes of the pump test (1,020 to 8.3 $\times$ 10^2 CFU/ml). Total heterotrophs continued to decrease over the entire 465 minutes of pumping. The final sample (BAC-4) contained 0.53 $\times$ 10^2 CFU/ml total heterotrophs. Specific hexadecane and diesel degraders showed a similar trend. Specific degraders in the 45-minute sample decreased by roughly 100 times, then continued to decrease up to 465 minutes at which point specific degraders were non-detectable ($<1 \times 10^1$ CFU/ml). Microorganisms capable of growth on the wood chip filtrate were present in the initial sample at slightly lower levels than the other specific degraders. The wood chip degraders also decreased by roughly 100 times after 45 minutes of the pump test, then continued to decrease up to 465 minutes to non-detectable levels ($<1 \times 10^1$ CFU/ml).

The wood chip filtrate plates were saved for additional testing. Various colony types from the wood chip plates were streaked onto hexadecane plates. Roughly half of the streaked colonies showed significant growth on the hexadecane plates.

After 72 hours of aeration testing, the microbial population in each water sample increased to the levels observed in the initial sample BAC-1 (Table 2 and Figures 1 and 2). After aeration of sample BAC-1, microbial numbers did not increase significantly from the initial numbers. Samples BAC-2, BAC-3, and BAC-4 appeared to be oxygen limited. The fact that the microbial numbers in sample BAC-1 did not increase significantly from the initial numbers, and the remaining samples increased to numbers similar to those observed in sample BAC-1 suggests that factors besides oxygen availability limited the total number achievable (e.g., carbon sources or available nutrients).

The field data collected by GeoEngineers showed decreasing dissolved oxygen levels with sample time. The dissolved oxygen content in the initial water was 2.0 mg/L, and this level steadily decreased to less than 1.0 mg/L (0.3–0.7 mg/L). The pH of the groundwater remained within 7.8 to 7.9. The electrical conductivity and salinity level were constant during the pump test.

4.0 CONCLUSIONS

The following conclusions can be made from this testing:

- The microbial numbers in the field samples represent reasonable numbers (10^3-10^5 CFU/mL) for an uncontaminated aquifer.
- The microbial numbers decreased consistently with the length of the pump test.
- Most of the recovered organisms were capable of specific hydrocarbon degradation and growth on wood chip filtrate.
- The presence of specific diesel and hexadecane degraders did not directly correlate with the presence of petroleum hydrocarbon contamination. The indigenous microorganisms were capable of growth on specific hydrocarbons, but may be living on "natural" organic matter. The only way to positively identify the presence of petroleum hydrocarbon contamination is to perform TPH analysis on the water samples.
- Adding oxygen increased the number of total heterotrophs and specific degraders in all samples except the initial sample (BAC-1). Numbers in all samples were similar after 72 hours of aeration, suggesting that growth of bacteria in water further from the well is oxygen-limited.
- At least some of the organisms from the wood chip filtrate plates were capable of growth on hexadecane.

These results suggest that there is a slightly aerated region near the well, probably due to gas exchange within the well casing. Microorganisms within this area are most likely using natural organic matter for a carbon substrate. Oxygen levels appear to decrease with increasing distance (as would be expected in a deep aquifer). Therefore, the population of total aerobic heterotrophs would also decrease in the areas with the lower oxygen levels. A majority of the microorganisms detected in the groundwater samples collected during the pump test were most likely washed off solids near the well. Therefore, the samples collected at the sequential pumping intervals decreased because the microorganisms near the well were being diluted.

The fact that a large proportion of these organisms could degrade hexadecane or grow on oil does not necessarily indicate that petroleum contamination is present in the aquifer. This testing showed that many of the cells could grow on natural organic materials, and some of these organisms could also grow on petroleum hydrocarbons. The later samples had non-detectable levels of petroleum hydrocarbons, but the number of total organisms and hydrocarbon degraders increased to levels similar to those observed in the initial samples. Therefore, it is likely that bacteria were growing on carbon sources other than petroleum, which are naturally present in the groundwater.

Total numbers reached values as high as 10^6 CFU/ml in BAC-3 which requires roughly 2 mg/L of organic carbon. This calculation is based on text book values (Brock, T. D., and M. T. Madigan, 1991. *Biology of Microorganisms*, Sixth Edition. New Jersey: Prentice Hall, 874 pp.) of 10^{-12} grams per cell and a conversion efficiency of 50 percent. The conversion efficiency accounts for the fact that organisms do not convert all food to biomass, but must respire roughly half of the carbon as carbon dioxide. Thus, most of these organisms must have been growing on carbon sources other than petroleum hydrocarbons, which were non-detectable in the groundwater samples (< 0.25 mg/L).

If you have any questions or concerns regarding this project, please contact me.

Sincerely,

REMEDIATION TECHNOLOGIES, INC.

Hans J. Stroo

Hans Stroo, Ph.D.
Senior Environmental Scientist

Enclosures

cc: H. Raymond
RETEC File No. 5-1965-000

TABLE 1

MICROBIAL COUNTS PERFORMED ON WATER SAMPLES FROM THE UNOCAL SITE IN COUPEVILLE

Sample ID	Total Heterotroph CFU/mL sample ($x10^2$)	Hexadecane Degrader CFU/mL sample ($x10^2$)	Diesel Degrader CFU/mL sample ($x10^2$)	Wood Chips CFU/mL sample ($x10^2$)
BAC-1	1020 +/- 130	490 +/- 72	560 +/- 49	94 +/- 23
BAC-2	8.3 +/- 0.38	2.4 +/- 0.28	2.4 +/- 0.61	0.83 +/- 0.15
BAC-3	2.6 +/- 0.42	2.6 +/- 0.42	0.63 +/- 0.23	0.43 +/- 0.31
BAC-4	0.53 +/- 0.21	< 0.10	< 0.10	< 0.10

NOTE: 1. Results represent the mean value and standard deviation of triplicate platings.
2. Results are reported as colonly forming units (CFU)/mL of sample.

TABLE 2

MICROBIAL COUNTS PERFORMED ON WATER SAMPLES AFTER 72 HOURS OF AERATION

Sample ID	Total Heterotroph CFU/mL sample ($x10^4$)	Hexadecane Degrader CFU/mL sample ($x10^4$)	Diesel Degrader CFU/mL sample ($x10^4$)	Wood Chips CFU/mL sample ($x10^4$)
BAC-1	15 +/- 4.0	2.6 +/- 0.55	2.1 +/- 0.58	0.70 +/- 0.04
BAC-2	54 +/- 1.0	18 +/- 2.3	5.3 +/- 0.42	0.58 +/- 0.007
BAC-3	139 +/- 12	8.2 +/- 1.6	0.40 +/- 0.06	1.3 +/- 0.24
BAC-4	14 +/- 0.60	6.8 +/- 0.61	2.7 +/- 0.26	0.09 +/- 0.02

NOTE: 1. Results represent the mean value and standard deviation of triplicate platings.
2. Results are reported as colonly forming units (CFU)/mL of sample.

RETEC

FIGURE 1

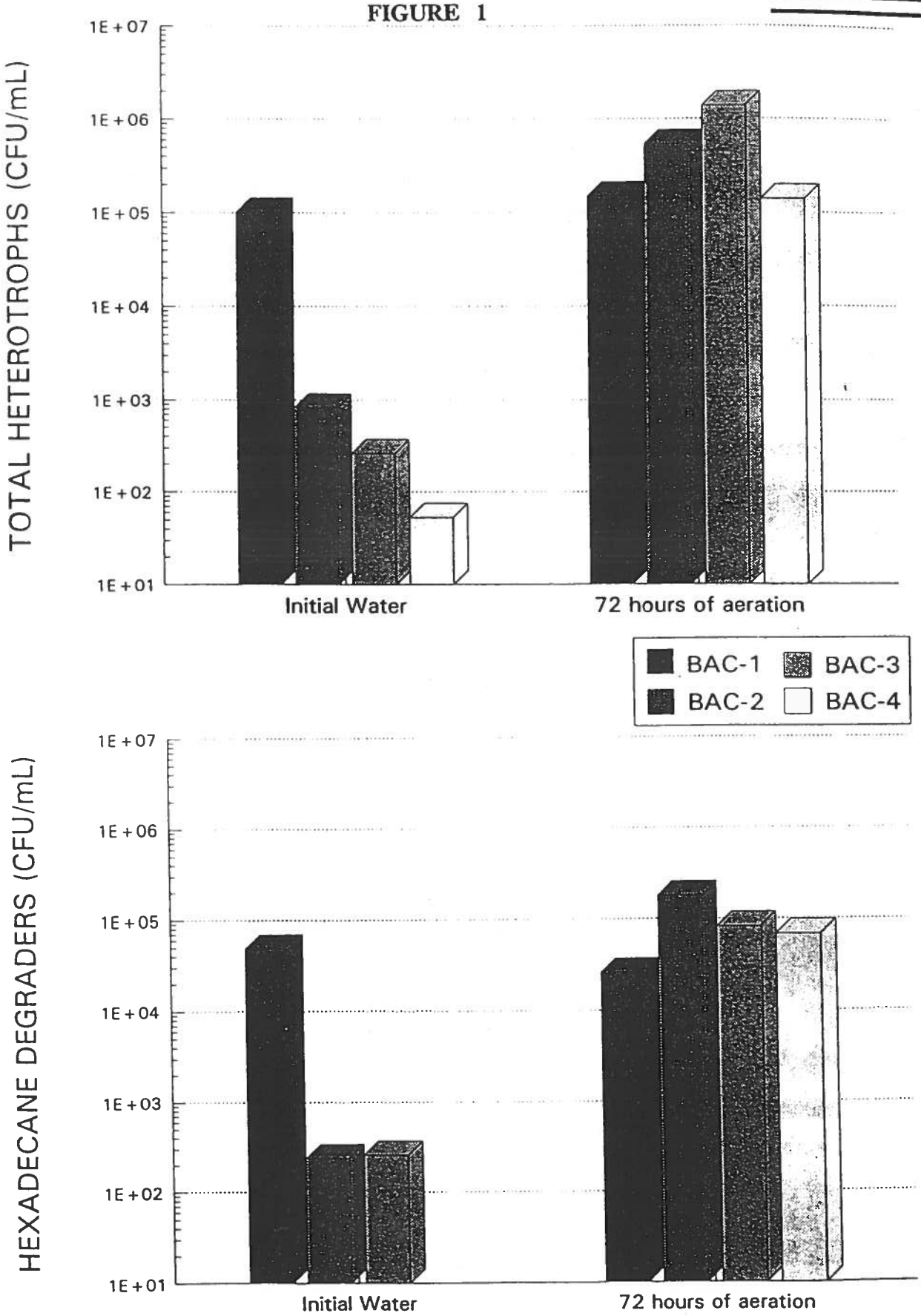
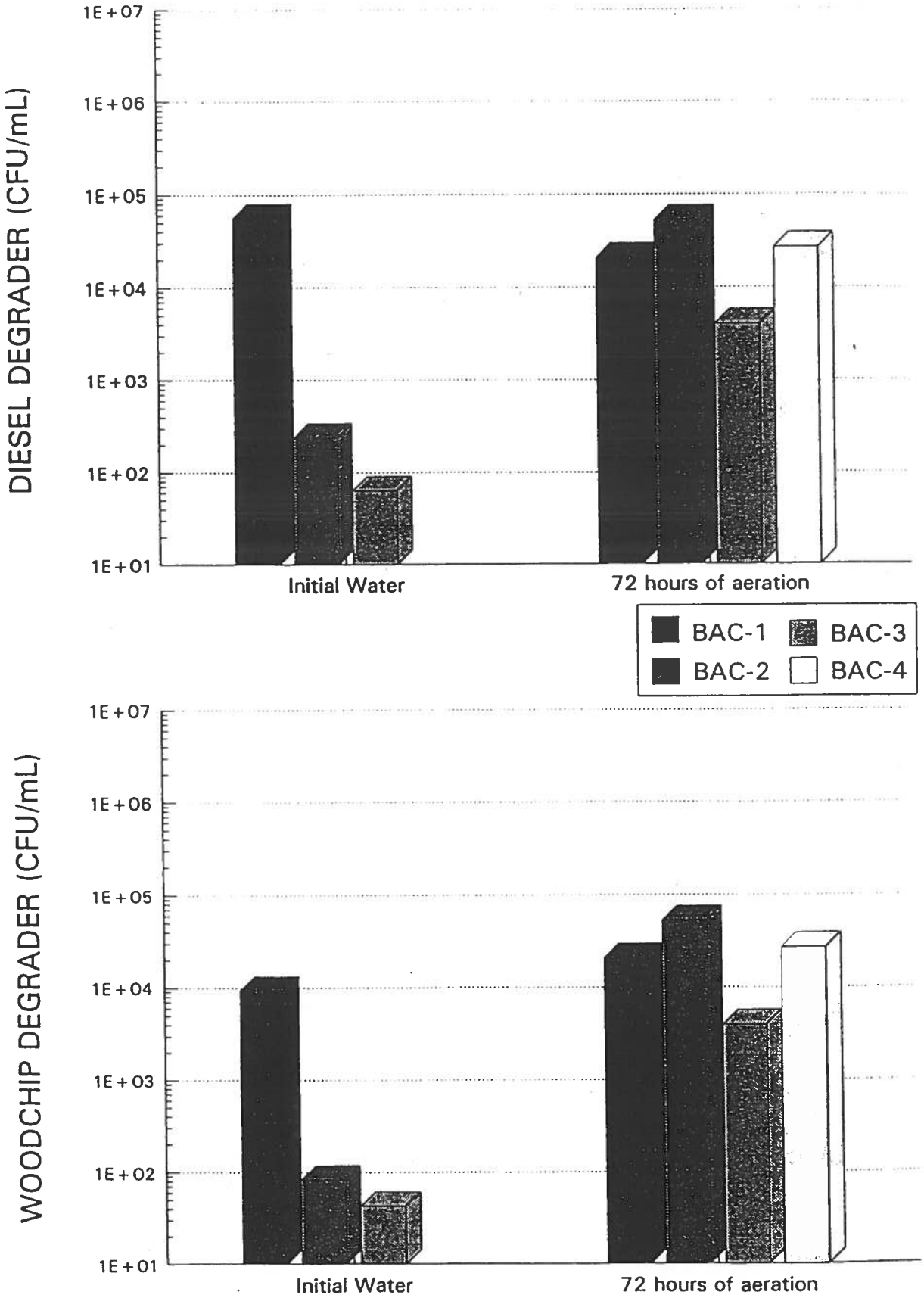


FIGURE 2


DIESEL DEGRADER (CFU/mL)
1E+07
1E+06
1E+05
1E+04
1E+03
1E+02
1E+01
Initial Water
72 hours of aeration
BAC-1
BAC-2
BAC-3
BAC-4
WOODCHIP DEGRADER (CFU/mL)
1E+07
1E+06
1E+05
1E+04
1E+03
1E+02
1E+01
Initial Water
72 hours of aeration