GW - ____001____

WORK PLANS

2008

Western Refining
BLOOMFIELD REFINERY

WNR
LISTED
NYSE

RECEIVED

2008 JUL 30 PM 12 22

July 29, 2008

James Bearzi, Bureau Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Bldg 1
Santa Fe, NM 87505

Re: Response to June 11, 2008 NOTICE OF DISAPPROVAL
Investigation Work Plan Group 2
Western Refining Southwest, Inc., Bloomfield Refinery
EPA ID# NMD089416416
HWB-GRCB-07-005

Dear Mr. Bearzi:

Western Refining Southwest, Inc., Bloomfield Refinery has prepared the following responses to your comments (dated June 11, 2008) on the referenced investigation work plan. The revised work plan is enclosed.

Comment 1

The last paragraph of the Executive summary states that "[a] review of historical documentation indicates that solid waste management unit (SWMU) No. 9 Landfill Pond and SWMU No. 11 Spray Irrigation Area have already been closed by NMED and thus no further action is proposed for these two areas." Western later states in Section 4.1 (Anticipated Activities) that soil borings and monitoring wells will be installed at SWMU No. 2 (North Bone Yard), SWMU No. 8 (the Landfill), and SWMU No. 11 (Spray Irrigation Area). NMED believes that SWMU No. 18 (Warehouse yard) should have been listed in Section 4.1 instead of SWMU No.11 (Spray Irrigation Area). If this is the case, Western must revise Section 4.1 to reference the correct SWMU.

Response: NMED is correct, in that SWMU No. 11 (Spray Irrigation Area) was incorrectly listed in Section 4.1 and the work plan has been revised to correctly list SWMU No. 18 (Warehouse Yard).

Comment 2

Western provided background information for the Landfill Pond in Section 2.3 (SWMU No. 9 Landfill Pond). Western discusses the collection of soil samples in 1985 and that a closure plan was completed in 1986. In addition, a letter from NMED to Bloomfield Refining Company, the predecessor of Western, dated January 25, 1994 indicates that NMED approved a closure plan for the landfill pond. Western proposes that this SWMU was closed in 1994 and no further investigation is needed. SWMU No. 9 was not closed by NMED. NMED provides the following comments:

a. NMED's administrative record does not contain a report that describes implementation of a closure plan.

b. Because NMED did not have corrective action authority delegated to it from EPA until 1996, all approvals for no further action (NFA) had to be approved and signed by EPA at that time.

c. Appendix B of the work Plan provides the *Report of Analytical Results for Engineering Science (Report)* dated May 28, 1986, which provides 1986 soil analytical data for the Landfill Pond. The data provided in the report lacks descriptions of sample collection methods and procedures; there is no way to determine if samples were collected properly, or which analytical results correspond to the sample locations provided in the figure. Historical documentation indicates that soil samples were collected in 1986 but the Landfill Pond continued to contain water until sometime in the early 1990's. It is not clear if contaminants entered the landfill Pond between 1986 (when sampling occurred) and the early 1990's.

d. Since the Landfill Pond data and documentation are incomplete, Western must install one boring in the center of what was formerly the Landfill Pond. Western must follow the drilling and sampling requirements addressed in the Work Plan and Comment 6. Western must revise the Work Plan to include this information in the appropriate sections and provide a figure that identifies the location of the proposed soil boring.

Response: As directed, one boring will be installed in the center of the former Landfill Pond. The boring will be drilled to the water table and a ground water sample collected for analysis. The work plan has been revised accordingly in Section 5.2 and Figures 2 and 9.

Comment 3

In Section 2.4 (SWMU No. 11 Spray Irrigation Area), Western provided background information stating "NMED approved the Closure Plan for the Unlined Evaporation Lagoons and the Spray Evaporation Area [Closure Plan] on August 28, 1996 with the requirement to continue monitoring ground water at MW-1 and MW-5."

NMED did not approve this Closure Plan or closure of this SWMU. The August 28, 1996 Approval letter was written and signed by the Oil conservation Division (OCD) and the Closure Plan was prepared for the OCD. Western must revise the Work Plan to reference the correct agency. At this time, NMED does not require further investigation of this area. Western must continue to monitor MW-3 as described in the Facility Wide Groundwater Monitoring Plan.

Response: The Work Plan (Section 2.4) has been revised to correctly refer to the OCD as the State agency approving the closure activities at the Spray Irrigation Area.

Comment 4

Western states in Section 3.2 (Subsurface Conditions) that "[f]igures six and seven present cross sections of the shallow subsurface based on borings logs from on-site monitoring well completions."

The cross sections are found as Figure 3 (Cross Section A-A') and Figure 4 (Cross Section B-B'). Western must revise the above sentence to reference the correct figures.

Response: The reference to the cross sections in Section 3.2 has been revised to accurately reflect Figure numbers 3 and 4.

Comment 5

Western must revise Section 4.1 (Anticipated Activities) to include the investigations of SWMU No. 9 (Landfill Pond) and SWMU No. 18 (Warehouse Yard). Western must remove reference to SWMU No. 11 (Spray Irrigation Area) because no investigation activities are proposed for this location. Western must revise all other sections that are affected by these changes (e.g. Section 5.2)

Response: Section 4.1 has been revised to include investigation at SWMU No. 9 (Landfill Pond) and No. 18 (Warehouse Yard), while removing reference to SWMU No. 11 (Spray Irrigation Area). All other relevant sections (e.g., 5.2 and Figures 2 and 9) of the Work Plan have been revised to provide for the investigation at SWMU No. 9.

Comment 6

Western states in the second paragraph of Section 5.1 (Drilling Activities) that "[a]ll soil borings will be drilled to a minimum depth of 10 feet with at least one boring at each of the individual potential source areas drilled to the top of saturation. Soil samples will be collected continuously and logged by a qualified geologist or engineer. If there is an indication of contamination based on field screening results at 10 feet, then the boring will be drilled deeper until no impacts are observed or the top of the saturation, whichever is achieved first."

Water is a primary mechanism for migration of contamination at the site. Western, therefore must revise the Work Plan to include the following:

a. Each boring must be drilled to the water table.
b. If contamination is detected at the water table, the boring must be drilled five feet below the groundwater table or to refusal.
c. Samples must be collected for laboratory analyses as defined in Section 5.2 (Soil Sampling) on page 14 (see comment 7).

Response:

Because many of the soil borings are very close to other planned borings (e.g., 30 to 40 feet at the Warehouse Yard) we believe there will be little, if any, benefit from drilling all borings to the water table. The Work Plan, as submitted in December 2007, proposes to potentially drill all borings to the water table if contamination is observed in soils; the purpose being to delineate vertical impacts to soil. We assume the comment to drill all borings to the water table is based on the desire to obtain a sample of ground water at each location. As noted above, many of the borings are very close and there will be little, if any, benefit from having ground water samples on such small spacing. In addition, at some areas (e.g., the Warehouse Yard) it is well documented that ground water is impacted throughout the entire area where borings are planned and thus having multiple ground water samples over a once again small spacing offers little benefit.

To provide additional ground water data where it may be beneficial, Western proposes to drill the southwestern most boring at SWMU No. 8 (Landfill) to the water table and collect a sample of ground water (see Figures 2 and 9 and Section 5.3.2). This will establish three monitoring wells at SWMU No. 8. In addition, to ensure that vertical delineation of impacts to soils is achieved, Section 5.1 is revised to require that all soil borings extend three feet beneath waste materials or any other signs of contamination.

At SWMU No. 2 (North Bone Yard), all soil borings will be drilled to the water table as requested and this is reflected by changes in Section 5.1 and 5.2. In addition, a monitoring well was added to the western portion of (North Bone Yard) (see Figures 2 and 8) and a boring (with a ground water sample) has been added at SWMU No. 9 (Landfill Pond) (see Figures 2 and 9, and discussion in Section 5.2).

Comment 7

In Section 5.2 (Soil Sampling), page 14, bullet 3, Western states that discrete soil samples will be collected "from the 6" interval just above saturation (deep borings)."

Western must revise the Work Plan to remove "deep borings" from this bullet. Since all borings will be drilled to the water table, a sample must still be collected at the water table in all borings.

Response: Pursuant to response to Comment No. 6, Western proposes to collect samples from the top of the water table from all borings that encounter the water table (i.e., deep borings).

Comment 8

Western provides a description for background sampling in Section 5.2.2 (Background Determination). From discussions with Western, it has been determined that soil background concentrations for metals is not necessary at this time. Western must remove Section 5.2.2 (Background Determination) and any other references to background determination (e.g., figures) from the Work Plan.

Response: Section 5.2.2 has been removed.

Comment 9

Western addresses Drilling Activities in Section 5.1 and states "[m[onitoring well construction/completions will be conducted in accordance with the requirements of Section IX of the Order."

Western must revise this Section to elaborate on the installation of monitoring wells. This must include, but is not limited to, identifying the well materials, anticipated depth of wells, well screen length, etc. During the installation of the monitoring wells, Western must field screen soil samples at 2.5 feet intervals for the presence of petroleum hydrocarbons. A soil sample must be collected at the water table and submitted to a laboratory for the analyses provides in Section 5.8 (Chemical Analyses) of the Work Plan. The Work Plan must be revised accordingly.

Response: Section 5.1 has been revised to include details on monitoring well installation that are consistent with the specifications in Section IX of the Order. This includes well materials, anticipated well depths and well screen length. Section 5.2.1 has been revised to reflect screening intervals of 2.5 feet. Section 5.2 has been amended to require collection of a soil sample at the top of the water table, which will be represented by the upper six inches of saturated soil.

Regarding well installation materials, the work plan proposes to use PVC for the well screen and casing. Western understands that NMED has reservations on the use of PVC due to sorption and leaching concerns; however, multiple studies have shown that PVC is a suitable material for use in our particular application and it is used widely throughout the environmental industry and is accepted by most, if not all relevant regulatory agencies. The related research has shown that earlier concerns over sorption and leaching with PVC well components was actually limited to flexible, not rigid PVC, which is proposed for use in the Work Plan. The existing wells at the facility were constructed using PVC and have not shown signs of deterioration. Enclosed you will find a number of published articles discussing the use of PVC versus alternative materials and it is clearly demonstrated that PVC is a good and appropriate choice of materials for our application.

Comment 10

In Section 5.3.2 (Groundwater Sampling) Western discusses the locations of new monitoring wells.

Western must revise this Section to include the figures that identify the locations of the new monitoring wells.

Response: Section 5.3.2 has been revised to include references to the applicable figures.

Comment 11

In Section 5.3.2 (Groundwater Sampling), Western states "[g]roundwater samples will initially be obtained from newly constructed monitoring wells no later than five days after the completion of well development. A second round of groundwater monitoring and sampling will be conducted no sooner than 30 days and not later than 75 days of the initial sampling event."

Western must revise this Section to state when well development of the newly installed monitoring wells will occur.

Response: Section 5.3.2 has been revised to specify that new monitoring wells will be developed once all new wells have been completed.

Comment 12

Western discussed well purging in Section 5.3.3 and states that "[w]ell purging may also be conducted in accordance with the NMED's Position paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated."

If Western is going to use groundwater purging and sampling methods other than low flow sampling techniques, then these techniques must be described in the revised Work Plan.

Response: Sections 5.3.3 and 5.3.4 have been amended to clarify that wells will be purged and samples collected with either new disposable bailers or dedicated bailers. As an alternative, Western may follow NMED's guidance for low flow sampling. The anticipated depth to ground water is greater than the operable range for peristaltic pumps so it is likely that the wells will be purged following standard practices as detailed in Section 5.3.3 using a bailer and then the actual ground water sample collected using the same bailer.

Comment 13

Western must revise Section 5.8 (Chemical Analysis) of the Work Plan to include the analyses of diesel range organics (DRO) extended and gasoline range organics (GRO) using EPA Method 8015B for all samples (soil and water) submitted for laboratory analysis. All groundwater samples must be analyzed for nitrate/nitrite and for general chemistry parameters. In addition all analytes detected by each analytical method used must be reported in the associated summary reports.

Response: Section 5.8 has been revised to include analyses for petroleum hydrocarbons by method 8015B and general chemistry parameters. The list of individual organic constituents has been removed and all detected organic constituents will be reported.

Comment 14

Western states in Section 7 (Schedule) that "[c]ompletion of the data gap analysis will complete all activities conducted under this investigation work plan. If the data gap analysis indicates that additional investigation activities are necessary to satisfy the site investigation objectives, then a revised investigation work plan will be submitted to the NMED for review and approval within 60 days of completing the data gap analysis. Otherwise, Western will proceed to prepare an investigation report pursuant to Section X.C of the Order. The investigation report will be submitted to the NMED within 120 days of completion of the data gap analysis."

NMED will not approve additional investigations (.e.g., Phase II investigation work plan) without reviewing the results from the previous investigation. NMED recommends Western submit an investigation report for NMED approval and if additional investigation is required, a Phase II investigation work plan should be proposed for submittal to NMED in accordance with Section X.C.11 of the Order. Western must revise Section 7 to address the submittal of an investigation report.

Response: As requested, Section 7 has been revised. It provides flexibility for NMED to direct Western to prepare a revised work plan and to collect additional data in order to obtain the objectives of the investigation; however, it is solely in NMED's discretion to request the additional data collection. Otherwise, an investigation report will be prepared directly after completion of the data gap analysis pursuant to X.C. of the Order

Comment 15

A reference page was found in the Figures Section of the Work Plan, but this page was not identified in the Table of Contents.

Western must revise the Work Plan to include the reference page in the Table of Contents and place the references in the correct Section of the Work Plan.

Response: A new section (Section 8) has been added for the references.

Comment 16

Western discusses an Investigation Derived Waste (IDW) management Plan in Appendix D. Western must revise this Appendix to describe how the solids captured on the decontamination pad and drill cuttings will be characterized for disposal.

Response: Additional information has been added to the IDW Management Plan in Appendix D to clarify the waste classification process. The materials will first be tested to determine if they are characteristically hazardous. If the materials are not hazardous, then additional testing will be conducted as required by the receiving facility to ensure only appropriately classified materials are transported to the receiving facility.

Comment 17

The following revision must be made to the Work Plan concerning SWMU No. 2 (Drum Storage Area, North Bone Yard). NMED requires Western to install an additional monitoring well to monitor for potential contaminants in the vicinity of East Outfall #1. The monitoring well must be located near the northwest corner of the fresh water ponds and south of the fence. NMED has marked the approximate location of the monitoring well on Figure 8 with a black X in a circle, see enclosed figure. The appropriate sections of the Work Plan must be revised to incorporate this addition.

Response: The additional well location has been added on Figures 2 and 8, and in the discussion in Section 5.3.2.

Comment 18

The comments addressed in this letter are section specific; however, the changes may affect other sections of the Work Plan. Western must ensure that the required changes are made to all applicable sections of the Work Plan.

Response: All applicable sections of the Work Plan have been revised as detailed above.

If you have questions or would like to discuss the revised work plan, please contact me at (505) 632-4171.

Sincerely,

James R. Schmaltz
Environmental Manager
Western Refining Southwest, Inc., Bloomfield Refinery

cc: Hope Monzeglio – NMED HWB
Wayne Price - NMOCD
Dave Cobrain – NMED HWB
John Kieling – NMED HWB
C. Frischkorn – NMED HWB
Laurie King – EPA Region 6
Allen Hains – Western Refining El Paso

LEACHING OF TRACE ORGANICS INTO WATER FROM FIVE COMMON PLASTICS

Five plastics were tested to quantify their release of trace organics.

by Carol M. Curran and Mason B. Tomson

Many types of plastics are available for laboratory and field use. In recent years Teflon has been accepted as the least contaminating and most inert plastic for environmental work. Unfortunately, Teflon can be 10 to 20 times more expensive than other plastics such as PVC or polypropylene. Often plastics are used to case small wells used to monitor trace level organics at $\mu g/L^{-1}$ levels and below. Little is known about the extent of either leaching or sorption of trace organics from plastics. If materials other than Teflon could be used with confidence, considerable time and expense could be saved in monitoring and laboratory workup.

Scalf et al. (1981) discuss the economic vs. analytical certainty trade-offs often necessary in field investigations. They discuss the particular problems associated with glued PVC casing, but they present no data nor do they discuss options.

Junk et al. (1974a) reported on the contamination of water as it flows through various plastics. They reported organic contamination levels up to 5 mg/L^{-1} with typically a few tens of $\mu g/L^{-1}$ of contamination from various PVC tubes. They also suggested that high levels of contamination might bleed out of PVC for long periods of time. If this were to happen with PVC or other plastic well casing materials, it would preclude their use in ground-water monitoring programs. This report by Junk et al. is often cited as justification for far more expensive well materials such as Teflon or stainless steel. Based upon the laboratory and field evidence reported herein, it will be suggested that the types of rigid PVC often used for well casing, do not produce significant contamination and may thus be safely used as an economic alternative in ground-water monitoring programs.

A systematic study of the adsorption and desorption of volatile organics, such as trichloroethylene, 1,1,1-trichloroethane and bromoform, and the metals lead and chromium, onto polyethylene, polypropylene and schedule 40 PVC was conducted recently by G.D. Miller (1982). All of his experiments were 40mL batch studies. He reported adsorption of typically 25 to 75 percent of the trace organics after four to six weeks of exposing plastic sections to contaminated water. When contaminated sections were placed in clean water, generally only 25 to 75 percent of the adsorbed trace organic could be desorbed. Unfortunately, the leaching of less volatile trace organics, such as plasticizers, from the plastic tubing sections was not determined. He concluded that schedule 40 PVC causes fewer monitoring interferences with volatile organics than polyethylene or polypropylene under the conditions of his experiments.

Previous field work at Rice University suggested that PVC-cased wells might be satisfactorily employed for sampling ground water for trace organics, at least under some circumstances (Tomson et al. 1979). Single-piece PVC-cased monitoring wells (2-inch I.D. x ~20 feet) at a Ft. Devens, Massachusetts, rapid infiltration site were sampled for trace organics in 1979. These PVC wells had been in place for nine years. Numerous trace organics were found at the sub-ppb level in the ground water directly downgradient (~400 feet) from the applied sewage. Almost no trace organics were found in a similarly cased control well nearby, which was not in the influence of the applied sewage. Similarly, in a recent Rice University field study of ground-water contaminant movement from a pit associated with a creosote treatment plant, eight 4-inch schedule 40 PVC monitoring wells were installed to a depth of about 30 feet (Bedient et al. 1982). Again, water from those wells near the pit was found to contain high levels (1 to 10^3 $\mu g/L^{-1}$) of organics typical of creosote operations; water from a well 300 feet downgradient was found to have a similar suite of organics at 95(+) percent lower concentration (as might be expected); and water from a control well cased in the same manner was found to be free of contamination. These field observations indicate that the PVC well

Ground Water Monitoring Review V.3, N.3

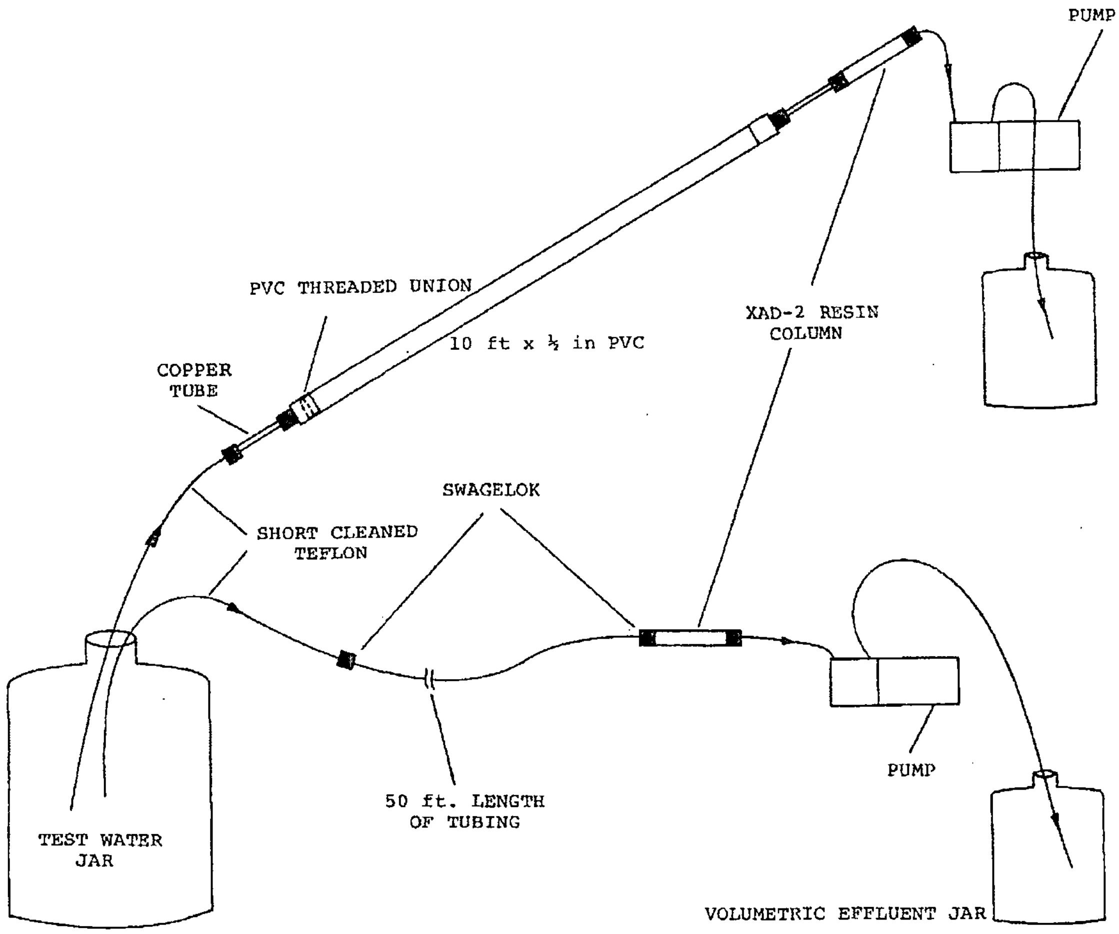


Figure 1. Tubing Test Setup

casings did not leach significant amounts of trace organics into, or sorb inordinate quantities of pollutants from, the sampled ground water.

The present research was initiated to better quantify the interaction of trace organics such as dichlorobenzene or naphthalene, with various plastics which may be usable either in the field or in the laboratory. The aqueous leaching and sorption of five plastics—Teflon, polyethylene, polypropylene, polyvinylchloride (PVC) glued and nonglued, and Tygon—were compared, with primary emphasis on rigid PVC because of its widespread use in monitoring wells.

Experimental

Tubing

Five plastics were used: polypropylene, polyethylene, Teflon, Tygon and PVC. Fifty-foot lengths of Teflon (TFE, Polypenco, Reading, Pennsylvania), Tygon (R-3603, Norton Co., Akron, Ohio), polypropylene (Resinol Type O®, Norton Co.), and polyethylene (Resinol Type A®, Norton Co.) tubing (1/8-inch I.D.) and three 10-foot lengths of PVC pipe (Grade 1, Type 1 from both R&G Sloane Mfg. Co. Inc., Sun Valley, California, and United Plastics, Houston, Texas,) (1/2-inch I.D.) were used. The internal surface areas of the lengths of tubing and pipe were equivalent. All tubings and pipe were purchased from the same distributor (A-1 Plastics, Houston, Texas).

PVC pipes were fitted into a PVC threaded union and reduced to 1/8 inch with a short (4-inch) piece of copper tubing. One length of PVC designated as "glued PVC" was glued at the threaded union with PVC pipe glue (Rector-Seal, Rector Corp.). The other pieces of PVC were connected to fittings with Teflon tape at the threaded union; no glue was used. All other fittings used were brass and stainless steel Swagelok®. PVC pipes were elevated at one end to a height of 3 feet so that the entire surface area would be contacted by the test water for the duration of each experiment (Figure 1).

In each experiment a short (3- to 5-foot) piece of cleaned Teflon tubing (3/16-inch I.D. x 1/8-inch O.D.) was used to convey test water from a glass reservoir to the influent end of the tubing or pipe. The exit was fitted to an 8mL Amberlite XAD-2 resin column and joined to a Masterflex pump to control flow at 30mL/min. A final length of tubing sent the effluent to a volumetric collection jar (Figure 1).

Sample Workup

The XAD-2 macroreticular resin columns were solvent-stripped and the extract processed and concentrated for Gas Chromatograph (GC) analysis according to the procedures of Junk et al. (1974b) with minor modifications (Tomson et al. 1979). One to 3 μL of the final concentrate was injected onto a Tracor 560 GC equipped with either a 50m fused silica Hewlett-Packard SP2100 capillary column or a 6-foot SP1240DA (Supelco) packed column and an FID detector.

With every experiment a blank of 20 l of water was taken through the same overall procedure, except the tubing or pipe was deleted (Figure 1).

Procedures

The first experiment involved pumping 20 l of organic-free water (at room temperature) with a 0.5 ppb naphthalene spike through each of the new tubings and the PVC pipe at 30mL min^{-1}. Water blanks were obtained by passing equivalent volumes of organic-free water directly through clean resin columns. During the second experiment 20 l of organic-free water spiked with 0.5 ppb para-dichlorobenzene was pumped through each of the five plastics at room temperature. The third experiment involved passing hot 80 C pure water (as might be used in a cleaning process) through each of the tubings, the glued PVC pipe and the PVC pipe with Teflon-taped unions. Ten liter volumes of organic-free water were heated to 80 C in glass jars and pumped quickly (400mL/min) through each of the tubings and pipes. After the hot-water flush, 20 l of 30 C water was pumped through each tubing at 30mL/min. Throughout each experiment, tubing leachates were collected on individual XAD-2 resin columns.

The first and second experiments were repeated using identical conditions except that a 0.05 $\mu g/L^{-1}$ naphthalene spike was used in the repetition of the second experiment.

Finally, a wax layer can develop on the inner wall of some PVC during manufacturing. To help remove this layer, one threaded PVC pipe, as before, was washed and swabbed (using a glass wool plug) three times with a strong detergent solution (Liqui-Nox) and then rinsed with water before use in the previous procedure.

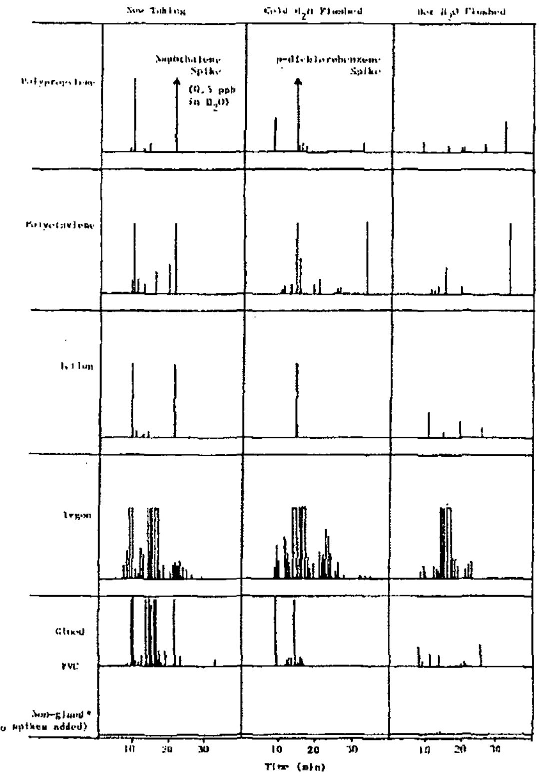


Figure 2. Graphic summary of capillary GC peak positions and heights from first set of experiments

Results and Discussion

A graphic summary of results from the first set of experiments is shown in Figure 2. Results of the second set of experiments were similar except a hot-water flush was not used. In most cases the resin blank showed little contamination and was subtracted from the sample chromatograms. The first set of experiments showed a decrease in the numbers of leachates after the second cool-water flush. However, the hot-water flush stimulated the release of additional contaminants (Figure 2). After cleaning one PVC pipe with detergents and swab, no leachates were found.

A semi-quantitative estimate of the total concentration of leachates in each case was made by using the peak area to calculate concentration of the internal spike (compared to a standard), then total concentration was calculated for each sample from the summed area of all the other peaks. The naphthalene and para-dichlorobenzene spikes were recovered at 80 to 100 percent in all tubing except those with Tygon which had a 50 percent or less recovery. After the first 20 l flush, total leachates from polyethylene, polypropylene, Teflon and Teflon-taped PVC were less than 2.0 ppb.

The recommended order with least contamination of the five plastics tested (after 40 l cool-water rinse) is the following:

Plastics	Upper Limit of Total Leachate Concentration
Teflon	None
PVC (nonglued)	0 to 0.1 ppb
Polyethylene	0.1 ppb
Polypropylene	0.5 ppb
PVC-glued	0.5 ppb
Tygon	1.0 ppb

As expected, Teflon showed the least contaminant leaching of the plastics studied. The results from PVC are consistent with our field observations, discussed earlier, but are much lower than the leachate values found by Junk et al. (1974a). The difference is probably because most of the PVC they used was "flexible." The flexibility is a result of adding large amounts of various plasticizers (up to 40 percent by weight). The PVC used in our work and generally used in monitoring wells is rigid and assembled with threaded joints. We also found lower total contaminant leaching for polyethylene and polypropylene than Junk et al., but this difference may have been a result of flow rate, tubing conditioning or specific manufacturing differences, because we have found similar overall recovery efficiencies using XAD-2 resin as reported by Junk et al. (1974a). It would be useful to study the relative leaching from plastics made by several manufacturers, but to date, no such information is available for comparison.

In summary, it can be inferred from data and reports presented herein that rigid PVC is an acceptable alternative to Teflon for monitoring wells if it is washed and rinsed with room temperature water before installation. Furthermore, depending upon desired detection limits, the plastics, polyethylene and then polypropylene, may be usable as well casing materials.

Biographical Sketches

Carol M. Curran is currently a research assistant in the Department of Environmental Science and Engineering at Rice University, Houston, Texas. She has a B.A.A.S. in biology from the University of Delaware. Curran has had a role in numerous publications in the fields of ground-water and surface-water monitoring and toxicology in the past five years at Rice University.

Mason B. Tomson received his B.S. in chemistry and mathematics from Southwestern State University, Weatherford, Oklahoma, in 1967. He received his Ph.D. in chemistry in 1972 from Oklahoma State University. From 1972 to 1977 Tomson studied at the State University of New York at Buffalo and was assistant to the provost, G.H. Nancollas, for four years. Tomson has been at Rice University, where he is an associate professor, since 1977. He has published more than 45 papers on water chemistry.

Acknowledgments

The authors gratefully acknowledge the cooperation and assistance of Dr. William J. Dunlap (Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma,) and Katherine M. Sloan for helpful discussion and suggestions, and Maurine Lee and Suzette Pruit for typing. Support for this work was provided by U.S. Environmental Protection Agency grants R-805292-02, CR806931-01 and CR806931-03.

References

Bedient, P.B. et al. 1982. Ground-water quality at a hazardous waste site. ASCE. J. Env. Eng. Div., submitted.

Junk, G.A. et al. 1974a. Contamination of water by synthetic polymer tubes. Envi. Sci. and Tech., v. 8, pp. 1100-1106.

Junk, G.A. et al. 1974b. Use of macroreticular resins in the analysis of water for trace organic contaminants. Journal of Chromatography, v. 7598, pp. 745-762.

Miller, G.D. 1982. Uptake and release of lead, chromium and trace-level volatile organics exposed to synthetic well casings. Proceedings of the Second National Symposium on Aquifer Restoration and Ground-Water Monitoring. National Water Well Association. Worthington. Ohio, pp. 236-245.

Scalf, M.R. et al. 1981. Manual of ground-water sampling procedures. National Water Well Association. Worthington. Ohio.

Tomson, M.B., S.R. Hutchins, J.M. King and C.H. Ward. 1979. Trace organic contamination of ground water: methods for study and preliminary results. III World Congress on Water Resources. Mexico City, Mexico. Papers, v. 8, pp. 3701-3709.

Comparison of Fiberglass and Other Polymeric Well Casings

Part II. Sorption and Leaching of Trace-Level Organics

by Thomas A. Ranney and Louise V. Parker

Abstract

This paper contains the results of a laboratory study that was designed to compare sorption of low (mg/L) concentrations of 11 organic solutes by six polymeric materials (acrylonitrile butadiene styrene [ABS], fluorinated ethylene propylene [FEP], fiberglass-reinforced epoxy [FRE] and fiberglass-reinforced plastic [FRP], polyvinyl chloride [PVC], and polytetrafluoroethylene [PTFE]).

During this six-week study, ABS sorbed analytes much more rapidly and to a greater extent than did the other materials, and PVC and FRE sorbed analytes more slowly and to a lesser extent than the other materials tested.

As the study progressed, an increasing number of spurious peaks were found in the high performance liquid chromatography (HPLC) chromatograms of some of our samples, indicating that leaching of some constituents had occurred. By the end of the study, there were 11 additional peaks in the ABS samples, five in the FRP samples, and one in the FRE samples. Analysis by purge and trap gas chromatography/mass spectrometry (GC/MS) of those samples and of well water samples that were exposed to the casings for 500 hours revealed the identity of some of the leached constituents: acrylonitrile and styrene (components of ABS), chloroform and ethylbenzene (an intermediate in the production of styrene) from the ABS pipe, and toluene, 1,1,1-trichloroethane, and ethyl benzene from the FRP casing.

Pages 107-112

Introduction

Materials that are used for well casings and screens in ground water monitoring wells should be strong and fabricated of materials that will remain intact once they are installed in the well, should not affect analyte concentrations in samples by leaching or sorbing organics or metals, and should resist degradation by the environment. Because none of the most commonly used materials for ground water monitoring wells (PTFE, PVC, and stainless steel [SS]) are ideal for all monitoring applications, we began these studies to assess the suitability of four alternative candidate well casing materials. These materials are ABS, FEP, FRE, and FRP. In part I of these studies (Ranney and Parker 1997), we assessed the ability of these materials to withstand degradation by chemicals, especially organic solvents. In that paper we compared these four materials with the other two commonly used polymeric materials, rigid PVC and PTFE. In this study, we will focus on sorption of organic solutes and leaching of organic constituents.

Literature Review

Sorption of Organic Solutes

We found two studies that addressed sorption of organic solutes by FEP, FRE, and ABS. Gillham and O'Hannesin (1990) conducted a study that compared sorption of ppb levels of six (mono)aromatic hydrocarbons by FRE, SS, PTFE, polyethylene (PE), and rigid and flexible PVC (RPVC and FPVC, respectively).

V.18, N. 2

They ranked the sorptiveness of the materials as (going from least sorptive to most): SS<RPVC<FRE<PTFE<PE<FPVC.

Jones and Miller (1988) also compared sorption of eight organic solutes that ranged in their aqueous solubility. The materials they tested included SS, (rigid) PVC, ABS, FEP, PTFE, and materials fluoride (PVDF). After six weeks, they found that there were losses of some of the analytes with all these materials and that no one material had a better performance than the other materials. However, it is difficult to determine what was the true mechanism(s) for those losses because they did not add a biocide, which would have prevented any microbial losses, and there did not appear to be any controls, which would allow one to account for losses due to volatilization or sorption by the container walls or cap.

Leaching of Organic Constituents

We were able to find only one study that has addressed the leaching of organic constituents from any of these materials. Cowgill (1988) tested intact FRE well casings and ground FRE casings (a powder) for leaching of any substance involved in its manufacture or any of the U.S. EPA priority pollutants. No organics were detected leaching from the powder after 72 hours' contact, but low levels of diethylphthalate and bisphenol A were found after three weeks. Bisphenol A is a component of manufacture (Cowgill 1988); diethylphthalate is a commonly used plasticizer. However, neither of these compounds was leached from the intact well casing pieces after three weeks.

Materials and Methods

Sorption of Organics

Six types of 5-cm-diameter (2-inch) well casing or pipe were used in this study: PVC, PTFE, FEP, ABS, FRE, and FRP. For PVC, PTFE, FEP, and FRE, we used well casings manufactured specifically for ground water monitoring. We were unable to find a manufacturer that made FEP well casings but did find one that made "pipe for sampling ground water." Because ABS well casing is no longer manufactured, we purchased ABS waste and vent pipe. The test pieces of the various materials were cut to slightly different lengths so that the final surface areas would be constant. Special care was taken to eliminate contamination from grease or oil during the cutting process. All the test pieces were placed in solutions of detergent and deionized water and sonicated for 20 minutes, then rinsed several times with deionized water to remove the detergent, sonicated for another 20 minutes in fresh deionized water, rinsed, drained, and left to air dry.

The test solutions contained 11 chemicals: cis-1,2-dichloroethylene (CDCE), trans-1,2-dichloroethylene (TDCE), benzene (BENZ), m-nitrotoluene (MNT), trichloroethylene (TCE), chlorobenzene (CLB), o-dichlorobenzene (ODCB), o-xylene (OXYL), p-dichlorobenzene (PDCB), m-xylene (MXYL), and tetrachloroethylene (perchloroethylene or PCE). Initial concentrations of analytes varied from 1 to 2 mg/L with the exception of BENZ, which had a concentration of approximately 0.5 mg/L. The test solutions were all prepared by adding each of the neat organics directly to well water in glass volumetric flasks. The water came from a deep water well in Enfield, New Hampshire. To prevent any biological loss of the organics, 40 mg/L $HgCl_2$ was added to the test solutions. Because three chemicals were less dense than water, a small headspace was left between the glass stopper and the surface of the test solution. Parafilm was then wrapped around the outside of the glass stopper and neck of the flask. The solutions were stirred with a magnetic bar for approximately three days. Before starting the experiment, the test solutions were examined with a magnifying glass to ensure that there were no undissolved droplets of solvent remaining.

Two pieces of one of the six materials were placed in individual 40-mL borosilicate glass vials. The vials were filled with aqueous test solution so that there was no headspace and then capped with Teflon®-lined plastic caps. Vials with test solutions but no material served as controls. The approximate ratio of material surface area to solution volume was 0.79 cm^2/mL. Separate vials were used for each sampling period so that the test solution could be discarded after sampling. There were seven sampling times: one hour, eight hours, 24 hours, 72 hours, (three days), 168 hours (seven days), 500 hours (three weeks), and 1000 hours (six weeks). For each material and time, there were three replicates.

When it was time to sacrifice a sample, a small aliquot of solution was transferred using a glass Pasteur pipette to an autosampler vial (1.8 mL) that was filled so there was no headspace and then capped. Teflon-backed silicone septa were used in the autosampler vials.

Analytical determination of the organic solute concentrations were by reversed-phase HPLC. A modular system was employed that consisted of a Spectra Physics SP 8810 isocratic pump, a Spectra Physics SP 8490 variable-wavelength UV detector set at 210 nm, a Spectra Physics SP 8875 autosampler with a 100-μL injection loop, and a Hewlett-Packard 3396 series II digital integrator. Separations were obtained on a 25-cm × 4.6-mm (5-μm) LC-18 column (Supelco) eluted with 62/38 (v/v) methanol/water at 1.5 mL/min. The detector response was obtained from the digital integrator operating in the peak height mode. Retention times of the analytes ranged from 4.0 to 16.3 minutes.

Leaching of Contaminants

The 1000-hour samples from the previous study were analyzed using purge and trap GC/MS to determine the identity of some of the spurious peaks that had been observed on the HPLC chromatograms. EPA method 8240 for volatile organics by GC/MS (U.S. EPA 1986) was used. The GC/MS system consisted of a Tekmar LSC-2 liquid sample concentrator, a Hewlett Packard 5890 series II gas chromatograph, and a Hewlett Packard 5970 series mass selective detector. One sample for each type of material plus a control sample were analyzed.

To confirm that the organics found in the test solutions resulted from leaching from the casing materials, we placed two pieces of the cleaned casing material (the same size as used previously) in 40-mL glass vials. These vials were then filled with the well water so there was no headspace. The well water also contained 40 mg/L $HgCl_2$ to prevent any biological activity. These samples were analyzed after approximately 500 hours contact time, using the purge and trap GC/MS method described previously. Only those materials that appeared to be leaching contaminants in the previous study (ABS, FRE, FRP) and a blank (water only) were tested; there were no replicates in this study.

Results and Discussion

Sorption of Organics

Figures 1a through k show sorption of the analytes by the various casing materials. Each figure shows the mean normalized values, which were determined by dividing the mean concentration for a particular material and time by the mean concentration of the control sample for the same time. These figures show three things: (1) ABS always sorbed analytes the most rapidly and to the greatest extent of all the materials tested; (2) PVC and FRE sorbed analytes the most slowly and to the least extent; and (3) neither PTFE, FEP, or FRP performed consistently better than the other.

For each material and time, the relative standard deviation of the (original) analyte concentrations was less than 10%, except for some of the later ABS samples. Those relative standard deviations were higher because the concentrations in these samples were low, approaching the detection limit. The raw data plus the results of the statistical analyses can be found in Ranney and Parker (1994).

Table 1 shows the time required for a 10% loss in analyte concentrations. For several organics, losses reached 10% in eight to 24 hours for PTFE, FEP, and FRP, and in one to eight hours for ABS. This was not the case for PVC and FRE. For PVC, the earliest a 10% loss was first observed was after 500 hours, and for FRE, it was 72 hours. For several compounds, losses never reached 10%. This was especially true for FRE and PVC.

Our results generally agree well with those of Gillham and O'Hannesin (1990) except that they found that the rate and extent of sorption of the (mono)aromatic hydrocarbons they tested were always greater for FRE than for PVC while we did not. By the end of our study, we found no significant difference between samples exposed to PVC vs. FRE for two of three compounds tested by Gillham and O'Hannesin (1990). Because both studies used a constant surface-area-to-solution-volume ratio (which differed between the two studies), we suspect that the reason these studies do not agree in this case is due to differences in the formulations of the polymers that were tested; they tested FRE tubing and PVC pipe, and we tested well casings.

Leaching of Contaminants

As the experiment progressed, we began to observe more and more spurious peaks in the chromatograms of some of the samples. By the end of the study, there were additional peaks in the chromatograms for the ABS, FRE, and FRP samples but not for the FEP, PTFE, and PVC samples. Two previous studies (Barcelona et al. 1985; Curran and Tomson 1983) did not find any organic constituents leaching from PTFE. Because FEP is also a fluoropolymer and similar in composition to PTFE, we expected it might behave similarly to PTFE. Generally, studies (Miller 1982; Curran and Tomson 1983) have shown that the leaching of organics from rigid PVC has been considerably less problematic than from flexible PVC tubing. This is because rigid PVC products contain almost no plasticizers (<0.01%) (Barcelona et al. 1984) and because standards promulgated by the National Sanitation Foundation in 1977 have reduced leached concentrations of vinyl chloride monomer (Aller et al. 1989) by limiting the amount of residual vinyl chloride monomer in PVC pipe and well casings.

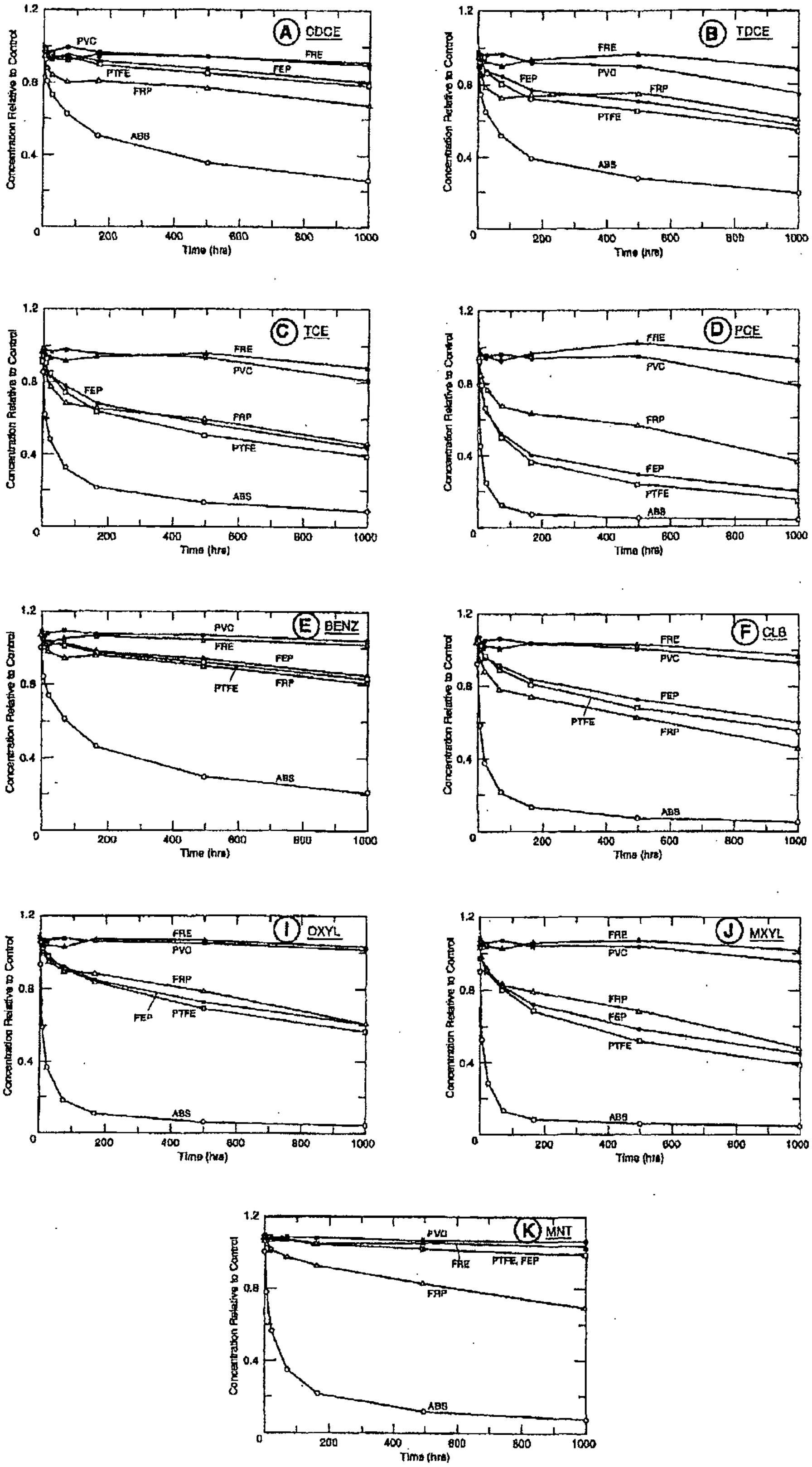
The ABS samples leached the most constituents, with 11 additional peaks by the end of the study. After one hour there was one spurious peak with the ABS sample. The chromatograms for the FRP solutions had one additional peak after 72 hours and five by the end of the study. There was only one additional peak in the chromatograms for the FRE samples; it appeared in the 72-hour samples. For all three of these materials, the size of the peaks increased as time continued.

Table 1

Contact Time (Hours) Required for the Material to Sorb 10% or More of the Analyte

Material	CDCE	TDCE	TCE	PCE	BENZ	CLB	ODCB	PDCB	OXYL	MXYL	MNT
PVC	1000	500	1000	1000	NL*	1000	1000	500	NL	1000	NL
PTFE	168	24	8	8	168	24	24	8	24	8	1000
FEP	500	24	8	1	168	24	8	8	24	8	NL
ABS	8	1	1	1	8	1	1	1	1	1	8
FRE	NL	72#	1000	NL	NL	1000	1000	72	NL	NL	NL
FRP	8	8	8	8	24	8	8	8	24	8	72

* Never lost 10% by the end of the study.
# Subsequent losses were less: 7% at 168 hours and 4% at 500 hours.



Figures 1a through 1 k. Sorption of analytes by the test materials.

When we analyzed the 1000-hour samples by purge and trap GC/MS, we were able to determine the identity of some (but not all) of the constituents that had leached from the ABS and FRP casings (Table 2). Leached constituents from the ABS pipe included acrylonitrile and styrene (two of the three components of ABS), chloroform, and ethylbenzene (which is an intermediate in the production of styrene). The concentrations of these compounds in the samples were quite low (<10 μg/L). We also found that the FRP casing had leached toluene; the leached concentration was approximately 100 μg/L. For both of these materials, there were more spurious peaks in the HPLC chromatograms than could be accounted for by the number of peaks that were found by GC/MS analyses. Thus, the other leached constituents that were not detected by GC analysis must be either nonvolatile or semi-volatile organics or inorganic compounds (e.g., metal salts). This was also true for the one leached constituent from the FRE casing. Based on Cowgill's (1988) earlier findings, we believe that compound was bisphenol A.

We conducted a leaching study to confirm that the substances we found in the previous samples were in fact due to leaching from the casing material. When the samples were analyzed after 500 hours contact by purge and trap GC/MS, we found essentially the same analytes as previously (Table 2). The concentrations in these samples were fairly comparable to the 1000-hour samples, given the difference in contact time (500 vs. 1000 hours). However, in this study, we identified more leached constituents from the FRP casing. In addition to finding toluene, we also found 1,1,1-trichloroethane and ethylbenzene. When we queried the manufacturer about this they stated that the mold release agent used at the time of manufacture of these particular casings could have contained these compounds and that they no longer use this product.

Table 2
Leaching of Constituents from Casing and Pipe Materials

Material	Treatment	No. Spurious Peaks by HPLC Analysis	No. Peaks by GC Analysis	Compounds Identified by GC/MS
ABS	1000 hours in test solution	11	6	acrylonitrile styrene chloroform ethylbenzene
FRP	1000 hours in test solution	5	1	toluene
FRE	1000 hours in test solution	1	0*	none
ABS	500 hours in well water		5	ethylbenzene styrene
FRP	500 hours in well water		5*	toluene 1,1,1-trichloroethane ethylbenzene
FRE	500 hours in well water		0	none

*Findings were confirmed by running the sample twice.

Conclusions

With respect to sorption of organic solutes, we would rank these materials (from least affected to most affected) as follows: FRE, PVC< FEP, PTFE, FRP<<ABS.

With respect to leaching of organic constituents, we would rank these materials (from those materials that leached the fewest constituents to those that leached the most constituents) as follows: PVC, FEP, PTFE< FRE < FRP<<ABS.

Clearly, PVC, FRE, PTFE, and FEP were the least active materials tested, and PVC was the least active material of all. Because the performance of FEP and PTFE was so similar, there does not appear to be any clear advantage or disadvantage to using one material over the other. Because ABS sorbed organics rapidly and leached several contaminants, this material does not appear to be desirable when monitoring organic contaminants. However, waste and vent pipe was tested in this study rather than well casing. It is possible that the formulation used in a casing might be sufficiently different that its performance would be improved substantially.

Although we believe these rankings can be useful when selecting a casing material, the reader must realize that these studies were limited in scope and indicate a potential for bias. The effects we observed in this study may be modified in a ground water monitoring well. For sorption, time for possible equilibration and/or water exchange could diminish losses. On the other hand, we expect that losses would be even greater for the more hydrophobic contaminants. Leaching also might increase with continued flushing as Junk et al. (1974) observed with flexible PVC or decrease with time as Packham (1971a and 1971b), Gross et al. (1974), and Boettner et al. (1981) have shown with rigid PVC pipe.

The selection of a casing material should never depend solely upon the analytes of interest. Other factors that should be considered when selecting a casing material include strength considerations (i.e., depth and diameter of the well) and the chemistry of the ground water (i.e., the ability of the material to withstand the environment). For example, PTFE screen will collapse in deep wells and stainless steel will corrode if there are high chloride concentrations in the ground water.

In Part III of this study, we will examine whether these materials sorb or leach metals and compare those results with the results from Parts I and II of this study to determine the overall suitability of these materials for monitoring ground water.

Acknowledgments

We thank the U.S. Army Environmental Center, Aberdeen Proving Ground, Maryland, and Martin H. Stutz, project monitor, for the financial support of this project. We also thank Chad Pidgeon and Philip Thorne, CRREL, for conducting the GC/MS analyses.

This publication reflects the personal views of the authors and does not suggest or reflect the policy, practices, programs, or doctrine of the U.S. Army or Government of the United States. The contents of this report

are not to be used for advertising or promotion purposes. Citation of brand names does not constitute an official endorsement or approval of the use of such commercial products.

References

Aller, L., T.W. Bennett, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nielsen, and J.E. Denne. 1989. *Handbook of suggested practices for the design and installation of groundwater monitoring wells*. Dublin, Ohio: National Water Well Association.

Barcelona, M.J., J.P. Gibb, and R.A. Miller. 1984. *A guide to the selection of materials for monitoring well construction and ground water sampling*. U.S. Environmental Protection Agency report no. EPA-600/2-84-024. Washington, D.C.: U.S. Government Printing Office.

Barcelona, M.J., J.A. Helfrich, and E.E. Garske. 1985. Sampling tubing effects on ground water samples. *Analytical Chemistry* 57, no. 2: 460-464.

Boettner, E.A., G.L. Ball, Z. Hollingsworth, and R. Aquino. 1981. *Organic and organotin compounds leached for PVC and CPVC pipe*. U.S. EPA report no. EPA-600/1-81-062. Cincinnati, Ohio: Health Effects Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

Cowgill, U.M. 1988. The chemical composition of leachate from a two-week dwell-time study of PVC casing and a three-week dwell time study of fiberglass reinforced epoxy well casing. In *Ground-water contamination: Field methods*, ASTM STP 963, ed. A.G. Collins and A.I. Johnson, 172-184. Philadelphia, Pennsylvania: American Society for Testing and Materials.

Curran, C.M., and M.B. Tomson. 1983. Leaching of trace organics into water from five common plastics. *Ground Water Monitoring Review* 3, no 3: 68-71.

Gillham, R.W, and S.F. O'Hannesin. 1990. Sorption of aromatic hydrocarbons by materials used in construction of ground-water monitoring sampling wells. In *Ground water and vadose zone monitoring*, ASTM STP 1053, ed. D.M. Nielsen and A.I. Johnson, 108-122. Philadelphia, Pennsylvania: American Society for Testing and Materials.

Gross, R.C., B. Engelbart, and S. Walter. 1974. *Aqueous extraction of lead stabilizers from PVC compounds*. Society of Plastic Engineering Technical Paper 20. Brookfield, Connecticut: Society of Plastic Engineers.

Jones, J.N., and G.D. Miller. 1988 Adsorption of selected organic contaminants onto possible well casing materials. In *Ground water contamination: Field methods*, ASTM STP 963, ed. A.G. Collins and A.I. Johnson, 185-198. Philadelphia, Pennsylvania: American Society for Testing and Materials.

Junk, G.A., H.J. Svec, R.D. Vick, and M.J. Avery. 1974. Contamination of water by synthetic polymer tubes. *Environmental Science and Technology* 8, no. 13: 1100–1106.

Miller, G.D. 1982. Uptake and release of lead, chromium, and trace level volatile organics exposed to synthetic well casings. In *Proceedings of the Second National Symposium on Aquifer Restoration and Ground Water Monitoring*, by National Water Well Association, ed. David M. Nielsen, 236-245. Worthington, Ohio: NWWA.

Packham, R.F. 1971a. The leaching of toxic substances from unplasticized PVC pipe. Part I. A critical study of laboratory test procedures. *Water Treatment and Examination* 20, no. 2: 144–151.

Packham, R.F. 1971b. The leaching of toxic substances from unplasticized PVC pipe. Part II. A survey of lead levels in PVC distribution systems. *Water Treatment and Examination* 20, no. 2: 152–164.

Ranney, T.A., and L.V. Parker. 1994. *Sorption of trace-level organics by ABS, FEP, FRE, and FRP well casings*. CRREL special report 94-15. Hanover, New Hampshire: U.S. Army Cold Regions Research and Engineering Laboratory.

Ranney, T.A., and L.V. Parker. 1997. Comparison of fiberglass and other polymeric well casings: Part I. Susceptibility to degradation by chemicals. *Ground Water Monitoring and Remediation* 17, no. 1: 97-103.

U.S. EPA. 1986. Test methods for evaluating solid waste, Volume 1B: Laboratory manual physical/chemical methods, 3rd ed. Washington, D.C.: Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency.

Biographical Sketches

***Thomas A. Ranney** is a staff scientist with Science and Technology Corp. (P.O. Box 127, Hanover, NH 03755). He received a B.S. in education from Castleton State College and an M.S. in plant and soil science from the University of Vermont. His current interests are in the development of analytical methods and in evaluating environmental sampling procedures.*

***Louise Parker** is a research physical scientist at the U.S. Army Cold Regions Research and Engineering Laboratory (72 Lyme Road, Hanover, NH 03755-1290). She received her B.A. in microbiology from the University of New Hampshire and an M.S. in food science and nutrition (food microbiology) from the University of Massachusetts. Her research interests are in ground water sampling and material interactions. She is a member of the Association of Ground Water Scientists and Engineers Division of the NGWA and has been active in ASTM subcommittee D18.21 on ground water and vadose zone investigations.*

Sampling Trace-Level Organic Solutes with Polymeric Tubing

Part I. Static Studies

by Louise V. Parker and Thomas A. Ranney

Abstract

Twenty polymeric tubings were filled with a test solution containing eight organic solutes. The test solutions were monitored for losses, indicating that sorption had occurred, and for signs that leaching of organic constituents had occurred. The tubings tested included seven flexible products and eight fluoropolymers. Among the rigid tubings tested, three fluoropolymers (fluorinated ethylene propylene [FEP], FEP-lined polyethylene, polyvinylidene fluoride) were the least sorptive tubings. However, even these tubings readily sorbed some of the analytes. Among the flexible tubings tested, a fluoroelastomer tubing and a tubing made of a copolymer of vinylidene fluoride and hexafluoropropylene were the least sorptive.

Several of the tubings tested leached constituents into the test solution. The polyurethane, polyamide, flexible polyvinyl chloride (PVC), polyester-lined PVC, and silicone-modified thermoplastic elastomer tubings were found to leach the most constituents. We were unable to detect any constituents leaching from the polyethylene tubings, the rigid fluoropolymer tubings, and one of the plasticized polypropylene tubings.

Pages 115-124

Introduction

Reported concentrations of contaminants in ground water samples should accurately reflect in situ values. Of concern in this two-part paper is whether polymeric tubings either sorb organic contaminants or leach organic constituents as the sample is pumped to the surface.

Sorption of Contaminants

All polymeric tubing materials tested (polyethylene [PE], polypropylene [PP], rubber, flexible polyvinyl chloride [PVC], polytetrafluoroethylene [PTFE], polyamide [nylon]) sorb some organic solutes (Curran and Tomson 1983; Ho 1983; Barcelona et al. 1985; Reynolds and Gillham 1985; Devlin 1987; Pearsall and Eckhardt 1987; Gillham and O'Hannesin 1990). Because of their greater density and crystallinity (Barcelona et al. 1985), rigid polymers are much less sorptive of organic solutes than flexible materials such as silicone rubber, latex rubber, and flexible PVC (Curran and Tomson 1983; Barcelona et al. 1985; Reynolds and Gillham 1985; Gillham and O'Hannesin 1990). PTFE was the least sorptive polymer tested in these studies.

In most cases, losses of organic solutes to polymers were attributed to absorption within the polymer matrix (Serota et al. 1972; Yasuda and Stannett 1975; Barcelona et al. 1985; Reynolds and Gillham 1985; Gillham and O'Hannesin 1990; Parker et al. 1990; Parker and Ranney 1994). Absorption/dissolution into the polymer surface occurs

V.17, N.4

first and is followed by diffusion into the polymer matrix. The diffusion process is regulated by the size of the permeant species, the extent of the polymer-permeant interaction, and structural characteristics of the polymer (Salame and Pinsky 1962; Serota et al. 1972). Structural characteristics of the polymer include intermolecular chain forces, crystallinity, and degree of cross-linking. Leggett and Parker (1994) were able to successfully model the partitioning of organic solutes with PTFE and rigid PVC by using the organic solute's basicity, acidity, polarity/polarizability, and molecular volume (linear solvation energy relationships).

There have been a few studies that have examined losses of organic solutes from solutions that were pumped through the tubings (i.e., under dynamic conditions). Typically, concentrations of volatile organic compounds (VOCs) were as much as 15 percent lower in samples pumped through silicone rubber tubing than in samples pumped through a PTFE or Teflon tubing (flow rates were 0.7 to 1.0 L/min.) (Ho 1983; Pearsall and Eckhardt 1987). Ho also reported that there were significant losses of two VOCs in a test solution that was pumped through PTFE tubing but did not quantify what those losses were.

However, only one study (Devlin 1987) has addressed what happens to analyte concentrations when a test solution is pumped through a tubing for an extended period of time (i.e., whether equilibration occurs). Devlin reported that representative samples could be obtained by flushing PE tubing with water for five to 10 minutes, and that the equilibration time depended upon the length of the tubing and the pumping rate. However, no data were provided to substantiate this claim.

Based on these studies, we know that concentrations of some organic analytes can be affected when contaminated water is pumped through some tubings. However, we do not know the extent of this effect with time.

Leaching of Organic Constituents

Several types of polymeric tubing (flexible PVC, various types of rubber, polyamide, high density PE [HDPE]) have been shown to leach organic constituents under either static or dynamic conditions (Junk et al. 1974; Curran and Tomson 1983; Barcelona et al. 1985). Flexible products, especially PVC and rubber, leach more organic constituents. Plasticizers are one of the most commonly found leached organic constituents, especially from flexible PVC and polyamide (Junk et al. 1974; Gron et al. 1996). The fluoropolymer PTFE has not been found to leach organic constituents (Junk et al. 1974; Curran and Tomson 1983; Barcelona et al. 1985; Devlin 1987). This material does not contain plasticizers or many additives. For some materials the information appears to be conflicting. For example, Barcelona et al. (1985) reported finding leached constituents from HDPE and PP tubings, while Miller (1982) was unable to for either low-density PE (LDPE) or PP materials, and Devlin (1987) was unable to for an unspecified type of PE tubing. These differences may be attributable to differences in the polymers tested (i.e., HDPE vs. LDPE), differences in the composition or manufacture of the polymer, or differences in the methods of testing and analysis.

Only one study has compared the effect flow rate (or linear velocity) has on leaching. Junk et al. (1974) observed that increasing the linear velocity rate of water (from 20 mL/min to 60 mL/min) through flexible PVC tubing increased leaching. They attributed this to erosion of the polymer matrix. Curran and Tomson (1983) noted that the total amount of contaminants they observed leaching from the PE and PP tubings was less than what Junk et al. (1974) had observed. They attributed this to differences in flow rate, tubing conditioning, or manufacturing. However, there can also be different formulations of the same polymer, and some constituents are more readily leached than others.

It is not clear what effect pumping time has on leaching. Several studies (Packham 1971a and 1971b; Gross et al. 1974; Boettner et al. 1981) have shown that leaching of organic constituents from rigid PVC pipe decreases with pumping time. This may also be true for some polymeric tubings. On the other hand, leaching may increase with time, or remain the same. Junk et al. (1974) reported that extensive rinsing of flexible PVC served no useful purpose because this material contains an almost inexhaustible source of plasticizers.

Clearly, not enough is known about the effect of flow rate or continued pumping on leaching of organic constituents from polymeric tubing.

Purpose

The previous studies show that flexible tubing materials can affect analyte concentrations by sorbing organic contaminants and by leaching organic constituents. However, a comprehensive comparison of the many tubings that are commercially available, especially the various types of fluoropolymers, does not exist. The purpose of this study was to compare, under static conditions, sorption of organic solutes by 20 sampling tubings that are commercially available and to look for leaching of contaminants from these materials. Thirteen rigid tubings and seven flexible tubings were selected for this study, and this included eight fluoropolymers (Table 1). This study was conducted at low ppm levels and not at high concentrations (approaching the aqueous solubility) where the rate of diffusion can be effected in some polymers. These data will be used to select several tubings for the second phase of this project, the dynamic studies.

Materials and Methods

Initial Sorption Study

Table 1 gives abbreviations for the polymers tested as well as dimensions and cost. The cost per 100 feet (30 m) of the tubing ranged from $19 for LDPE to $870 for the fluoroelastomer.

Table 1
Polymeric Tubing Used in Sampling Trace-Level Organics

	$Cost Per ft.[b]	Tubing Dimensions		Surface-Area-to-Solution-Volume Ratio (cm^{-1})
		I.D. (cm)	Length (cm)	
Flexible Polymers[a]				
Polypropylene-based material with plasticizer (formulation 1)	0.58	0.64	20	6.3
Polypropylene-based material with plasticizer (formulation 2)	2.48	0.64	20	6.3
Polyvinyl chloride (PVC)	0.89	0.64	20	6.3
Thermoplastic elastomer[c] (TPE)	0.96	0.64	20	6.3
Linear copolymer of vinylidene fluoride and hexafluoropropylene P(VDF-HFP)	1.99	0.64	20	6.3
Polyurethane	0.64	0.64	20	6.3
Fluoroelastomer	8.70	0.64	20	6.3
Rigid Polymers[d]				
Polyethylene, low density (LDPE)	0.19	0.64	20	6.3
Polyethylene, cross-linked high density (XLPE)	0.43	0.64	20	6.3
Polyethylene liner in ethyl vinyl acetate (EVA) shell	0.57	0.64	20	6.3
Polyethylene liner cross-linked to ethyl vinyl acetate (EVA) shell	1.08	0.64	20	6.3
Co-extruded polyester lining in PVC shell	0.77	0.64	20	6.3
Polypropylene (PP)	0.27	0.64	20	6.3
Polyamide (nylon 12)	0.71	0.71	18	5.6
Polytetrafluoroethylene (PTFE)	4.27	0.75	17	5.3
Perfluoroalkoxy (PFA)	5.58	0.64	20	6.3
Ethylenetetrafluoroethylene (ETFE)	5.50	0.48	27	8.4
Polyvinylidene fluoride (PVDF)	1.80	0.64	20	6.3
Fluorinated ethylene polypropylene (FEP)	3.90	0.64	20	6.3
FEP-lined polyethylene	3.00	0.64	20	6.3

[a] Finger pressure can collapse tubing.
[b] Cost varies with quantity, dimensions, and supplier.
[c] Styrene-ethylene-butylene block copolymer modified with silicone oil.
[d] Can be stepped on without collapsing the tubing.

The test solution for this study consisted of low mg/L concentrations of eight organic compounds: nitrobenzene (NB), trans-1,2-dichloroethylene (TDCE), m-nitrotoluene (MNT), trichloroethylene (TCE), chlorobenzene (CLB), o-dichlorobenzene (ODCB), p-dichlorobenzene (PDCB), and tetrachloroethylene (PCE). It was prepared by dissolving the neat (undiluted) organic chemicals in well water (taken from a deep water well in Hartland, Vermont) as described by Parker and Ranney (1996). Initial concentrations of the organic solutes varied from 10 to 16 mg/L. The test solution also contained 40 mg/L of mercuric chloride, which was added to prevent losses due to biological activity.

Because three types of tubing (PTFE, ETFE, and polyamide) had different internal diameters, the tubings were cut to varying lengths to give the same internal surface area, 40 cm^2 (Table 1). The cut tubing pieces were rinsed with several volumes of deionized water and left to air dry. One end of each of the tubings was plugged with a small piece of solid glass rod inserted to a depth of 1 cm, and then secured with a plastic tubing clamp.

There were five sampling times (one, eight, 24, 48, and 72 hours) and two replicates for each material and sampling time. The tubings were filled using a glass repipettor in random order in batches, with the one-hour samples first, then the eight-hour samples, and so on. The tubings were filled so there was no headspace and then the top was sealed with a glass rod and clamp as described previously. The tubings were stored in the dark at room temperature.

Three subsamples of the test solution (test solution blanks) were collected at the beginning and end of filling each batch of tubings. These samples were prepared by filling HPLC autosampler vials (1.8 mL) with the test solution so that there was no headspace, sealing the vials with Teflon-lined plastic caps, and then storing in the dark in a refrigerator. These samples were collected in this manner so that losses due to volatilization during the filling process could be accounted for. As expected, concentrations of the more volatile organic compounds were slightly lower in the batches that were poured last (Parker and Ranney 1996). These samples were analyzed at the same time the solutions in the tubings were analyzed.

When it was time to sample a tubing, one of the plugged ends was cut and a Pasteur pipet was used to transfer an aliquot of the test solution to an HPLC autosampler vial. Analytical determinations were performed using reversed phase HPLC (RP-HPLC). A modular system was employed consisting of a Spectra Physics SP8875 autosampler with a 100µL injection loop, SP8810 isocratic pump, and SP8490 variable wavelength detector set at 215 nm, and a Hewlett Packard 3396 series II digital integrator operating in the peak height mode. Separations were obtained on a 25 cm × 0.46 cm (5 µm) LC-18 column (Supelco) eluted with 65/35 (V/V) methanol/water at a flow rate of 2.0 mL/min.

For each analyte, a single-compound standard was made by adding the neat compound to methanol so that the concentration was approximately 2000 mg/L. A combined standard, consisting of approximately 200 mg/L of each analyte, was made by dilution in methanol. These standards were kept in a freezer. Working standards were made each sampling day by diluting the combined standard, which had been warmed to room temperature, in deionized water. Each of the working standard solutions was run in triplicate. The method detection limits (MDL) for the analytes were obtained according to the EPA protocol (*Federal Register* 1984).

Second Sorption Study

A second study was conducted so that sorption of the analytes by the three tubings with different surface-area-to-solution-volume ratios (PTFE, ETFE, and polyamide) could be more accurately compared with the other 17 tubings. In this study, 5-cm pieces of the three tubing types were placed in three different-sized glass vials (9, 25, and 40 mL). The test solution was made of the same organic compounds and in the same manner as in the previous study. The solution was poured into the vials so there was no headspace and the vials were capped with Teflon-lined plastic caps. The total surface-area-to-solution-volume ratios were, for PTFE, 0.70, 1.15, 3.55; for ETFE, 0.45, 0.74, and 2.15; and for nylon, 0.69, 1.14, and 3.59. Controls consisted of each of the same-sized vials filled with only test solution. Samples (including controls) were taken after one hour, eight hours, and 24 hours. There were duplicates for each sample time and tubing type, including the controls. All samples were kept in the dark at room temperature. When it was time to take a sample, an aliquot from each vial was transferred to an autosampler vial using a Pasteur pipet. Analyses were performed as described previously.

Data Handling and Analyses for the Sorption Studies

For each analyte and time in the first study, a one-way analysis of variance (ANOVA) test was conducted on the initial concentration data (i.e., among all the replicates) to determine if the tubings had any significant effect (at the 95 percent confidence level) on the analyte concentrations. Significant differences were found in all cases. Fisher's protected least significant difference test was then performed to determine which tubing materials were significantly different (at the 95 percent confidence level) from the test solution blanks and each other. Mean normalized concentration values were derived by taking the mean concentration of a given analyte exposed to a given tubing at a given sampling time and dividing it by the mean concentration in the test solution blanks for the same analyte and time.

The second study compared sorption of the same analytes by the three tubings with three different surface-area-to-solution-volume ratios. The results from the second sorption show that as the material surface-area-to-solution-volume ratio increases, sorption of the more hydrophobic analytes also increases (Parker and Ranney 1996). For each material, analyte, and time, the normalized values that were derived in this study along with the normalized values for these materials from the previous study were used to obtain a best-fit equation using Cricket Graph software. These equations were then used to determine what the adjusted normalized values would have been for these three materials if the surface-area-to-solution-volume ratio had been the same as the other 17 tubings.

Analysis of Leachates

Chromatograms for solutions exposed to a number of different tubings contained spurious peaks, which suggests that some of the tubing constituents had leached. Identification of some of the leached constituents was accomplished by analyzing one of each of the final (72 hour) samples that appeared to leach constituents for semi-volatile organic compounds using gas chromatography/mass spectrometry (GC/MS). Two GC/MS systems were used, each with a different column. The first system consisted of a Hewlett-Packard (HP) 5890 series II gas chromatograph and an HP 5970 mass selective detector with an HP-1 capillary column, 25-m × 0.2-mm I.D. (0.33 μm). The second GC/MS system consisted of an HP 5890 series II gas chromatograph, an HP 5972 mass selective detector, and an HP 7673 auto-injector with an HP-5 capillary column, 30 m × 0.25 mm I.D. (0.25 μm). Operating parameters for both instruments consisted of an initial column temperature of 60°C (hold 1 minute), then ramp to 300°C at 6°C/min (hold 19 minutes). The injector/detector temperatures were 250°C and 300°C, respectively. The carrier gas was helium with a linear velocity of 20 cm/sec set at 60°C. For the first instrument, 3 μL were injected manually; for the second instrument, 1 μL was injected by auto injection. Both injections had a splitless hold time of 45 seconds. For both instruments, the scan range $m/z = 45–550$ at 0.7 sec/scan. Tentative identification of the organic compounds was done by matching the spectral patterns with others in the system's library.

Results and Discussion

Sorption Studies

Tables 2, 3, and 4 give the mean normalized values for three of the analytes (PDCB, PCE, NB) that were exposed to the 20 tubings. Data for these particular analytes are presented because PDCB and PCE were two of the most readily sorbed analytes, and NB was generally the least readily sorbed analyte. A mean normalized value of 1.00 represents no loss of analyte for a given tubing and time. In parentheses next to the original mean normalized values are the adjusted mean normalized values for the PTFE, ETFE, and polyamide tubings. Data for the other five analytes (TDCE, MNT, TCE, CLB, ODCB) and raw data for all the analyses can be found in Parker and Ranney (1996).

Table 2

Means of Normalized[1] Concentrations of p-dichlorobenzene (PDCB) in Solutions Exposed to Polymeric Tubing[2]

	Exposure Time (Hour)				
	1	8	24	48	72
Flexible Tubings					
Polyurethane	0.016	D	D	D	D
PVC	0.014	0.001	0.001	D	D
TPE	0.016	D	D	D	D
Plasticized PP (formulation 1)	0.015	0.001	D	D	D
Plasticized PP (formulation 2)	0.013	0.001	0.001	D	D
P(VDF-HFP)	0.218	0.087	0.053	0.038	0.026
Fluoroelastomer	0.173	0.072	0.045	0.034	0.024
Rigid Tubings					
Polyamide	.089 (.081)	.021 (.011)	.013 (.006)	0.011	0.008
PP	0.133	0.049	0.031	0.023	0.018
Polyester lining in PVC shell	0.022	0.002	0.001	0.001	0.001
LDPE	0.038	0.010	0.006	0.004	0.003
XLPE	0.036	0.009	0.006	0.004	0.003
PE lining in EVA shell	0.042	0.008	0.003	0.002	0.001
PE cross-linked to EVA shell	0.036	0.006	0.002	0.001	0.001
ETFE	.468 (.574)	.248 (.351)	.136 (.227)	0.097	0.068
PTFE	.535 (.496)	.264 (.211)	.175 (.131)	0.123	0.100
PFA	0.605	0.343	0.224	0.181	0.135
PVDF	0.609	0.410	0.282	0.229	0.183
FEP-lined PE	0.719	0.544	0.418	0.329	0.251
FEP	0.704	0.512	0.365	0.286	0.225

1 = For a given analyte and time, normalized concentrations equal the mean concentration (mg/L) in solution exposed to tubing divided by the mean concentration (mg/L) in the test solution blank.

2 = Percent RSD values for raw data ranged from 0 percent to 44 percent, with 81 percent of the %RSD values 10 percent or less.

D = Analyte concentrations were less than MDL, 0.0086 mg/L.

( ) = Values in parentheses are adjusted to a material surface-area-to-solution-volume ratio equivalent to the other tubing materials.

Table 3

Means of Normalized[1] Concentrations of Tetrachloroethylene (PCE) in Solutions Exposed to Polymeric Tubing[2]

	Exposure Time (Hour)				
	1	8	24	48	72
Flexible Tubings					
Polyurethane	0.019	0.002	0.002	0.001	0.001
PVC	0.018	0.002	0.001	0.001	0.001
TPE	0.018	0.001	0.0004	D	D
Plasticized PP (formulation 1)	0.017	0.001	0.0005	0.0005	0.001
Plasticized PP (formulation 2)	0.015	0.001	0.001	0.0005	D
P(VDF-HFP)	0.287	0.134	0.076	0.063	0.043
Fluoroelastomer	0.224	0.106	0.058	0.048	0.034
Rigid Tubings					
Polyamide	.169 (.155)	.049 (.032)	.027 (.016)	0.023	0.018
PP	0.131	0.049	0.028	0.024	0.019
Polyester lining in PVC shell	0.031	0.005	0.003	0.002	0.002
LDPE	0.043	0.012	0.006	0.005	0.003
XLPE	0.042	0.012	0.007	0.005	0.004
PE lining in EVA shell	0.046	0.008	0.004	0.003	0.002
PE cross-linked to EVA shell	0.042	0.010	0.004	0.003	0.004
ETFE	.449 (.557)	.246 (.352)	.126 (.234)	0.105	0.076
PTFE	.392 (.345)	.149 (.111)	.092 (.066)	0.069	0.058
PFA	0.463	0.225	0.120	0.107	0.081
PVDF	0.747	0.600	0.412	0.397	0.336
FEP-lined PE	0.576	0.375	0.246	0.196	0.143
FEP	0.573	0.351	0.212	0.173	0.133

1 = For a given analyte and time, normalized concentrations equal the mean concentration (mg/L) in solution exposed to tubing divided by the mean concentration (mg/L) in the test solution blank.

2 = Percent RSD values for raw data ranged from 0 percent to 40 percent, with 71 percent of the %RSD values 10 percent or less.

D = Analyte concentrations were less than MDL, 0.0035 mg/L.

( ) = Values in parentheses are adjusted to a material surface-area-to-solution-volume ratio equivalent to the other tubing materials.

Table 4

Means of Normalized[1] Concentrations of Nitrobenzene (NB) in Solutions Exposed to Polymeric Tubing[2]

	Exposure Time (Hour)				
	1	**8**	**24**	**48**	**72**
Flexible Tubings					
Polyurethane	0.071	0.027	0.021	0.021	0.014
PVC	0.108	0.082	0.098	0.112	0.073
TPE	0.149	0.049	0.033	0.022	0.013
Plasticized PP (formulation 1)	0.210	0.076	0.038	0.018	0.009
Plasticized PP (formulation 2)	0.202	0.066	0.029	0.013	0.009
P(VDF-HFP)	0.669	0.474	0.353	0.274	0.205
Fluoroelastomer	0.610	0.415	0.297	0.242	0.185
Rigid Tubings					
Polyamide	.688 (.675)	.446 (.403)	.292 (.235)	0.221	0.173
PP	0.934	0.863	0.808	0.748	0.674
Polyester lining in PVC shell	0.129	0.048	0.038	0.030	0.028
LDPE	0.734	0.559	0.422	0.339	0.261
XLPE	0.730	0.536	0.405	0.323	0.261
PE lining in EVA shell	0.721	0.494	0.302	0.154	0.080
PE cross-linked to EVA shell	0.688	0.459	0.247	0.126	0.068
ETFE	.956 (.969)	.889 (.912)	.825 (.860)	0.758	0.676
PTFE	1.00 (.985)	.956 (.944)	.950 (.921)	0.925	0.910
PFA	0.987	1.00	0.974	0.963	0.938
PVDF	0.858	0.774	0.701	0.605	0.540
FEP-lined PE	0.976	1.01	0.997	0.985	0.946
FEP	0.981	0.989	0.990	0.967	0.941

1 = For a given analyte and time, normalized concentrations equal the mean concentration (mg/L) in solution exposed to tubing divided by the mean concentration (mg/L) in the test solution blank.

2 = Percent RSD values for raw data ranged from 0 percent to 20 percent, with 88 percent of the %RSD values 5 percent or less.

D = Analyte concentrations were less than MDL, 0.0017 mg/L.

( ) = Values in parentheses are adjusted to a material surface-area-to-solution-volume ratio equivalent to the other tubing materials.

The percent relative standard deviations (%RSD) for the test solution blank or control replicates were 5 percent or less in both studies (Parker and Ranney 1996). Generally, the %RSDs for the solutions exposed to the tubings were also 5 percent or less for NB (Table 4) and 10 percent or less for the more sorptive analytes, PDCB and PCE (Tables 2 and 3). As would be expected, higher %RSDs were found in cases where the solution concentrations approached the detection limit.

All the tubings sorbed at least some of the more sorption-prone or hydrophobic analytes. For some tubings, sorption of some organic solutes was rapid (i.e., losses equaled or exceeded 95 percent after only a one-hour contact time; Table 5). Generally, the flexible tubings, except for the two fluorinated products (the fluoroelastomer and P[VDF-HFP]), were the most highly sorptive tubings tested. Among the rigid materials, the polyester-lined PVC and the four polyethylene materials (LDPE, XLPE, PE cross-linked to an ethyl vinyl acetate [EVA] shell, PE-lined EVA) were the most highly sorptive.

Table 6 summarizes the results of our statistical analyses by listing the least sorptive materials for each of the analytes. We see that generally the rigid fluoropolymers (FEP, FEP-lined PE, PVDF, PTFE, PFA, ETFE) were the least sorptive. Specifically, PVDF was the least sorptive material for TDCE, TCE, and PCE, and FEP and FEP-lined PE were the second least sorptive materials. For the other five analytes (NB, MNT, CLB, ODCB, PDCB), FEP-lined PE was the least sorptive material and FEP was the second least sorptive material. It is not clear why FEP-lined PE performed better than the FEP for most of these analytes, especially given that the PE materials are much more sorptive. Sorption of the organic solutes by FEP and PVDF roughly correlates with the polarity of the organic solutes and the fluoropolymers. That is, the more polar PVDF (Brandrup and Immergut 1989) was more sorptive of the more polar organic solutes tested (NB, MNT, CLB, ODCB) than FEP was, and FEP was more sorptive of the less polar compounds (PCE, TCE, TDCE), with the exception of PDCB. We believe that these losses could be successfully modeled using the multiparameter linear solvation energy relationships (acidity, basicity, polarity/polarizability, and molecular volume) used by Leggett and Parker (1994) for rigid PVC and PTFE.

Even though FEP, FEP-lined PE, and PVDF were generally the least sorptive materials tested, they were still highly sorptive of the more hydrophobic analytes such as PCE and PDCB. For example, after 24 hours, losses of these two analytes by these three materials ranged from approximately 60 to 80 percent. Clearly, long-term storage of aqueous solutions of organic compounds in fluoropolymer containers would be problematic.

Leaching Study

When the chromatograms of sample solutions exposed to the tubings were compared with the control sample solutions, additional or spurious peaks were

Table 5

Mean Percent Loss of Analytes[1] in Solutions Exposed to Various Polymeric Tubings for One Hour[2]

Tubing Material	Analytes							
Flexible tubings	NB	TDCE	MNT	TCE	CLB	ODCB	PDCB	PCE
Fluoroelastomer	39	38	66	55	66	80	83	78
Polyurethane	93	96	96	98	98	98	98	98
PVC	89	94	96	97	98	98	99	98
TPE	85	96	94	98	98	98	98	98
Plasticized PP (formulation 1)	79	94	93	98	98	98	98	98
Plasticized PP (formulation 2)	80	95	93	98	98	98	99	98
P(VDF-HEP)	31	33	59	47	58	75	78	71
Rigid tubings								
Polyamide	31(32)	42(44)	54(55)	68(70)	75(77)	89(90)	91(92)	83(84)
PP	7	44	20	64	66	81	87	87
Polyester-lined PVC	87	90	94	95	96	98	98	97
LDPE	37	69	57	86	89	95	96	96
XLPE	37	69	58	86	89	95	96	96
PE-lined EVA	28	71	57	86	90	94	96	95
PE cross-linked to EVA shell	31	73	61	87	90	95	96	96
ETFE[1]	4(3)	37(29)	10(7)	39(30)	34(26)	38(30)	53(43)	55(44)
PTFE[1]	0(2)	24(28)	3(3)	33(37)	24(27)	31(34)	46(50)	61(66)
PFA	1	20	3	28	20	25	40	54
PVDF	14	12	28	15	24	37	39	25
FEP-lined PE	2	19	3	23	16	18	28	42
FEP	2	15	3	21	14	18	30	43

[1] For each analyte, mean percent loss equals (1.0-normalized concentration) times 100.

[2] Values in parentheses are adjusted to a materials surface-area-to-solution-volume ratio equivalent to the other 17 tubings.

Table 6

Least Sorptive Tubings Based on the LSD Test Results from Parker and Ranney (1996)

Analyte	Least Sorptive Tubings	Second Least Sorptive Tubings	Third Least Sorptive Tubings	Fourth Least Sorptive Tubings
NB nitrobenzene	FEP-lined PE FEP PFA	PTFE	ETFE	PVDF
TDCE trans-dichloroethylene	PVDF	FEP FEP-lined PE	PFA	PTFE
MNT m-nitrotoluene	FEP-lined PE	FEP	PFA	PTFE
TCE trichloroethylene	PVDF	FEP-lined PE FEP	PFA	PTFE
CLB chlorobenzene	FEP-lined PE	FEP	PFA	PVDF
ODCB o-dichlorobenzene	FEP-lined PE	FEP	PFA	PTFE PVDF
PDCB p-dichlorobenzene	FEP-lined PE	FEP	PVDF	PFA
PCE tetrachloroethylene	PVDF	FEP-lined PE FEP	ETFE PFA PTFE	P(VDF-HFP) Fluoroelastomer

Table 7
Number of Spurious HPLC Peaks Found in Solutions Exposed to Tubing Materials and Possible Identity of Leachates

	Contact time (hour)		
	1	72	Possible Identification (Percent Match)
Flexible Tubings			
Plasticized PP (formulation 1)	1	1	not identified
Plasticized PP (formulation 2)	0	0	
PVC	3	8	hexacosane (90 percent)
TPE	1	4	hexanedioic acid, dioctyl ester (83 percent)
P(VDF-HFP)	1	1	not identified
Polyurethane	5	12	hexanoic acid, 2-ethyl (78 percent)
Fluoroelastomer	1	1	not identified
Rigid Tubings			
LDPE	0	0	
XLPE	0	0	
PE-lined EVA	0	0	
PE cross-linked to EVA shell	0	0	
Polyester-lined PVC	1	4	not identified
PP	1	1	hexanedioic, dioctyl ester (87 percent)
Polyamide	2	9	benzenesulfonamide, N-butyl (90 percent)
PTFE	0	0	
PFA	0	0	
ETFE	0	0	
PVDF	0	0	
FEP	0	0	
FEP-lined PE	0	0	

seen in the solutions exposed to some of the tubings, indicating that some constituents had leached. After 72 hours, solutions exposed to nine of the tubings had spurious peaks (Table 7). The chromatograms for the solutions exposed to the polyurethane, polyamide, and PVC tubings contained the most spurious peaks. The chromatograms for the solutions exposed to the rigid fluoropolymers, the polyethylenes, and one of the plasticized polypropylenes (formulation 2) did not contain any spurious peaks. This plasticized polypropylene tubing was the only flexible tubing that did not appear to leach any constituents. We should note that UV detectors are not universal detectors and there are many organic compounds that would not be detected with this type of detector.

Test solutions that contained leached constituents were analyzed for semi-volatile organic compounds by GC/MS to determine the identity of some of the analytes. Only those matches where the quality of the match was greater than 75 percent are shown (Table 7). The leachates that were tentatively identified were primarily plasticizers and lubricants such as hexanedioic dioctyl ester from the PP and TPE tubings, n-butyl-benzene sulfonamide from the polyamide tubing, and 2-ethyl hexanoic acid from the polyurethane tubing. Gron et al. (1996) also reported finding n-butyl-benzenesulfonamide leaching from polyamide tubing. Hexacosane (a 26-carbon alkane) leached from the PVC tubing, but we cannot explain its presence unless it was used as a lubricant.

Based on the leaching findings, the least desirable tubings for sampling organic solutes are polyurethane, polyamide, (flexible) PVC, polyester-lined PVC, and silicone-modified thermoplastic elastomer. The most desirable tubings are those where either one or no leached constituents were detected (i.e., all four polyethylene tubings, the fluoropolymer tubings, and the polypropylene tubings, both plasticized and unplasticized)

Conclusions

Based on the results from these studies, the rigid fluoropolymers appear to be the best suited for sampling ground water because they were the least sorptive of organic solutes and they did not leach any detectable constituents. Among the fluoropolymers, FEP, FEP-lined PE, and PVDF were the least sorptive materials tested.

In instances where a more flexible tubing is required (e.g., in the head of a peristaltic pump), the two fluorinated tubings [the fluoroelastomer and P(VDF-HFP)] were much less sorptive of organic solutes than the other flexible tubings. In addition, only one constituent was detected leaching from each of these two tubings.

The tubings with the poorest performance with respect to both sorption and leaching were the polyurethane and flexible PVC tubing. However, the polyamide, polyester-lined PVC, and silicone-modified thermoplastic elastomer would also be undesirable if they continued to leach organic constituents under dynamic conditions as Gron et al. (1996) observed with polyamide in their field studies.

Because the fluoropolymer tubings are expensive, it would be desirable to use a less expensive material if it did not impact sample quality during the relatively short contact time typical of most sampling situations. It is possible that the biases we observed in this study may either increase or decrease under dynamic conditions. With respect to sorption of organic solutes, we expect that losses due to sorption would be reduced, or possibly eliminated, with time as equilibrium is approached.

Leaching of constituents, however, may increase or decrease with exposure. Several leaching studies (Packham 1971a and 1971b; Gross et al. 1974; Boettner et al. 1981) have shown that much of the leaching that occurs from rigid PVC pipe decreases with time and is considered a surface phenomenon. If leaching of contaminants from other polymers is primarily a surface phenomenon, then we would expect that leaching would decrease with time. On the other hand, if leaching still occurs with continued flushing, as Junk et al. (1974) observed with flexible PVC, then leaching rather than sorption may dictate which tubings are suitable for sampling ground water.

We used the findings in this study to evaluate sorption and leaching under dynamic conditions, and those results will be published as Part II of this paper in the Winter 1998 of this journal.

Acknowledgments

We thank the U.S. Army Environmental Center (USAEC), Aberdeen Proving Ground, Maryland, and Martin H. Stutz, project monitor, for their support of this work. We also thank the technical reviewers for their comments.

This publication reflects the personal views of the authors and does not suggest or reflect the policy, practices, programs, or doctrine of the U.S. Army or Government of the United States. The contents of this report are not to be used for advertising or promotional purposes. Citation of brand names does not constitute an official endorsement or approval of the use of such commercial products.

References

Barcelona, M.J., J.A. Helfrich, and E.E. Garske. 1985. Sampling tubing effects on ground water samples. *Analytical Chemistry* 57, no. 2: 460–464.

Boettner, E.A., G.L. Ball, Z. Hollingsworth, and R. Aquino. 1981. *Organic and organotin compounds leached for PVC and CPVC pipe.* U.S. EPA, report number EPA-600/1-81-062, Cincinnati, Ohio: Office of Research and Development.

Brandrup, J., and E.H. Immergut. 1989. *Polymer handbook. Third Edition.* New York: John Wiley and Sons Inc.

Curran, C.M., and M.B. Tomson. 1983. Leaching of trace organics into water from five common plastics. *Ground Water Monitoring Review* 3, no. 3: 68–71.

Devlin, J.F. 1987. Recommendations concerning materials and pumping systems used in the sampling of groundwater contaminated with volatile organics. *Water Pollution Research Journal of Canada* 22, no. 1: 65–72.

Federal Register. 1984. Definition and procedure for the determination of the method detection limit. Code of Federal Regulations, Part 136, Appendix B, October 26. *Federal Register* 49, no. 209: 43430-43431.

Gillham, R.W., and S.F. O'Hannesin. 1990. Sorption of aromatic hydrocarbons by materials used in construction of ground-water sampling wells. In *Ground water and vadose zone monitoring*, ASTM STP 1053, 108–122. Philadelphia, Pennsylvania: American Society for Testing and Materials.

Gron, C., J.O. Madsen, Y. Simonsen, and H. Boren. 1996. Contamination of ground water samples from well installations. *Environmental Technology* 17, no. 6: 613–619.

Gross, R.C., B. Engelbart, and S. Walter. 1974. *Aqueous extraction of lead stabilizers from PVC compounds.* Society of Plastic Engineering Technical Paper 20, 527–531. Brookfield, Connecticut: Society of Plastic Engineers.

Ho, J.S.-Y. 1983. Effect of sampling variables on recovery of volatile organics in water. *Journal of the American Water Works Association* 75, no. 11: 583–586.

Junk, G.A., H.J. Svec, R.D. Vick, and M.J. Avery. 1974. Contamination of water by synthetic polymer tubes. *Environmental Science and Technology* 8, no. 13: 1100–1106.

Leggett, D.C., and L.V. Parker. 1994. Modeling the equilibrium partitioning of organic contaminants between PTFE, PVC, and groundwater. *Environmental Science and Technology* 28, no. 7: 1229–1233.

Miller, G.D. 1982. Uptake and release of lead, chromium, and trace level volatile organics exposed to synthetic well casings. In *Proceedings of the Second National Symposium on Aquifer Restoration and Ground Water Monitoring*, 236–245, by National Water Well Association and National Center for Ground Water Research. Worthington, Ohio: NWWA.

Packham, R.F. 1971a. The leaching of toxic substances from unplasticized PVC pipe. Part I. A critical study of laboratory test procedures. *Water Treatment and Examination* 20, no. 2: 144–151.

Packham, R.F. 1971b. The leaching of toxic substances from unplasticized PVC pipe. Part II. A survey of lead levels in PVC distribution systems. *Water Treatment and Examination* 20, no. 2: 152–164.

Parker, L.V., and T.A. Ranney. 1994. Effect of concentration on sorption of dissolved organics by PVC, PTFE, and stainless steel well casings. *Ground Water Monitoring and Remediation* 14, no. 3: 139–149.

Parker, L.V., and T.A. Ranney. 1996. *Sampling trace-level organics with polymer tubings.* CRREL special report 96-3. Hanover, New Hampshire: US Army Cold Regions Research and Engineering Laboratory.

Parker, L.V., A.D. Hewitt, and T.F. Jenkins. 1990. Influence of casing materials on trace-level chemicals in well water.

Ground Water Monitoring Review 10, no. 2: 146–156.

Pearsall, K.A., and D.A.V. Eckhardt. 1987. Effects of selected sampling equipment and procedures on the concentrations of trichloroethylene and related compounds in ground water samples. *Ground Water Monitoring Review* 7, no. 2: 64–73.

Reynolds, G.W., and R.W. Gillham. 1985. Absorption of halogenated organic compounds by polymer materials commonly used in ground water monitors. In *Proceedings of Second Canadian/American Conference on Hydrogeol-ogy: Hazardous Wastes in Ground Water: A Soluble Dilemma*, 125-132, by National Water Well Association. Dublin, Ohio: NWWA.

Salame, M., and J. Pinsky. 1962. Permeability prediction. *Modern Packaging* 37, no. 9: 153.

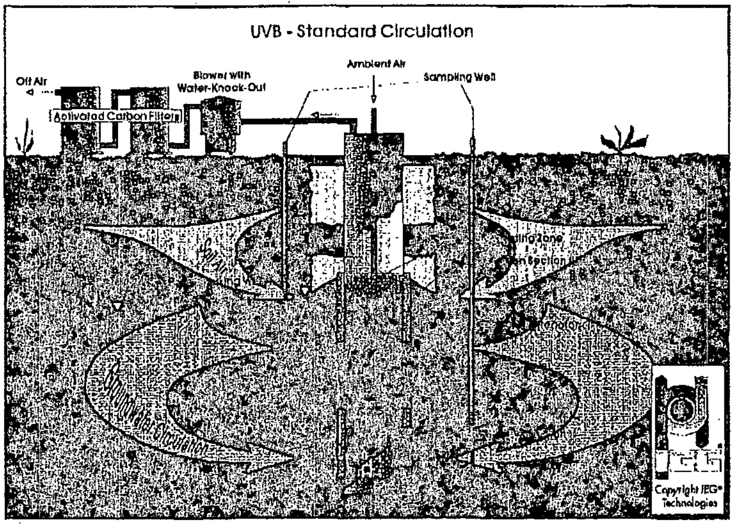
Serota, D.G., M.C. Meyer, and J. Autian. 1972. Effects of structure on permeability of substituted anilines from aqueous solution through polyethylene. *Journal of Pharmaceutical Sciences* 61, no. 3: 416–419.

Yasuda, H., and V. Stannett. 1975. Permeability coefficients. In *Polymer handbook*, eds. J. Brandrup and E.H. Immergut, 2nd edition, III-229 to III-240. New York: Wiley Interscience Publications.

Biographical Sketches

Louise V. Parker *is a research physical scientist at the U.S. Army Cold Regions Research and Engineering Laboratory (72 Lyme Road, Hanover, NH 03755-1290). She received her B.A. in microbiology from the University of New Hampshire and her M.S. in food science and nutrition from the University of Massachusetts. Her research interests are in material interactions in ground water sampling, including recent studies on decontaminating ground water sampling devices. She is a member of the Association of Ground Water Scientists and Engineers and has been active in ASTM subcommittee D18.21 on Ground Water and Vadose Zone Investigations.*

Thomas A. Ranney is a staff scientist with Science and Technology Corp. (P.O. Box 127, Hanover, NH 03755). He received his B.S. in education from Castleton State College and his M.S. in plant and soil science from the University of Vermont. His research interests are evaluating environmental sampling procedures and development of analytical methods.



Potential of Common Well Casing Materials to Influence Aqueous Metal Concentrations

by Alan D. Hewitt

Abstract

Static leaching and sorption laboratory studies were performed to assess the potential of polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), and two types of stainless steel (SS 304 and SS 316) well casing materials to influence metal concentrations in ground water solutions with low dissolved oxygen. Overall, PTFE was inert, whereas one or both stainless steels significantly altered the solution concentrations of Cd, Cr, Cu, Pb, Fe, and Ni. PVC was generally more reactive than PTFE, but did not significantly alter the solution metal concentrations as often, or as greatly, as either of the stainless casings.

Introduction

The validity of estimates of analyte concentration in ground water samples collected from monitoring wells has recently received considerable attention. This issue, with regard to the selection of a monitoring well construction material, stems from the U.S. Environmental Protection Agency (U.S. EPA) recommendation that stainless steel and polytetrafluoroethylene (PTFE) be used instead of polyvinyl chloride (PVC) when volatile organic compounds will be analyzed during the well's lifetime (U.S. EPA 1986). Because screening for all hazardous waste analytes regulated by the U.S. EPA must be performed at least once, this recommendation is interpreted by some agencies as prohibiting the use of PVC.

A review of the literature published prior to 1986 reveals no substantial evidence (nor were any references provided in U.S. EPA [1986]) for the basis of this decision. Subsequent well casing studies concerned with material effects on solution analyte concentration have observed the following. During ground water sample collection from steel and stainless steel (SS) wells under stagnant condition and after purging, leaching of Fe, Cd, Cr, and Mn has been observed (Houghton and Berger 1984, Barcelona and Helfrich 1986). Laboratory studies monitoring the metals listed in the National Interim Primary Drinking Water Regulations (NIPDWR, Table 1), found either or both SS 316 and SS 304 to affect the solution concentration of Ba, Cr, Cu, and Pb, while PVC and PTFE were far less influential (Hewitt 1989, Parker et al. 1990). Laboratory studies concerned with organic analytes (Gillham and O'Hannesin 1988, Parker et al. 1990, Reynolds et al. 1990) reported that sorption of several halogenated compounds (i.e., tetrachloroethylene) was more rapid for TFE than PVC. Although none of these studies can predict the actual effects that will be incurred when sampling from a well, they do address the issue of material inertness. As the time between well purging and sampling diminishes, so does the issue of well casing material effects (Nielsen 1988).

In this study, leaching and sorption experiments were performed comparing PVC, PTFE, SS 304 and SS 316 well casing materials in low dissolved oxygen (DO) solutions. The low DO condition was imposed to eliminate the development of visible surface oxidation on the stainless casings. In previous studies (Hewitt 1989, Parker et al. 1990) roughly half of the stainless steel casings developed rust sites. Surface oxidation, presumably by galvanic action, could explain the significant effects observed for the stainless steels. In addition, the low-DO condition addresses the anoxic conditions common to very deep wells, where material strength requirements, combined with U.S. EPA material recommendations, currently limit well casing selection to only the stainless steels.

Materials and Methods

Materials

Sections of PVC, PTFE, SS 304, and SS 316 well casings (1.2m long, 5.0cm I.D.) specifically manufactured (factory cleaned) for ground water monitoring

TABLE 1
National Interim Primary Drinking Water Regulation Levels (*Federal Register* 1975)

Metal	NIPDWR Levels (μg/L)
As	50
Ba	1000
Cd	10
Cr	50
Pb	50
Hg	2
Se	10
Ag	50

V. 12, N. 2

were cut in approximately 2 cm lengths. The exact lengths of the casing rings were adjusted based on the pipe's diameter and wall thickness to normalize the surface area (80 cm^2). During pipe milling (cutting and edge filing), precautions were taken to prevent exposure to grease, dirt, solvents, and other foreign substances. Casing rings were individually rinsed several times prior to use with deionized distilled water, and air dried in a Class 100 clean air station. All cleaning and subsequent operations were performed within a cleanroom complex, and plastic gloves or nylon tweezers were used to handle the rings.

Polypropylene jars (69 mm O.D. x 62 mm high, 125 mL) were used as exposure vessels for individual casing rings. These vessels and all other materials (i.e., collection bottles, tubing, etc.) that came into contact with the well water were appropriately cleaned with either dilute nitric acid or soap and water followed by several rinses with deionized distilled water. A glove bag served as the nitrogen environmental chamber for these low-DO experiments. The ground water used here and previously (Hewitt 1989, Parker et al. 1990) was collected from a 76 m-deep domestic artesian well located in Weathersfield, Vermont.

Test Design and Setup

Experiments designed to study both the sorption and leaching of metals were performed in a positive nitrogen atmospheric chamber. Low dissolved oxygen water was created by purging with nitrogen, thereby lowering this constituent from its native level of 9.0 mg/L to below 1.0 mg/L (Table 2). In the leaching experiment, the metals analyzed were Cd, Cr, Cu, Pb, Fe, and Ni. The sorption experiment studied the solution concentrations of Cd, Cr, Cu, and Pb, introduced at concentrations that were approximately one-fifth the NIPDWR (Table 1). The concentration of native Fe in the water was also monitored in the sorption study. The metal analytes in this study were major constituents of stainless steel or had previously been found to be influenced by casing materials (Hewitt 1989, Parker et al. 1990). Hewitt (1991) provides a more detailed discussion of the experimental setup and procedure.

For the leaching experiment, triplicates of each casing material and the control (no casing) were prepared for treatment periods of two, eight, 24, and 120 hours. Casing rings were submerged in 60 mL of water inside capped vessels. After treatment each casing ring was removed from the vessel and the remaining solution (60 mL) was acidified, thus sacrificing the sample and vessel. This sample collection method was deemed necessary for the leaching study, because released metals, particularly cations, could be lost to the plastic vessel walls (Masse et al. 1981). In addition to the samples and control, four additional vessels without well casings were included, one for each exposure period, to monitor pH, DO, and oxidation/reduction potential (ORP).

The sorption study followed this same experimental design, with triplicates of the four casing materials and the control, and a vessel for monitoring the solution parameters for each treatment period. Here, sample aliquots of 2.5 mL were removed and acidified after two, eight, 24, and 72 hours of treatment, from an initial solution volume of 100 mL. Sample aliquots could be removed in this fashion because the controls could account for the loss of metals to the vessel walls.

Analysis

Metal analyses were performed using Graphite Furnace Atomic Absorption (GFAA) with a Perkin-Elmer

TABLE 2
Ground Water Parameters Measured In Situ and for Experimental Monitoring Solutions

	DO (mg/L)	pH	ORP (mV)	Conductance (μmhos)
In situ ground water	9.0	7.4	280	*230
Leaching experiment monitoring solutions				
Stock	0.4	8.4	190	240
2 hr	1.3	8.4	180	—
8 hr	1.2	8.4	180	—
24 hr	1.7	8.7	180	—
120 hr	0.6	8.9	170	—
Sorption experiment monitoring solutions				
Stock	0.9	8.1	200	—
2 hr	1.8	8.1	—	—
8 hr	1.6	8.1	190	—
24 hr	0.8	8.5	170	—
72 hr	0.3	8.9	150	—

*Conductivity of ground water measured just prior to purging.

TABLE 3

Summary of Statistical Analyses for Average Analyte Concentrations (µg/L) During the Leaching Experiment. (Materials with common underlining are not different at the 95 percent confidence level as determined by the least significant difference [LSD].)

	Time	Well Casing				
Static Leaching Experiment						
Cadmium						
	2 hr	Control	PTFE	PVC	SS 304	SS316
		0.03	0.04	0.10	0.22	0.36
		———	———	———		
(LSD = 0.16)				———	———	
					———	———
	8 hr	Control	PTFE	PVC	SS 304	SS 316
		0.03	0.03	0.22	0.40	0.49
		———	———	———		
(LSD = 0.36)				———	———	———
	24 hr	Control	PTFE	SS 304	SS 316	PVC
		0.03	0.03	0.17	0.20	0.27
(LSD = 0.29)		———	———	———	———	———
	120 hr	Control	PTFE	SS 316	SS 304	PVC
		0.03	0.03	0.04	0.09	0.24
(LSD = 0.28)		———	———	———	———	———
Chromium						
	2 hr	Control	PTFE	SS 304	PVC	SS 316
		0.24	0.28	0.62	0.72	1.35
(LSD = 1.12)		———	———	———	———	———
	8 hr	Control	PTFE	PVC	SS 316	SS 304
		0.29	0.35	0.38	2.04	4.44
(LSD = 5.91)		———	———	———	———	———
	24 hr	Control	PTFE	PVC	SS 316	SS 304
		0.28	0.30	0.68	1.89	2.29
(LSD = 2.59)		———	———	———	———	———
	120 hr	PTFE	Control	PVC	SS 316	SS 304
		0.34	0.37	0.38	2.19	3.06
(LSD = 3.25)		———	———	———	———	———
Copper						
	2 hr	Control	PTFE	PVC	SS 304	SS 316
		0.47	1.13	1.85	6.90	31.2
		———	———	———	———	
(LSD = 11.5)						———
	8 hr	Control	PTFE	PVC	SS 304	SS 316
		0.49	0.73	1.44	5.02	25.3
		———	———	———	———	
(LSD = 15.3)						———
	24 hr	Control	PTFE	PVC	SS 304	SS 316
		0.50	0.70	2.35	8.09	20.0
		———	———	———	———	
(LSD = 8.67)						———
	120 hr	Control	PTFE	PVC	SS 304	SS 316
		0.49	0.99	1.66	3.56	16.2
		———	———	———	———	
(LSD = 7.02)						———
Lead						
	2 hr	Control	PTFE	SS 304	SS 316	PVC
		0.10	0.14	0.55	0.79	0.94
(LSD = 0.98)		———	———	———	———	———
	8 hr	Control	PTFE	PVC	SS 316	SS 304
		0.10	0.18	0.36	0.95	6.58
(LSD = 11.7)		———	———	———	———	———
	24 hr	Control	PTFE	SS 316	PVC	SS 304
		0.10	0.18	0.27	0.93	1.42
		———	———	———		
(LSD = 0.59)					———	———
	120 hr	Control	PTFE	SS 316	PVC	SS 304
		0.10	0.12	0.34	0.36	1.65
		———	———	———	———	
(LSD = 0.55)						———
Iron						
	2 hr	Control	PTFE	PVC	SS 304	SS 316
		9.93	11.4	12.0	16.7	22.7
		———	———	———	———	
(LSD = 7.65)					———	———
	8 hr	Control	PVC	PTFE	SS 304	SS 316
		9.77	11.0	13.4	14.9	55.6
(LSD = 85.8)		———	———	———	———	———
	24 hr	PTFE	Control	PVC	SS 304	SS 316
		9.50	9.80	11.5	20.0	28.9
		———	———	———	———	
(LSD = 16.1)					———	———
	120 hr	PVC	PTFE	Control	SS 316	SS 304
		9.10	9.60	10.0	17.1	48.2
(LSD = 40.8)		———	———	———	———	———
Nickel						
	2 hr	Control	PVC	PTFE	SS 304	SS 316
		2.2	2.2	2.4	3.2	13.5
		———	———	———	———	
(LSD = 6.9)						———
	8 hr	Control	PTFE	PVC	SS 304	SS 316
		2.2	2.2	2.2	3.52	16.0
		———	———	———	———	
(LSD = 5.2)						———
	24 hr	Control	PTFE	PVC	SS 304	SS 316
		2.2	2.2	2.2	5.0	10.4
		———	———	———	———	
(LSD = 3.0)						———
	120 hr	Control	PVC	PTFE	SS 304	SS 316
		2.2	2.2	2.4	6.1	12.0
		———	———	———	———	
(LSD = 8.7)					———	———

Model 403 Atomic Absorption Spectrophotometer (AAS) coupled with a Perkin-Elmer Model 2200 heated graphite atomizer. Instrumental procedures followed the guidelines provided in the manufacturer's instrument manual (Perkin-Elmer 1981). The analytical procedures were designed to achieve method detection limits (MDLs) below 1 percent of the NIPDWR levels (Table 1). The MDLs were established as described in the *Federal Register* (1984).

Dissolved oxygen, pH, and ORP were determined spectrophotometrically using high-range AccuVac reagent vials (Hach 25150) and a Dr/2 spectrometer (Hach), with a semimicro glass combination Ross Model 81-03 electrode (Orion), and with a Model 97-78-00 platinum redox electrode (Orion), respectively.

For each experiment and metal the data for the sample triplicates of each casing material and control were subjected to a one-way analysis of variance (ANOVA) and a least-significant-difference (LSD) test at the 95 percent confidence level.

Results

Leaching Experiment

Table 3 shows the results for the statistical analyses of the Cd, Cu, Cr, Pb, Fe, and Ni concentrations determined. PTFE was not observed to leach any of the metals determined, relative to the control. PVC leached significantly more Pb for the 24-hour treatment period, while SS 304 leached more Pb for the 24- and 120-hour treatment periods and more Cd for the two- and eight-hour treatment periods, relative to PTFE and the control. Stainless steel 316 leached significantly more Cd for two- and eight-hour treatment periods, and frequently leached more Cu, Fe, and Ni in comparison to PTFE, PVC, and the control. Ranking the materials based on their tendency to leach the metals studied shows that PTFE < PVC < SS 304 << SS 316.

Sorption Experiment

Table 4 shows the results of the statistical analyses for the spiked metals and native Fe. This analysis did not reveal any statistically significant differences between PTFE and the control or between PVC and PTFE. Stainless steel 316 showed significant leaching of Cu and sorption of Pb for three out of four treatment periods, while SS 304 sorbed more Cd, Cr, and Pb for at least half the treatment periods relative to PTFE, PVC, and the control. Ranking the materials based on their ability to sorb the metals studied shows that PTFE < PVC < SS 316 << SS 304.

Discussion

From the time of ground water collection to the end of each of the experiments there were shifts in chemical equilibria. The low DO condition, however, did prevent visible surface oxidation from forming on the stainless steel casings, as was observed in our earlier studies (Hewitt 1989, Parker et al. 1990). The DO in earlier efforts was around 9.0 mg/L, the same as the in situ concentration determined for this study (Table 2). This high level of DO has previously been cited as being corrosive (Aller et al. 1989).

Assessing first those metals that are major constituents of one of the materials tested reveals the expected: the two stainless casings leached Fe, Ni, and Cr (Table 3), and SS 304 sorbed Cr (Table 4). Clearly, samples that are to be analyzed for a given analyte should not be exposed to materials containing that analyte.

With regard to the aqueous concentrations of Cd, Cu, and Pb, PTFE was the least reactive material, and the stainless steels the most reactive in terms of releasing or providing sites for sorption. This finding is also consistent with earlier laboratory studies (Hewitt 1989, Parker et al. 1990), indicating that independent of visible corrosion, active sites exist on stainless steel casings that can either release or sorb metals of concern to human health.

Common to these experiments and our previous studies (Hewitt 1989, Parker et al. 1990) were aberrant aqueous metal concentrations determined for individual samples that could be treated as outliers. In all cases the aberrant concentrations were found in samples exposed to the stainless steel casings. This frequently resulted in variances that were not homogeneous with the other casing materials. The comparison of inhomogeneous variances weakens the statistical analysis, making the interpretation overly conservative. This explains why significant differences were not distinguished in some cases where the mean concentrations were numerically different by as much as an order of magnitude. The author has chosen to handle the data in this fashion because, in his opinion, the aberrant values were not random, but inherent to the stainless steel casing material.

The application of static laboratory findings to the dynamic and environmentally sensitive conditions that exist for sampling ground water is not straightforward. However, because the two-hour treatment period showed significant leaching by both stainless steel casings and sorption by both stainless steel and PVC (Pb only) casings (Table 5), the potential material effects demonstrated here cannot be easily dismissed with respect to the time lapse between purging and sampling.

Conclusion

If only metal analytes are of concern, PTFE is the best material for ground water monitoring wells with respect to material inertness. Ground water samples analyzed for trace metals would be more suspect if taken from wells constructed with stainless steel than if taken from wells made of either PVC or PTFE. This finding holds for both corrosive (Hewitt 1989, Parker et al. 1990) and non-corrosive environments. Studies concerned with levels of aqueous organic constituents have shown PTFE to be more prone to sorption of analytes than either PVC or stainless steel (Gillham and O'Hannesin 1988, Parker et al. 1990, Reynolds et al. 1990). In terms of a material's inertness, PVC is the best compromise among those tested here, for monitoring wells installed to monitor trace levels or for the early detection of contaminants in ground water.

TABLE 4

Summary of Statistical Analyses for Average Analyte Concentrations (μg/L) During the Sorption Experiment.

(Materials with common underlining are not different at the 95 percent confidence level as determined by the least significant difference [LSD].)

	Time	Well Casing				
Sorption Experiment						
Cadmium						
	2 hr	SS 304	PTFE	Control	PVC	SS 316
		2.18	2.24	2.28	2.28	2.31
(LSD = 0.12)						
	8 hr	SS 304	SS 316	PVC	PTFE	Control
		1.85	2.16	2.19	2.22	2.25
(LSD = 0.20)						
	24 hr	SS 304	SS 316	PVC	PTFE	Control
		1.48	1.96	2.11	2.19	2.23
(LSD = 0.29)						
	72 hr	SS 304	PVC	SS 316	Control	PTFE
		0.82	1.27	1.46	2.04	2.13
(LSD = 1.42)						
Chromium						
	2 hr	SS 304	PTFE	Control	PVC	SS 316
		11.3	12.1	12.2	12.3	12.4
(LSD = 0.79)						
	8 hr	SS 304	PTFE	Control	SS 316	PVC
		10.7	12.1	12.1	12.2	12.4
(LSD = 1.36)						
	24 hr	SS 304	Control	PTFE	PVC	SS 316
		10.5	12.2	12.2	12.4	12.5
(LSD = 1.45)						
	72 hr	SS 304	SS 316	Control	PTFE	PVC
		8.36	11.4	11.9	12.1	12.5
(LSD = 4.36)						
Copper						
	2 hr	PTFE	Control	PVC	SS 304	SS 316
		10.4	10.5	10.8	12.2	23.2
(LSD = 7.42)						
	8 hr	SS 304	PTFE	PVC	Control	SS 316
		9.33	9.93	10.2	10.7	27.6
(LSD = 7.55)						
	24 hr	SS 304	PVC	PTFE	Control	SS 316
		6.84	9.41	9.61	9.91	30.0
(LSD = 7.39)						
	72 hr	SS 304	PVC	PTFE	Control	SS 316
		4.48	6.24	8.75	9.38	18.9
(LSD = 10.9)						
Lead						
	2 hr	SS 316	SS 304	PVC	PTFE	Control
		8.56	8.73	9.32	9.83	10.1
(LSD = 0.61)						
	8 hr	SS 316	SS 304	PVC	PTFE	Control
		5.17	5.73	8.49	9.54	9.98
(LSD = 1.45)						
	24 hr	SS 316	SS 304	PVC	PTFE	Control
		2.94	3.65	7.98	9.11	9.62
(LSD = 2.05)						
	72 hr	SS 316	SS 304	PVC	Control	PTFE
		1.64	2.26	4.45	8.42	8.51
(LSD = 4.50)						
Iron						
	2 hr	PVC	Control	PTFE	SS 316	SS 304
		8.76	9.11	10.9	13.2	19.6
(LSD = 16.9)						
	8 hr	Control	PTFE	PVC	SS 316	SS 304
		8.66	8.71	8.97	12.3	19.6
(LSD = 17.1)						
	24 hr	PTFE	PVC	Control	SS 316	SS 304
		7.75	8.31	8.08	11.8	18.9
(LSD = 15.6)						
	72 hr	PTFE	PVC	Control	SS 316	SS 304
		6.91	6.93	7.35	9.89	11.3
(LSD = 6.61)						

TABLE 5
Well Casing Material(s) that Leached or Sorbed a Significantly Greater Amount Relative to the Control, for a Two-Hour Treatment Period

	Metal Influenced					
	Fe	Ni	Cd	Cu	Cr	Pb
Leached	SS 316 SS 304	SS 316	SS 316 SS 304	SS 316	—	—
Sorbed	—	—	—	—	SS 304	SS 316 SS 304 PVC

Acknowledgments

This project was funded under the Corps of Engineers Environmental Quality Technology Project (AF 25) and the research was monitored by Martin H. Stutz, U.S. Army Toxic and Hazardous Materials Agency and Dr. John Cullinane, U.S. Army Engineer Waterways Experiment Station. The author thanks Louise Parker, Dr. Clarence Grant, and Dr. Thomas F. Jenkins for critical review of the text.

This publication reflects the personal views of the author and does not suggest or reflect policy, practices, programs, or doctrine of the U.S. Army or Government of the United States.

References

Aller, L., T.W. Bennett, G. Hackett, R.J. Petty, J.H. Lehr, H. Sedoris, D.M. Nielsen, and J.E. Denne. 1989. *Handbook of Suggested Practices for the Design and Installation of Ground Water Monitoring Wells.* National Water Well Association, Dublin, Ohio.

Barcelona, M.J. and J.A. Helfrich. 1986. Well construction and purging effects on ground-water samples. *Environmental Science and Technology,* v. 20, no. 11, pp. 1179–1184.

Federal Register. 1984. Definition and procedure for the determination of the method detection limit. Code of Federal Regulations, Part 136, Appendix B, October 26.

Federal Register. 1975. Maximum Allowable Limits in Drinking Water, v. 40, no. 51, pp. 11990–11998, March 14.

Gillham, R.W. and S.T. O'Hannesin. 1988. Sorption of aromatic hydrocarbons by materials used in construction of ground-water sampling wells. ASTM STP #1053, Standards Development for Ground Water and Vadose Zone Monitoring Investigations, ASTM, Philadelphia, Pennsylvania.

Hewitt, A.D. 1989. Leaching of Metal Pollutants from Four Well Casings Used for Ground-Water Monitoring. USA Cold Regions Research and Engineering Laboratory, Special Report 89-32.

Hewitt, A.D. 1991. Potential Influences of Common Well Casings on Metal Concentrations in Low Dissolved Oxygen Well Water. USA Cold Regions Research and Engineering Laboratory, CRREL Report 91-13

Houghton, R.L. and M.E. Berger. 1984. Effects of well casings composition and sampling method on apparent quality of ground water. In *Proceedings, The Fourth National Symposium and Exposition on Aquifer Restoration and Ground Water Monitoring.* National Water Well Association, Worthington, Ohio, pp. 203–213.

Nielsen, D.M. 1988. Much ado about nothing: The monitoring well construction material controversy. *Ground Water Monitoring Review,* v. 8, no. 1, pp. 4–5.

Masse, R., F.J.M.J. Maessen, and J.J.M. De Geoeij. 1981. Loss of silver, arsenic, cadmium, selenium and zinc traces from distilled water and artificial sea-water by sorption on various container surfaces. *Analytica Chimica Acta,* v. 127, pp. 181–193.

Parker, L.V., A.D. Hewitt, and T.F. Jenkins. 1990. Influence of casing materials on trace-level chemicals in well water. *Ground Water Monitoring Review,* v. 10, no. 2. pp. 146–156.

Perkin-Elmer. 1981. Analytical methods for furnace atomic absorption spectroscopy. The Perkin-Elmer Corp., Norwalk, Connecticut, Part No. B010-0108.

U.S. EPA. 1986. RCRA (Resource Conservation and Recovery Act) Ground Water Monitoring Technical Enforcement Guidance Document. U.S. Environmental Protection Agency, Washington, D.C.

Reynolds, G.W., J.T. Hoff, and R.W. Gillham. 1990. Sampling bias caused by materials used to monitor halocarbons in ground water. *Environmental Science and Technology,* v. 24, no. 1, pp. 135–142.

Biographical Sketch

Alan D. Hewitt is a research physical scientist at the Cold Regions Research and Engineering Laboratory (CRREL) (72 Lyme Rd., Hanover, NH 03755-1290). He has a B.A. in chemistry from the University of New Hampshire and an M.S. in chemical oceanography from the University of Connecticut. Present areas of interest are ground water monitoring, identification of hazardous waste in environmental samples, and the chemistry of snow and ice.

RPS JDC

404 Camp Craft Rd., Austin, TX 78746
Tel: (512) 347 7588 Fax: (512) 347 8243
Internet: www.rpsgroup.com/energy

INVESTIGATION WORK PLAN
GROUP 2

(SWMU No. 2 Drum Storage Area North Bone Yard, SWMU No. 8 Inactive Landfill, SWMU No. 9 Landfill Pond, SWMU No. 11 Spray Irrigation Area, and SWMU No. 18 Warehouse Yard)

Bloomfield Refinery
Western Refining Southwest, Inc.
#50 Rd 4990
Bloomfield, New Mexico 87413

December 2007
(Revised July 2008)

James R. Schmaltz
Environmental Manager
Western Refining Southwest, Inc.,
Bloomfield Refinery

Scott T. Crouch
Scott T. Crouch, P.G.
Senior Consultant

RPS JDC, Inc.
404 Camp Craft Rd.
Austin, TX 78746

Table of Contents

List of Sections

Table of Contents (Continued)

List of Tables

List of Figures

List of Appendices

Executive Summary

The Bloomfield Refinery, which is located in the Four Corners Area of New Mexico, has been in operation since the late 1950s. Past inspections by State and federal environmental inspectors have identified locations where releases to the environment may have occurred. These locations are generally referred to as Solid Waste Management Units (SWMUs) or Areas of Concern (AOCs).

Pursuant to the terms and conditions of an Order issued on July 27, 2007 by the New Mexico Environment Department (NMED) to San Juan Refining Company and Giant Industries Arizona, Inc. for the Bloomfield Refinery, this Investigation Work Plan has been prepared for the SWMUs designated as Group 2. This includes SWMU No. 2 Drum Storage Area North Bone Yard, SWMU No. 8 Inactive Landfill, SWMU No. 9 Landfill Pond, SWMU No. 11 Spray Irrigation Area, and SWMU No. 18 Warehouse Yard. The Order requires that San Juan Refining Company and Giant Industries Arizona, Inc. determine and evaluate the presence, nature, and extent of historical releases of contaminants at the aforementioned SWMUs. A Class I permit modification was approved on June 10, 2008 to reflect the change in ownership of the refinery to Western Refining Southwest, Inc. The operator is now Western Refining Southwest, Inc. – Bloomfield Refinery.

The planned investigation activities include soil and groundwater samples, which will be collected and analyzed for potential site-related constituents. The specific sampling locations, sample collection procedures, and analytical methods are included. These activities are based, in part, on the results of previous site investigation activities. A review of historical documentation indicates that investigations have already been conducted at SWMU No. 8 Inactive Landfill, SWMU No. 9 Landfill Pond and SWMU No. 11 Spray Irrigation Area. The New Mexico Oil Conservation Division (OCD) previously closed the Spray Irrigation Area and no further action is proposed for this SWMU.

1 Introduction

The Bloomfield Refinery is located immediately south of Bloomfield, New Mexico in San Juan County (Figure 1). The physical address is #50 Road 4990, Bloomfield, New Mexico 87413. The Bloomfield Refinery is located on 285 acres (0.45 square miles). Bordering the facility is a combination of federal and private properties. Public property managed by the Bureau of Land Management lies to the south. The majority of undeveloped land in the vicinity of the facility is used extensively for oil and gas production and, in some instances, grazing. U.S. Highway 44 is located approximately one-half mile west of the facility. The topography of the main portion of the site is generally flat with steep bluffs to the north where the San Juan River intersects Tertiary terrace deposits.

The Bloomfield Refinery is a crude oil refinery currently owned by Western Refining Southwest, Inc., which is a wholly owned subsidiary of Western Refining Company, and it is operated by Western Refining Southwest, Inc. – Bloomfield Refinery. The Bloomfield Refinery has an approximate refining capacity of 18,000 barrels per day. Various process units are operated at the facility, including crude distillation, reforming, fluidized catalytic cracking, sulfur recovery, merox treater, catalytic polymerization, and diesel hydrotreating. Current and past operations have produced gasoline, diesel fuels, jet fuels, kerosene, propane, butane, naphtha, residual fuel, fuel oils, and LPG.

On July 27, 2007, the New Mexico Environment Department (NMED) issued an Order to San Juan Refining Company and Giant Industries Arizona, Inc. ("Western") requiring investigation and corrective action at the Bloomfield Refinery. This Investigation Work Plan has been prepared for the Solid Waste Management Units (SWMUs) designated as Group 2 in the Order. This includes:

- SWMU No. 2 Drum Storage Area North Bone Yard (North Bone Yard);
- SWMU No. 8 Inactive Landfill (Landfill);
- SWMU No. 9 Landfill Pond;
- SWMU No. 11 Spray Irrigation Area; and
- SWMU No. 18 Warehouse Yard.

The location of the individual SWMUs is shown on Figure 2 and all of the SWMUs except the Warehouse Yard are located at the far eastern end of the refinery property. The Warehouse Yard is located on the far western end of the property. Only two of the SWMUs (North Bone Yard and Warehouse Yard) are still actively used by Western. The Spray Irrigation Area was previously closed by the OCD in August 1996. The Landfill and associated pond area have been inactive since 1989.

The purpose of the site investigation is to determine and evaluate the presence, nature, and extent of releases of contaminants in accordance with 20.4.1.500 New Mexico Administrative Code (NMAC) incorporating 40 Code of Federal Regulations (CFR) Section 264.101. The investigation activities will be conducted in accordance with Section IV of the Order.

2 Background

This section presents background information for each of the SWMUs, including a review of historical waste management activities for each location to identity the following:

- type and characteristics of all waste and all contaminants handled in the subject SWMU;
- known and possible sources of contamination;
- history of releases; and
- known extent of contamination.

2.1 SWMU No. 2 Drum Storage Area North Bone Yard

The North Bone Yard (Drum Storage Area) is located to the north of the fresh water pond and south of the Hammond Ditch. It is enclosed by a fence with a single entry point at the southwest corner and is used to store various pieces of equipment, including some scrap metal that is routinely shipped off-site for recycling. In addition, some empty drums may be temporarily stored in this area (see photos in Appendix A). No waste materials are currently managed in this area.

During an inspection conducted by EPA in 1984, several drums containing solvents and oils used in the refining process were noted as being stored in this area. The drums were removed from the North Bone Yard in July 1987 and placed in a designated drum storage area in the warehouse yard located on the west side of the refinery. There has not been a report of any releases from the drums in the North Bone Yard; however, there is no record of historical soil samples from this area. Monitoring well MW-1 is located within the North Bone Yard and numerous ground water samples have been collected and analyzed. The analytical results are included in Tables 1 – 4. There is no indication of ground water impacts at SWMU No. 2 based on the ground water analyses at MW-1.

2.2 SWMU No. 8 Landfill

The "landfill", which has been identified as SWMU No. 8, is a located to the east of the tank farm. In 1982, sludge was removed from the North and South Aeration Lagoons (known earlier as the North and South Oily Water Ponds) and disposed of in an off-site hazardous disposal facility. The underlying potentially contaminated soils, which were removed from beneath the North and South Aeration Lagoons, were placed in the landfill. The potential contaminants placed in the landfill in 1982 were formed during the secondary treatment of the refinery wastewaters and as such the types of and characteristics of the waste are well known. This includes the more prevalent types of hydrocarbons (e.g., BTEX and semi-volatile organics) associated with crude oil and refined petroleum products and possibly inorganic contaminants (e.g., lead and chromium) that are utilized in or are byproducts of the refining process.

This area was investigated in 1985 to support preparation of a Closure Plan for the API Wastewater Ponds, Landfill and the Landfill Pond (related documentation in Appendix B). Eight soil samples were collected from across the area of the landfill and analyzed for benzene, toluene, ethylbenzene, and xylene (BTEX), phenolics, total chromium, and total lead. The results of these analyses are included in Table 5. As indicated, all analyses were non-detect with detection limits below the applicable action levels except for benzene, which was non-detect but had detection limits above the action level. There is no map of the actual sample locations but the area of the landfill was divided into quadrants and two samples from depths of 0-6" and 6-12" were collected from the center of each quadrant.

In 1989, approximately 2,000 yards of soil were excavated and stockpiled at one location within the landfill. This activity was taken to support closure of this area and in 1991 Bloomfield filed a petition for delisting of these stockpiled materials, which had earlier been classified as a listed hazardous waste (K051 – API separator sludge from the petroleum refining industry). The stockpiled soils were sampled to support the delisting petition and the results are summarized in Table 4 of the Hazardous Waste Delisting Petition Petroleum Contaminated Soil document prepared by ERM-Rocky Mountain, Inc. in April 1991. The Environmental Protection Agency (EPA) granted the delisting petition, with an effective date of September 3, 1996. On February 25, 1998, the Oil Conservation Division approved the on-site disposal of these soils as fill material near the naphtha loading rack with the placement of clean soil as a cap.

There is no record of any other waste materials being placed in the landfill with the possible exception of minor quantities of catalyst fines and sulfur. The area is currently inactive as shown in the pictures in Appendix A. A review of the area indicates that there are no subsurface features in the area of the landfill (e.g., pipelines) that could affect contaminant migration.

2.3 SWMU No. 9 Landfill Pond

The Landfill Pond is located to the northeast of SWMU No. 8 Landfill and immediately east of SWMU No. 10 Fire Training Area (Figure 2). The "pond" was created when a shallow arroyo was blocked by the construction of the Hammond Irrigation Ditch. This area was designated as a SWMU due to the fact that it is topographically lower than the landfill and EPA was concerned that stormwater flowing from the landfill could have transported contaminants to this location. Wastes have not historically been and are not today managed in this area. The potential contaminants that could have impacted this area are the same contaminants that were placed in the landfill (SWMU No. 8).

Seven soil samples were collected from the Landfill Pond in 1985. All of the samples were analyzed for BTEX, phenolics, total chromium, and total lead, and one of the samples was analyzed for the EPA Skinner List constituents. The results of these analyses are include on pages 7 – 16 of the Report of Analytical Results for Engineering Science Bloomfield Refining Company, which was prepared by Rocky Mountain Analytical Laboratory on May 28, 1986 (Appendix B). As indicated, all analyses were non-detect with the exception of chromium and lead, which had low concentrations below the action levels.

In 1986, a closure plan for the API Wastewater Ponds, Landfill, and Landfill Pond was completed. The closure plan documented that the existing conditions at the landfill pond were protective of human health and the environment and proposed no additional actions. The proposed closure plan was submitted for public comment from December 10, 1993 through January 9, 1994. One comment was received, which recommended that measures be taken to prevent water from ponding in the site for extended periods of time. NMED approved closure of the landfill pond on January 25, 1994 and noted that no changes were required to the proposed closure plan. The January 25, 1994 letter, a copy of which is included in Appendix B, stated the following, "No additional closure activities are required to demonstrate clean closure of the site." In correspondence dated June 11, 2008, NMED noted that their administrative record does not contain a report that describes implementation of a closure plan and that NMED did not have corrective action authority delegated from EPA until 1996, thus any prior approvals of no further action should have been approved and signed by EPA.

2.4 SWMU No. 11 Spray Irrigation Area

The Spray Irrigation Area is located across the road south of the landfill and east of Tank 45 (Figure 2). This area covered approximately 10 acres and was irrigated through stationary sprinkler heads with refinery wastewater pumped from the north evaporation pond. A dike was located around the area to prevent runoff. The irrigation activities were conducted from 1981 through 1994, primarily during the summer months (March to October). The irrigation activities stopped in 1995 when the Class 1 injection well was put into service. No other waste management activities were conducted in this location. The potential contaminants that may have impacted this area are the same petroleum refinery wastes discussed above for SWMUs No. 8 and 9.

A closure plan entitled, Closure Plan for the Unlined Evaporation Lagoons and the Spray Evaporation Area, was completed on August 13, 1996. A copy of the closure plan is included in Appendix C. The results of analytical testing on soil samples collected from the Spray Irrigation Area are discussed on pages 2 and 3 of the closure plan and are summarized in a table in Attachment C to the closure plan. A map showing sample locations is included in Attachment B of the closure plan. On page 3 of the closure plan, Giant proposed to use the Spray Irrigation Area as the site for Giant's Pipeline and Transportation truck shop and office building. The activities associated with the construction were to include grading the area to eliminate the dikes. Otherwise, no additional activities were proposed. A monitoring well (MW-5) is located within the Spray Irrigation Area that is screened within the shallow aquifer but this well has been dry for at least the last six years. MW-3 is located immediately down-gradient of SWMU No. 11 and chemical analyses of ground water samples collected from MW-3 are summarized in Tables 1 – 3. These data do not indicate any impacts from the historical irrigation activities. Manganese was detected at low concentrations that are above the standard but it is likely these concentrations are representative of background concentrations. Similar manganese concentrations were detected in MW-8, which is also in an up-gradient location relative to site operations.

The New Mexico Oil Conservation Division (OCD) approved the Closure Plan for the Unlined Evaporation Lagoons and the Spray Evaporation Area on August 28, 1996 with the requirement to continue monitoring ground water at MW-1 and MW-5. As noted above, MW-5 is dry. A copy of the August 28, 1996 OCD letter is included in Appendix C.

2.5 SWMU No. 18 Warehouse Yard

The Warehouse Yard lies at the far western end of the refinery, west of the main office and warehouse buildings. It is enclosed on the east, south and west sides by a fence and is partially open to the refinery complex on the north side. During an inspection conducted in 1987, drums containing solvents and oils used in the refining process were noted as being stored within this area. Pictures of the former drum storage location are included in Appendix A. In 1988, the refinery changed its methods of storing bulk chemical products in drums to utilizing portafeed tanks and stainless-steel totes located within the process area. In addition, the drum storage area (drum storage rack) in the Warehouse Yard was upgraded by constructing a metal frame storage area with a concrete floor and curbing with a collection sump. After the upgrade, only drums containing primarily lube oils were stored in the original drum storage area. An above ground storage tank that contains gasoline is located within the yard and it has secondary containment. The warehouse yard has historically been used and is still primarily used today for shipping and receiving.

No soil samples have been collected for analysis from within the Warehouse Yard but there is one recovery well (RW-1). Separate phase hydrocarbon (SPH) has historically been present in RW-1; however, this well is located down-gradient of a larger area of ground water contamination that extends from the refinery tank farm to the processing units. There is no currently available data to suggest the impacts to ground water are from any releases within the Warehouse Yard.

There is a liquid petroleum gas (LPG) pipeline and water line that runs along the western end of the warehouse yard but they are not close to the former drum storage location. There is a septic drain field in the area where the drums were originally stored.

3 Site Conditions

The conditions at the site, including surface and subsurface conditions that could affect the fate and transport of any contaminants, are discussed below. This information is based on recent visual observations and historical subsurface investigations.

3.1 Surface Conditions

Regionally, the surface topography slopes toward the floodplain of the San Juan River, which runs along the northern boundary of the refinery complex. To the south of the refinery, the drainage is to the northwest. North of the refinery, surface water flows in a southeasterly direction toward the San Juan River. The active portion of the refinery property, where the process units and storage tanks are located, is generally of low relief with an overall northwest gradient of approximately 0.02 ft/ft. The refinery sits on an alluvial floodplain terrace deposit and there is a steep bluff (approx. drop of 90 feet) at the northern boundary of the refinery where the San Juan River intersects the floodplain terrace, which marks the southern boundary of the floodplain.

There are two locally significant arroyos, one immediately east and another immediately west of the refinery, which collect most of the surface water flows in the area, thus significantly reducing surface water flows across the refinery. A minor drainage feature is located on the eastern portion of the refinery, where the Landfill Pond (SWMU No. 9) is located and there are several steep arroyos along the northern refinery boundary that primarily capture only local surface water flows and minor ground water discharges.

The refinery complex is bisected by County Rd #4990 (Sulivan Road), which runs east-west. The process units, storage tanks (crude oil and liquid products), and wastewater treatment systems are located north of the county road. The crude oil and product loading racks, LPG storage tanks and loading racks, maintenance buildings/90-day storage area, pipeline offices, transportation truck shop, and the Class I injection well are located south of the county road. There is very little vegetation throughout these areas with most surfaces composed of concrete, asphalt, or gravel. The area between the refinery and the San Juan River does have limited vegetation on slopes that are not too steep to support vegetation.

3.2 Subsurface Conditions

Numerous soil borings and monitoring wells have been completed across the refinery property during previous site investigations and installation of the slurry wall, which runs along the northern and western refinery boundary. Based on the available site-specific and regional subsurface information, the site is underlain by the Quaternary Jackson Lake terrace deposits, which unconformably overlie the Tertiary Nacimiento Formation. The Jackson Lake deposits consist of fine grained sand, silt and clay that grades to coarse sand, gravel and cobble size material closer to the contact with the Nacimiento Formation. The Jackson Lake Formation is over 40 feet near thick near the southeast portion of the site and generally thins to the northwest toward the San Juan River. The Nacimiento Formation is primarily composed of fine grained materials (e.g., carbonaceous mudstone/claystone with interbedded sandstones) with a reported local thickness of approximately 570 feet (Groundwater Technology, 1994).

Figures 3 and 4 present cross-sections of the shallow subsurface based on borings logs from on-site monitoring well completions. The uppermost aquifer is under water table conditions and occurs within the sand and gravel deposits of the Jackson Lake Formation. The Nacimiento Formation functions as an aquitard at the site and prevents site related contaminants from migrating to deeper aquifers. The potentiometric surface as measured in April 2007 is presented as Figure 5 and shows the groundwater flowing to the northwest, toward the San Juan River.

Previous site investigations have identified and delineated impacts to groundwater from historical site operations. Figure 6 shows the distribution of SPH in the subsurface based on the apparent thickness of SPH measured in monitoring wells. Dissolved-phase impacts are depicted on Figure 7.

4 Scope of Services

4.1 Anticipated Activities

Pursuant to Section IV of the Order, a scope of services was developed to determine and evaluate the presence, nature, extent, fate, and transport of contaminants. To accomplish this objective, soil borings and monitoring wells will be installed at the North Bone yard (SWMUs No. 2), the landfill (SWMU No. 8), the Landfill Pond (SWMU No. 9), and the Warehouse Yard (SWMU No. 18). Soil borings will be installed and samples collected as discussed in Section 5.2. The installation of monitoring wells and collection of groundwater samples is discussed in Section 5.3.

4.2 Background Information Research

Documents containing the results of previous investigations and subsequent routine groundwater monitoring data from monitoring wells were reviewed to facilitate development of this work plan. The previous collected data provides very good information on the overall subsurface conditions, including hydrogeology and contaminant distribution within groundwater. The data collected under this scope of services will supplement the existing groundwater information and provide SWMU-specific information regarding contaminant occurrence and distribution within soils.

4.3 Collection and Management of Investigation Derived Waste

Drill cuttings, excess sample material and decontamination fluids, and all other investigation derived waste (IDW) associated with soil borings will be contained and characterized using methods based on the boring location, boring depth, drilling method, and type of contaminants suspected or encountered. All purged groundwater and decontamination water will be characterized prior to disposal unless it is disposed in the refinery wastewater treatment system upstream of the API Separator. An IDW management plan is included as Appendix D.

4.4 Surveys

The horizontal coordinates and elevation of each surface sampling location; the surface coordinates and elevation of each boring or test pit, the top of each monitoring well casing, and the ground surface at each monitoring well location; and the locations of all other pertinent structures will be determined by a registered New Mexico professional land surveyor in accordance with the State Plane Coordinate System (NMSA 1978 47-1-49-56 (Repl. Pamp. 1993)). Alternate survey methods may be proposed by the Respondents in site specific work plans. Any proposed survey method must be approved by the Department prior to implementation. The surveys will be conducted in accordance with Sections 500.1

through 500.12 of the Regulations and Rules of the Board of Registration for Professional Engineers and Surveyors Minimum Standards for Surveying in New Mexico. Horizontal positions will be measured to the nearest 0.1-ft, and vertical elevations will be measured to the nearest 0.01-ft.

5 Investigation Methods

The purpose of the site investigation is to determine and evaluate the presence, nature, and extent of releases of contaminants. Guidance on selecting and developing sampling plans as provided in *Guidance for Choosing a Sampling Design for Environmental Data Collection* (EPA, 2000) was utilized to select the appropriate sampling strategy for each of the SWMUs.

5.1 Drilling Activities

Soil and monitoring well borings will be drilled using either hollow-stem auger or if necessary, air rotary methods. Monitoring well construction/completions will be conducted in accordance with the requirements of Section IX of the Order. The preferred method will be hollow-stem auger to increase the ability to recover undisturbed samples and potential contaminants. The drilling equipment will be properly decontaminated before drilling each boring.

All soil borings will be drilled to a minimum depth of 10 feet with at least one boring at each of the individual potential source areas drilled to the top of saturation, with the exception of SWMU No. 2 where all soil borings will be drilled to the water table. Soil samples will be collected continuously and logged by a qualified geologist or engineer. If there is an indication of contamination based on field screening results at 10 feet, then the boring will be drilled deeper until no impacts (e.g., presence of waste materials in landfill areas) are observed or to the top of saturation, whichever is achieved first. Soil borings will be drilled three feet beneath the deepest evidence of waste materials or other signs of contamination. If contamination is detected at the water table, then the boring will be drilled five feet below the water table or to refusal, whichever occurs first. Soil borings to be completed as permanent monitoring wells will be drilled to the top of bedrock (Nacimiento Formation) and the anticipated completion depths range from 25 to 40 feet. Slotted (0.01 inch) rigid PVC well screen will be placed at the bottom of the well and will extend for 15 feet to ensure that the entire saturated zone is open to the well. Rigid PVC with threads will be utilized for the well casing and no glues/solvents will be utilized. A 10/20 sand filter pack will be installed to two feet over the top of the well screen. Pursuant to Section IX.C. of the Order, a minimum of two feet of bentonite seal will be placed over the filter pack and hydrated. An annular grout will be pumped by tremie method to within two feet of the ground surface and allowed to cure for a minimum of 24 hours before surface pad and protective casing are installed.

The NMED will be notified as early as practicable if conditions arise or are encountered that do not allow the advancement of borings to the specified depths or at planned sampling locations. The drilling and sampling will be accomplished under the direction of a qualified engineer or geologist who will maintain a detailed log of the materials and conditions encountered in each boring. Both sample information and visual observations of the cuttings and core samples will be recorded on the boring log. Known site features and/or site survey grid markers will be used as references to locate each boring prior to surveying the location as described in Section 4.4. The boring locations will be measured to the nearest foot, and locations will be recorded on a scaled site map upon completion of each boring.

5.2 Soil Sampling

SWMU No. 2 includes the North Bone Yard and former drum storage area. The location where the drums, which contained solvents and lubricants, were stored in the past is known and is a relatively small area. Judgmental sampling will allow for sample collection at the known areas of potential impact, while a probability-based design could result in sample locations outside the area of concern. A judgmental design will also allow for samples to be collected immediately beneath the area where empty drums are currently stored and scrap metal is stored on a temporary basis. There are no subsurface features (e.g., pipelines or utilities) that could affect contaminant distribution. As shown on Figure 8, three soil borings will be installed beneath the area where drums were formerly stored, two borings are to be located within the area currently used for storage of empty drums and three soil borings will be installed at the area used for scrap metal storage. Unlike the other SWMUs, all soil borings at SWMU No. 2 will be drilled to the water table. At the direction of NMED, an additional soil boring, which will be completed as a permanent monitoring well, will be installed at the far western end of the North Bone Yard. If there are any visible indications of releases at the surface, then soil borings will be relocated to the specific identified areas.

SWMU No. 8 was a historic landfill area and there is no current information that would support a sample design based on judgmental samples. An appropriate sampling design to locate any areas of contamination within the area of the landfill is a systematic or grid sampling design. No subsurface utilities or pipelines cross this area. The individual sample locations have been selected by laying a grid (100’ by 100’) over the area where the landfill is located. Each boring will represent an area of approximately 10,000 square feet or one fourth of an acre. This is very conservative for a commercial/industrial facility and is less than the half-acre exposure area commonly used for residential properties (EPA, 1991 and EPA, 1996). This spacing results in 12 locations where soil borings will be installed, as shown on Figure 9.

As directed by NMED, one soil boring will be installed in the center of the former Landfill Pond (Figure 9). The boring will be drilled to the water table or refusal if bedrock is encountered first.

The location where drums were stored on the ground at SWMU No. 18, prior to construction of the paved and covered drum storage rack facility, is shown on Figure 2. Because the location of drum storage is known and this is a small area that is only approximately 50 feet long and 30 feet wide judgmental samples will be collected. One of the on-site septic drain fields is located in this area and it is possible it could affect contaminant migration but the permeable nature of soils present on-site will lessen any influence from the drain field. Four soil borings will be located within this area and individual boring locations may be adjusted based on any visual indications of releases to surface soils (Figure 10).

A decontaminated split-barrel sampler or continuous five-foot core barrel will be used to obtain samples during the drilling of each boring. Surface samples may be collected using decontaminated, hand-held stainless steel sampling device, shelby tube, or thin-wall sampler, or a pre-cleaned disposable sampling device. A portion of the sample will be placed in pre-cleaned, laboratory-prepared sample containers for laboratory chemical analysis. The use of an Encore® Sampler or other similar device will be used during collection of soil samples for VOC analysis. The remaining portions of the sample will be used for logging and field screening as discussed in Section 5.2.1. Sample handling and chain-of-custody procedures will be in accordance with the procedures presented below in Section 5.4.

Discrete soil samples will be collected for laboratory analyses at the following intervals:

- 0-6" (all borings);
- 18-24" (all borings);
- from the 6" interval at the top of saturation (deep borings);
- the sample from each boring with the greatest apparent degree of contamination, based on field observations and field screening; and
- any additional intervals as determined based on field screening results.

Quality Assurance/Quality Control (QA/QC) samples will be collected to monitor the validity of the soil sample collection procedures as follows:

- field duplicates will be collected at a rate of 10 percent;
- equipment blanks will be collected from all sampling apparatus at a frequency of 10 percent or one per day if disposable sampling equipment is used; and
- field blanks will be collected at a frequency of one per day.

5.2.1 Soil Sample Field Screening and Logging

Samples obtained from the borings will be screened in the field on 2.5 foot intervals for evidence of contaminants. Field screening results will be recorded on the exploratory boring and excavation logs. Field screening results will be used to aid in the selection of soil samples for laboratory analysis. The primary screening methods include: (1) visual examination, (2) olfactory examination, and (3) headspace vapor screening for volatile organic compounds. Additional screening for site- or release-specific characteristics such as pH or for specific compounds using field test kits may be conducted where appropriate.

Visual screening includes examination of soil samples for evidence of staining caused by petroleum-related compounds or other substances that may cause staining of natural soils such as elemental sulfur or cyanide compounds. Headspace vapor screening targets volatile organic compounds and involves placing a soil sample in a plastic sample bag or a foil sealed container allowing space for ambient air. The container will be sealed and then shaken gently to expose the soil to the air trapped in the container. The sealed container will be allowed to rest for a minimum of 5 minutes while vapors equilibrate. Vapors present within the sample bag's headspace will then be measured by inserting the probe of the instrument in a small opening in the bag or through the foil. The maximum value and the ambient air temperature will be recorded on the field boring or test pit log for each sample.

The monitoring instruments will be calibrated each day to the manufacturer's standard for instrument operation. A photo-ionization detector (PID) equipped with a 10.6 or higher electron volt (eV) lamp or a combustible gas indicator will be used for VOC field screening. Field screening results may be site- and boring-specific and the results may vary with instrument type, the media screened, weather conditions, moisture content, soil type, and type of contaminant, therefore, all conditions capable of influencing the results of field screening will be recorded on the field logs.

The physical characteristics of the samples (such as mineralogy, ASTM soil classification, moisture content, texture, color, presence of stains or odors, and/or field screening results), depth where each sample was obtained, method of sample collection, and other observations will be recorded in the field log by a qualified geologist or engineer. Detailed logs of each boring will be completed in the field by a qualified engineer or geologist. Additional information, such as the presence of water-bearing zones and any unusual or noticeable conditions encountered during drilling, will be recorded on the logs.

5.3 Groundwater Water Monitoring

5.3.1 Groundwater Levels

Groundwater level and SPH thickness measurements will be obtained at each new monitoring well prior to purging in preparation for a sampling event. Measurement data and the date and time of each measurement will be recorded on a site monitoring data sheet. The depth to groundwater and SPH thickness levels will be measured to the nearest 0.01 ft. The depth to groundwater and SPH thickness will be recorded relative to the surveyed well casing rim or other surveyed datum. A corrected water table elevation will be provided in wells containing SPH by adding 0.8 times the measured SPH thickness to the measured water table elevation. Groundwater and SPH levels will be measured in all wells within 48 hours of the start of obtaining water level measurements. All automated and manual extraction of SPH and water from recovery wells, observation wells, and collection wells, which is close enough to affect measurements at the new wells, will be discontinued for 48 hours prior to the measurement of water and product levels.

Groundwater level and SPH thickness measurements will also be obtained at each new monitoring well during the next regularly scheduled facility-wide groundwater sampling event to facilitate preparation of a facility-wide potentiometric surface map.

5.3.2 Groundwater Sampling

New monitoring wells will be installed at SWMUs No.2, No. 8, and No. 18. At North Bone Yard (SWMU No. 2) and the Warehouse Yard (SWMU No. 18), wells will be completed on the down-gradient side of areas where drums were historically stored, as shown on Figures 8 and 10, respectively. An additional well will be installed at the far western end of the North Bone Yard. Similarly, two wells will be installed on the down-gradient side of the landfill (SWMU No. 8) as indicated on Figure 9. In addition, if any other deep soil borings encounter groundwater, then a groundwater sample will be collected for analysis prior to plugging the boring.

New monitoring wells will be developed once all new wells have been completed and it may take several days to complete well development. Groundwater samples will initially be obtained from newly constructed monitoring wells no later than five days after the completion of well development. A second round of groundwater monitoring and sampling will be conducted no sooner than 30 days and not later than 75 days of the initial sampling event. Subsequent sampling events will be dependent upon the analytical results of the first two sampling events and as specified by the NMED. All monitoring wells scheduled for sampling during a groundwater sampling event will be sampled within 15 days of the start of the monitoring and sampling event. Groundwater samples will be collected from borings not intended to be completed as monitoring wells prior to abandonment of the borings, if ground water is encountered.

5.3.3 Well Purging

All zones in each monitoring well will be purged by removing groundwater with a dedicated bailer or new disposable bailer prior to sampling in order to ensure that formation water is being sampled. Purge volumes (a minimum of three well volumes including filer pack) will be determined by monitoring, at a minimum, groundwater pH, specific conductance, dissolved oxygen concentrations, oxidation-reduction potential, and temperature after every two gallons or each well volume, whichever is less, has been purged from the well. Purging will continue, as needed, until the specific conductance, pH, and temperature readings are within 10 percent between readings for three consecutive measurements. Field water quality parameters will also be compared to historical data provided in Table 6 to ensure that the measurements are indicative of formation water. The volume of groundwater purged, the instruments used, and the readings obtained at each interval will be recorded on the field-monitoring log. Well purging may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring* (October 30, 2001, as updated).

5.3.4 Groundwater Sample Collection

Groundwater samples will be collected within 24 hours of the completion of well purging using dedicated bailers or new disposal bailers. Alternatively, well sampling may also be conducted in accordance with the NMED's Position Paper *Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Groundwater Monitoring* (October 30, 2001), as updated). Sample collection methods will be documented in the field monitoring reports. The samples will be transferred to the appropriate, clean, laboratory-prepared containers provided by the analytical laboratory. Sample handling and chain-of-custody procedures will be in accordance with the procedures presented below in Section 5.3.5.

Groundwater samples intended for metals analysis will be submitted to the laboratory as total metals samples. QA/QC samples will be collected to monitor the validity of the groundwater sample collection procedures as follows:

- Field duplicate water samples will be obtained at a frequency of ten percent, with a minimum, of one duplicate sample per sampling event;
- Field blanks will be obtained at a minimum frequency of one per day per site or unit. Field blanks will be generated by filling sample containers in the field with deionized water and

submitting the samples, along with the groundwater samples, to the analytical laboratory for the appropriate analyses.

- Equipment rinsate blanks will be obtained for chemical analysis at the rate of ten percent or a minimum of one rinsate blank per sampling day. Equipment rinsate blanks will be collected at a rate of one per sampling day if disposable sampling equipment is used. Rinsate samples will be generated by rinsing deionized water through unused or decontaminated sampling equipment. The rinsate sample will be placed in the appropriate sample container and submitted with the groundwater samples to the analytical laboratory for the appropriate analyses.

- Trip blanks will accompany laboratory sample bottles and shipping and storage containers intended for VOC analyses. Trip blanks will consist of a sample of analyte-free deionized water prepared by the laboratory and placed in an appropriate sample container. The trip blank will be prepared by the analytical laboratory prior to the sampling event and will be kept with the shipping containers and placed with other water samples obtained from the site each day. Trip blanks will be analyzed at a frequency of one for each shipping container of samples to be analyzed for VOCs.

5.4 Sample Handling

At a minimum, the following procedures will be used at all times when collecting samples during investigation, corrective action, and monitoring activities:

1. Neoprene, nitrile, or other protective gloves will be worn when collecting samples. New disposable gloves will be used to collect each sample;

2. All samples collected of each medium for chemical analysis will be transferred into clean sample containers supplied by the project analytical laboratory with the exception of soil, rock, and sediment samples obtained in Encore® samplers. Sample container volumes and preservation methods will be in accordance with the most recent standard EPA and industry accepted practices for use by accredited analytical laboratories. Sufficient sample volume will be obtained for the laboratory to complete the method-specific QC analyses on a laboratory-batch basis; and

3. Sample labels and documentation will be completed for each sample following procedures discussed below. Immediately after the samples are collected, they will be stored in a cooler with ice or other appropriate storage method until they are delivered to

the analytical laboratory. Standard chain-of-custody procedures, as described below, will be followed for all samples collected. All samples will be submitted to the laboratory soon enough to allow the laboratory to conduct the analyses within the method holding times. At a minimum, all samples will be submitted to the laboratory within 48 hours after their collection.

Chain-of-custody and shipment procedures will include the following:

1. Chain-of-custody forms will be completed at the end of each sampling day, prior to the transfer of samples off site.

2. Individual sample containers will be packed to prevent breakage and transported in a sealed cooler with ice or other suitable coolant or other EPA or industry-wide accepted method. The drainage hole at the bottom of the cooler will be sealed and secured in case of sample container leakage. Temperature blanks will be included with each shipping container.

3. Each cooler or other container will be delivered directly to the analytical laboratory.

4. Glass bottles will be separated in the shipping container by cushioning material to prevent breakage.

5. Plastic containers will be protected from possible puncture during shipping using cushioning material.

6. The chain-of-custody form and sample request form will be shipped inside the sealed storage container to be delivered to the laboratory.

7. Chain-of-custody seals will be used to seal the sample-shipping container in conformance with EPA protocol.

8. Signed and dated chain-of-custody seals will be applied to each cooler prior to transport of samples from the site.

9. Upon receipt of the samples at the laboratory, the custody seals will be broken, the chain-of-custody form will be signed as received by the laboratory, and the conditions of the samples will be recorded on the form. The original chain-of-custody form will remain with the laboratory and copies will be returned to the relinquishing party.

10. Copies of all chain-of-custody forms generated as part of sampling activities will be maintained on-site.

5.5 Decontamination Procedures

The objective of the decontamination procedures is to minimize the potential for cross-contamination. A designated decontamination area will be established for decontamination of drilling equipment, reusable sampling equipment and well materials. The drilling rig will be decontaminated prior to entering the site or unit. Drilling equipment or other exploration equipment that may come in contact with the borehole will be decontaminated by steam cleaning, by hot-water pressure washing, or by other methods approved by the Department prior to drilling each new boring.

Sampling or measurement equipment, including but not limited to, stainless steel sampling tools, split-barrel or core samplers, well developing or purging equipment, groundwater quality measurement instruments, and water level measurement instruments, will be decontaminated in accordance with the following procedures or other methods approved by the Department before each sampling attempt or measurement:

1. Brush equipment with a wire or other suitable brush, if necessary or practicable, to remove large particulate matter;
2. Rinse with potable tap water;
3. Wash with nonphosphate detergent or other detergent approved by the Department (examples include Fantastik™, Liqui-Nox®);
4. Rinse with potable tap water; and
5. Double rinse with deionized water.

All decontamination solutions will be collected and stored temporarily as described in Section 4.3. Decontamination procedures and the cleaning agents used will be documented in the daily field log.

5.6 Field Equipment Calibration Procedures

Field equipment requiring calibration will be calibrated to known standards, in accordance with the manufacturers' recommended schedules and procedures. At a minimum, calibration checks will be conducted daily, or at other intervals approved by the Department, and the instruments will be recalibrated, if necessary. Calibration measurements will be recorded in the daily field logs. If field equipment becomes inoperable, its use will be discontinued until the necessary repairs are made. In the interim, a properly calibrated replacement instrument will be used.

5.7 Documentation of Field Activities

Daily field activities, including observations and field procedures, will be recorded in a field log book. The original field forms will be maintained at the Facility. Copies of the completed forms will be maintained in a bound and sequentially numbered field file for reference during field activities. Indelible ink will be used to record all field activities. Photographic documentation of field activities will be performed, as appropriate. The daily record of field activities will include the following:

1. Site or unit designation;
2. Date;
3. Time of arrival and departure;
4. Field investigation team members including subcontractors and visitors;
5. Weather conditions;
6. Daily activities and times conducted;
7. Observations;
8. Record of samples collected with sample designations and locations specified;
9. Photographic log;
10. Field monitoring data, including health and safety monitoring;
11. Equipment used and calibration records, if appropriate;
12. List of additional data sheets and maps completed;
13. An inventory of the waste generated and the method of storage or disposal; and
14. Signature of personnel completing the field record.

5.8 Chemical Analyses

All samples collected for laboratory analysis will be submitted to an accredited laboratory. The laboratory will use the most recent standard EPA and industry-accepted analytical methods for target analytes as the testing methods for each medium sampled. Chemical analyses will be performed in accordance with the most recent EPA standard analytical methodologies and extraction methods.

Groundwater and soil samples will be analyzed by the following methods:

- SW-846 Method 8260 volatile organic compounds;
- SW-846 Method 8270 semi-volatile organic compounds;
- SW-846 Method 8015B gasoline and diesel range organics.

Groundwater and soil samples will also be analyzed for the following metals using the indicated analytical methods.

Analyte	Analytical Method
Antimony	SW-846 method 6010/6020
Arsenic	SW-846 method 6010/6020
Barium	SW-846 method 6010/6020
Beryllium	SW-846 method 6010/6020
Cadmium	SW-846 method 6010/6020
Chromium	SW-846 method 6010/6020
Cobalt	SW-846 method 6010/6020
Cyanide	SW-846 method 335.3/335.2 mod
Lead	SW-846 method 6010/6020
Mercury	SW-846 method 7470/7471
Nickel	SW-846 method 6010/6020
Selenium	SW-846 method 6010/6020
Silver	SW-846 method 6010/6020
Vanadium	SW-846 method 6010/6020
Zinc	SW-846 method 6010/6020

In addition, groundwater samples will also be analyzed for the following general chemistry parameters.

Analyte	Analytical Method
Bicarbonate	SW-846 method 310.1
Chloride	EPA method 300.0
Sulfate	EPA method 300.0
Calcium	SW-846 method 7140
Magnesium	SW-846 method 7450
Sodium	SW-846 method 7770
Potassium`	SW-846 method 7610
Manganese	SW-846 method 6010/6020
Nitrate/nitrite	EPA method 300.0
Ferric/ferrous Iron	SW-846 method 6010/6020

As discussed in section 5.3.3, field measurements will be obtained for pH, specific conductance, dissolved oxygen concentrations, oxidation-reduction potential, and temperature.

5.9 Data Quality Objectives

The Data Quality Objectives (DQOs) were developed to ensure that newly collected data are of sufficient quality and quantity to address the projects goals, including Quality Assurance/Quality Control (QA/QC) issues. The project goals are established in the Order and are to determine and evaluate the presence, nature, and extent of releases of contaminants at specified SWMUs. The type of data required to meet the project goals includes chemical analyses of soil and groundwater to determine if there has been a release of contaminants at the individual SWMUs.

The quantity of data is SWMU specific and is based on the historical operations at individual locations. The quality of data that is required is consistent across locations and is specified in Section VIII.D.7.c of the Order. In general, method detection limits should be 20% or less of the applicable background levels, cleanup standards and screening levels.

Additional DQOs include precision, accuracy, representativeness, completeness, and comparability. Precision is a measurement of the reproducibility of measurements under a given set of circumstances and is commonly stated in terms of standard deviation or coefficient of variation (EPA, 1987). Precision is also specific to sampling activities and analytical performance. Sampling precision will be evaluated through the analyses of duplicate field samples and laboratory replicates will be utilized to assess laboratory precision.

Accuracy is a measurement in the bias of a measurement system and may include many sources of potential error, including the sampling process, field contamination, preservation, handling, sample matrix, sample preparation, and analysis techniques (EPA, 1987). An evaluation of the accuracy will be performed by reviewing the results of field/trip blanks, matrix spikes, and laboratory QC samples.

Representativeness is an expression of the degree to which the data accurately and precisely represent the true environmental conditions. Sample locations and the number of samples have been selected to ensure the data is representative of actual environmental conditions. Based on SWMU specific conditions, this may include either biased (i.e., judgmental) locations/depths or unbiased (systematic grid samples) locations, as discussed in Section 5.2 for soils and 5.3.2 for groundwater. In addition, sample collection techniques (e.g., purging of monitoring wells to collect formation water) will be utilized to help ensure representative results. An evaluation of on-going groundwater monitoring results will be performed to assess representativeness.

Completeness is defined as the percentage of measurements taken that are actually valid measurements, considering field QA and laboratory QC problems. EPA Contract Laboratory Program (CLP) data has been found to be 80-85% complete on a nationwide basis and this has been extrapolated to indicate that Level III, IV, and V analytical techniques will generate data that are approximately 80% complete (EPA, 1986). As an overall project goal, the completeness goal is 85%; however, some samples may be critical base on location or field screening results and thus a sample – by-sample evaluation will be performed to determine if the completeness goals have been obtained.

Comparability is a qualitative parameter, which expresses the confidence with which one data set can be compared to another. Industry standard sample collection techniques and routine EPA analytical methods will be utilized to help ensure data are comparable to historical and future data. Analytical results will be reported in appropriate units for comparison to historical data and cleanup levels.

6 Monitoring and Sampling Program

6.1 Groundwater Monitoring

After the initial investigation activities are completed, a second round of groundwater samples will be collected to confirm the initial groundwater analyses for samples collected at new monitoring wells. The groundwater samples will be collected no sooner than 30 days after the initial sampling event and no later than 75 days after the initial sampling event. If possible, the second sampling event will be timed to coincide with the regularly scheduled semiannual groundwater sampling events. The samples will be analyzed for the same constituents for which the first samples were analyzed.

Any subsequent sampling events will be based on the results of the first two analyses and will be approved by the NMED prior to implementation.

7 Schedule

This investigation work plan will be implemented within 90 days of NMED approval. The estimated timeframes for each of the planned activities is as shown below:

- field work (inclusive of all soil and initial groundwater sampling) -- five weeks;
- laboratory analyses for initial sampling event – four weeks;
- data reduction and validation (soils and initial groundwater event) – three weeks;
- second groundwater sampling event – one week;
- laboratory analyses for second groundwater sampling event – three weeks;
- data reduction and validation (second groundwater event) – two weeks; and
- data gap analysis – three weeks.

Completion of the data gap analysis will complete all activities conducted under this investigation workplan. If the data gap analysis indicates that additional investigation activities are necessary to satisfy the site investigation objectives, then Western may notify the NMED of the need to conduct additional assessment at the conclusion of the data gap analysis. If such notification is provided to NMED, any and all relevant information collected by Western will be provided to NMED, which pertains to the determination that additional assessment is required. If so directed by NMED, then Western will prepare and submit a revised investigation work plan to collect the data identified in the data gap analysis. This revised investigation work plan will be submitted to the NMED for review and approval within 60 days of notice to proceed. Otherwise, Western will prepare an investigation report pursuant to Section X.C of the Order. The investigation report will be submitted to the NMED within 120 days of completion of the data gap analysis.

8 References

EPA, 1987, Data Quality Objectives for Remedial Response Activities; United States Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, OSWER Directive 9355.0-7B, 85p

EPA, 1991, Human Health Evaluation Manual, Part B: "Development of Risk-Based Preliminary Remediation Goals; United States Environmental Protection Agency, Office of Solid Waste and Emergency Response; Memorandum December 13, 1991, OSWER Directive 9285.7-01B, 54p.

EPA, 1996, Soil Screening Guidance: User's Guide; United States Environmental Protection Agency, Office of Solid Waste and Emergency Response; Publication 9355.4-23, p. 123.

EPA, 2000, Guidance on Choosing a Sampling Design for Environmental Data Collection, EPA/240/R-02/005, EPA QA/G-5S, 168 p.

EPA, 2006, Guidance on Systematic Planning Using the Data Quality Objectives Process, United States Environmental Protection Agency, Office of Environmental Information; EPA/240/B-06/001, p. 111.

Groundwater Technology, 1994, RCRA Facility Investigation/Corrective Measures Study Report Bloomfield Refining Company #50 County Road 4990 Bloomfield, New Mexico, p.51.

Tables

Table 1
Volatile Organic Ground Water Analytical Results Summary
Group 2 Investigation Work Plan
Bloomfield Refinery - Bloomfield, New Mexico

		Parameters				
		Benzene (mg/L)	**Toluene (mg/L)**	**Ethylbenzene (mg/L)**	**Xylene (mg/L)**	**MTBE (mg/L)**
WQCC 20NMAC 6.2.3103 (mg/L):		**0.005 (2)**	**0.75 (1)**	**0.7 (2)**	**0.62 (1)**	**0.011 (3)**
Well ID:	**Date Sampled:**					
MW #1	4/1/2007	<0.001	<0.001	<0.001	<0.002	<0.0025
	8/15/2006	<0.001	<0.001	<0.001	<0.003	<0.0015
	4/5/2006	<0.001	<0.001	<0.001	<0.003	<0.0025
	8/5/2005	0.0011	<0.001	<0.001	<0.001	<0.001
	4/11/2005	0.0013	<0.0005	<0.0005	0.0011	<0.0025
	8/23/2004	<0.0005	<0.0005	<0.0005	<0.0005	<0.0025
	3/3/2004	<0.0005	<0.0005	<0.0005	<0.0005	<0.0025
	8/21/2003	<0.001	<0.001	<0.001	<0.001	<0.001
	3/3/2003	<0.0005	0.00063	0.00065	0.0043	<0.0025
MW #3	4/5/2006	<0.001	<0.001	<0.001	<0.003	<0.0025
	8/5/2005	<0.001	<0.001	<0.001	<0.001	<0.001
	4/11/2005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0025
	8/21/2003	<0.001	<0.001	<0.001	<0.001	<0.001
MW #8	4/1/2007	<0.001	<0.001	<0.001	<0.002	<0.0025
	8/15/2006	<0.001	<0.001	<0.001	<0.003	<0.0015
	4/5/2006	<0.001	<0.001	<0.001	<0.003	<0.0025
	8/5/2005	<0.001	<0.001	<0.001	<0.001	<0.001
	4/11/2005	0.00053	<0.0005	<0.0005	0.0008	<0.0025
	8/23/2004	<0.0005	<0.0005	<0.0005	<0.0005	<0.0025
	8/21/2003	<0.001	<0.001	<0.001	<0.001	<0.001

Notes:
mg/L = milligram per liter
MW = monitoring well
RW = recovery well
NA = not analyzed
NE = not established
MTBE = methyl tertiary butyl ether
1 - WQCC 20NMAC 6.2.33103 = New Mexico Standard for Groundwater of 10,000 ug/L TDS or less.
2 - EPA Maximum Contaminant Level
3 - EPA Region VI Human Health Medium-Specific Screening Level 2007

Table 2
Total Metals Ground Water Analytical Results Summary
Group 2 Investigation Work Plan
Bloomfield Refinery - Bloomfield, New Mexico

		Parameters							
		Arsenic (mg/L)	**Barium (mg/L)**	**Cadmium (mg/L)**	**Chromium (mg/L)**	**Lead (mg/L)**	**Selenium (mg/L)**	**Silver (mg/L)**	**Mercury (mg/L)**
40 CFR 141.62 MCL (mg/L):		**0.01** (1)	**2.0**	**0.005**	**0.10**	**0.015**	**0.05**	**0.1** (2)	**0.002**
Well ID:	**Date Sampled:**								
MW #1	8/15/2006	<0.020	0.023	<0.0020	<0.0060	<0.0050	<0.050	<0.0050	<0.0002
	8/5/2005	NA	NA	NA	<0.006	<0.005	NA	NA	NA
	8/23/2004	<0.02	0.052	<0.002	<0.006	<0.005	<0.05	<0.005	<0.0002
MW #3	8/5/2005	NA	NA	NA	0.016	<0.005	NA	NA	NA
	8/21/2003	NA	NA	NA	0.029	**0.022**	NA	NA	<0.0002
MW #8	8/15/2006	<0.020	0.018	<0.002	<0.006	<0.005	<0.05	<0.005	<0.0002
	8/5/2005	NA	NA	NA	0.33	<0.005	NA	NA	NA
	8/23/2004	<0.02	0.071	<0.002	1.9	<0.005	<0.05	<0.005	<0.0002
	8/21/2003	NA	NA	NA	0.72	<0.005	NA	NA	<0.0002

Notes:
mg/L = milligram per liter
MW = monitoring well
RW = recovey well
NA= not analyzed
NE = not established
40 CFR 141.62 MCL = National Primar Drinking Water Regulations: Maxiumum Contaminant Levels and Maximum Residual Disinfectant Levels
(1) MCL as of 1/23/2006
(2) National secondary drinking water regulation

Table 3
Dissolved Metals Ground Water Analytical Results Summary
Group 2 Investigation Work Plan
Bloomfield Refinery- Bloomfield, New Mexico

		Parameters															
		Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silver (mg/L)	Sodium (mg/L)	Uranium (mg/L)	Zinc (mg/L)
WQCC 20NMAC 6.2.3103 (mg/L):		**0.01**	**1.0**	**0.01**	**NE**	**0.05**	**1.0**	**1.0**	**0.05**	**NE**	**0.20**	**NE**	**0.05**	**0.05**	**NE**	**0.03 (1)**	**10.0**
Well ID:	**Date Sampled:**																
MW #1	8/15/2006	<0.02	0.023	<0.002	74	<0.006	<0.006	<0.02	<0.005	18	0.09	2.4	<0.05	<0.005	120	<0.1	0.047
	8/5/2005	<0.02	0.022	<0.002	68	<0.006	<0.006	0.14	<0.005	18	0.14	2.7	<0.05	<0.005	140	<0.1	<0.005
	8/23/2004	<0.02	0.025	<0.002	67	<0.006	<0.006	0.27	<0.005	18	0.13	2.1	<0.05	<0.005	110	<0.1	0.021
	8/15/2006	<0.02	0.46	<0.002	61	<0.006	<0.006	<0.005	<0.005	16	0.08	2.6	0.043	<0.005	150	<0.1	0.12
MW #3	8/5/2005	<0.02	0.018	<0.002	480	<0.006	<0.006	0.047	<0.005	130	**0.43**	7.6	<0.05	<0.005	1300	<0.1	0.018
	8/21/2003	<0.02	0.3	<0.002	490	<0.006	<0.006	0.27	<0.005	140	**0.58**	10	0.024	<0.005	1100	<0.1	0.094
MW #8	8/15/2006	<0.02	0.018	<0.002	230	<0.006	<0.006	0.033	<0.005	35	**0.42**	3.2	<0.05	<0.005	380	<0.1	0.044
	8/5/2005	<0.02	0.021	<0.002	230	<0.006	<0.006	0.078	<0.005	37	**0.65**	3.1	<0.05	<0.005	360	<0.1	0.014
	8/23/2004	<0.02	0.021	<0.002	210	<0.006	<0.006	0.059	<0.005	35	**0.57**	3	<0.05	<0.005	360	<0.1	0.022
	8/21/2003	<0.02	0.36	<0.002	200	<0.006	<0.006	0.044	<0.005	38	**0.68**	4	**0.09**	<0.005	350	<0.1	0.13

Notes:
mg/L = milligram per liter
MW = monitoring well
RW = recovery well
NE = not established
NA = Not Analyzed
WQCC 20NMAC 6.2.33103 = New Mexico Standard for Groundwater of 10,000 ug/L or less

Table 4
General Chemistry Ground Water Analytical Results Summary
Group 2 Investigation Work Plan
Bloomfield Refinery - Bloomfield, New Mexico

		Parameters										
		Fluoride (mg/L)	Chloride (mg/L)	Bromide (mg/L)	Nitrite (mg/L)	Nitrogen (mg/L)	Phosphorus (mg/L)	Sulfate (mg/L)	TDS (mg/L)	E.C. (umhos/cm)	CO_2 (mg/L)	Alk (mg/L)
WQCC 20NMAC 6.2.3103 (mg/L):		**1.6**	**250**	**NE**	**NE**	**10**	**NE**	**600**	**1000**	**NE**	**NE**	**NE**
Well ID:	**Date Sampled:**											
MW #1	8/15/2006	0.65	17	<0.50	1.2	NA	<0.50	190	640	940	240	270
	8/5/2005	0.68	31	<0.50	<0.10	2.1	<0.50	190	650	980	300	300
	8/23/2004	0.63	29	0.14	<0.10	1.9	<0.50	220	650	870	220	240
	8/15/2006	0.58	33	0.32	<0.10	1.6	<0.50	200	610	820	240	262
MW #8	8/15/2006	0.67	**300**	1.5	26	NA	<0.50	980	2200	3200	200	210
	8/5/2005	0.79	**260**	<2.5	<0.50	27	<0.50	740	2000	2900	260	260
	8/23/2004	0.64	250	1.2	NA	NA	<0.50	920	2100	2600	210	230
	8/21/2003	0.66	**260**	5	<0.10	14	<0.50	950	2100	2900	220	208

Notes:
Alk = alkalinity, total
CO_2 = Carbon Dioxide
E.C. = electrical conductivity
TDS = total dissolved solids
umhos/cm = micro-mhos per centimeter
mg/L = milligram per liter
NE = not established
NA = not analyzed
MW = monitoring well
RW = recovery well
WQCC 20NMAC 6.2.33103 = New Mexico Standard for Groundwater of 10,000 ug/L or less

Table 5
Volatile Organic Soil Analytical Results Summary
Group 2 Investigation Work Plan
Bloomfield Refinery - Bloomfield, New Mexico

			Parameters						
			Benzene (mg/kg)	Toluene (mg/L)	Ethylbenzene (mg/L)	Xylene (mg/L)	Phenolics	Chromium III	Lead
	Soil Screening Levels (mg/kg):		0.02 (3)	21.7 (3)	20.2 (3)	2.06 (3)	47.4 (3)	100,000 (1-2)	800 (1-2)
Sample No.	Sample Location	Date Sampled							
51469-01	L1 & L2, 0-6" Quad. #1 - Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	11	10
51469-02	L3 & L4, 6-12" Quad. #1 - Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	8.9	9.8
51469-03	L5 & L6, 0-6" Quad. #2 - Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	9.9	9
51469-04	L7 & L8, 6-12" Quad. #2 -Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	7.6	6.7
51469-05	L9 & L10, 0-6" Quad #3 - Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	7.8	7.6
51469-06	L11 & L12, 6-12" Quad. #3 - Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	7.4	7
51469-07	L13 & L14, 0-6" Quad. #4 - Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	9.1	8.2
51469-08	L15 & L16, 6-12" Quad #4 - Landfill	10/16/1985	<0.5	<1.0	<1.0	<2.0	<0.1	7	7.7

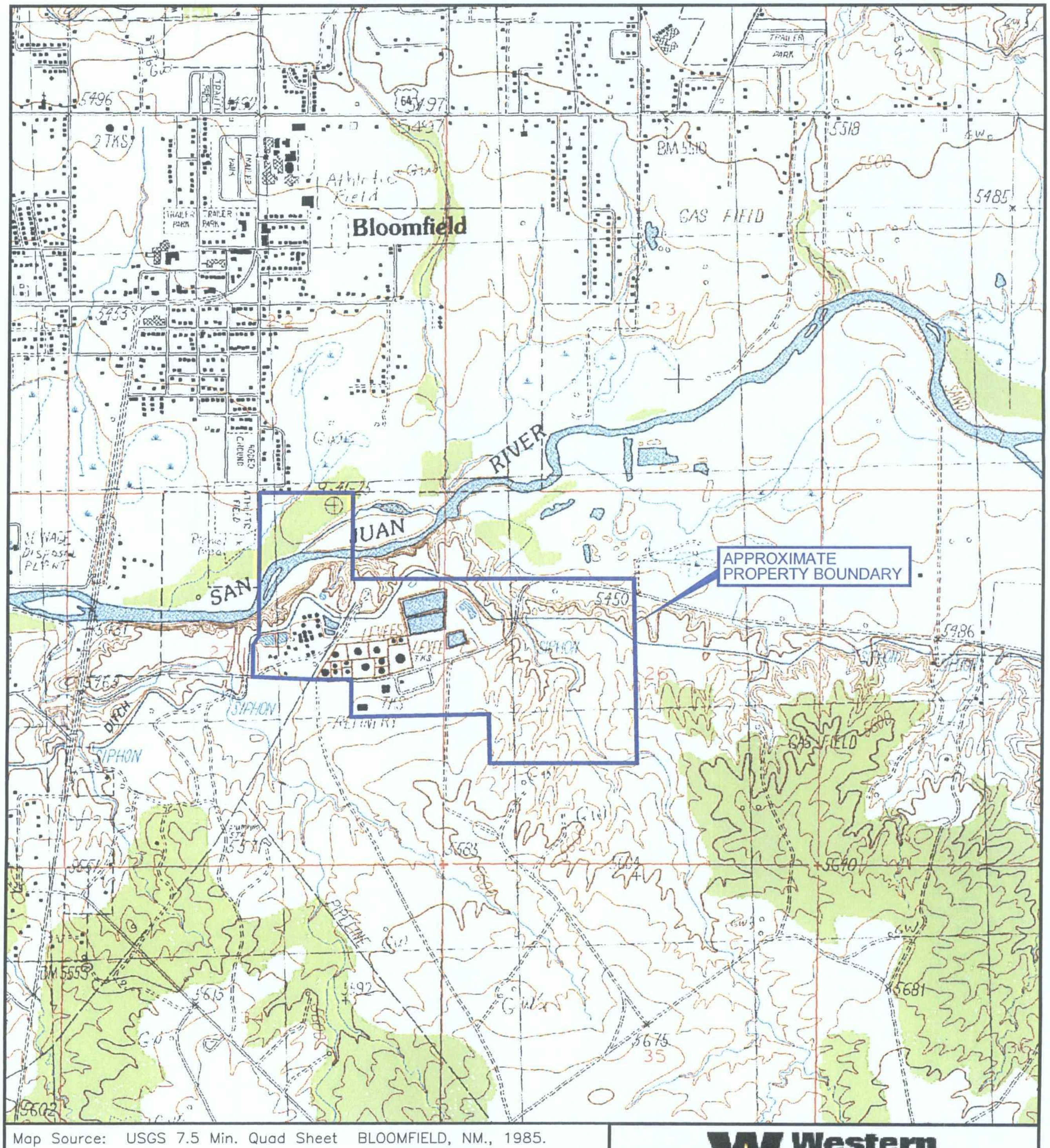
Table 6
Field Measurement Summary
Group 2 Investigation Work Plan
Western Refinery Company - Bloomfield, New Mexico

		Field Measurements				
Well ID:	Date Sampled:	E.C. (umhos/cm)	pH (s.u.)	Temperature (deg F)	DO (mg/L)	ORP (--)
#1 East O/F	3/4/2004	NM	NM	NM	NM	NM
	3/4/2003	1049	6.71	51	NM	NM
#2 East O/F	3/4/2004	1199	7.23	47	NM	NM
	3/4/2003	973	7.03	45	NM	NM
#3 East O/F	3/4/2004	1224	7.36	49	NM	NM
	3/4/2003	1083	7.04	50	NM	NM
MW #1	8/15/2006	952	7.03	64	0.9	223
	4/6/2006	815	6.84	56	NR	NR
	8/1/2005	986	7.02	63	9.2	106
	4/1/2005	1115	6.90	54	NR	NR
	8/23/2004	927	6.90	63	5.4	-532
	3/2/2004	887	7.51	53	NM	NM
	8/21/2003	1001	7.41	63	6.5	105
	3/3/2003	1285	8.01	54	NM	NM
MW #3	8/15/2006	NS	NS	NS	NS	NS
	4/6/2006	7212	7.02	65	NR	NR
	8/1/2005	7685	6.98	67	NS	-44
	4/6/2005	2535	7.02	61	NS	NS
	8/23/2004	7558	6.96	64	NS	-11
	8/25/2003	7818	6.96	66	NM	57
MW #5	8/15/2006	NS	NS	NS	NS	NS
	4/6/2006	NS	NS	NS	NS	NS
	8/1/2005	NS	NS	NS	NS	NS
	4/4/2005	NS	NS	NS	NS	NS
	8/23/2004	NS	NS	NS	NS	NS
	8/25/2003	NS	NS	NS	NS	NS
MW #8	8/15/2006	2966	7.04	61	0.5	231
	4/6/2006	2791	6.97	58	NR	NR
	8/1/2005	2730	6.91	59	7.3	114
	4/12/2005	2481	7.04	59	NR	NR
	8/19/2004	2600	7.02	62	2.9	142
	8/25/2003	2654	6.98	60	7.1	176

Notes:

deg F = degrees Fahrenheit
E.C. = electrical conductivity
mg/L = milligrams per liter
MW = monitoring well
NM = not measured
NR = not required
ORP = Oxidation-reduction potential
SPH = separate phase hydrocarbon contained in well, not sampled
s.u. = standard units (recorded by portable pH meter)
umhos/cm = micro-mhos per centimeter
NS = not sampled, well is dry
NPP = no product present

Figures



Map Source: USGS 7.5 Min. Quad Sheet BLOOMFIELD, NM., 1985.

0 2000
SCALE IN FEET

QUADRANGLE LOCATION

Western Refining

WESTERN REFINING COMPANY

PROJ. NO.: Western Refining	DATE: 6/19/08	FILE: WestRef-A25

FIGURE 1
SITE LOCATION MAP
GIANT BLOOMFIELD REFINERY

404 Camp Craft Road
Austin, Texas 78746

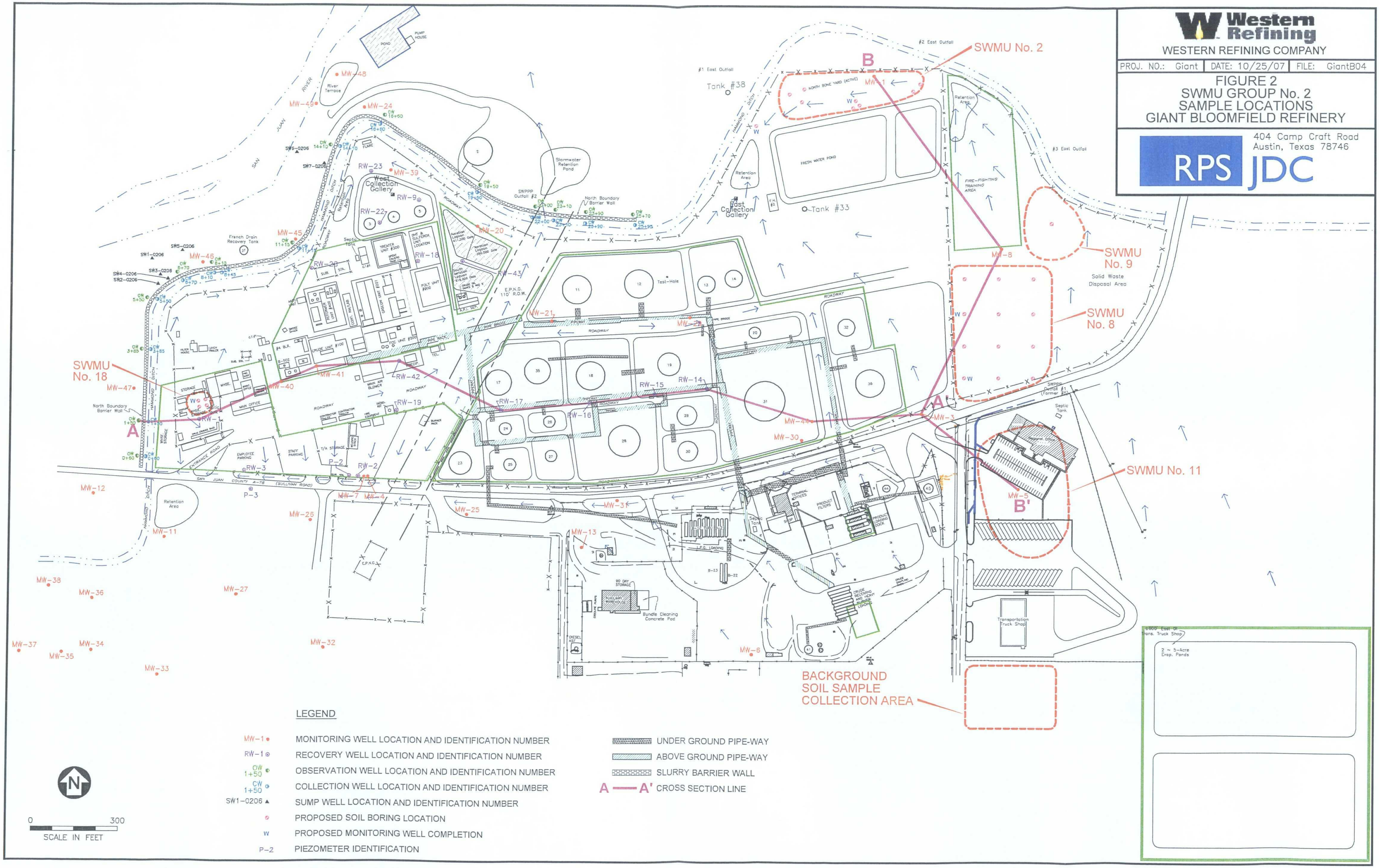
RPS JDC

Western Refining
WESTERN REFINING COMPANY

PROJ. NO.: Giant | DATE: 10/25/07 | FILE: GiantB04

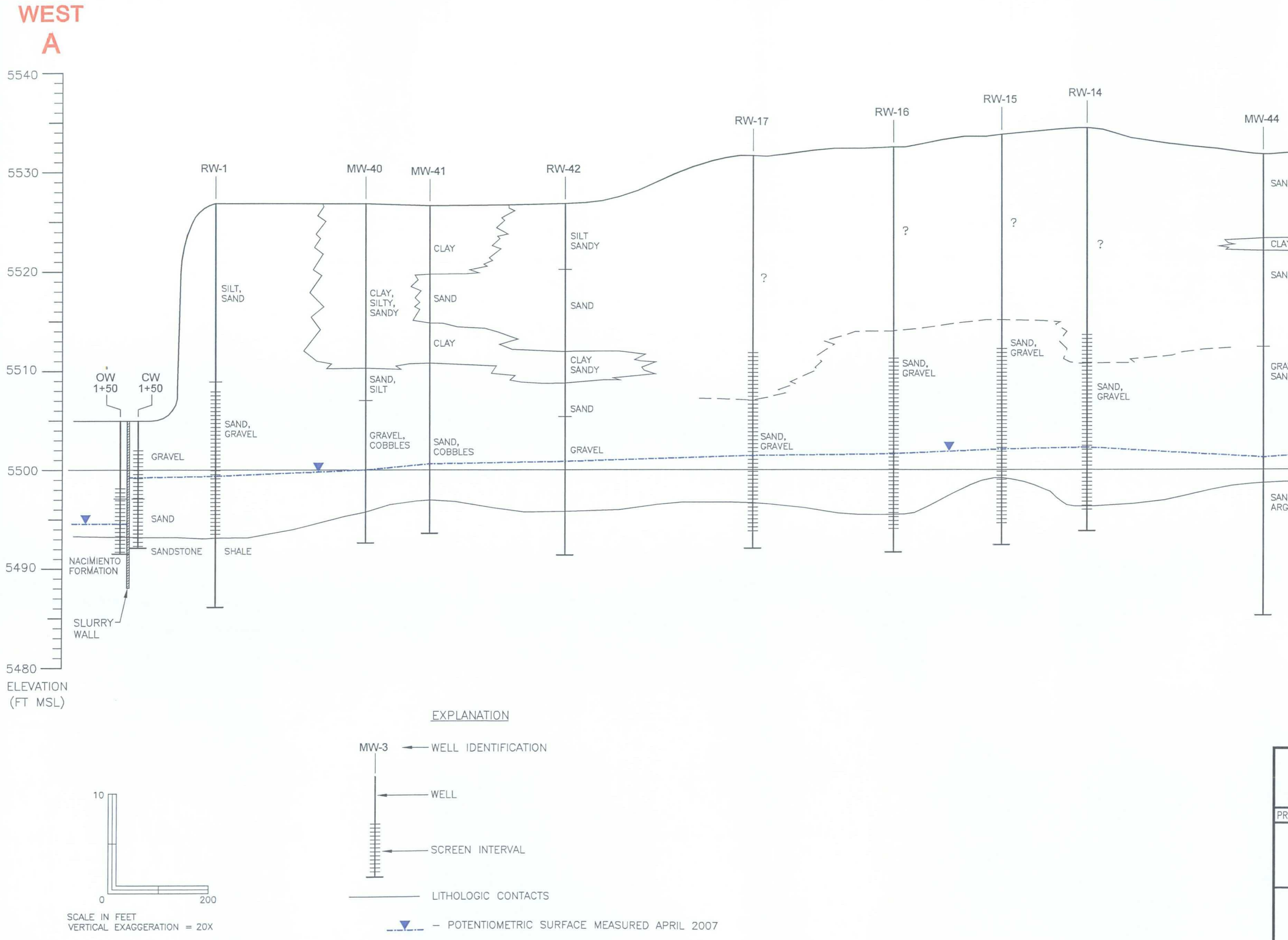
FIGURE 2
SWMU GROUP No. 2
SAMPLE LOCATIONS
GIANT BLOOMFIELD REFINERY

RPS JDC
404 Camp Craft Road
Austin, Texas 78746



LEGEND

MW-1 ●	MONITORING WELL LOCATION AND IDENTIFICATION NUMBER
RW-1 ⊚	RECOVERY WELL LOCATION AND IDENTIFICATION NUMBER
OW 1+50 ●	OBSERVATION WELL LOCATION AND IDENTIFICATION NUMBER
CW 1+50 ●	COLLECTION WELL LOCATION AND IDENTIFICATION NUMBER
SW1-0206 ▲	SUMP WELL LOCATION AND IDENTIFICATION NUMBER
○	PROPOSED SOIL BORING LOCATION
W	PROPOSED MONITORING WELL COMPLETION
P-2	PIEZOMETER IDENTIFICATION
▨	UNDER GROUND PIPE-WAY
▨	ABOVE GROUND PIPE-WAY
▨	SLURRY BARRIER WALL
A —— A'	CROSS SECTION LINE



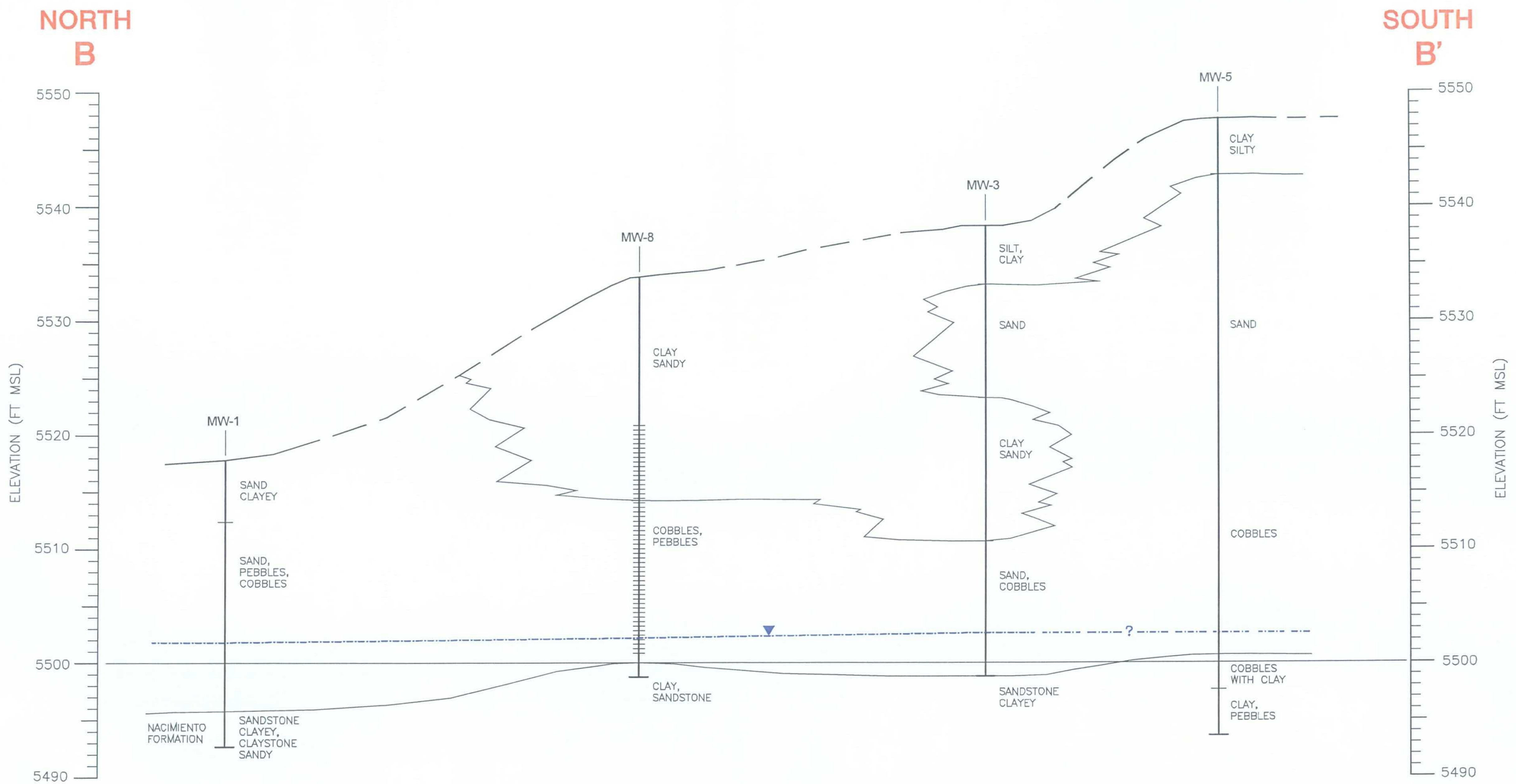
WESTERN REFINING COMPANY

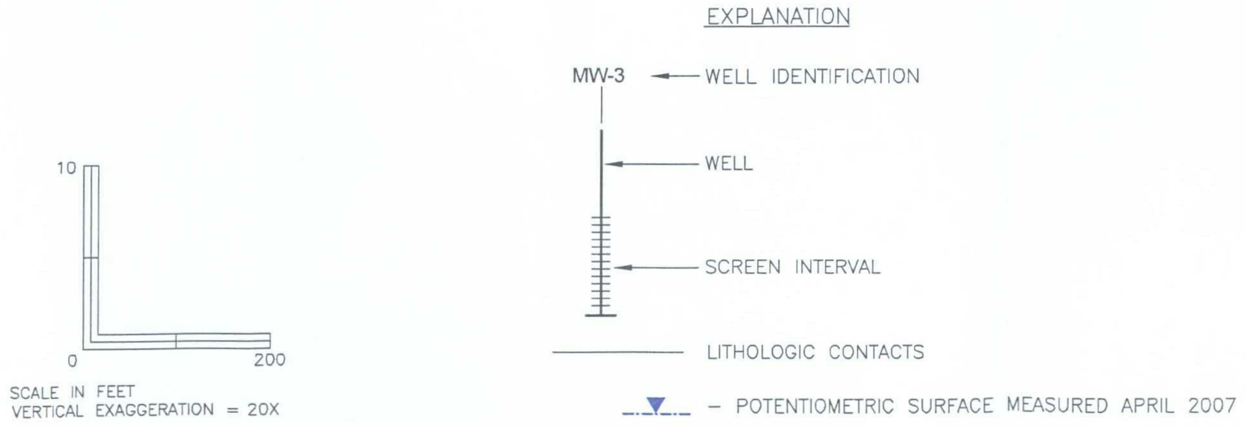
PROJ. NO.:Western Refining | DATE: 6/19/08 | FILE:WestRef–B06

FIGURE 3
CROSS SECTION A-A'
WEST TO EAST
GIANT BLOOMFIELD REFINERY

404 Camp Craft Road
Austin, Texas 78746

RPS JDC



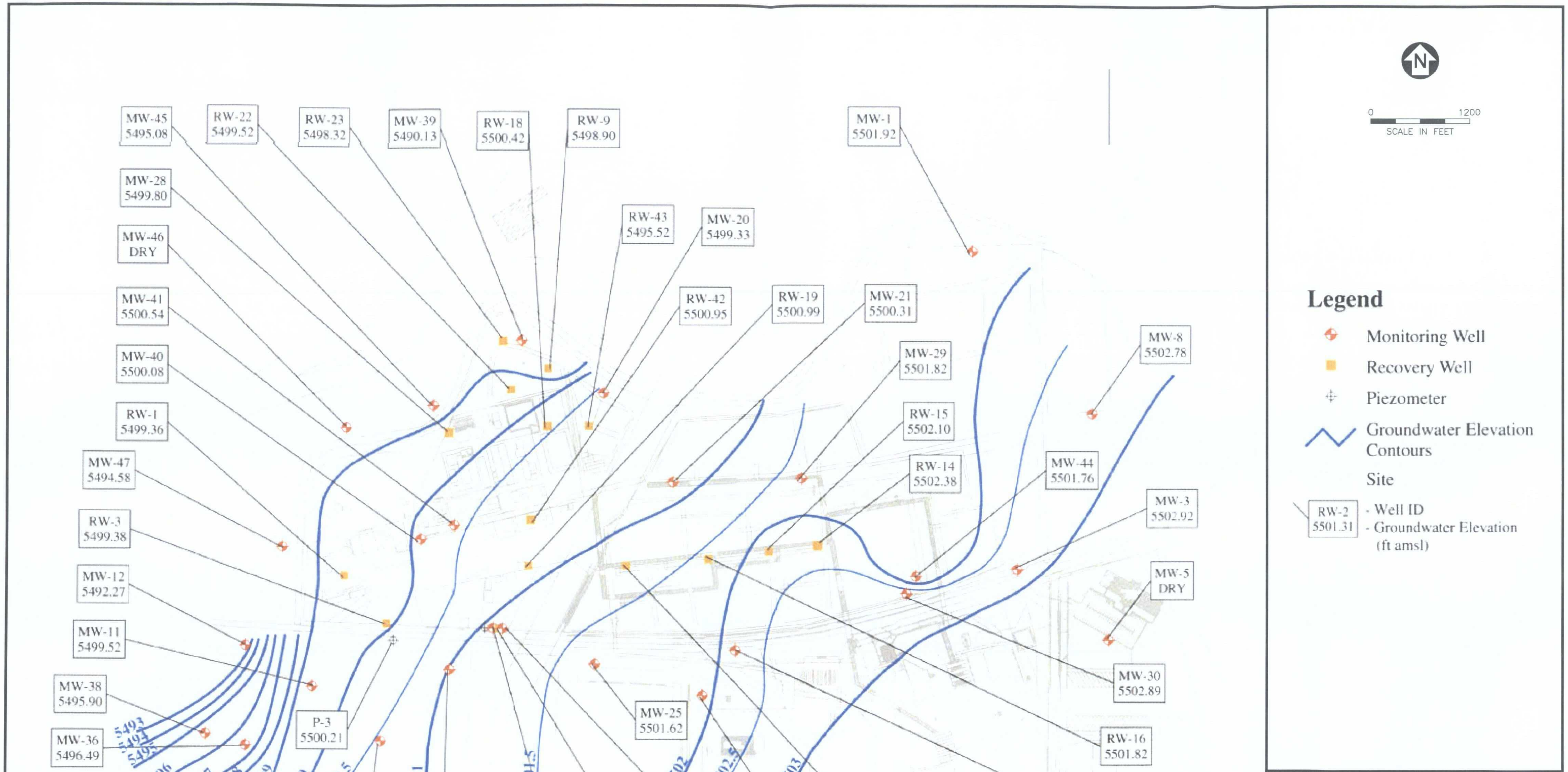


Western Refining
WESTERN REFINING COMPANY

PROJ. NO.: Western Refining	DATE: 6/19/08	FILE:WestRef–B07

FIGURE 4
CROSS SECTION B-B'
NORTH TO SOUTH
GIANT BLOOMFIELD REFINERY

RPS JDC
404 Camp Craft Road
Austin, Texas 78746



Map Source: Malcolm–Pirnie Facility–Wide Groundwater Monitoring Plan, Western Refining Bloomfield Refinery, Figure 7 Groundwater.mxd, July 2007.

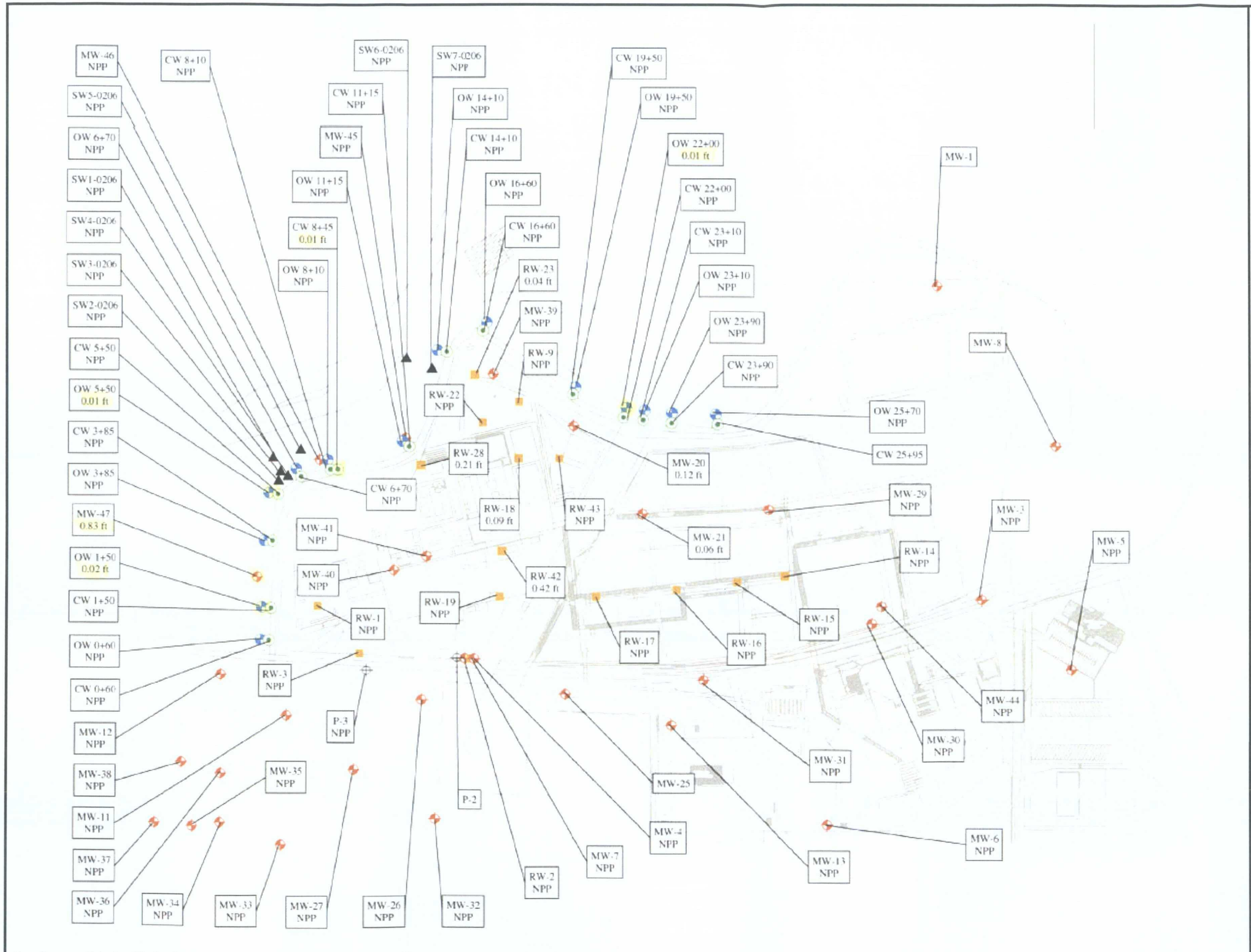
Western Refining

WESTERN REFINING COMPANY

PROJ. NO.: Western Refining	DATE: 6/19/08	FILE: WestRef-B08

FIGURE 5
APRIL 2007
POTENTIOMETRIC SURFACE
GIANT BLOOMFIELD REFINERY

RPS JDC
404 Camp Craft Road
Austin, Texas 78746



Map Source: Malcolm-Pirnie Facility-Wide Groundwater Monitoring Plan, Western Refining Bloomfield Refinery, Figure 8 Separate Phase Hydrocarbon Map.mxd, July 2007.

Legend

- Monitoring Well
- Observation Well
- ■ Recovery Well
- ⌖ Piezometer
- ● Collection Well
- ▲ Sump Well
- Site

MW-35 NPP - Well ID

ft = Feet

NPP = No Product Present
NA = Not Available

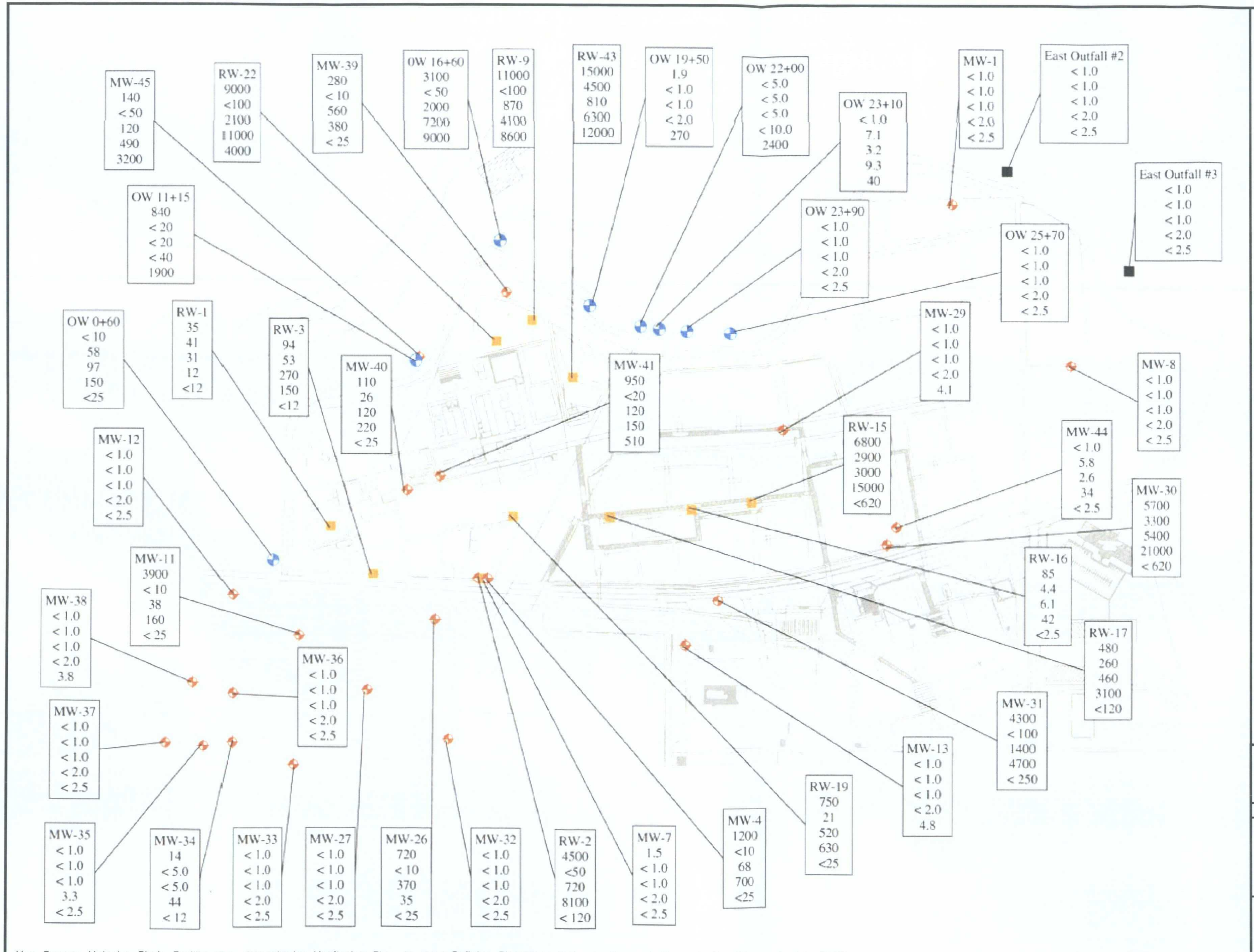
Note:
OWs and CWs were collected on 1/15/07
SWs were collected on 1/2/07

Western Refining
WESTERN REFINING COMPANY

PROJ. NO.: Western Refining	DATE: 6/19/08	FILE:WestRef-B09

FIGURE 6
SPRING 2007
SEPARATE PHASE
HYDROCARBON THICKNESS MAP
GIANT BLOOMFIELD REFINERY

RPS JDC
404 Camp Craft Road
Austin, Texas 78746



Map Source: Malcolm-Pirnie Facility-Wide Groundwater Monitoring Plan, Western Refining Bloomfield Refinery, Figure 4 Concentration Map.mxd, July 2007.

N

0 1200
SCALE IN FEET

Legend

- ● Monitoring Well
- ● Observation Well
- ■ Outfall
- ■ Recovery Well
- Site

MW-35	
< 1.0	- Benzene
< 1.0	- Toluene
< 1.0	- Ethylbenzene
3.3	- Xylenes, Total
< 2.5	- MTBE

All concentrations in micrograms per liter (ug/L)

Western Refining
WESTERN REFINING COMPANY

PROJ. NO.: Western Refining | DATE: 6/19/08 | FILE:WestRef-B10

FIGURE 7
SPRING 2007
DISSOLVED-PHASE
GROUNDWATER DATA
GIANT BLOOMFIELD REFINERY

404 Camp Craft Road
Austin, Texas 78746
RPS JDC

Aerial Map Source: Google Maps, 2007.

LEGEND

●	PROPOSED SOIL BORING LOCATION
W	PROPOSED MONITORING WELL COMPLETION
MW-1 ●	MONITORING WELL LOCATION

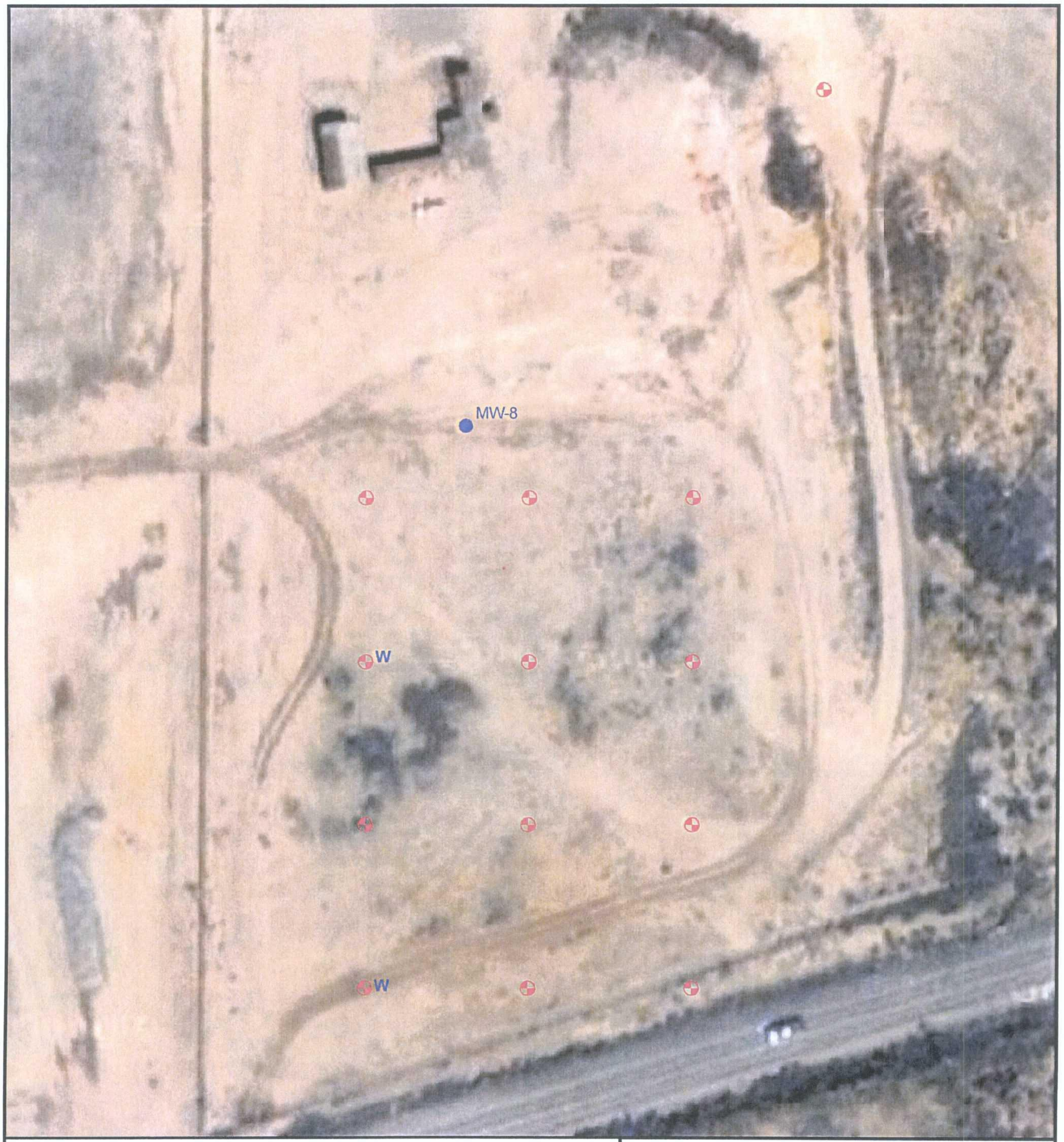
Western Refining

WESTERN REFINING COMPANY

PROJ. NO.: Giant | DATE: 10/25/07 | FILE: GiantA01

FIGURE 8
SWMU No. 2
SAMPLE LOCATION MAP
GIANT BLOOMFIELD REFINERY

RPS JDC
404 Camp Craft Road
Austin, Texas 78746



Aerial Map Source: Google Maps, 2007.

Western Refining

WESTERN REFINING COMPANY

PROJ. NO.: Giant	DATE: 10/26/07	FILE: GiantA02

FIGURE 9
SWMUs No. 8 AND No. 9 SAMPLE LOCATION MAP GIANT BLOOMFIELD REFINERY

404 Camp Craft Road
Austin, Texas 78746

RPS JDC

N

0 80
SCALE IN FEET

LEGEND

⊕	PROPOSED SOIL BORING LOCATION
W	PROPOSED MONITORING WELL COMPLETION
MW-8 ●	*MONITORING WELL LOCATION*

Appendix A

Photographs

North Bone Yard (SWMU No. 2)
Looking West at staging area for empty drums.

North Bone Yard
Looking northwest from center

North Bone Yard (SWMU No. 2)
Empty drums being loaded for transport.

North Bone Yard
MW-1

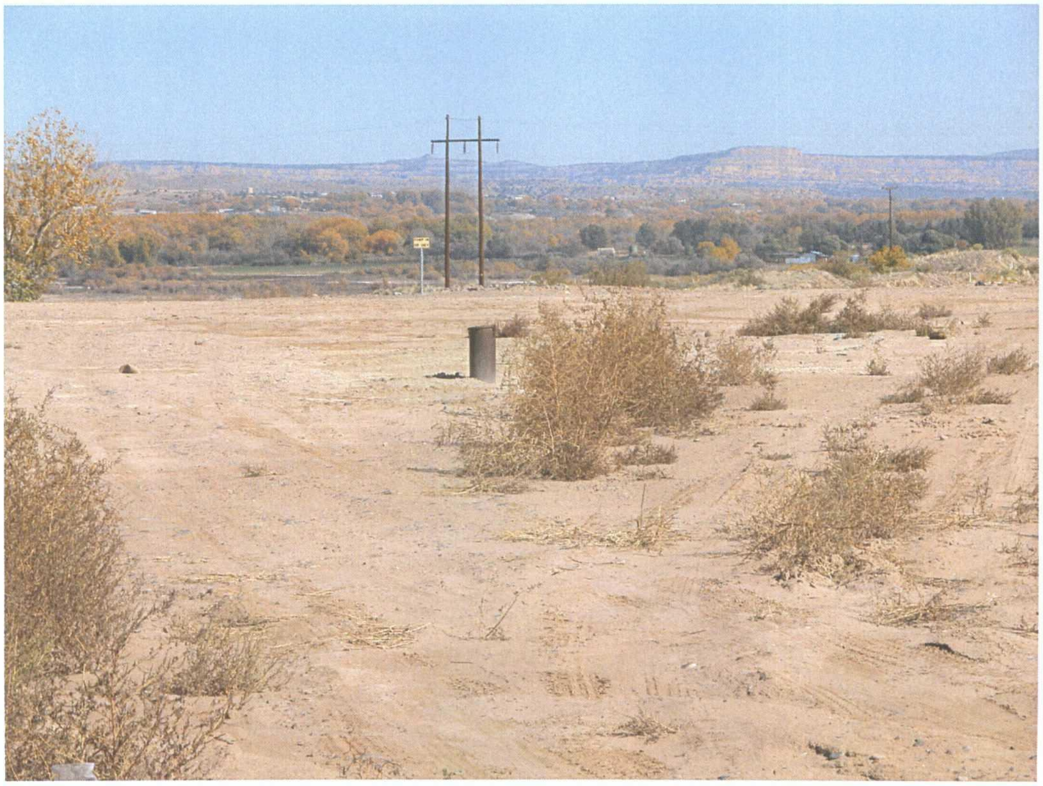
North Bone yard
Scrap metal storage area.

Landfill (SWMU No. 8)
Looking to southeast across landfill

Landfill
Looking south from Northwest corner.

Landfill
Looking southeast across landfill area.

Landfill
Looking east across landfill, MW-8 off to left.



Landfill
Closeup of MW-8.

Spray Irrigation Area (SWMU No. 11)
Looking to southeast across former irrigation area.

Warehouse Yard (SWMU No. 18)
Looking to north across former drum storage area.

Warehouse Yard
Looking north across western portion of former drum storage area.

Appendix B

Landfill (SWMU No. 8) and Landfill Pond (SWMU No. 9) Historical Documentation

GARDERE & WYNNE
ATTORNEYS AND COUNSELORS
1500 DIAMOND SHAMROCK TOWER
DALLAS, TEXAS 75201
214-979-4500

WRITER'S DIRECT DIAL NUMBER

TELECOPIER 214 979 4667
CABLE: GARWYN
TELEX 73-0197

(214) 979-4569

June 4, 1986

James L. Turner, Esq.
Assistant Regional Counsel
U.S. Environmental Protection Agency
Region VI
InterFirst Two Building
1201 Elm Street
Dallas, Texas 75270

Re: Bloomfield Refining Company
RCRA Docket No. VI-501-H;
<u>Consent Agreement and Final Order</u>

Dear Jim:

On May 20, 1986, I received your letter dated May 19, 1986 which requested certain information on sampling results submitted to you and the New Mexico Environmental Improvement Division (NMEID) on February 13, 1986. You also requested a status report on performance items in paragraphs 1 through 3 (including subparagraphs) of the above-referenced order. The purpose of this letter is to respond to both requests.

In connection with your questions about the sampling results, I am submitting the attached letter from Mr. James E. Rumbo of Engineering-Science, the Company's technical consultant. This letter responds to all five items listed in your information request.

I now turn to the requested status report, based on information provided to me by the Company. Our response focuses on those items which contemplate affirmative performance on the part of the Respondent.

<u>Paragraph 1</u>

The civil penalty of $5,700 has been paid.

Paragraph 2C

The API separator was thoroughly cleaned in November 1985. The material removed was handled and manifested as a hazardous waste. It was transported to U.S. Pollution Control, Inc.'s Grassy Mountain facility near Clive, Utah. On May 23, 1986, the sludge level was 0.5 feet.

Paragraph 2D

The prescribed documentation is available at the facility.

Paragraph 2E

Spent caustic is removed from the existing spent caustic tank in less than 90 days, and the standards established under 40 C.F.R. 262.34, and its New Mexico equivalent are being observed. However, an entirely new spent caustic tank system has been installed to further comply with the repair and maintenance obligations of this paragraph. It includes a substantial concrete slab, containment dike, and new piping to insure that no discharge of caustic can occur. This system is scheduled to be operational by June 13, 1986. The existing system will then be closed in accordance with 40 C.F.R. § 265.197 and its New Mexico equivalent.

Paragraph 2F

All of the material removed from the SOWP and NOWP in October 1985 was properly handled as a hazardous waste. The required engineering certification of removal will be submitted in conjunction with the final closure plan.

Paragraph 3

The activities specified in "A Sampling and Closure Proposal for the API Wastewater Ponds, Landfill, and Landfill Pond at the Bloomfield Refinery," attached to the above-referenced order as Exhibit B, have been completed. In accordance with the order, the Company submitted a closure plan and proof of financial responsibility on November 22, 1985. On February 13, 1986, the Company provided to EPA and NMEID copies of analytical results and analysis, as contemplated in Exhibit B and to supplement the November 22, 1985 closure plan. Following consultation with NMEID on the plan now before that agency, the Company expects to finalize the closure plan and move forward, as appropriate, on implementation.

If you have any questions or would like additional information, please contact me at your convenience.

Sincerely,

Joseph F. Guida

JFG:ta
8711S

Enclosures

cc: Ms. Denise Fort
Mr. Jack Ellvinger

bcc: Mr. Harry F. Mason
Mr. Chris Hawley

ES ENGINEERING-SCIENCE

2901 NORTH INTERREGIONAL • AUSTIN. TEXAS 78722 • 512/477-9901

CABLE ADDRESS: ENGINSCI
TELEX: 77-6442

June 2, 1986

Mr. James L. Turner
Assistant Regional Counsel
U.S. EPA, Region VI
Interfirst Two Building
1201 Elm Street
Dallas, TX 75270

Re: Bloomfield Refining Company, Inc.
Gary Refining Corp.
RCRA Docket No. VI-501-H; Consent Agreement and Final Order

Dear Mr. Turner:

Submitted herewith is a response to your letter dated 19 May 1986 to Joe Guida. The subject of your letter was the results obtained from a sampling effort performed by ES personnel at the Bloomfield Refinery pursuant to meeting mutually agreed on stipulations of the consent agreement. You noted concerns expressed by the NMEID director about the validity of sampling results and submitted a list of five requests for additional data which has been reproduced here for convenience:

(1) A list of the detection limits set for samples 51469-01 through 29, "Inorganic Parameters for Phenolics."

(2) A description of the protocol used to conduct sample analysis in all samples.

(3) A comprehensive description of the QA/QC for obtaining all samples and conducting the laboratory analysis of them.

(4) An explanation of how the detection limits were established for the "Skinner Base/Neutral Organics" and why these fluctuate from 400 to 4,000 ug/kg in some cases.

(5) A facility map detail of the landfill, landfill pond, and north and south API pond areas, showing all sample locations.

The field sampling effort was designed, planned, and executed carefully to provide representative samples from the areas of interest. The laboratory employed on the project performed state-of-the-art analyses of the samples and reported results in report form. Any "absence of compounds that would normally be present at a refinery" is likely to represent a lack of compounds in the material that was sampled rather than deficient sampling or laboratory technique.

A revised report submitted by the contract laboratory is included in this submittal and should adequately address the first two requests for information. Pages 7 and 8 of the report should satisfy request number 1. The analytical methodology section (pages 18-20) should satisfy request number 2.

QA/QC procedures for the sampling effort were followed for both the local sampling sites and sampling equipment. Transport of samples to the laboratory was made in a timely and secure manner. In the case of the API ponds, the sampling locations within each pond were first cleaned with a series of washes consisting of (in chronological order) alconox soap solution, deionized water, methanol, and deionized water. Clean sampling equipment was utilized to extract and store samples. After each sample collection in all sampling areas, equipment was washed thoroughly using the same series of washes mentioned above. Samples were placed in the appropriate containers and individually enclosed in Zip-loc bags and stored in ice in a cooler. The cooler was sent to the contract laboratory via Federal Express utilizing standard chain-of-custody procedures.

Quality control measures utilized by the laboratory have been enumerated in previously submitted information but have been reiterated here for completeness:

> "A method blank was analyzed daily to determine any interferences in the system. Four samples were spiked with known amounts of the targeted compounds to determine the percent recovery. One of the samples was run in duplicate. All the results of the above were satisfactory.
>
> In addition to the above controls, all standards, samples, and blanks were analyzed with an internal standard present to ensure consistency in the system."

With regard to request number 4, detection limits are obviously based on a laboratory's ability to detect concentrations of a substance of interest using a selected laboratory technique. Some compounds are harder to detect than others due to the compound's inherent characteristics (e.g., molecular weight, polarity) and the relative degree to which other compounds interfere with interpretation of results (in the case of GC/MS). For example, in the laboratory report submitted for BRC, the detection limit for benzidine is listed to be 4,000 ug/kg compared with anthracene having a detection limit of 400 ug/kg. In this example, benzidine is harder to detect than anthracene, and the detection limit for benzidine is therefore higher than the detection limit for anthracene. It should also be noted that the detection limits utilized for analysis are typical of the analytical methods specified and are comparable to the analytical detection limits for the same and similar compounds in soils analyzed under EPA's Contract Laboratory Program.

Figures 1 through 4 depict a facility map with details of sampling areas as solicited in request number 5. The specific sampling sites within the landfill area were not defined, however, due to the lack of a specific area with which to reference the sample locations. During the sampling effort, the area of the landfill observed to be contaminated was irregularly shaped and inconsistent in areal extent with the land area depicted on earlier facility plans. For this reason, that portion of the landfill area appearing to have some contamination was selected for sampling and divided into quadrants. The midpoint of each quadrant (selected by eye) was then sampled. Distances between sampling sites were measured with a tape and ranged from 25 to 65 feet. An approximation of the sampling area within the landfill has been shown on Figure 1.

I trust that the above information is sufficient to answer any questions you may have. If you have any additional questions, please do not hesitate to call.

Sincerely,

James E. Rumbo

James E. Rumbo, P.E.
Project Engineer

Enclosures

dg

FIGURE 1
BLOOMFIELD REFINERY FACILITY MAP

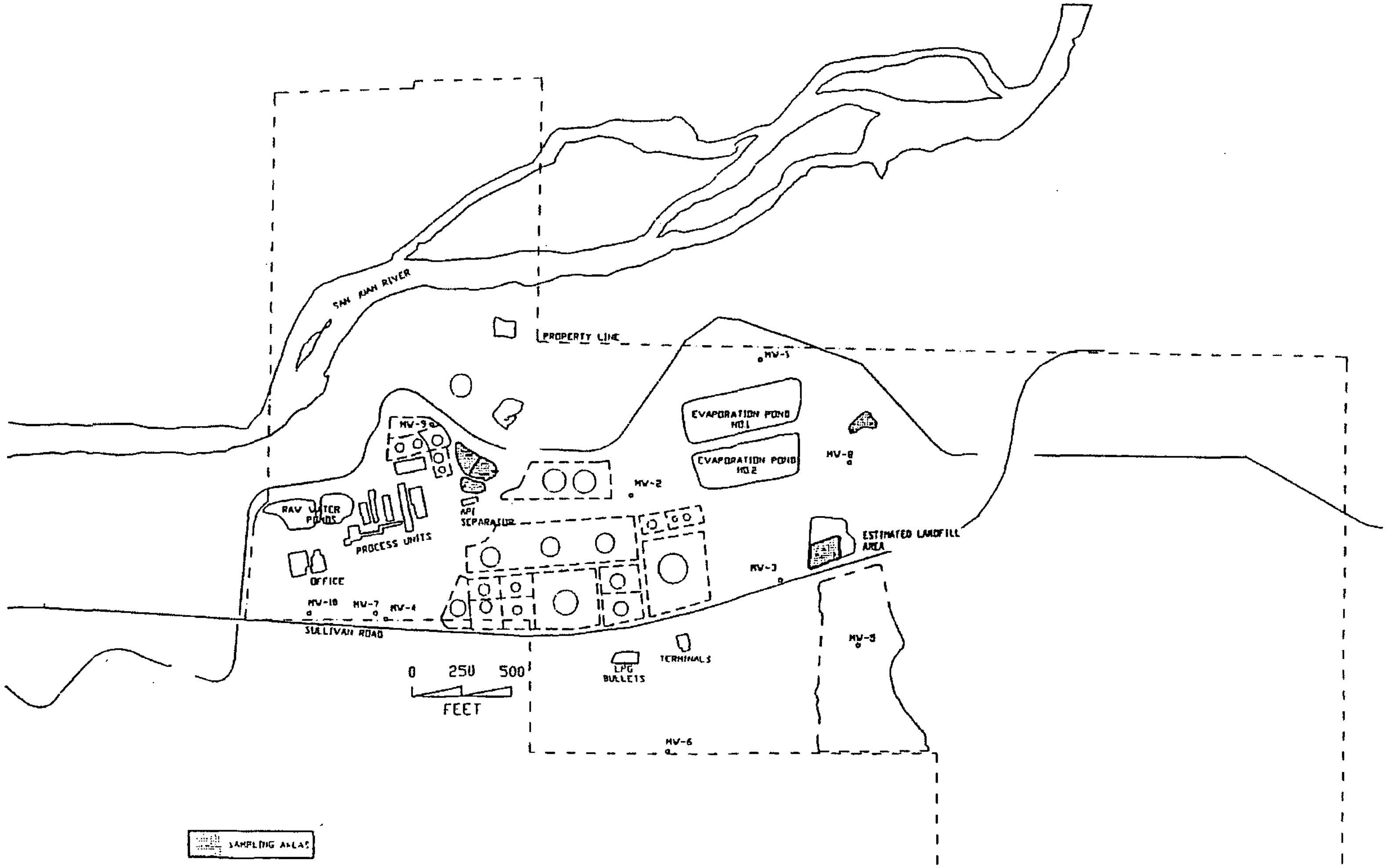
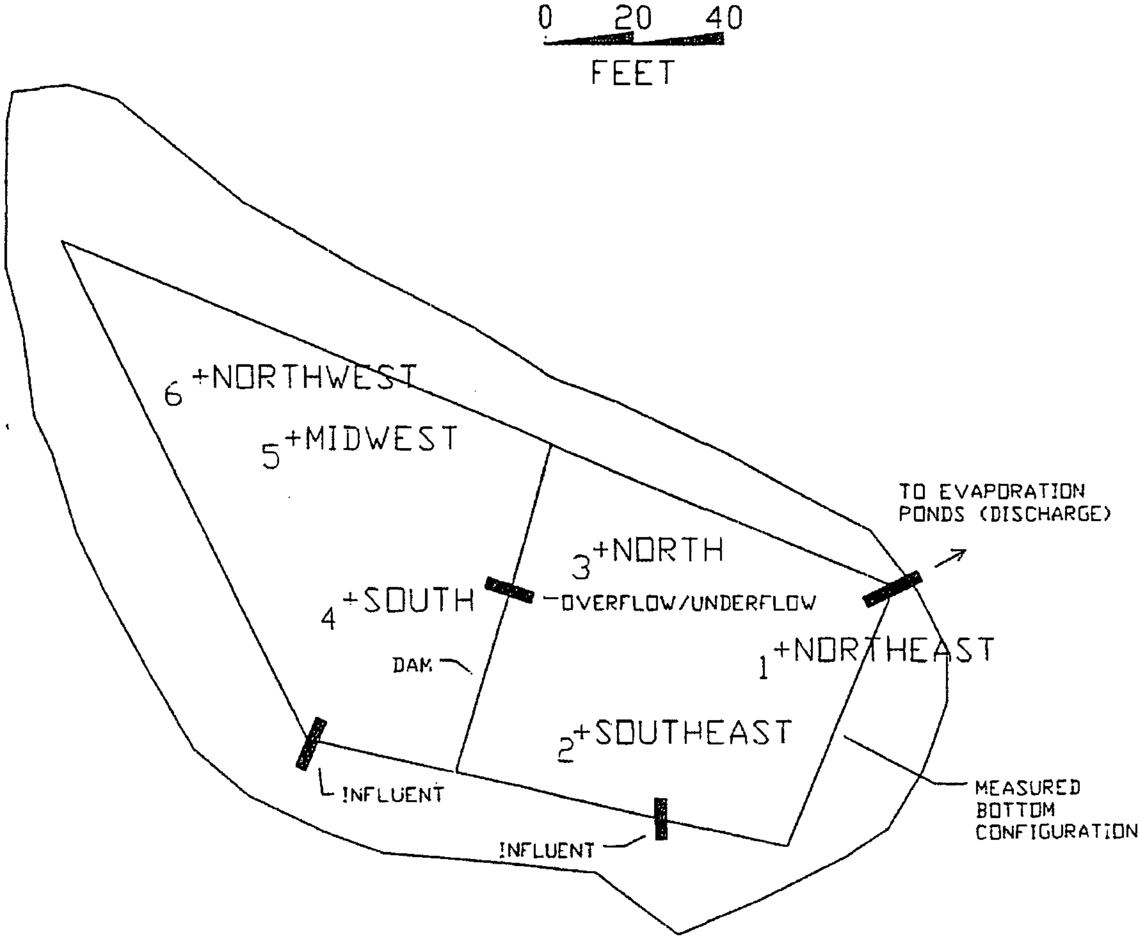


FIGURE 2
NORTH API POND



+ SAMPLE SITE

FIGURE 3
SOUTH API POND

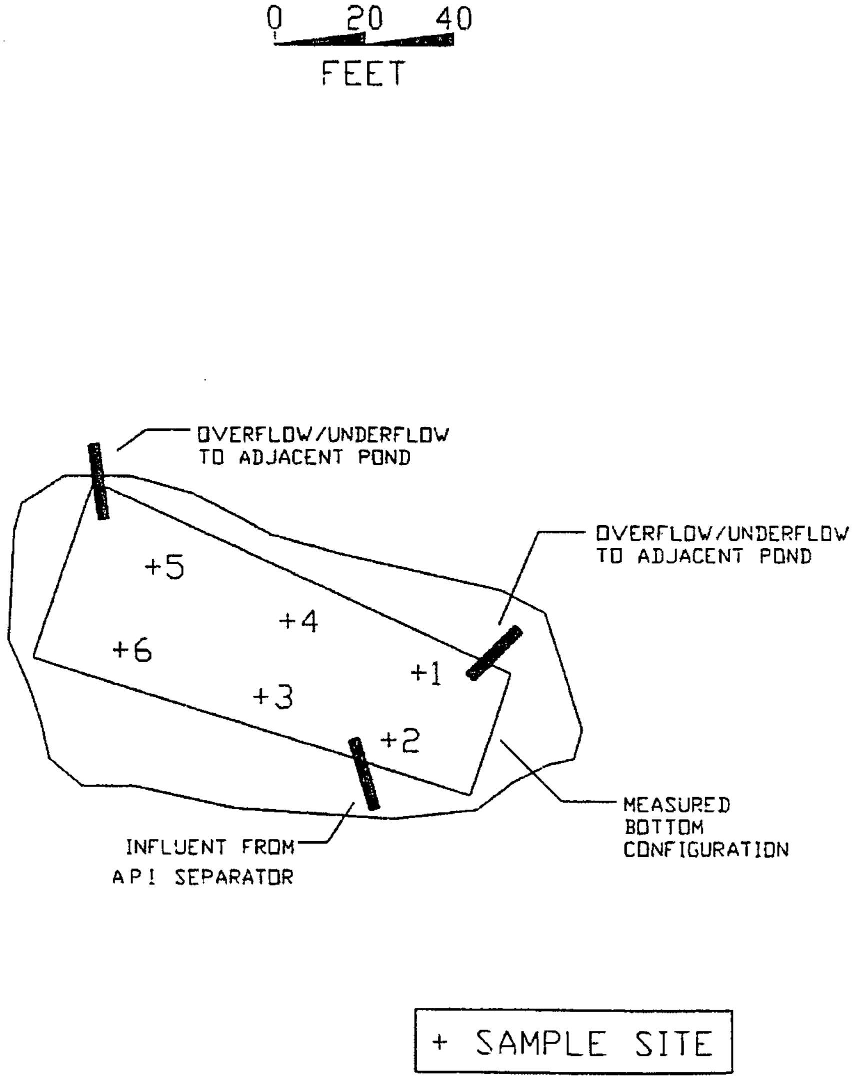
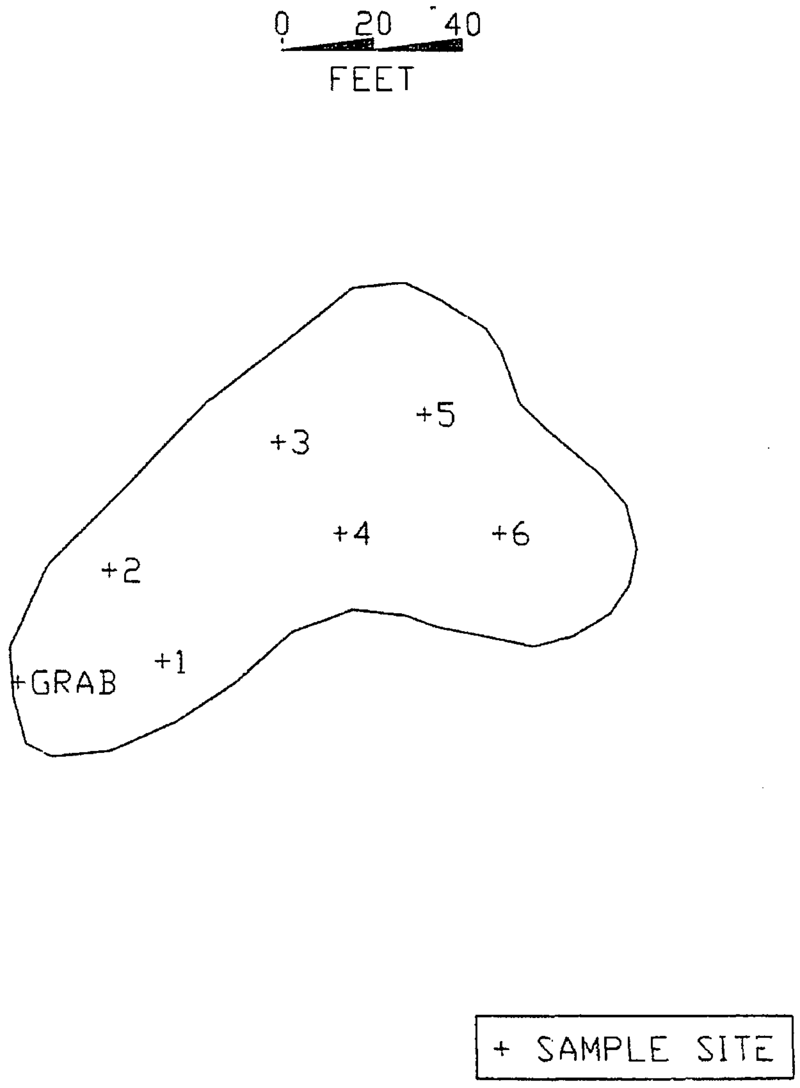


FIGURE 4
LANDFILL POND



REPORT OF ANALYTICAL RESULTS

FOR

ENGINEERING SCIENCE
BLOOMFIELD REFINING COMPANY

Prepared By:

Rocky Mountain Analytical Laboratory
5530 Marshall Street
Arvada, CO 80004

May 28, 1986

I. INTRODUCTION

On October 19, 1985 Rocky Mountain Analytical Laboratory received 29 soil samples from Bloomfield Refining Company, collected by Engineering Science. The analyses performed on these samples have been categorized as follows:

- Analyses for Appendix VIII organic constituents, and
- Analyses for selected constituents and phenolics.

Appendix VIII Constituents

The analytical parameters selected were based on recent communication with EPA concerning RCRA monitoring requirements for petroleum companies. The parameters selected were based on a subset of Appendix VIII hazardous constituents commonly referred to as the "Skinner" list. Communications from EPA in late 1984 contained various versions of this list. During this time RMAL, under contract to the American Petroleum Institute, performed several studies evaluating analytical methods proposed ~~for~~ measuring the constituents in these various lists. Due in part to efforts by RMAL and others, the EPA in early 1985 revised this list. The documents which were used by RMAL in defining the analytical parameters are listed in a bibliography at the end of this report. This list, as revised, contains 46 organic compounds and is presented in Table 1. The organic compounds are further subdivided into volatile and semivolatile (extractable) compounds.

Additional Tests

In addition to the tests for the full "Skinner" list, some samples were analyzed only for a specific subset of this list. The subset was benzene, toluene, xylene, lead, chromium and total phenolics.

All samples were shipped by air freight to RMAL's Denver, Colorado laboratory. Each sample was assigned a unique RMAL sample number as shown in the enclosed Sample Description Information sheet. These sample numbers were used throughout the project to track and control the analytical work and are used in this document for reporting the results from each analyses.

SAMPLE DESCRIPTION INFORMATION

for

Engineering Science - Bloomfield Refining Company

RMA Sample No.	Sample Description	Sample Type	Date Sampled	Date Received
51469-01	L1 & L2, 0-6" Quadrant #1 - Landfill	Soil	10/16/85	10/19/85
51469-02	L3 & L4, 6-12" Quadrant #1 - Landfill	Soil	10/16/85	10/19/85
51469-03	L5 & L6, 0-6" Quadrant #2 - Landfill	Soil	10/16/85	10/19/85
51469-04	L7 & L8, 6-12" Quadrant #2 - Landfill	Soil	10/16/85	10/19/85
51469-05	L9 & L10, 0-6" Quadrant #3 - Landfill	Soil	10/16/85	10/19/85
51469-06	L11 & L12, 6-12" Quadrant #3 - Landfill	Soil	10/16/85	10/19/85
51469-07	L13 & L14, 0-6" Quadrant #4 - Landfill	Soil	10/16/85	10/19/85
51469-08	L15 & L16, 6-12" Quadrant #4 - Landfill	Soil	10/16/85	10/19/85
51469-09	LP1 & LP2, 0-6" Points 1 & 2 @ Landfill Pond	Soil	10/16/85	10/19/85
51469-10	LP3 & LP4, 6-12" Points 1 & 2 @ Landfill Pond	Soil	10/16/85	10/19/85
51469-11	LP5 & LP6, 0-6" Points 3 & 4 @ Landfill Pond	Soil	10/16/85	10/19/85
51469-12	LP7 & LP8, 6-12" Points 3 & 4 @ Landfill Pond	Soil	10/16/85	10/19/85
51469-13	LP9 & LP10, 0-6" Points 5 & 6 @ Landfill Pond	Soil	10/16/85	10/19/85
51469-14	LP11 & LP12, 6-12" Points 5 & 6 @ Landfill Pond	Soil	10/16/85	10/19/85
51469-15	LP13 & LP14, 0-6" S. Evaporation Pond - Landfill Pond	Soil	10/16/85	10/19/85
51469-16	MS1 & MS2, Mystery Sample	Soil	10/16/85	10/19/85
51469-17	APS1 & APS2, 0-6" NE & SE of South API Pond	Soil	10/15/85	10/19/85
51469-18	APS3 & APS4, 6-12" NE & SE of South API Pond	Soil	10/15/85	10/19/85
51469-19	APS5 & APS6, 0-6" N & S of South API Pond	Soil	10/15/85	10/19/85
51469-20	APS7 & APS8, 6-12" N & S of South API Pond	Soil	10/15/85	10/19/85

SAMPLE DESCRIPTION INFORMATION

for

Engineering Science - Bloomfield Refining Company

(Continued)

RMA Sample No.	Sample Description	Sample Type	Date Sampled	Date Received
51469-21	APS9 & APS10, 0-6" NW & SW of South API Pond	Soil	10/15/85	10/19/85
51469-22	APS11 & APS12, 6-12" NW & SW of South API Pond	Soil	10/15/85	10/19/85
51469-23	APS13, 0-6" SE near influent S. API Pond	Soil	10/15/85	10/19/85
51469-24	APN1 & APN2, 0-6" NE & SE of North API Pond	Soil	10/15/85	10/19/85
51469-25	APN3 & APN4, 6-12" NE & SE of North API Pond	Soil	10/15/85	10/19/85
51469-26	APN5 & APN6, 0-6" N & S of North API Pond	Soil	10/15/85	10/19/85
51469-27	APN7 & APN8, 6-12" N & S of North API Pond	Soil	10/15/85	10/19/85
51469-28	APN9 & APN10, 0-6" NW & SW of North API Pond	Soil	10/15/85	10/19/85
51469-29	APN11 & APN12, 6-12" NW & SW of North API Pond	Soil	10/15/85	10/19/85

May 28, 1986

TABLE 1. APPENDIX VIII HAZARDOUS CONSTITUENT SUBSET FOR PETROLEUM REFINERY STUDIES*

Volatile Organics

- Benzene
- Carbon Disulfide
- Chlorobenzene
- Chloroform
- 1,2-Dibromoethane
- 1,2-Dichloroethane
- 1,4-Dioxane
- Methyl ethyl ketone
- Styrene
- Ethyl Benzene
- Toluene
- Xylenes
  - Xylenes, m
  - Xylenes, o & p

Base/Neutral Organics

- Anthracene
- Benz(a)anthracene
- Benzo(b)fluoranthene
- Benzo(j)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Bis(2-ethylhexyl)phthalate
- Butyl benzyl phthalate
- Chrysene
- Dibenz(a,h)acridine
- Dibenz(a,h)anthracene
- Di-n-butyl phthalate

Base/Neutral Organics (Cont.)

- Dichlorobenzenes
  - o-Dichlorobenzene
  - m-Dichlorobenzene
  - p-Dichlorobenzene
- Diethyl phthalate
- 7,12-Dimethylbenz(a)anthracene
- Dimethyl phthalate
- Di-n-octyl phthalate
- Fluoranthene
- Indene
- Methyl chrysene
- 1-Methylnaphthalene
- Naphthalene
- Phenanthrene
- Pyrene
- Pyridine
- Quinoline

Acid Organics

- Benzenethiol
- Cresols
  - o-Cresol
  - p&m-Cresol
- 2,4-Dimethylphenol
- 2,4-Dinitrophenol
- 4-Nitrophenol
- Phenol

*"Petitions to Delist Hazardous Wastes, A Guidance Manual," EPA/530-SW-85-003, April, 1985.

II. RESULTS

The analytical results are presented in the data tables in this section. The data are organized into the tables described below:

- Phenolics,
- Total Chromium and Lead,
- Skinner Volatile Organics,
- Skinner Base/Neutral Organics,
- Skinner Acid Organics, and
- Volatile Aromatics.

For each of the parameters in the phenolics and the metals tables, the result and detection limit is present for each sample. The term ND is used to indicate the parameter was not detected at the detection limit shown.

The term BDL (Below Detection Limit) is used in the skinner organic results tables to indicate that the compound is not present at the detection limit shown. The detection limits for the Appendix VIII organic compounds were obtained from a study of the analytical methods performed by RMAL under contract to the American Petroleum Institute (API)[1]. Analytical standards are not available for three compounds. These compounds cannot be measured; they have been listed in the results tables and have been footnoted to show that standards were not available.

As explained in more detail in the analytical methodology section, the samples were screened prior to analysis in order to optimize the detection limit for each sample and minimize instrumental problems associated with analyzing samples containing

---

[1] "Recovery and Detection Limits of Organic Compounds in Petroleum Refinery Wastes", January 25, 1985.

relatively high concentrations. This process resulted in high dilutions for several samples containing high concentrations of the target compounds. For these samples, the detection limits for compounds not detected are proportionately high. Also, the compounds which were reported close to (less than two times) the detection limits may be suspect.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

PHENOLICS

Parameter	Units	51469-01	51469-02	51469-03	51469-04
Phenolics	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)

Parameter	Units	51469-05	51469-06	51469-07	51469-08
Phenolics	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)

Parameter	Units	51469-09	51469-10	51469-11	51469-12
Phenolics	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)

Parameter	Units	51469-13	51469-14	51469-15	51469-16
Phenolics	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)

Parameter	Units	51469-17	51469-18	51469-19	51469-20
Phenolics	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)

Parameter	Units	51469-21	51469-22	51469-23	51469-24
Phenolics	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)

ND = Not detected.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

PHENOLICS (Continued)

Parameter	Units	51469-25	51469-26	51469-27	51469-28
Phenolics	mg/kg	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)

Parameter	Units	51469-29
Phenolics	mg/kg	ND (0.1)

ND = Not detected.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

CHROMIUN AND LEAD

Parameter	Units	51469-01		51469-02		51469-03		51469-04	
Chromium	mg/kg	11	(0.5)	8.9	(0.5)	9.9	(0.5)	7.6	(0.5)
Lead	mg/kg	10	(2.5)	9.8	(2.5)	9.0	(2.5)	6.7	(2.5)

Parameter	Units	51469-05		51469-06		51469-07		51469-08	
Chromium	mg/kg	7.8	(0.5)	7.4	(0.5)	9.1	(0.5)	7.0	(0.5)
Lead	mg/kg	7.6	(2.5)	7.0	(2.5)	8.2	(2.5)	7.7	(2.5)

Parameter	Units	51469-09		51469-10		51469-11		51469-12	
Chromium	mg/kg	6.2	(0.5)	8.1	(0.5)	7.8	(0.5)	10	(0.5)
Lead	mg/kg	9.0	(2.5)	8.5	(2.5)	8.9	(2.5)	12	(2.5)

Parameter	Units	51469-13		51469-14		51469-15		51469-16	
Chromium	mg/kg	8.0	(0.5)	7.8	(0.5)	2.3	(0.5)	2.4	(0.5)
Lead	mg/kg	12	(2.5)	13	(2.5)	4	(2.5)	4	(2.5)

Parameter	Units	51469-17		51469-18		51469-19		51469-20	
Chromium	mg/kg	4.4	(0.5)	5.3	(0.5)	5.5	(0.5)	14	(0.5)
Lead	mg/kg	5	(2.5)	5	(2.5)	5	(2.5)	4	(2.5)

Detection limits in parentheses.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

CHROMIUM AND LEAD (Cont.)

Parameter	Units	51469-21	51469-22	51469-23	51469-24
Chromium	mg/kg	6.8 (0.5)	27 (0.5)	4.9 (0.5)	7.8 (0.5)
Lead	mg/kg	5.1 (2.5)	5.9 (2.5)	6.0 (2.5)	4 (2.5)

Parameter	Units	51469-25	51469-26	51469-27	51469-28
Chromium	mg/kg	3.2 (0.5)	3.6 (0.5)	2.3 (0.5)	2.9 (0.5)
Lead	mg/kg	3 (2.5)	5 (2.5)	3 (2.5)	3 (2.5)

Parameter	Units	51469-29
Chromium	mg/kg	12 (0.5)
Lead	mg/kg	4 (2.5)

Detection limits in parentheses.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

VOLATILE AROMATICS - GC/PID

Parameter	Units	51469-01		51469-02		51469-03		51469-04	
Benzene	ug/kg	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Ethylbenzene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Toluene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylene, m	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylenes, o & p	ug/kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)

Parameter	Units	51469-05		51469-06		51469-07		51469-08	
Benzene	ug/kg	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Ethylbenzene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Toluene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylene, m	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylenes, o & p	ug/kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)

Parameter	Units	51469-09		51469-10		51469-11		51469-12	
Benzene	ug/kg	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Ethylbenzene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Toluene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylene, m	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylenes, o & p	ug/kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)

Parameter	Units	51469-13		51469-14		51469-15		51469-16	
Benzene	ug/kg	1.3	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Ethylbenzene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Toluene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylene, m	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylenes, o & p	ug/kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)

ND = Not detected.   Detection limits in parentheses.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

(Continued)

VOLATILE AROMATICS - GC/PID

Parameter	Units	51469-17		51469-18		51469-19		51469-20	
Benzene	ug/kg	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Ethylbenzene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Toluene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylene, m	ug/kg	5.3	(1.0)	ND	(3.0)	ND	(4.0)	ND	(2.0)
Xylenes, o & p	ug/kg	2.1	(2.0)	ND	(3.0)	ND	(2.0)	ND	(4.0)

Parameter	Units	51469-21		51469-22		51469-23		51469-24	
Benzene	ug/kg	ND	(0.5)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Ethylbenzene	ug/kg	ND	(1.0)	ND	(4.0)	ND	(1.0)	ND	(1.0)
Toluene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(2.0)	ND	(1.0)
Xylene, m	ug/kg	ND	(1.0)	ND	(25)	ND	(1.0)	ND	(1.0)
Xylenes, o & p	ug/kg	ND	(4.0)	ND	(25)	ND	(2.0)	ND	(2.0)

Parameter	Units	51469-25		51469-26		51469-27		51469-28	
Benzene	ug/kg	ND	(0.5)	ND	(0.5)	ND	(0.5)	ND	(0.5)
Ethylbenzene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Toluene	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylene, m	ug/kg	ND	(1.0)	ND	(1.0)	ND	(1.0)	ND	(1.0)
Xylenes, o & p	ug/kg	ND	(2.0)	ND	(2.0)	ND	(2.0)	ND	(2.0)

Parameter	Units	51469-29	
Benzene	ug/kg	ND	(0.5)
Ethylbenzene	ug/kg	ND	(1.0)
Toluene	ug/kg	ND	(1.0)
Xylene, m	ug/kg	ND	(1.0)
Xylenes, o & p	ug/kg	ND	(2.0)

ND = Not detected. Detection limits in parentheses. *Analyses incomplete.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

PERCENT MOISTURE

Sample Number	Percent Moisture	Sample Number	Percent Moisture
51469-01	4%	51469-16	4%
51469-02	5%	51469-17	9%
51469-03	4%	51469-18	10%
51469-04	3%	51469-19	10%
51469-05	3%	51469-20	8%
51469-06	3%	51469-21	6%
51469-07	6%	51469-22	6%
51469-08	4%	51469-23	8%
51469-09	23%	51469-24	5%
51469-10	14%	51469-25	5%
51469-11	18%	51469-26	7%
51469-12	13%	51469-27	5%
51469-13	22%	51469-28	4%
51469-14	14%	51469-29	4%
51469-15	28%		

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

SKINNER VOLATILE ORGANICS, SOIL

Parameter	Units	51469-15		51469-16		51469-23	
Acrolein	ug/kg	BDL	(30)	BDL	(30)	BDL	(30)
Acrylonitrile*	ug/kg	-	-	-	-	-	-
Benzene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Carbon disulfide	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Carbon tetrachloride	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Chlorobenzene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Chloromethane	ug/kg	BDL	(10)	BDL	(10)	BDL	(10)
1,2 Dibromoethane	ug/kg	BDL	(20)	BDL	(20)	BDL	(20)
Chloroform	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Dichloromethane	ug/kg	BDL	(10)	BDL	(10)	BDL	(10)
1,1-Dichloroethane	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
1,2-Dichloroethane	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
1,1-Dichloroethylene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Dichloropropane	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Methyl ethyl ketone	ug/kg	BDL	(10)	53	(10)	BDL	(10)
Styrene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
1,1,2,2-Tetrachloroethane	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Tetrachloroethylene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Toluene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
1,2-trans-Dichloroethylene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
1,1,1-Trichloroethane	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
1,1,2-Trichloroethane	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)
Trichloroethylene	ug/kg	BDL	(5)	BDL	(5)	BDL	(5)

BDL = Below detection limit. Detection limits in parentheses.
*Not consistantly recovered using Method 8240.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

SKINNER BASE/NEUTRAL ORGANICS, SOILS

Parameter	Units	51469-15		51469-16		51469-23	
Anthracene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Benzidine	ug/kg	BDL	(4000)	BDL	(4000)	BDL	(4000)
Benz(c)acridine**	ug/kg	-	-	-	-	-	-
Benzo(a)anthracene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Benzo(a)pyrene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Benzo (b) fluoranthene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Benzo (k) fluoranthene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Bis (2-chloroethyl)ether	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Bis (2-chloroisopropyl)ether	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Bis (2-ethylhexyl)phthalate	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Butyl benzyl phthalate	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
2-Chloronaphthalene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Chrysene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Dibenz(a,h)acridine**	ug/kg	-	-	-	-	-	-
Dibenz(a,j)acridine	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
7,12-DimethylBenz(a)anthracene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Dibenz(a,h) anthracene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
7H Dibenzo(c,g)carbazole	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
1,2-Dichlorobenzene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
1,3-Dichlorobenzene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
1,4-Dichlorobenzene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Diethyl phthalate	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Dimethyl phthalate	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Di-n-butyl phthalate	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
2,4-Dinitrotoluene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
2,6-Dinitrotoluene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Di-n-octyl phthalate	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
1,2-Diphenylhydrazine*	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Fluoranthene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)

BDL = Below detection limit. Detection limits in parentheses. *Measured as azobenzene.
**Not consistantly recovered using Method 8270, or no analytical standard available.

ANALYTICAL RESULTS

for

Engineering Science - Bloomfield Refining Company

SKINNER BASE/NEUTRAL ORGANICS, SOIL (Cont.)

Parameter	Units	51469-15		51469-16		51469-23	
Indene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Indeno(1,2,3-cd)pyrene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Methyl Benz(c)phenanthrene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
3-Methylcholanthrene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Methyl Chrysene**	ug/kg	-	-	-	-	-	-
Naphthalene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Nitrobenzene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
n-Nitrosodiethylamine	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
5-Nitroacenapthene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Quinoline	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Phenanthrene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Pyrene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
1,2,4-Trichlorobenzene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Trimethyl Benz(a)anthracene	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)

SKINNER ACID ORGANICS

Parameter	Units	51469-15		51469-16		51469-23	
2-Chlorophenol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
o-Cresol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
m/p-Cresol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
2,4-Dimethylphenol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
4,6-Dinitro-o-phenol	ug/kg	BDL	(2000)	BDL	(2000)	BDL	(2000)
2,4-Dinitrophenol	ug/kg	BDL	(4000)	BDL	(4000)	BDL	(4000)
2-Nitrophenol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
4-Nitrophenol	ug/kg	BDL	(800)	BDL	(800)	BDL	(800)
p-Chloro-m-cresol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Pentachlorophenol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
Phenol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)
2,4,6-Trichlorophenol	ug/kg	BDL	(400)	BDL	(400)	BDL	(400)

BDL = Below detection limit. Detection limits in parentheses.

**Not consistantly recovered using Method 8270, or no analytical standard available.

III. ANALYTICAL METHODOLOGY

The methods for the metals and organic compounds were derived from three sources of EPA methods,· 1) the methods promulgated in 40 CFR 136 for priority pollutants, 2) the methods published in SW-846 and 3) methods developed by the EPA-EMSL/LV for Superfund investigations, as well as several documents published by the EPA and RMAL in 1984 and 1985. These methods all use the same generic technology as summarized below:

- o Metals, acid digestion followed by analysis by ICP supported by graphite furnace AA,
- o Volatile Organics, purge and trap GC/MS, and
- o Semivolatile (base/neutral and acid) organics, solvent extraction followed by capillary column GC/MS.

The EPA (40 CFR 136, SW-846 and Superfund) methods were, to a large degree, developed and validated to determine the priority pollutants in a broad spectrum of environmental samples. Between October 1983 and July 1985 the EPA released three methods manuals and a "Guidance Manual" which were compendiums of modified SW-846 methods specifically adapted for the analysis of Appendix VIII constituents in petroleum refining wastes (not water samples). The most useful of these documents was an October, 1984 draft methods manual which unfortunately was never formally distributed by EPA, apparently in order to avoid a conflict with a proposed rule in the October 1, 1984 Federal Register. However, even this document (as discussed by an RMAL review for API in December, 1984) lacked many important details that are critical to the successful analysis of environmental samples impacted by petroleum refineries.

Thus, although the methods used by RMAL were based on these various EPA documents, the actual details of each method were implemented by RMAL as explained in more detail below. The various documents which were used to establish RMAL's approach are listed in a bibliography. The discussion below references method numbers in SW-846. However, it should be noted that several different versions of these methods are cited in the various EPA documents. In addition to the documents listed in the bibliography, RMAL has continued a dialogue through phone conversations and meetings with EPA/OSW to ensure that this approach is in line with the Agency's expectations. Much of RMAL's approach is being incorporated in pending Agency promulgations.

Total Metals

Metals were determined using inductively coupled plasma-atomic emission spectroscopy (ICP). Prior to analysis, the samples were prepared using Method 3050. The ICP was preprogrammed to perform off peak background correction on both the high and low wavelength sides of the analytical peaks of interest as appropriate. One hundred interelemental corrections were also automatically applied to the analysis. A matrix spike is analyzed as a quality control check for the ICP analyses.

Skinner Volatile Organics

Volatile organic compounds were determined by purge and trap gas chromatography/mass spectrometry (GC/MS) using Method 8240 with the appropriate sample introduction procedure. The appropriate procedure was determined using a screening procedure consisting of a liquid-liquid extraction with hexadecane followed by direct injection of an aliquot of the extract into a gas chromatograph with flame ionization detection (GC/FID). All volatile samples were screened in this way before GC/MS analysis. The GC/FID screening results were evaluated to determine the amount of sample to use that provides the lowest detection limits possible without overloading the GC/MS system.

Skinner Semivolatile Organics

Semivolatile organics were determined by capillary column GC/MS using SW-846 Method 8270. Soil samples were extracted using SW-846 Sonication Method 3550. After extraction, the samples were subjected to Method 3530 to separate the extract into acidic and basic fractions. The basic fraction was then cleaned up using Method 3570 to generate aliphatic and aromatic fractions. GC/MS analyses were then performed on the acidic and aromatic fractions.

Identification and quantitation of the target compounds determined by GC/MS were performed according to the process described in Methods 8240 and 8270. In summary, this process has the following features:

- Multipoint calibration for each compound to establish instrument response using multiple internal standards,

- Identification of compounds using a computerized reverse search with selected key fragment ions, and
- Quantitation using the previously determined response factors.

Volatile Aromatics

The samples were analyzed for benzene, ethyl benzene, toluene, and xylenes using purge and trap methodology to extract and concentrate the volatile compounds. The samples were desorbed into a gas chromatograph equipped with a photoionization detector (P.I.D.). Identification and quantitation were determined using internal and external standards.

Phenolics

Phenolics were determined colorimetrically using SW-846 Method 9065.

V. BIBLIOGRAPHY

A. Documents Pertaining to Appendix VIII Constituents

1) January, 1984 letter form Myles Morse pertaining to delisting petitions as well as land treatment demonstrations, including sampling procedures and data requirements.

2) March, 1984 letter to delisting petitioners from Barbara Bush revising target parameters.

3) April, 1984 memo from John Skinner to Permit Branch Chiefs concerning land treatment containing target parameters and analytical methods.

4) May, 1984 memo from John Skinner clarifying previous memo.

5) September, 1984 letter to Petitioners from Barbara Bush distributing Refinery Handbook.

6) November, 1984 letter from Eileen Claussen to all delisting petitioners describing new RCRA requirements.

7) May 3, 1985 RMAL Memo.

8) January 8, 1985 RMAL letter to Eileen Claussen, EPA-OSW.

B. Documents Pertaining to Analytical Methods

1) "Handbook for the Analysis of Petroleum Refinery Residuals and Waste", October, 1984 - prepared by Radian Corporation for EPA/OSW.

2) "Evaluation of the Applicability of the SW-846 Manual To Support All RCRA Subtitle C Testing", December 20, 1984 - prepared by Rocky Mountain Analytical Laboratory for API.

3) "Comments on the 'Handbook for the Analysis of Petroleum Refinery Residuals and Waste, October, 1984'", December 12, 1984 - prepared by Rocky Mountain Analytical Laboratory for API.

4) "Comments on the 'Handbook for the Analysis of Petroleum Refinery Residuals and Waste, April 2, 1984", August 15, 1984 - prepared by Rocky Mountain Analytical Laboratory for API.

5) "Handbook for the Analysis of Petroleum Refinery Residuals and Waste", April 2, 1984 - prepared by S-Cubed for EPA/OSW.

6) EPA document "Guidance for the Analysis of Refinery Wastes", July 5, 1985.

7) "Recovery and Detection Limits of Organic Compounds in Petroleum Refinery Wastes", January 25, 1985.

8) SW-846 - "Test Methods for Evaluating Solid Waste, Physical Chemical Methods" USEPA, 2nd Edition, 1982.

9) 40CFR136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act."

State of New Mexico
ENVIRONMENT DEPARTMENT
Harold Runnels Building
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502
(505) 827-2850

BRUCE KING
GOVERNOR

JUDITH M. ESPINOSA
SECRETARY

RON CURRY
DEPUTY SECRETARY

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

January 25, 1994

Mr. David Roderick, Refinery Manager
Bloomfield Refining Company
P.O. Box 159
Bloomfield, New Mexico 87413

Dear Mr. Roderick:

RE: Bloomfield Refining Company Landfill Pond Closure Plan Approval (EPA I.D. No. NMD089416416)

The New Mexico Environment Department (NMED) hereby approves the closure plan for the Bloomfield Refining Company (BRC) landfill pond located near Bloomfield, New Mexico. The approved plan for the landfill pond is contained in the document entitled, "Final Closure Plan for the API Wastewater Ponds, Landfill, and Landfill Pond at the Bloomfield Refinery" dated July 1986. The effective date of the closure plan approval is the date you receive this letter.

The Hazardous and Radioactive Materials Bureau (HRMB) of the NMED released the proposed closure plan and associated documents for a thirty (30) day public comment period which ran from December 10, 1993, through January 9, 1994. The HRMB received one written comment during the public notice period. A copy of the comment is enclosed for your information. The recommendation stated in the comment that BRC take measures to prevent water from ponding in this site for extended periods of time does not require a change in the final approved closure plan. Thus, no changes were made to the proposed closure plan in finalizing our approval. No additional closure activities are required to demonstrate clean closure of the site.

Please contact Marc Sides of my staff at (505) 827-4308 if you have any questions

Sincerely,

Kathleen M. Sisneros

Kathleen M. Sisneros, Director
Water and Waste Management Division

Enclosure

cc: David Neleigh, EPA Permits
Greg Lyssy, EPA Enforcement
Mark Wilson, US Fish and Wildlife
Benito Garcia, HRMB
Barbara Hoditschek, HRMB
Marc Sides, HRMB
File - Red

Appendix C

Spray Irrigation Area (SWMU No. 11) Historical Documentation

NEW MEXICO ENERGY, MINERALS
& NATURAL RESOURCES DEPARTMENT

OIL CONSERVATION DIVISION
2040 South Pacheco Street
Santa Fe, New Mexico 87505
(505) 827-7131

August 28, 1996

CERTIFIED MAIL
RETURN RECEIPT NO. P-288-258-604

Mr. Lynn Shelton
Environmental Manager
Giant Industries
P.O. Box 159
Bloomfield, NM 87413

RE: Closure Plan for the Unlined Evaporation
Lagoons and the Spray Evaporation Area.
Date August 13, 1996.

Dear Mr. Shelton:

The New Mexico Oil Conservation Division (OCD) has reviewed the above captioned plan from Giant regarding the closure/modification of the "Unlined Evaporation Lagoons/Spray Evaporation Area." The OCD approves of the closure and modification as proposed with the following conditions:

1. The monitoring and sampling of monitoring wells MW-1 and MW-5 will continue as previously approved. When the CMS (dated December 21, 1995) is approved, OCD will be open to reconsidering the continued monitoring of MW-1 and MW-5.

2. Any discharge/spill or leak that is a result of the modification/construction will be reported to the OCD Aztec District office at (505)-334-6178 pursuant to WQCC 1203 and OCD Rule 116.

Please note, OCD approval does not relieve Giant for liability should this closure/modification result in contamination to surface water, groundwater, or the environment. Further, OCD approval does not relieve Giant from responsibility with other Federal, State, or Local Regulations that may apply. Public notice was not issued because this modification was part of the previous discharge plan renewal conditions.

If Giant has any questions regarding this matter please feel free to call me at (505)-827-7152.

Sincerely,

Roger Anderson

Roger C. Anderson
Bureau Chief

xc: Mr. Denny Foust - Environmental Geologist

CLOSURE PLAN
FOR THE
UNLINED EVAPORATION LAGOONS
AND THE
SPRAY EVAPORATION AREA

GIANT REFINING COMPANY - BLOOMFIELD
#50 COUNTY ROAD 4990
BLOOMFIELD, NEW MEXICO

PREPARED FOR:

NEW MEXICO OIL CONSERVATION DIVISION

PREPARED BY:

LYNN SHELTON
ENVIRONMENTAL MANAGER
GIANT REFINING COMPANY - BLOOMFIELD

AUGUST 13, 1996

TABLE OF CONTENTS

CLOSURE PLAN FOR THE UNLINED EVAPORATION LAGOONS AND THE SPRAY EVAPORATION AREA

GIANT REFINING COMPANY - BLOOMFIELD
DISCHARGE PLAN GW-001

I. INTRODUCTION:

The Unlined Evaporation Lagoons and the Spray Evaporation Area (see Site Plan, Attachment A) have been identified in the Discharge Plan as units to be closed. Giant Refining Company - Bloomfield (GRC) has assumed the responsibility for entering into closure of those units. This closure plan will outline the closure activities and the subsequent uses of those units.

II. GENERAL INFORMATION:

1. **Name of Discharger, Operator, and Owner**

San Juan Refining Company
P.O. Box 159
Bloomfield, New Mexico 87413
(505) 632 8013

2. **Facility Contacts**

Lynn Shelton, Environmental Manager

3. **Location of Facility**

286.93 acres, more or less, being that portion of the NW1/4 NE1/4 and the S1/2 NE1/4 and the N1/2 NE1/4 SE1/4 of Section 27, and the S1/2 NW1/4 and the N1/2 NW1/4 SW1/4 and the SE1/4 NW1/4 SW1/4 and the NE1/4 SW1.4 of Section 26, Township 29 North, Range 11 West, NMPM, San Juan County, New Mexico.

4. **Type of Operation**

Giant Refining Company - Bloomfield (GRC) is a petroleum refinery with a nominal crude capacity in barrels per calendar day (bpcd) of 18,000. Processing units include crude desalting, crude distillation, catalytic hydrotreating, catalytic reforming, fluidized catalytic cracking, catalytic polymerization, diesel hydrodesulfurization, gas concentration and treating, and sulfur recovery.

Crude supplies are delivered by pipeline and tank trucks. Products are sold, via tank trucks, from a product terminal operated by GRC.

III. BACKGROUND INFORMATION:

The Unlined Evaporation Lagoons consist of two earthen dike lagoons (lined with 4-6 inches of bentonite) of approximately 2.5 acres each. The process wastewater effluent flowed from the

North Oily Water Pond into the north Unlined Lagoon and then into the south Unlined Lagoon. The water evaporated in place or was transferred to the Spray Evaporation Area to enhance evaporation. Studies showed the lagoons to seep water at a rate of 10 to 20 gallons per minute. Monitor Well MW-1, which is immediately down-gradient of the lagoons, has traditionally been sampled semi-annually to detect any contamination of the uppermost perched water table that might be associated with the seepage from these lagoons.

After completion of the Class I injection well, the ponds were decommissioned in 1994 and scheduled for closure. The water remaining in the ponds was allowed to evaporate. Soil samples around the lagoons were collected and analyzed in 1993 during the RCRA Facility Investigation and found to be non-hazardous.

The Spray Evaporation Area was used to spray process water from the Unlined Evaporation Lagoons to enhance evaporation. Although diked to prevent runoff, the area did not typically store water. Because of the dikes, the RFI study concluded that the Spray Evaporation Area as well as the Unlined Evaporation Lagoons were unlikely to allow runoff to contaminate surface waters. Monitor Well MW-5 is immediately down-gradient of the evaporation area and has been traditionally sampled semi-annually to detect any contamination to the uppermost perch water table as a result from seepage from the spray evaporation activities.

The Spray Evaporation Area was decommissioned in 1994.

GRC is preparing this Closure Plan as required by the facility's Discharge Plan GW-001, Section 6.1.4 and the Attachment To The Discharge Plan GW-001 Approval Letter, dated January 29, 1996.

IV. GEOLOGY / HYDROLOGY:

Geology and hydrology at the refinery are amply documented in the Discharge Permit GD-001, Section 9.0. Site Characteristics, and is included here by reference.

V. SAMPLING AND ANALYSIS:

GRC arranged for a technician from Philip Environmental to sample the Unlined Evaporation Lagoons, the Spray Evaporation Area, and a background sample on July 10, 1996. The samples were collected according to standard SW-846 protocol at sampling points selected by GRC and approved by the Oil Conservation Division. The sampling event of July 10, 1996 was witnessed by Mr. Denny Foust of the OCD Aztec office.

A copy of the sampling site drawings, the Soil Sample Identification Numbering System, the WQCC constituent list (including both the WQCC standard and the lab reporting limits), the approval letter from OCD dated June 20, 1996, and the soil sampling report from Philip Environmental are included as Attachment B.

The soil samples were analyzed by Inter-Mountain Laboratories, Inc. in Farmington, New Mexico. The results of those analyses were tabulated to expedite reference. The original and tabulated analytical data is presented in Attachment C.

VI. DISCUSSION OF ANALYTICAL RESULTS:

Analytical data indicates that no organic hydrocarbons were detected in either the Unlined Evaporation Lagoons or the Spray Evaporation Area. Elevated levels of some metals over the background sample were observed, particularly Iron and Aluminum. Chromium and Lead were detected at very near background levels, with Selenium not being detected in any sample. Inorganic Chloride and Sulfate were observed at slightly above background levels. pH was observed at relatively neutral levels.

GRC concludes that the analytical data does not present any justification for additional cleanup activities prior to closure and reuse of the affected areas.

VII. CLOSURE:

GRC proposes to enter into clean closure of both the Unlined Evaporation Lagoons and the Spray Evaporation Area. Sampling and analysis performed in 1993 and 1996 has demonstrated that there is no evidence of potential releases at the facility from any future use of either unit. Future uses of the units, which is described below, either make beneficial use of the unit (Unlined Evaporation Lagoons) or require site work at the unit (Spray Evaporation Area) that is similar to what would be performed in normal closure.

Based on the above conclusions, GRC proposes that no additional closure activity other than those described below will be required. Furthermore, GRC proposes that the semi-annual sampling and analysis of monitoring wells MW-1 and MW-5 be discontinued.

VIII. FUTURE USE OF THE UNITS:

GRC proposes to use the decommissioned Unlined Evaporation Lagoons as fresh water make-up ponds. These two lagoons would replace the two smaller make-up ponds that are presently in service. The additional capacity of the new lagoons would provide GRC with additional flexibility in the use of the river water make-up via additional settling time for suspended solids, particularly when the river is turbid, and additional capacity in case of river pump failure. The use of the unlined evaporation lagoons will not create an increased possibility of contamination to the uppermost perched water table. Furthermore, the seepage rates of the two sets of lagoons are nearly identical.

GRC proposes to use the Spray Evaporation Area as the site for Giant's Pipeline and Transportation truck shop and parking area as well as an office complex. Civil work performed at the site will be essentially the same as would be performed by installing and grading a soil cap under normal closure activities. The entire site would be graded and profiled to provide for construction of the new facilities which would eliminate the dikes in the spray evaporation area.

IX. CONCLUSION:

GRC has provided analytical data that corroborates the 1993 RFI data that indicates that no concentrations of hazardous constituents exist in either the Unlined Evaporation Lagoons or the Spray Evaporation Area that would require extraordinary closure activities The future uses of the affected units will make beneficial use of the land that are occupied by the two units.

ATTACHMENT A

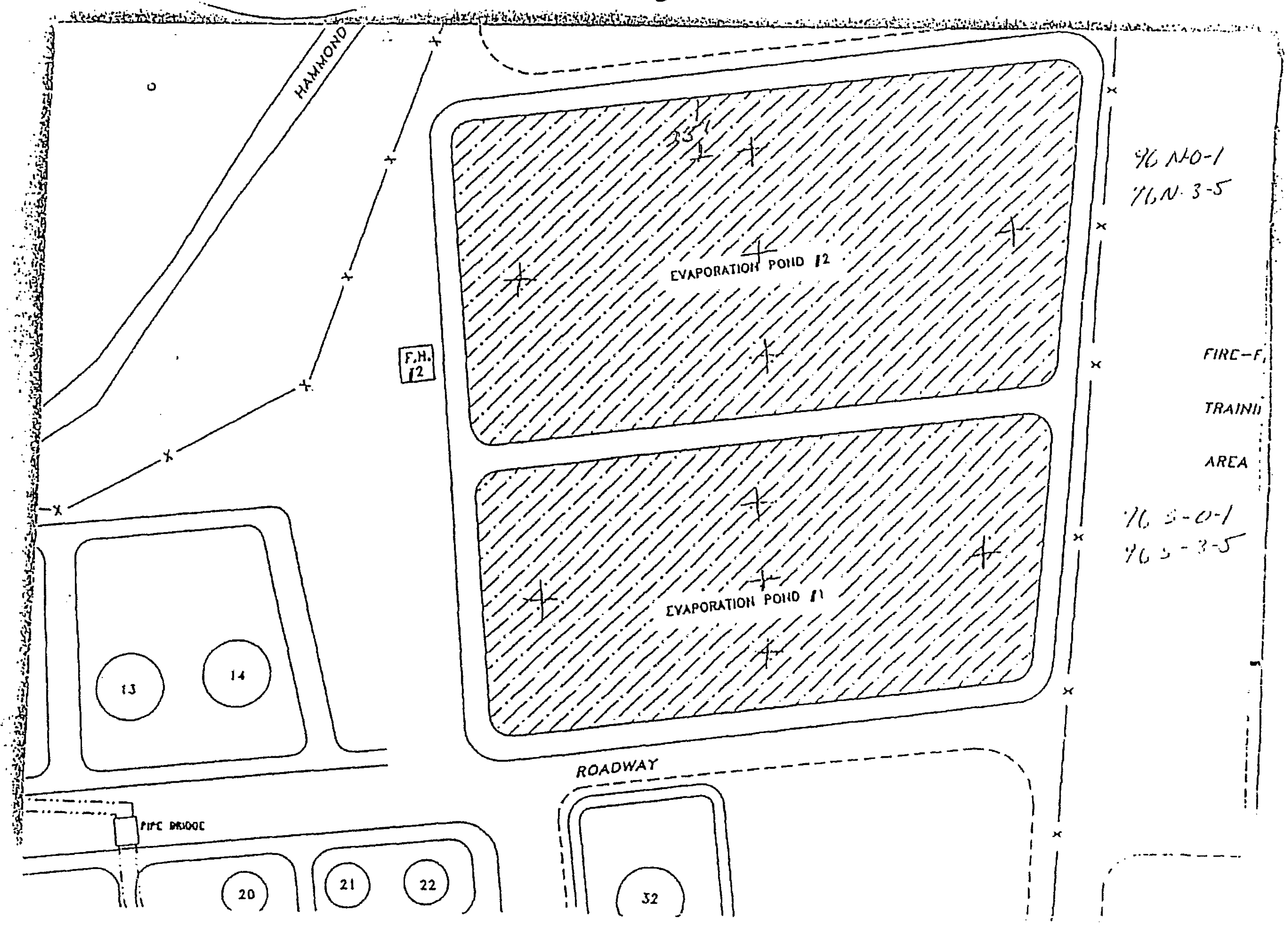
ATTACHMENT B

7/1/96

SAMPLE [illegible]

COMPOSITE AT [illegible]

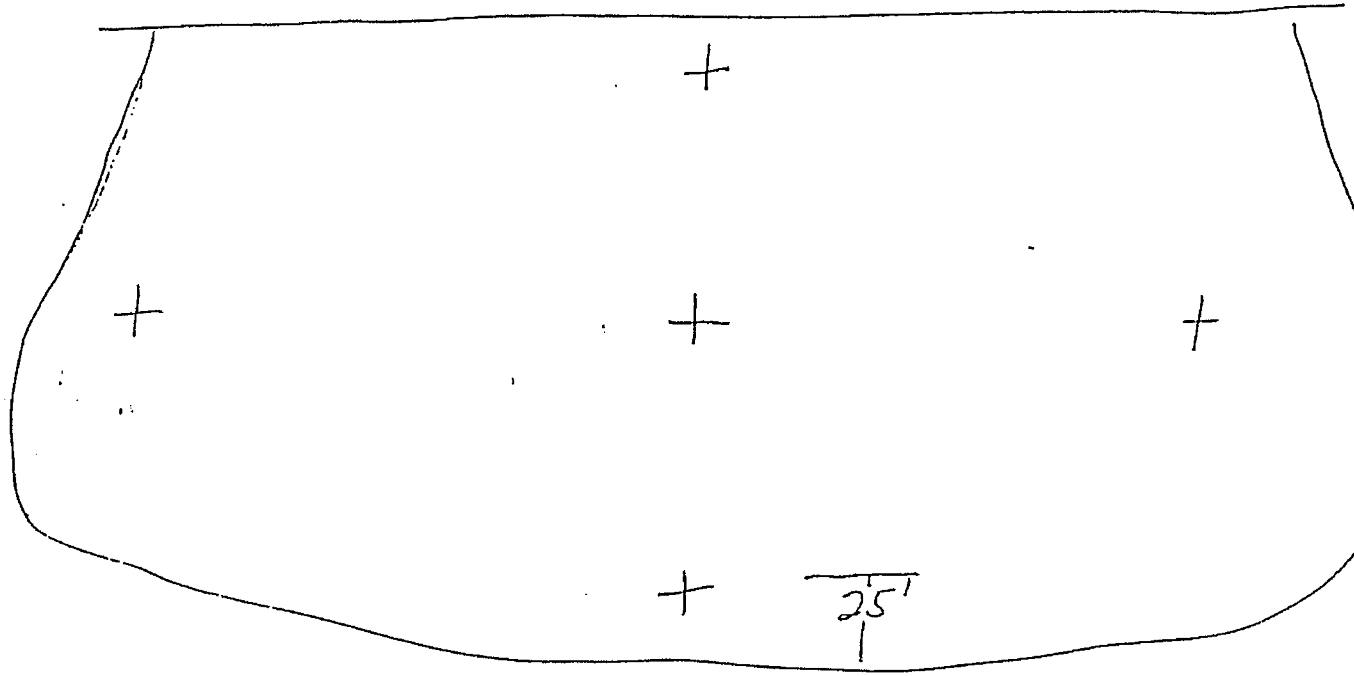
COMPOSITE AT [illegible] 3.0 [illegible]



96 N0-1
96N-3-5

96 S-0-1
96 S-3-5

EVAPORATION SPRAY AREA



96 E-0-1
96 E-3-5

NOT TO SCALE TLS 7/1/96

SOIL SAMPLE IDENTIFICATION NUMBERING SYSTEM

OCD SOIL SAMPLING EVENT
JULY 10, 1996
GIANT REFINING COMPANY - BLOOMFIELD

EXAMPLE:

96 N - 0-1

96 = 1996 Sampling Event

N = North Evaporation Lagoon
S = South Evaporation Lagoon
E = Spray Evaporation Area
B = Background Sample

0-1 = Surface to 1 foot depth interval
3-5 = Three to five feet depth interval

Total of eight samples, each location composited.

WQCC CONSTITUENT LIST

1996 OCD SAMPLING EVENT

JULY 10, 1996

Parameter	WQCC Standard (mg/l)	Lab Reporting Limit (mg/kg)
Arsenic	0.1	0.25
Barium	1.0	1.0
Cadmium	0.01	0.05
Chromium	0.05	0.5
Cyanide	0.2	0.2
Flouride	1.6	1.6
Lead	0.05	0.25
Total Mercury	0.002	0.2
Nitrate (NO3 as N)	10.0	10.0
Selenium	0.05	0.25
Silver	0.05	0.5
Uranium	5.0	10.0
Benzene	0.01	0.2
Toluene	0.75	0.2
Carbon Tetrachloride	0.01	0.2
1,2-Dichloroethane	0.01	0.2
1,1-Dichloroethylene	0.005	0.2
1,1,2,2-Tetrachloroethylene	0.02	0.2
1,1,2-Trichloroethylene	0.1	0.2
Ethylbenzene	0.75	0.2
Total Xylenes	0.62	0.2
Methylene Chloride	0.1	0.2
Chloroform	0.1	0.2
1,1-Dichloroethane	0.025	0.2
Ethylene Dibromide	0.0001	0.2
1,1,1-Trichloroethane	0.06	0.2
1,1,2-Trichlorethane	0.01	0.2
1,1,2,2-Tetrachloroethane	0.01	0.2
Vinyl Chloride	0.001	0.2
PAHs: total Naphthalene plus monomethylnaphthalenes	0.03	0.6
Benzo(a)pyrene	0.0007	0.5
Chloride	250	250
Copper	1.0	1.0
Iron	1.0	1.25
Manganese	0.2	0.5
Phenols	0.005	1.0
Sulfate (SO4)	600	600
Zinc	10	10.0
pH	6 to 9	6 to 9
Aluminum	5.0	5.0
Boron	0.75	2.5
Cobalt	0.05	0.5
Molybdenum	1.0	1.0
Nickel	0.2	0.5

STATE OF NEW MEXICO
ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT
OIL CONSERVATION DIVISION
2040 S PACHECO
SANTA FE, NEW MEXICO 87505
(505) 827-7131

June 20, 1996

CERTIFIED MAIL
RETURN RECEIPT NO.P-594-835-145

Mr. Lynn Shelton
Environmental Manager
Giant Industries
P.O. Box 159
Bloomfield, NM 87413

RE: Soil Sampling Parameters
Faxed to OCD on May 6, 1996

Dear Mr. Shelton:

The New Mexico Oil Conservation Division (OCD) has reviewed the Fax submitted from Giant regarding the sampling of the soil underlying the evaporation lagoons. The OCD approves of the list with the requirement that only WQCC 3103 A, B, and C constituents be analyzed for in the soils utilizing approved sample collection and analysis methods as outlined in SW-846 and approved by the EPA. The OCD will require Giant to contact the Santa Fe Office at (505)-827-7156 and Mr. Denny Foust with the District at 334- 6178 one week before the soil samples are taken so that the OCD may have a representative at the site during the sample collection.

Please submit the results with a cover letter discussing the course of action Giant wishes to pursue with the area that are being sampled for these parameters outlined above to the Santa Fe OCD office for approval with a copy sent to Mr. Denny Foust with the Aztec District OCD office.

If Giant has any questions regarding this matter please feel free to call me at (505)-827-7156.

Sincerely,

Patricio W. Sanchez
Petroleum Engineering Specialist

XC: Mr. Denny Foust

PHILIP
ENVIRONMENTAL

Environmental Services Group
Southern Region

July 22, 1996

Project 16633

Mr. Lynn Shelton
Environmental Manager
Giant Refining Company
P.O. Box 159
Bloomfield, New Mexico 87413

RE: Report for Soil Sampling at Giant Refining Company's Evaporation Spray Areas at the Bloomfield Refinery, Bloomfield, New Mexico

Dear Mr. Shelton:

On July 10, 1996, Philip Environmental Services Corporation (Philip) initiated field work for soil sampling at Giant Refining Company's (Giant) Bloomfield Refinery, Bloomfield, New Mexico. Composite soil samples were collected within two separate Evaporation Lagoons and one Evaporation Spray Area, located at the Bloomfield Refinery, in addition to the collection of two composite background samples.

Sampling activities were conducted in the presence of representatives from Giant and the New Mexico Oil Conservation Division. Samples were preserved on ice and hand delivered by Giant, under chain of custody, to Inter-Mountain Laboratories Inc., in Farmington, New Mexico and were analyzed for New Mexico Water Quality Control Commission (WQCC) parameters, which are presented in Attachment A.

METHODOLOGY

Five-point composite soil samples were collected from two distinct layers within each evaporation Lagoon. One sample point was located in the middle of the Lagoon, with the other four sample points at locations 25 feet from each side of the containment dike in each Lagoon. Sample locations are presented in Attachment B. The first five-point composite sample was collected from the surface to approximately 1 foot below ground surface (bgs). The second five-point composite sample was collected from approximately 3 -5 feet bgs.

In addition to the samples collected within the three Evaporation Lagoons, two background samples were collected from an area upgradient of the Evaporation Lagoons. The background samples were collected from two separate borings, which were composited at intervals of 0 -1 foot bgs and 3 -5 foot bgs.

PHILIP ENVIRONMENTAL SERVICES CORPORATION
4000 Monroe Road • Farmington NM 87401
(505) 326-2262 • Fax (505) 326-2368

Samples were collected from each boring by advancing a stainless steel hand auger to the desired depth, and placing the soil in a stainless steel bowl. After soil was collected from the specified interval from each of the five separate borings within the Lagoon, it was then composited and containerized. Sample containers were labeled with a unique identification number, depth of collection, and sample time and date. Samples were then preserved on ice prior to delivery to the laboratory..

Prior to sample collection, all sampling equipment was decontaminated with an Alconox™ detergent and potable water wash, followed by a propanol rinse. When not in use, sampling equipment was kept covered to avoid potential contamination.

SUMMARY

A total of six five-point composite samples were collected from the Evaporation Lagoons, with two five-point composite samples collected from the background area. Sample identification numbers, locations, and soil descriptions are presented in Soil Sampling Data Sheets in Attachment C. Soil collected from the North Evaporation Lagoon from the 0 -1 foot and 3 -5 foot bgs intervals exhibited a black discolored sandy clay interval. Soil collected form the South Evaporation Lagoon exhibited a dark gray discolored sandy clay interval within the 0 -1 foot bgs sample interval. Samples collected from the spray evaporation area and the background area did not exhibit any visible discoloration.

If you have any questions or require further information, please feel free to contact Cory M. Chance at Philip's Farmington, New Mexico office at (505) 326-2262.

Sincerely,

PHILIP ENVIRONMENTAL SERVICES CORPORATION

Cory M. Chance

Cory M. Chance
Geologist

Attachments:

A. WQCC Analytical Parameters
B. Sample Locations
C. Soil Sampling Data forms

ATTACHMENT A

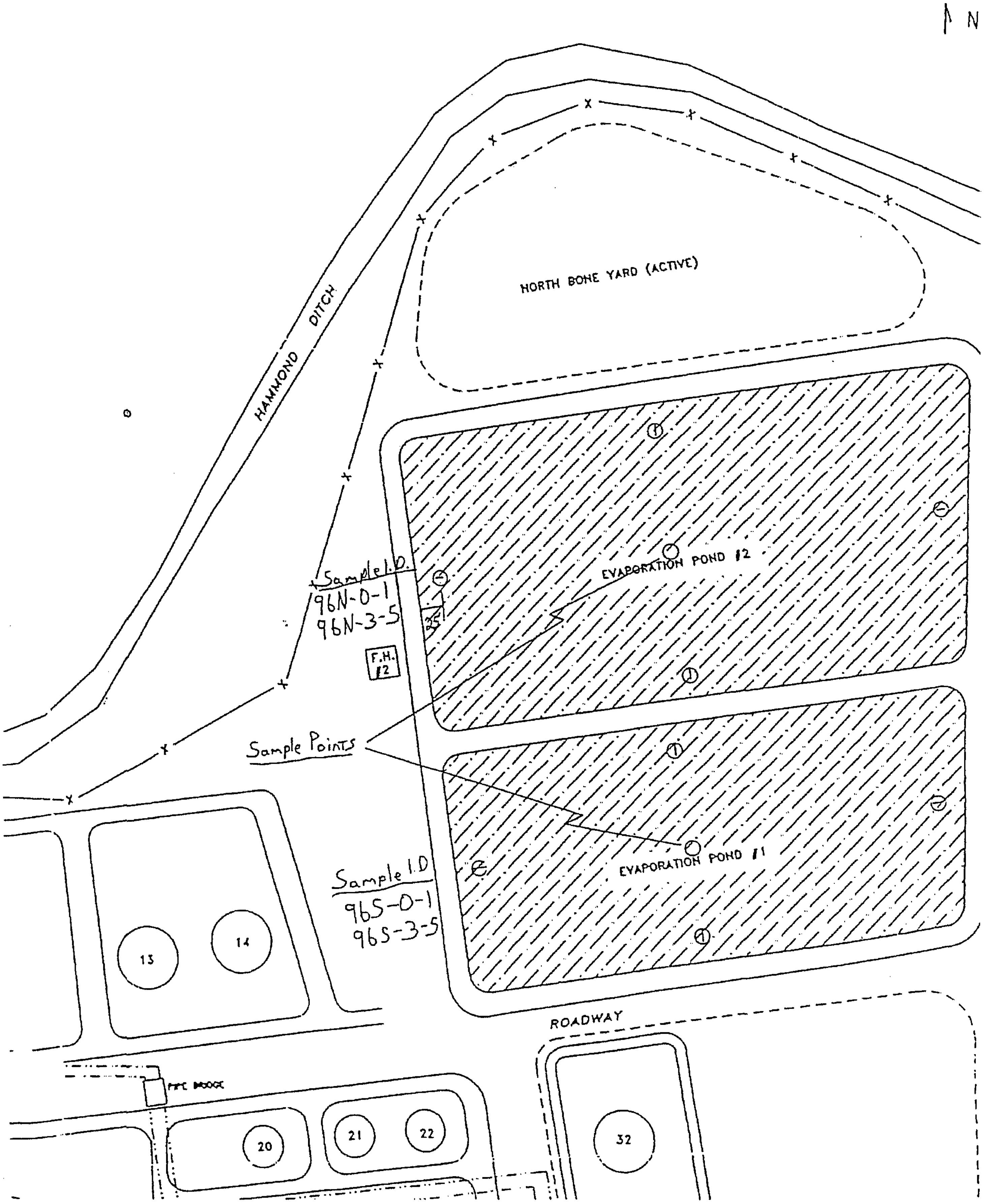
WQCC CONSTITUENT LIST

1996 OCD SAMPLING EVENT

JULY 10, 1996

Parameter	WQCC Standard (mg/l)	Lab Reporting Limit (mg/kg)
Arsenic	0.1	0.25
Barium	1.0	1.0
Cadmium	0.01	0.05
Chromium	0.05	0.5
Cyanide	0.2	0.2
Flouride	1.6	1.6
Lead	0.05	0.25
Total Mercury	0.002	0.2
Nitrate (NO3 as N)	10.0	10.0
Selenium	0.05	0.25
Silver	0.05	0.5
Uranium	5.0	10.0
Benzene	0.01	0.2
Toluene	0.75	0.2
Carbon Tetrachloride	0.01	0.2
1,2-Dichloroethane	0.01	0.2
1,1-Dichloroethylene	0.005	0.2
1,1,2,2-Tetrachloroethylene	0.02	0.2
1,1,2-Trichloroethylene	0.1	0.2
Ethylbenzene	0.75	0.2
Total Xylenes	0.62	0.2
Methylene Chloride	0.1	0.2
Chloroform	0.1	0.2
1,1-Dichloroethane	0.025	0.2
Ethylene Dibromide	0.0001	0.2
1,1,1-Trichloroethane	0.06	0.2
1,1,2-Trichlorethane	0.01	0.2
1,1,2,2-Tetrachloroethane	0.01	0.2
Vinyl Chloride	0.001	0.2
PAHs: total Naphthalene plus monomethylnaphthalenes	0.03	0.6
Benzo(a)pyrene	0.0007	0.5
Chloride	250	250
Copper	1.0	1.0
Iron	1.0	1.25
Manganese	0.2	0.5
Phenols	0.005	1.0
Sulfate (SO4)	600	600
Zinc	10	10.0
pH	6 to 9	6 to 9
Aluminum	5.0	5.0
Boron	0.75	2.5
Cobalt	0.05	0.5
Molybdenum	1.0	1.0
Nickel	0.2	0.5

ATTACHMENT B


N
HAMMOND DITCH
NORTH BONE YARD (ACTIVE)
EVAPORATION POND #2
Sample I.D.
96N-0-1
96N-3-5
3.5'
F.H. #2
Sample Points
EVAPORATION POND #1
Sample I.D
96S-0-1
96S-3-5
13
14
ROADWAY
PIPE BRIDGE
20
21
22
32

PHILIP ENVIRONMENTAL

SITE SKETCH

Serial No. SS-

Title Evaporation Spray Area + Backgrour

Project Name Giant Soil Sampling

Project No. 16633

Project Manager C M Chance

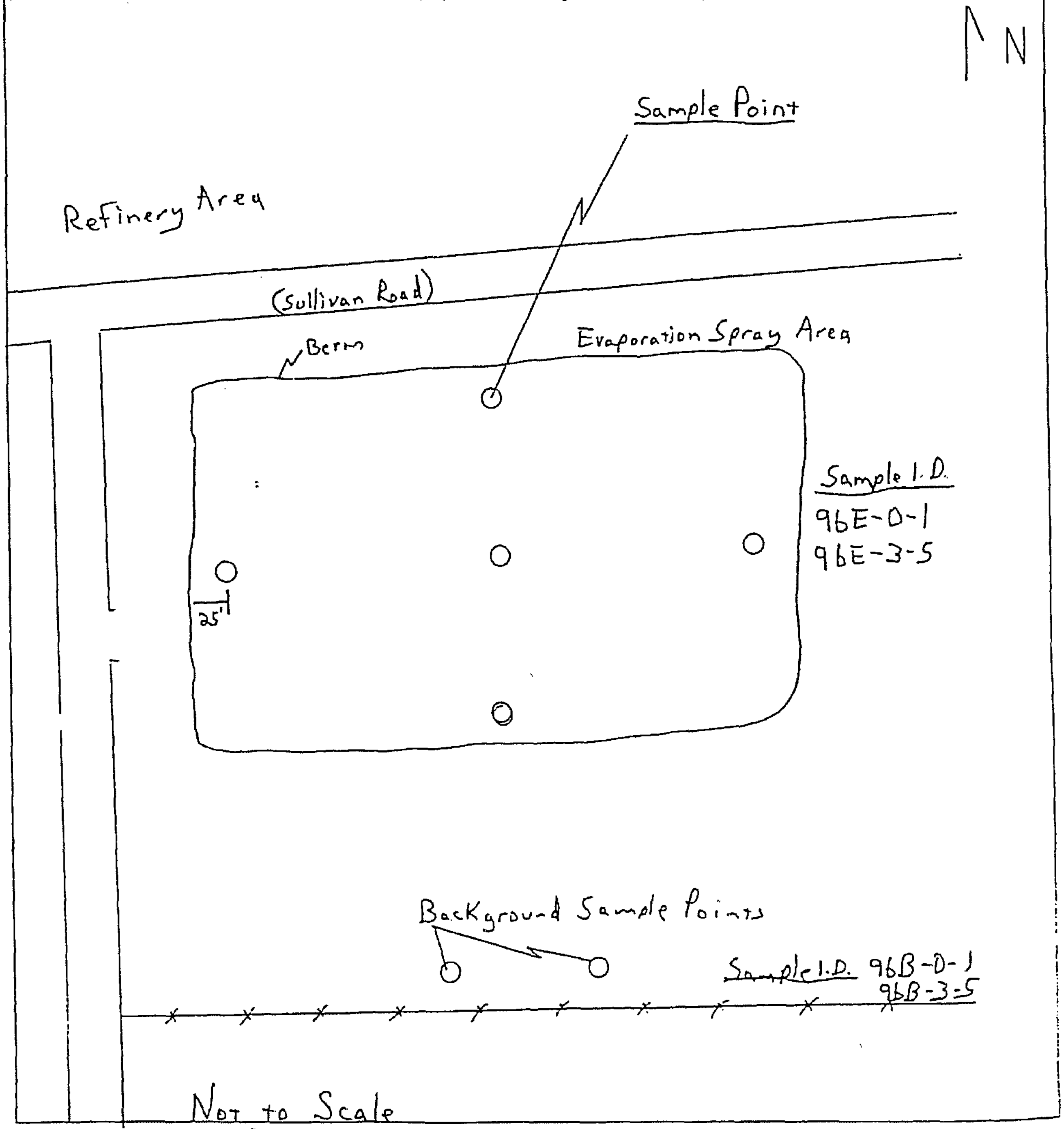
Phase.Task No. 1000.77

Client Company Giant Refining Co

Site Name Bloomfield Refinery

Site Address Bloomfield, NM

(Include north arrow and scale or dimensions. If available, preprint CAD drawing of site on this form.)



Sketched by (signature) Cory Chance

Date 7/11/96

ATTACHMENT C

PHILIP ENVIRONMENTAL

SOIL/SEDIMENT/SLUDGE SAMPLING DATA

Serial No SSSSD

Date 7/10/96

Project Name Giant Soil Sampling

Project No. 16633

Project Manager CM Chance

Phase.Task No. 1000 .77

Client Company Giant

Site Name Giant Refinery

Site Address Bloomfield, New Mexico

Sampling Method
☑ Hand Auger
☐ Spoon
☐ Backhoe
☐ Drill Rig
☐ Other

QA
☐ Primary
☐ Duplicate

Reason For Collection
☑ Lab Analysis
☐ On-Site Headspace
☐ Physical Testing
☐ Other

Type of Sample
☐ Grab
☑ Composite

Portable Screening Instrument Used ☐ None

Type	Manufacturer	Model
☐ PID (Lamp ____ eV)		
☐ FID		
☐ CGI		
☐ Other		
☐ Other		

Sample No.	Location	Time Collected	Sample Type			Volume Collected	Field Instrument Reading
			Soil	Sed.	Slg		
96N-0-1	North Evaporation Lagoon	1015	✓			3-500ml 1-1000ml	
	Lt br-br silty SAND abnt clay, F-med, tr gravel, Blk clayey sand						
96N-3-5	A/A	1130	✓			A/A	
96S-0-1	South Evaporation Lagoon	1345	✓			A/A	
	DK Gry, sandy clay, wet, odor						
96S-3-5	lt br sand, vf-f sand, mod clay, sl moist, tr gravel	1430	✓			A/A	

Chain-of-Custody Form Number ____________

Comments ____________

Signature Cory M Chance Date 7/10/96 Reviewer ______ Date ______

PHILIP
ENVIRONMENTAL

SOIL/SEDIMENT/SLUDGE SAMPLING DATA

Serial No SSSSD

Date 7/11/96

Project Name Giant Soil Sampling

Project No. 16633

Project Manager CM Chance

Phase Task No. 1000.77

Client Company Giant

Site Name Giant Refinery (Bloomfield Refinery)

Site Address Bloomfield, New Mexico

Sampling Method
- ☑ Hand Auger
- ☐ Spoon
- ☐ Backhoe
- ☐ Drill Rig
- ☐ Other

Type of Sample
- ☐ Grab
- ☑ Composite

QA
- ☐ Primary
- ☐ Duplicate

Reason For Collection
- ☑ Lab Analysis
- ☐ On-Site Headspace
- ☐ Physical Testing
- ☐ Other

Portable Screening Instrument Used ☐ None

Type	Manufacturer	Model
☐ PID (Lamp ____ eV)		
☐ FID		
☐ CGI		
☐ Other		
☐ Other		

Sample No.	Location	Time Collected	Sample Type			Volume Collected	Field Instrument Reading
			Soil	Sed.	Slg		
96E-0-1	Spray Evaporation Area	0945	✓			3-500 ml 1-1000 ml	
	Lt Br SILT, tr f-med sand, tr-mdl clay, dry						
96E-3-5	Lt Br silty CLAY, tr f-med sand, dry	1045	✓			A/A	
96B-0-1	Background (S. of Evap. Area along S. fence line)	1145	✓			A/A	
	Lt br silty tr vf-f sand, clay, loose, dry						
96B-3-5	Lt br silty sand, vf-f sand, tr clay, loose, dry	1200	✓			A/A	

Chain-of-Custody Form Number

Comments

Signature Cory M. Chance Date 7/11/96 Reviewer Date

ATTACHMENT C

TABULATED ANALYTICAL DATA FOR CLOSURE ACTIVITIES

GIANT REFINING COMPANY - BLOOMFIELD

JULY, 1996

NORTH UNLINED LAGOON

Parameter	Units	0-1 Foot Result	3-5 Feet Result	WQCC Standard	Laboratory Limit
Aluminum	mg/kg	6,144.00	6,020.00	5.00	5.00
Arsenic	mg/kg	<0.50	<0.50	0.10	0.25
Barium	mg/kg	99.40	93.20	1.00	1.00
Boron	mg/kg	49.50	47.30	0.75	2.50
Cadmium	mg/kg	<0.10	<0.10	0.01	0.05
Chromium	mg/kg	8.00	5.80	0.05	0.50
Cobalt	mg/kg	3.38	3.01	0.05	0.50
Copper	mg/kg	6.09	4.68	1.00	1.00
Iron	mg/kg	7,722.00	8,416.00	1.00	1.25
Lead	mg/kg	7.22	6.80	0.05	0.25
Manganese	mg/kg	140.00	173.00	0.20	0.50
Mercury	mg/kg	<0.10	<0.10	0.002	0.20
Molybdenum	mg/kg	<1.00	<1.00	1.00	1.00
Nickel	mg/kg	5.64	5.46	0.20	0.50
Selenium	mg/kg	<0.50	<0.50	0.05	0.25
Silver	mg/kg	<1.00	<1.00	0.05	0.50
Uranium	mg/kg	54.90	60.40	5.00	10.00
Zinc	mg/kg	30.30	23.30	10.00	10.00
Lab pH	s.u.	6.90	8.00	6 to 9	6 to 9
Fluoride	ppm	0.53	1.25	1.60	1.60
Chloride	ppm	3783.00	998.00	250.00	250.00
Sulfate	ppm	3638.00	370.00	600.00	600.00
Cyanide	mg/Kg	<0.10	<0.10	0.20	0.20
Nitrate as Nitrogen	ppm	0.46	0.05	10.00	10.00
Benzene	mg/kg	ND	ND	0.01	0.20
Toluene	mg/kg	ND	ND	0.75	0.20
Carbon Tetrachloride	mg/kg	ND	ND	0.01	0.20
1,2-Dichloroethane	mg/kg	ND	ND	0.01	0.20
1,1-Dichloroethylene	mg/kg	ND	ND	0.0005	0.20
1,1,2,2-Tetrachloroethylene	mg/kg	ND	ND	0.02	0.20
1,1,2-Trichloroethylene	mg/kg	ND	ND	0.1	0.20
Ethylbenzene	mg/kg	ND	ND	0.75	0.20
Total Xylenes	mg/kg	ND	ND	0.62	0.20
Methylene Chloride	mg/kg	ND	ND	0.1	0.20
Chloroform	mg/kg	ND	ND	0.1	0.20
1,1-Dichloroethane	mg/kg	ND	ND	0.025	0.20
Ethylene Dibromide	mg/kg	ND	ND	0.0001	0.20
1,1,1-Trichloroethane	mg/kg	ND	ND	0.06	0.20
1,1,2-Trichloroethane	mg/kg	ND	ND	0.01	0.20
1,1,2,2-Tetrachloroethane	mg/kg	ND	ND	0.01	0.20
Vinyl Chloride	mg/kg	ND	ND	0.01	0.20
PAHs total Naphthalene plus	mg/kg				
monomethylnaphthalenes	mg/kg	ND	ND	0.03	0.50
Benzo(a)pyrene	mg/kg	ND	ND	0.0007	0.50

TABULATED ANALYTICAL DATA FOR CLOSURE ACTIVITIES

GIANT REFINING COMPANY - BLOOMFIELD

JULY, 1996

SOUTH UNLINED LAGOON

Parameter	Units	0-1 Foot Result	3-5 Feet Result	WQCC Standard	Laboratory Limit
Aluminum	mg/kg	7,646.00	3,820.00	5.00	5.00
Arsenic	mg/kg	<0.50	<0.50	0.10	0.25
Barium	mg/kg	154.00	48.10	1.00	1.00
Boron	mg/kg	47.60	40.60	0.75	2.50
Cadmium	mg/kg	<0.10	<0.10	0.01	0.05
Chromium	mg/kg	30.90	4.20	0.05	0.50
Cobalt	mg/kg	3.99	1.78	0.05	0.50
Copper	mg/kg	10.70	3.46	1.00	1.00
Iron	mg/kg	10,486.00	5,068.00	1.00	1.25
Lead	mg/kg	7.72	4.93	0.05	0.25
Manganese	mg/kg	230.00	107.00	0.20	0.50
Mercury	mg/kg	<0.10	<0.10	0.002	0.20
Molybdenum	mg/kg	<1.00	<1.00	1.00	1.00
Nickel	mg/kg	8.34	3.04	0.20	0.50
Selenium	mg/kg	<0.50	<0.50	0.05	0.25
Silver	mg/kg	3.11	<1.00	0.05	0.50
Uranium	mg/kg	69.50	29.50	5.00	10.00
Zinc	mg/kg	52.30	15.70	10.00	10.00
Lab pH	s.u.	7.10	7.90	6 to 9	6 to 9
Fluoride	ppm	0.35	2.71	1.60	1.60
Chloride	ppm	2711.00	445.00	250.00	250.00
Sulfate	ppm	3193.00	469.00	600.00	600.00
Cyanide	mg/Kg	0.25	<0.10	0.20	0.20
Nitrate as Nitrogen	ppm	0.69	0.08	10.00	10.00
Benzene	mg/kg	ND	ND	0.01	0.20
Toluene	mg/kg	ND	ND	0.75	0.20
Carbon Tetrachloride	mg/kg	ND	ND	0.01	0.20
1,2-Dichloroethane	mg/kg	ND	ND	0.01	0.20
1,1-Dichloroethylene	mg/kg	ND	ND	0.0005	0.20
1,1,2,2-Tetrachloroethylene	mg/kg	ND	ND	0.02	0.20
1,1,2-Trichloroethylene	mg/kg	ND	ND	0.1	0.20
Ethylbenzene	mg/kg	ND	ND	0.75	0.20
Total Xylenes	mg/kg	ND	ND	0.62	0.20
Methylene Chloride	mg/kg	ND	ND	0.1	0.20
Chloroform	mg/kg	ND	ND	0.1	0.20
1,1-Dichloroethane	mg/kg	ND	ND	0.025	0.20
Ethylene Dibromide	mg/kg	ND	ND	0.0001	0.20
1,1,1-Trichloroethane	mg/kg	ND	ND	0.06	0.20
1,1,2-Trichloroethane	mg/kg	ND	ND	0.01	0.20
1,1,2,2-Tetrachloroethane	mg/kg	ND	ND	0.01	0.20
Vinyl Chloride	mg/kg	ND	ND	0.01	0.20
PAHs: total Naphthalene plus	mg/kg				
monomethylnaphthalenes	mg/kg	ND	ND	0.03	0.50
Benzo a)pyrene	mg/kg	ND	ND	0.0007	0.50

TABULATED ANALYTICAL DATA FOR CLOSURE ACTIVITIES

GIANT REFINING COMPANY - BLOOMFIELD

JULY, 1996

SPRAY EVAPORATION AREA

Parameter	Units	0-1 Foot Result	3-5 Feet Result	WQCC Standard	Laboratory Limit
Aluminum	mg/kg	10,122.00	7,102.00	5.00	5.00
Arsenic	mg/kg	1.16	0.53	0.10	0.25
Barium	mg/kg	195.00	189.00	1.00	1.00
Boron	mg/kg	55.80	56.90	0.75	2.50
Cadmium	mg/kg	0.16	<0.10	0.01	0.05
Chromium	mg/kg	9.48	7.48	0.05	0.50
Cobalt	mg/kg	5.06	4.11	0.05	0.50
Copper	mg/kg	3.58	2.32	1.00	1.00
Iron	mg/kg	13,097.00	10,569.00	1.00	1.25
Lead	mg/kg	11.60	7.69	0.05	0.25
Manganese	mg/kg	223.00	240.00	0.20	0.50
Mercury	mg/kg	<0.10	<0.10	0.002	0.20
Molybdenum	mg/kg	<1.00	1.05	1.00	1.00
Nickel	mg/kg	1.16	7.38	0.20	0.50
Selenium	mg/kg	<0.50	<0.50	0.05	0.25
Silver	mg/kg	<1.00	<1.00	0.05	0.50
Uranium	mg/kg	86.40	66.40	5.00	10.00
Zinc	mg/kg	45.30	30.60	10.00	10.00
Lab pH	s.u.	7.60	7.80	6 to 9	6 to 9
Fluoride	ppm	1.15	1.76	1.60	1.60
Chloride	ppm	2582.00	1235.00	250.00	250.00
Sulfate	ppm	2156.00	724.00	600.00	600.00
Cyanide	mg/Kg	<0.10	<0.10	0.20	0.20
Nitrate as Nitrogen	ppm	6.42	0.51	10.00	10.00
Benzene	mg/kg	ND	ND	0.01	0.20
Toluene	mg/kg	ND	ND	0.75	0.20
Carbon Tetrachloride	mg/kg	ND	ND	0.01	0.20
1,2-Dichloroethane	mg/kg	ND	ND	0.01	0.20
1,1-Dichloroethylene	mg/kg	ND	ND	0.0005	0.20
1,1,2,2-Tetrachloroethylene	mg/kg	ND	ND	0.02	0.20
1,1,2-Trichloroethylene	mg/kg	ND	ND	0.1	0.20
Ethylbenzene	mg/kg	ND	ND	0.75	0.20
Total Xylenes	mg/kg	ND	ND	0.62	0.20
Methylene Chloride	mg/kg	ND	ND	0.1	0.20
Chloroform	mg/kg	ND	ND	0.1	0.20
1,1-Dichloroethane	mg/kg	ND	ND	0.025	0.20
Ethylene Dibromide	mg/kg	ND	ND	0.0001	0.20
1,1,1-Trichloroethane	mg/kg	ND	ND	0.06	0.20
1,1,2-Trichloroethane	mg/kg	ND	ND	0.01	0.20
1,1,2,2-Tetrachloroethane	mg/kg	ND	ND	0.01	0.20
Vinyl Chloride	mg/kg	ND	ND	0.01	0.20
PAHs Total Naphthalene plus	mg/kg				
monomethylnaphthalenes	mg/kg	ND	ND	0.03	0.60
Benzo(a)pyrene	mg/kg	ND	ND	0.0007	0.50

TABULATED ANALYTICAL DATA FOR CLOSURE ACTIVITIES

GIANT REFINING COMPANY - BLOOMFIELD

JULY, 1996

BACKGROUND SAMPLE

Parameter	Units	0-1 Foot Result	3-5 Feet Result	WQCC Standard	Laboratory Limit
Aluminum	mg/kg	6,199.00	3,266.00	5.00	5.00
Arsenic	mg/kg	<0.50	<0.50	0.10	0.25
Barium	mg/kg	166.00	56.00	1.00	1.00
Boron	mg/kg	55.00	51.90	0.75	2.50
Cadmium	mg/kg	0.10	<0.10	0.01	0.05
Chromium	mg/kg	6.85	3.16	0.05	0.50
Cobalt	mg/kg	3.84	1.83	0.05	0.50
Copper	mg/kg	2.18	3.87	1.00	1.00
Iron	mg/kg	9,401.00	4,751.00	1.00	1.25
Lead	mg/kg	8.00	4.99	0.05	0.25
Manganese	mg/kg	205.00	113.00	0.20	0.50
Mercury	mg/kg	<0.10	<0.10	0.002	0.20
Molybdenum	mg/kg	<1.00	<1.00	1.00	1.00
Nickel	mg/kg	7.27	3.46	0.20	0.50
Selenium	mg/kg	<0.50	<0.50	0.05	0.25
Silver	mg/kg	<1.00	<1.00	0.05	0.50
Uranium	mg/kg	84.10	31.10	5.00	10.00
Zinc	mg/kg	33.20		10.00	10.00
Lab pH	s.u.	7.50	8.20	6 to 9	6 to 9
Fluoride	ppm	0.77	0.38	1.60	1.60
Chloride	ppm	1054.00	324.00	250.00	250.00
Sulfate	ppm	2790.00	395.00	600.00	600.00
Cyanide	mg/Kg	<0.10	<0.10	0.20	0.20
Nitrate as Nitrogen	ppm	14.20	<0.05	10.00	10.00
Benzene	mg/kg	ND	ND	0.01	0.20
Toluene	mg/kg	ND	ND	0.75	0.20
Carbon Tetrachloride	mg/kg	ND	ND	0.01	0.20
1,2-Dichloroethane	mg/kg	ND	ND	0.01	0.20
1,1-Dichloroethylene	mg/kg	ND	ND	0.0005	0.20
1,1,2,2-Tetrachloroethylene	mg/kg	ND	ND	0.02	0.20
1,1,2-Trichloroethylene	mg/kg	ND	ND	0.1	0.20
Ethylbenzene	mg/kg	ND	ND	0.75	0.20
Total Xylenes	mg/kg	ND	ND	0.62	0.20
Methylene Chloride	mg/kg	ND	ND	0.1	0.20
Chloroform	mg/kg	ND	ND	0.1	0.20
1,1-Dichloroethane	mg/kg	ND	ND	0.025	0.20
Ethylene Dibromide	mg/kg	ND	ND	0.0001	0.20
1,1,1-Trichloroethane	mg/kg	ND	ND	0.05	0.20
1,1,2-Trichloroethane	mg/kg	ND	ND	0.01	0.20
1,1,2,2-Tetrachloroethane	mg/kg	ND	ND	0.01	0.20
Vinyl Chloride	mg/kg	ND	ND	0.01	0.20
PAHs: total Naphthalene plus	mg/kg				
monomethylnaphthalenes	mg/kg	ND	ND	0.03	0.60
Benzo(a)pyrene	mg/kg	ND	ND	0.0007	0.50

iml
Inter·Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

5 August 1996

Lynn Shelton
Giant Refining Co.
P. O. Box 159
Bloomfield, NM 87413

Mr. Shelton:

Enclosed please find the report for the samples received by our laboratory for analysis on July 10, 1996.

If you have any questions about the results of these analyses, please don't hesitate to call me at your convenience.

Sincerely,

Anna Schaerer

Anna Schaerer
Organic Analyst/IML-Farmington

Enclosure

xc: File

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Client:	Giant Refining Co.		
Project:	Bloomfield		
Sample ID:	96S-0-1	Date Reported:	08/05/96
Laboratory ID:	0396G01318	Date Sampled:	07/10/96
Sample Matrix:	Soil	Time Sampled:	1:30 PM
Condition:	Cool/Intact	Date Received:	07/10/96

Parameter	Analytical Result	Units
Lab pH	7.1	s.u.
Fluoride	0.35	ppm
Chloride	2,711	ppm
Sulfate	3,193	ppm
Cyanide	0.25	mg/Kg
Nitrate as Nitrogen	0.69	ppm
Trace Metals (Total)		
Aluminum	7,646	mg/Kg
Arsenic	<0.5	mg/Kg
Barium	154	mg/Kg
Boron	47.6	mg/Kg
Cadmium	<0.10	mg/Kg
Chromium	30.9	mg/Kg
Cobalt	3.99	mg/Kg
Copper	10.7	mg/Kg
Iron	10,486	mg/Kg
Lead	7.72	mg/Kg
Manganese	230	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	<1.00	mg/Kg
Nickel	8.34	mg/Kg
Selenium	<0.50	mg/Kg
Silver	3.11	mg/Kg
Uranium	69.5	mg/Kg
Zinc	52.3	mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992

Comments:

Reported by ______

Reviewed by ______

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Client: Giant Refining Co.
Project: Bloomfield
Sample ID: 96S-3-5
Laboratory ID: 0396G01319
Sample Matrix: Soil
Condition: Cool/Intact

Date Reported: 08/05/96
Date Sampled: 07/10/96
Time Sampled: 2:30 PM
Date Received: 07/10/96

Parameter	Analytical Result	Units
Lab pH	7.9	s.u.
Fluoride	2.71	ppm
Chloride	445	ppm
Sulfate	469	ppm
Cyanide	<0.10	mg/Kg
Nitrate as Nitrogen	0.08	ppm
Trace Metals (Total)		
Aluminum	3,820	mg/Kg
Arsenic	<0.50	mg/Kg
Barium	48.1	mg/Kg
Boron	40.8	mg/Kg
Cadmium	<0.10	mg/Kg
Chromium	4.20	mg/Kg
Cobalt	1.78	mg/Kg
Copper	3.46	mg/Kg
Iron	5,068	mg/Kg
Lead	4.93	mg/Kg
Manganese	107	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	<1.0	mg/Kg
Nickel	3.04	mg/Kg
Selenium	<0.50	mg/Kg
Silver	<1.0	mg/Kg
Uranium	29.5	mg/Kg
Zinc	15.7	mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992.

Comments:

Reported by__________

Reviewed by__________

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Client:	Giant Refining Co.		
Project:	Bloomfield		
Sample ID:	96N-0-1	Date Reported:	08/05/96
Laboratory ID:	0396G01320	Date Sampled:	07/10/96
Sample Matrix:	Soil	Time Sampled:	10:11 AM
Condition:	Cool/Intact	Date Received:	07/10/96

Parameter	Analytical Result	Units
Lab pH	6.9	s.u.
Fluoride	0.53	ppm
Chloride	3,783	ppm
Sulfate	3,638	ppm
Cyanide	<0.10	mg/Kg
Nitrate as Nitrogen	0.46	ppm
Trace Metals (Total)		
Aluminum	6,144	mg/Kg
Arsenic	<0.50	mg/Kg
Barium	99.4	mg/Kg
Boron	49.5	mg/Kg
Cadmium	<0.10	mg/Kg
Chromium	8.00	mg/Kg
Cobalt	3.38	mg/Kg
Copper	6.09	mg/Kg
Iron	7,722	mg/Kg
Lead	7.22	mg/Kg
Manganese	140	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	<1.00	mg/Kg
Nickel	5.64	mg/Kg
Selenium	<0.50	mg/Kg
Silver	<1.0	mg/Kg
Uranium	54.9	mg/Kg
Zinc	30.3	mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992.

Comments:

Reported by ____________ Reviewed by ____________

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Client: Giant Refining Co.
Project: Bloomfield
Sample ID: 96N-3-5
Laboratory ID: 0396G01321
Sample Matrix: Soil
Condition: Cool/Intact

Date Reported: 08/05/96
Date Sampled: 07/10/96
Time Sampled: 11:30 AM
Date Received: 07/10/96

Parameter	Analytical Result	Units
Lab pH	8.0	s.u.
Fluoride	1.25	ppm
Chloride	998	ppm
Sulfate	370	ppm
Cyanide	<0.10	mg/Kg
Nitrate as Nitrogen	0.05	ppm
Trace Metals (Total)		
Aluminum	6,020	mg/Kg
Arsenic	<0.50	mg/Kg
Barium	93.2	mg/Kg
Boron	47.3	mg/Kg
Cadmium	<0.10	mg/Kg
Chromium	5.80	mg/Kg
Cobalt	3.01	mg/Kg
Copper	4.68	mg/Kg
Iron	8,416	mg/Kg
Lead	6.80	mg/Kg
Manganese	173	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	<1.0	mg/Kg
Nickel	5.46	mg/Kg
Selenium	<0.50	mg/Kg
Silver	<1.0	mg/Kg
Uranium	60.4	mg/Kg
Zinc	23.3	mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency. November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992.

Comments:

Reported by ________

Reviewed by ________

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Quality Control / Quality Assurance

Known Analysis

Total Metals

Client:	Giant Refining	Date Reported:	08/05/96
Project:	Bloomfield	Date Sampled:	07/10/96
Lab ID:	0396G01318-22	Date Received:	07/10/96
Matrix:	Soil		
Condition:	Cool / Intact		

Known Analysis

Parameter	Found Result	Known Result	Units	Percent Recovery
Aluminum	0.94	1.00	mg/L	94%
Arsenic	0.009	0.010	mg/L	90%
Barium	0.91	1.00	mg/L	91%
Boron	0.95	1.00	mg/L	95%
Cadmium	0.004	0.004	mg/L	100%
Chromium	1.02	1.00	mg/L	102%
Cobalt	0.91	1.00	mg/L	91%
Copper	0.005	0.005	mg/L	100%
Iron	0.96	1.00	mg/L	96%
Lead	0.040	0.040	mg/L	100%
Manganese	1.01	1.00	mg/L	101%
Mercury	0.440	0.400	mg/L	110%
Molybdenum	1.01	1.00	mg/L	101%
Nickel	1.01	1.00	mg/L	101%
Selenium	0.010	0.010	mg/L	100%
Silver	0.004	0.004	mg/L	98%
Uranium	1.19	1.00	mg/L	119%
Zinc	1.01	1.00	mg/L	101%

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846. United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed , November 1992.

Comments:

Reported By:

Reviewed By:

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Quality Control / Quality Assurance

Spike Analysis

Total Metals

Client: Giant Refining
Project: Bloomfield
Lab ID: 0396G01318-22
Matrix: Soil
Condition: Cool / Intact

Date Reported: 08/05/96
Date Sampled: 07/10/96
Date Received: 07/10/96

Spike Analysis

Parameter	Spiked Sample Result (mg/L	Sample Result (mg/L	Spike Added (mg/L	Percent Recovery
Aluminum	9.14	<0.05	10.0	91%
Arsenic	0.029	0.001	0.030	93%
Barium	1.26	0.88	0.50	92%
Boron	0.89	0.44	0.50	99%
Cadmium	0.002	<0.001	0.002	108%
Chromium	0.58	0.07	0.50	103%
Cobalt	0.47	0.03	0.50	89%
Copper	0.007	0.002	0.005	106%
Iron	9.28	<0.025	10.00	93%
Lead	0.032	0.010	0.025	106%
Manganese	1.63	1.24	0.50	98%
Mercury	0.55	<0.10	0.50	98%
Molybdenum	0.53	<0.10	0.50	105%
Nickel	0.56	0.05	0.50	103%
Selenium	0.024	0.001	0.025	92%
Silver	0.003	<0.001	0.003	108%
Uranium	0.95	0.49	0.50	102%
Zinc	0.79	0.27	0.50	109%

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992.

Comments:

Reported By:

Reviewed By:

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington, New Mexico 87401

Quality Control / Quality Assurance

Blank Analysis
Total Metals

Client: Giant Refining
Project: Bloomfield
Lab ID: 0396G01318-22
Matrix: Soil
Condition: Cool / Intact

Date Reported: 08/05/96
Date Sampled: 07/10/96
Date Received: 07/10/96

Blank Analysis

Parameter	Result	Detection Limit (mg/L)
Aluminum	ND	5.00
Arsenic	ND	0.50
Barium	ND	1.00
Boron	ND	5.00
Cadmium	ND	0.10
Chromium	ND	1.00
Cobalt	ND	1.00
Copper	ND	0.10
Iron	ND	2.50
Lead	ND	0.50
Manganese	ND	1.00
Mercury	ND	0.10
Molybdenum	ND	1.00
Nickel	ND	1.00
Selenium	ND	0.50
Silver	ND	1.00
Uranium	ND	20.0
Zinc	ND	5.00

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992

Comments:

Reported by:

Reviewed by:

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96 S-0-1
Project ID: Bloomfield, NM
Lab ID: B965796 0396G01318
Matrix: Soil

Date Reported: 07/30/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/16/96
Date Analyzed: 07/18/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg

Continued

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96 S-0-1
Project ID: Bloomfield, NM
Lab ID: B965796 0396G01318
Matrix: Soil

Date Reported: 07/30/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/16/96
Date Analyzed: 07/18/96

Parameter	Result	PQL	Units
Continued			
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	94	70 - 121
Bromofluorobenzene	107	74 - 121
Toluene-d8	109	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992.

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client:	GIANT REFINING COMPANY			
Sample ID:	96 S-0-1		Date Reported:	07/25/96
Project ID:	Bloomfield, NM		Date Sampled:	07/10/96
Lab ID:	B965796	0396G01318	Date Received:	07/12/96
Matrix:	Soil		Date Extracted:	07/17/96
			Date Analyzed:	07/22/96

Parameter	Result	PQL	Units
1,2,4-Trichlorobenzene	ND	5.0	mg/kg
1,2-Dichlorobenzene	ND	5.0	mg/kg
1,3-Dichlorobenzene	ND	5.0	mg/kg
1,4-Dichlorobenzene	ND	5.0	mg/kg
2,4,5-Trichlorophenol	ND	10	mg/kg
2,4,6-Trichlorophenol	ND	10	mg/kg
2,4-Dichlorophenol	ND	5.0	mg/kg
2,4-Dimethylphenol	ND	5.0	mg/kg
2,4-Dinitrophenol	ND	10	mg/kg
2,4-Dinitrotoluene	ND	5.0	mg/kg
2,6-Dinitrotoluene	ND	5.0	mg/kg
2-Chloronaphthalene	ND	5.0	mg/kg
2-Chlorophenol	ND	5.0	mg/kg
2-Methylnaphthalene	ND	5.0	mg/kg
2-Methylphenol	ND	5.0	mg/kg
2-Nitroaniline	ND	25	mg/kg
2-Nitrophenol	ND	5.0	mg/kg
3,3'-Dichlorobenzidine	ND	10	mg/kg
3-Methylphenol/4-Methylphenol	ND	5.0	mg/kg
3-Nitroaniline	ND	25	mg/kg
4,6-Dinitro-2-methylphenol	ND	25	mg/kg
4-Bromophenyl-phenylether	ND	5.0	mg/kg
4-Chloro-3-methylphenol	ND	10	mg/kg
4-Chloroaniline	ND	10	mg/kg
4-Chlorophenyl-phenylether	ND	5.0	mg/kg
4-Nitroaniline	ND	10	mg/kg
4-Nitrophenol	ND	10	mg/kg
Acenaphthene	ND	5.0	mg/kg

Continued

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 S-0-1
Project ID: Bloomfield, NM
Lab ID: B965796 0396G01318
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/22/96

Parameter	Result	PQL	Units
Continued			
Acenaphthylene	ND	5.0	mg/kg
Anthracene	ND	5.0	mg/kg
Benzo(a)anthracene	ND	5.0	mg/kg
Benzo(a)pyrene	ND	5.0	mg/kg
Benzo(b)fluoranthene	ND	5.0	mg/kg
Benzo(g,h,i)perylene	ND	5.0	mg/kg
Benzo(k)fluoranthene	ND	5.0	mg/kg
Benzoic Acid	ND	25	mg/kg
Benzyl Alcohol	ND	10	mg/kg
bis(2-Chloroethoxy)methane	ND	5.0	mg/kg
bis(2-Chloroethyl)ether	ND	5.0	mg/kg
bis(2-Chloroisopropyl)ether	ND	5.0	mg/kg
bis(2-Ethylhexyl)phthalate	ND	25	mg/kg
Butylbenzylphthalate	ND	5.0	mg/kg
Chrysene	ND	5.0	mg/kg
Di-n-Butylphthalate	ND	25	mg/kg
Di-n-Octylphthalate	ND	25	mg/kg
Dibenz(a,h)anthracene	ND	5.0	mg/kg
Dibenzofuran	ND	5.0	mg/kg
Diethylphthalate	ND	5.0	mg/kg
Dimethylphthalate	ND	5.0	mg/kg
Fluoranthene	ND	5.0	mg/kg
Fluorene	ND	5.0	mg/kg
Hexachlorobenzene	ND	10	mg/kg
Hexachlorobutadiene	ND	10	mg/kg
Hexachlorocyclopentadiene	ND	5.0	mg/kg
Hexachloroethane	ND	10	mg/kg
Indeno(1,2,3-cd)pyrene	ND	5.0	mg/kg

Continued

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 S-0-1
Project ID: Bloomfield, NM
Lab ID: B965796 0396G01318
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/22/96

Parameter	Result	PQL	Units
Continued			
Isophorone	ND	5.0	mg/kg
N-Nitrosodi-n-propylamine	ND	5.0	mg/kg
N-Nitrosodiphenylamine	ND	5.0	mg/kg
Naphthalene	ND	5.0	mg/kg
Nitrobenzene	ND	5.0	mg/kg
Pentachlorophenol	ND	25	mg/kg
Phenanthrene	ND	5.0	mg/kg
Phenol	ND	5.0	mg/kg
Pyrene	ND	5.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	52	19 - 122
2-Fluorobiphenyl	65	30 - 115
2-Fluorophenol	46	25 - 121
Nitrobenzene-d5	53	23 - 120
Phenol-d6	51	24 - 113
Terphenyl-d14	47	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst __________

Reviewed __________

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96 S-3-5
Project ID: Bloomfield, NM
Lab ID: B965797 0396G01319
Matrix: Soil

Date Reported: 07/30/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/16/96
Date Analyzed: 07/18/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
,cetone	ND	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg

Continued

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96 S-3-5
Project ID: Bloomfield, NM
Lab ID: B965797 0396G01319
Matrix: Soil

Date Reported: 07/30/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/16/96
Date Analyzed: 07/18/96

Parameter	Result	PQL	Units
Continued			
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	90	70 - 121
Bromofluorobenzene	100	74 - 121
Toluene-d8	102	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992.

Analyst E.D. 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 S-3-5
Project ID: Bloomfield, NM
Lab ID: B965797 0396G01319
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/23/96

Parameter	Result	PQL	Units
1,2,4-Trichlorobenzene	ND	1.0	mg/kg
1,2-Dichlorobenzene	ND	1.0	mg/kg
1,3-Dichlorobenzene	ND	1.0	mg/kg
1,4-Dichlorobenzene	ND	1.0	mg/kg
2,4,5-Trichlorophenol	ND	2.0	mg/kg
2,4,6-Trichlorophenol	ND	2.0	mg/kg
2,4-Dichlorophenol	ND	1.0	mg/kg
2,4-Dimethylphenol	ND	1.0	mg/kg
2,4-Dinitrophenol	ND	2.0	mg/kg
2,4-Dinitrotoluene	ND	1.0	mg/kg
2,6-Dinitrotoluene	ND	1.0	mg/kg
2-Chloronaphthalene	ND	1.0	mg/kg
2-Chlorophenol	ND	1.0	mg/kg
2-Methylnaphthalene	ND	1.0	mg/kg
2-Methylphenol	ND	1.0	mg/kg
2-Nitroaniline	ND	5.0	mg/kg
2-Nitrophenol	ND	1.0	mg/kg
3,3'-Dichlorobenzidine	ND	2.0	mg/kg
3-Methylphenol/4-Methylphenol	ND	1.0	mg/kg
3-Nitroaniline	ND	5.0	mg/kg
4,6-Dinitro-2-methylphenol	ND	5.0	mg/kg
4-Bromophenyl-phenylether	ND	1.0	mg/kg
4-Chloro-3-methylphenol	ND	2.0	mg/kg
4-Chloroaniline	ND	2.0	mg/kg
4-Chlorophenyl-phenylether	ND	1.0	mg/kg
4-Nitroaniline	ND	2.0	mg/kg
4-Nitrophenol	ND	2.0	mg/kg
Acenaphthene	ND	1.0	mg/kg

Continued

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client:	GIANT REFINING COMPANY			
Sample ID:	96 S-3-5		Date Reported:	07/25/96
Project ID:	Bloomfield, NM		Date Sampled:	07/10/96
Lab ID:	B965797	0396G01319	Date Received:	07/12/96
Matrix:	Soil		Date Extracted:	07/17/96
			Date Analyzed:	07/23/96

Continued

Parameter	Result	PQL	Units
Acenaphthylene	ND	1.0	mg/kg
Anthracene	ND	1.0	mg/kg
Benzo(a)anthracene	ND	1.0	mg/kg
Benzo(a)pyrene	ND	1.0	mg/kg
Benzo(b)fluoranthene	ND	1.0	mg/kg
Benzo(g,h,i)perylene	ND	1.0	mg/kg
Benzo(k)fluoranthene	ND	1.0	mg/kg
Benzoic Acid	ND	5.0	mg/kg
Benzyl Alcohol	ND	2.0	mg/kg
bis(2-Chloroethoxy)methane	ND	1.0	mg/kg
bis(2-Chloroethyl)ether	ND	1.0	mg/kg
bis(2-Chloroisopropyl)ether	ND	1.0	mg/kg
bis(2-Ethylhexyl)phthalate	ND	5.0	mg/kg
Butylbenzylphthalate	ND	1.0	mg/kg
Chrysene	ND	1.0	mg/kg
Di-n-Butylphthalate	ND	5.0	mg/kg
Di-n-Octylphthalate	ND	5.0	mg/kg
Dibenz(a,h)anthracene	ND	1.0	mg/kg
Dibenzofuran	ND	1.0	mg/kg
Diethylphthalate	ND	1.0	mg/kg
Dimethylphthalate	ND	1.0	mg/kg
Fluoranthene	ND	1.0	mg/kg
Fluorene	ND	1.0	mg/kg
Hexachlorobenzene	ND	2.0	mg/kg
Hexachlorobutadiene	ND	2.0	mg/kg
Hexachlorocyclopentadiene	ND	1.0	mg/kg
Hexachloroethane	ND	2.0	mg/kg
Indeno(1,2,3-cd)pyrene	ND	1.0	mg/kg

Continued

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 S-3-5
Project ID: Bloomfield, NM
Lab ID: B965797 0396G01319
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/23/96

Continued

Parameter	Result	PQL	Units
Isophorone	ND	1.0	mg/kg
N-Nitrosodi-n-propylamine	ND	1.0	mg/kg
N-Nitrosodiphenylamine	ND	1.0	mg/kg
Naphthalene	ND	1.0	mg/kg
Nitrobenzene	ND	1.0	mg/kg
Pentachlorophenol	ND	5.0	mg/kg
Phenanthrene	ND	1.0	mg/kg
Phenol	ND	1.0	mg/kg
ne	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	55	19 - 122
2-Fluorobiphenyl	62	30 - 115
2-Fluorophenol	58	25 - 121
Nitrobenzene-d5	63	23 - 120
Phenol-d6	64	24 - 113
Terphenyl-d14	47	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

ference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96 N-0-1
Project ID: Bloomfield, NM
Lab ID: B965798 0396G01320
Matrix: Soil

Date Reported: 07/30/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/16/96
Date Analyzed: 07/18/96

Parameter	Result	PQL	Units
Continued			
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	92	70 - 121
Bromofluorobenzene	107	74 - 121
Toluene-d8	105	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992

Analyst E.O. 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 N-0-1
Project ID: Bloomfield, NM
Lab ID: B965798 0396G01320
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/22/96

Parameter	Result	PQL	Units
1,2,4-Trichlorobenzene	ND	5.0	mg/kg
1,2-Dichlorobenzene	ND	5.0	mg/kg
1,3-Dichlorobenzene	ND	5.0	mg/kg
1,4-Dichlorobenzene	ND	5.0	mg/kg
2,4,5-Trichlorophenol	ND	10	mg/kg
2,4,6-Trichlorophenol	ND	10	mg/kg
2,4-Dichlorophenol	ND	5.0	mg/kg
2,4-Dimethylphenol	ND	5.0	mg/kg
2,4-Dinitrophenol	ND	10	mg/kg
2,4-Dinitrotoluene	ND	5.0	mg/kg
2,6-Dinitrotoluene	ND	5.0	mg/kg
2-Chloronaphthalene	ND	5.0	mg/kg
2-Chlorophenol	ND	5.0	mg/kg
2-Methylnaphthalene	ND	5.0	mg/kg
2-Methylphenol	ND	5.0	mg/kg
2-Nitroaniline	ND	25	mg/kg
2-Nitrophenol	ND	5.0	mg/kg
3,3'-Dichlorobenzidine	ND	10	mg/kg
3-Methylphenol/4-Methylphenol	ND	5.0	mg/kg
3-Nitroaniline	ND	25	mg/kg
4,6-Dinitro-2-methylphenol	ND	25	mg/kg
4-Bromophenyl-phenylether	ND	5.0	mg/kg
4-Chloro-3-methylphenol	ND	10	mg/kg
4-Chloroaniline	ND	10	mg/kg
4-Chlorophenyl-phenylether	ND	5.0	mg/kg
4-Nitroaniline	ND	10	mg/kg
4-Nitrophenol	ND	10	mg/kg
Acenaphthene	ND	5.0	mg/kg

Continued

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 N-0-1
Project ID: Bloomfield, NM
Lab ID: B965798 0396G01320
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/22/96

Parameter	Result	PQL	Units
Continued			
Isophorone	ND	5.0	mg/kg
N-Nitrosodi-n-propylamine	ND	5.0	mg/kg
N-Nitrosodiphenylamine	ND	5.0	mg/kg
Naphthalene	ND	5.0	mg/kg
Nitrobenzene	ND	5.0	mg/kg
Pentachlorophenol	ND	25	mg/kg
Phenanthrene	ND	5.0	mg/kg
Phenol	ND	5.0	mg/kg
Pyrene	ND	5.0	mg/kg

JALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	49	19 - 122
2-Fluorobiphenyl	58	30 - 115
2-Fluorophenol	44	25 - 121
Nitrobenzene-d5	49	23 - 120
Phenol-d6	49	24 - 113
Terphenyl-d14	42	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst RRD

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96 N-3-5
Project ID: Bloomfield, NM
Lab ID: B965799 0396G01321
Matrix: Soil

Date Reported: 07/30/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/16/96
Date Analyzed: 07/17/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg
nzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg

Continued

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96 N-3-5
Project ID: Bloomfield, NM
Lab ID: B965799 0396G01321
Matrix: Soil

Date Reported: 07/30/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/16/96
Date Analyzed: 07/17/96

Parameter	Result	PQL	Units
Continued			
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	99	70 - 121
Bromofluorobenzene	110	74 - 121
luene-d8	111	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992.

Analyst E.D. 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 N-3-5
Project ID: Bloomfield, NM
Lab ID: B965799 0396G01321
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/23/96

Parameter	Result	PQL	Units
1,2,4-Trichlorobenzene	ND	1.0	mg/kg
1,2-Dichlorobenzene	ND	1.0	mg/kg
1,3-Dichlorobenzene	ND	1.0	mg/kg
1,4-Dichlorobenzene	ND	1.0	mg/kg
2,4,5-Trichlorophenol	ND	2.0	mg/kg
2,4,6-Trichlorophenol	ND	2.0	mg/kg
2,4-Dichlorophenol	ND	1.0	mg/kg
2,4-Dimethylphenol	ND	1.0	mg/kg
2,4-Dinitrophenol	ND	2.0	mg/kg
2,4-Dinitrotoluene	ND	1.0	mg/kg
'-Dinitrotoluene	ND	1.0	mg/kg
2-Chloronaphthalene	ND	1.0	mg/kg
2-Chlorophenol	ND	1.0	mg/kg
2-Methylnaphthalene	ND	1.0	mg/kg
2-Methylphenol	ND	1.0	mg/kg
2-Nitroaniline	ND	5.0	mg/kg
2-Nitrophenol	ND	1.0	mg/kg
3,3'-Dichlorobenzidine	ND	2.0	mg/kg
3-Methylphenol/4-Methylphenol	ND	1.0	mg/kg
3-Nitroaniline	ND	5.0	mg/kg
4,6-Dinitro-2-methylphenol	ND	5.0	mg/kg
4-Bromophenyl-phenylether	ND	1.0	mg/kg
4-Chloro-3-methylphenol	ND	2.0	mg/kg
4-Chloroaniline	ND	2.0	mg/kg
4-Chlorophenyl-phenylether	ND	1.0	mg/kg
4-Nitroaniline	ND	2.0	mg/kg
4-Nitrophenol	ND	2.0	mg/kg
Acenaphthene	ND	1.0	mg/kg

Continued

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 N-3-5
Project ID: Bloomfield, NM
Lab ID: B965799 0396G01321
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/23/96

Continued

Parameter	Result	PQL	Units
Acenaphthylene	ND	1.0	mg/kg
Anthracene	ND	1.0	mg/kg
Benzo(a)anthracene	ND	1.0	mg/kg
Benzo(a)pyrene	ND	1.0	mg/kg
Benzo(b)fluoranthene	ND	1.0	mg/kg
Benzo(g,h,i)perylene	ND	1.0	mg/kg
Benzo(k)fluoranthene	ND	1.0	mg/kg
Benzoic Acid	ND	5.0	mg/kg
Benzyl Alcohol	ND	2.0	mg/kg
bis(2-Chloroethoxy)methane	ND	1.0	mg/kg
(2-Chloroethyl)ether	ND	1.0	mg/kg
bis(2-Chloroisopropyl)ether	ND	1.0	mg/kg
bis(2-Ethylhexyl)phthalate	ND	5.0	mg/kg
Butylbenzylphthalate	ND	1.0	mg/kg
Chrysene	ND	1.0	mg/kg
Di-n-Butylphthalate	ND	5.0	mg/kg
Di-n-Octylphthalate	ND	5.0	mg/kg
Dibenz(a,h)anthracene	ND	1.0	mg/kg
Dibenzofuran	ND	1.0	mg/kg
Diethylphthalate	ND	1.0	mg/kg
Dimethylphthalate	ND	1.0	mg/kg
Fluoranthene	ND	1.0	mg/kg
Fluorene	ND	1.0	mg/kg
Hexachlorobenzene	ND	2.0	mg/kg
Hexachlorobutadiene	ND	2.0	mg/kg
Hexachlorocyclopentadiene	ND	1.0	mg/kg
Hexachloroethane	ND	2.0	mg/kg
Indeno(1,2,3-cd)pyrene	ND	1.0	mg/kg

Continued

EPA METHOD 8270
HSL SEMI-VOLATILE COMPOUNDS
BASE/NEUTRAL/ACID EXTRACTABLES

Client: GIANT REFINING COMPANY
Sample ID: 96 N-3-5
Project ID: Bloomfield, NM
Lab ID: B965799 0396G01321
Matrix: Soil

Date Reported: 07/25/96
Date Sampled: 07/10/96
Date Received: 07/12/96
Date Extracted: 07/17/96
Date Analyzed: 07/23/96

Parameter	Result	PQL	Units
Continued			
Isophorone	ND	1.0	mg/kg
N-Nitrosodi-n-propylamine	ND	1.0	mg/kg
N-Nitrosodiphenylamine	ND	1.0	mg/kg
Naphthalene	ND	1.0	mg/kg
Nitrobenzene	ND	1.0	mg/kg
Pentachlorophenol	ND	5.0	mg/kg
Phenanthrene	ND	1.0	mg/kg
Phenol	ND	1.0	mg/kg
Pyrene	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	51	19 - 122
2-Fluorobiphenyl	51	30 - 115
2-Fluorophenol	44	25 - 121
Nitrobenzene-d5	49	23 - 120
Phenol-d6	50	24 - 113
Terphenyl-d14	46	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst________________

Reviewed________________

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

QUALITY ASSURANCE / QUALITY CONTROL

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

LAB QA/QC
EPA METHOD 8240
INSTRUMENT BLANK

Date Analyzed: 07/18/96
Lab ID: IBS006200
Matrix:

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg
2-Hexanone	ND	1.0	mg/kg

Continued

LAB QA/QC
EPA METHOD 8240
INSTRUMENT BLANK

Date Analyzed: 07/18/96
Lab ID: IBS006200
Matrix:

Parameter	Result	PQL	Units
Continued			
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
Bromofluorobenzene	106	74 - 121
1,2-Dichloroethane-d4	89	70 - 121
Toluene-d8	107	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Analyst E-D · 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

LAB QA/QC
EPA METHOD 8240
INSTRUMENT BLANK

Date Analyzed: 07/17/96
Lab ID: IBS006199
Matrix:

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg k
Carbon Disulfide	ND	1.0	mg k
Xylenes (total)	ND	1.0	mg k
2-Hexanone	ND	1.0	mg k

Continued

LAB QA/QC
EPA METHOD 8240
INSTRUMENT BLANK

Date Analyzed: 07/17/96
Lab ID: IBS006199
Matrix:

Parameter	Result	PQL	Units
Continued			
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
Bromofluorobenzene	111	74 - 121
1,2-Dichloroethane-d4	92	70 - 121
Toluene-d8	110	81 - 117

Analyst E.O. 7/31/96

Reviewed

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

LAB QA/QC
EPA METHOD 8240
METHOD BLANK

Date Analyzed: 07/17/96
Lab ID: MBS006198
Matrix: Sand
Date Extracted: 07/16/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg

Continued

LAB QA/QC
EPA METHOD 8240
METHOD BLANK

Date Analyzed: 07/17/96
Lab ID: MBS006198
Matrix: Sand
Date Extracted: 07/16/96

Parameter	Result	PQL	Units
Continued			
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	95	70 - 121
Bromofluorobenzene	105	74 - 121
Toluene-d8	110	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Analyst E.O. 7/31/96

Reviewed

LAB QA/QC
EPA METHOD 8270
METHOD BLANK

Date Analyzed: 07/20/96
Lab ID: MBS96199
Matrix: Soil
Date Extracted: 07/17/96

Parameter	Result	PQL	Units
1,2,4-Trichlorobenzene	ND	1.0	mg/kg
1,2-Dichlorobenzene	ND	1.0	mg/kg
1,3-Dichlorobenzene	ND	1.0	mg/kg
1,4-Dichlorobenzene	ND	1.0	mg/kg
2,4,5-Trichlorophenol	ND	2.0	mg/kg
2,4,6-Trichlorophenol	ND	2.0	mg/kg
2,4-Dichlorophenol	ND	1.0	mg/kg
2,4-Dimethylphenol	ND	1.0	mg/kg
2,4-Dinitrophenol	ND	2.0	mg/kg
2,4-Dinitrotoluene	ND	1.0	mg/kg
2,6-Dinitrotoluene	ND	1.0	mg/kg
2-Chloronaphthalene	ND	1.0	mg/kg
2-Chlorophenol	ND	1.0	mg/kg
2-Methylnaphthalene	ND	1.0	mg/kg
2-Methylphenol	ND	1.0	mg/kg
2-Nitroaniline	ND	5.0	mg/kg
2-Nitrophenol	ND	1.0	mg/kg
3,3'-Dichlorobenzidine	ND	2.0	mg/kg
3-Methylphenol/4-Methylphenol	ND	1.0	mg/kg
3-Nitroaniline	ND	5.0	mg/kg
4,6-Dinitro-2-methylphenol	ND	5.0	mg/kg
4-Bromophenyl-phenylether	ND	1.0	mg/kg
4-Chloro-3-methylphenol	ND	2.0	mg/kg
4-Chloroaniline	ND	2.0	mg/kg
4-Chlorophenyl-phenylether	ND	1.0	mg/kg
4-Nitroaniline	ND	2.0	mg/kg
4-Nitrophenol	ND	2.0	mg/kg
Acenaphthene	ND	1.0	mg/kg
Acenaphthylene	ND	1.0	mg/kg
Anthracene	ND	1.0	mg/kg
Benzo(a)anthracene	ND	1.0	mg/kg
Benzo(a)pyrene	ND	1.0	mg/kg
Benzo(b)fluoranthene	ND	1.0	mg/kg

Continued

LAB QA/QC
EPA METHOD 8270
METHOD BLANK

Date Analyzed: 07/20/96
Lab ID: MBS96199
Matrix: Soil
Date Extracted: 07/17/96

Continued

Parameter	Result	PQL	Units
Benzo(g,h,i)perylene	ND	1.0	mg/kg
Benzo(k)fluoranthene	ND	1.0	mg/kg
Benzoic Acid	ND	5.0	mg/kg
Benzyl Alcohol	ND	2.0	mg/kg
bis(2-Chloroethoxy)methane	ND	1.0	mg/kg
bis(2-Chloroethyl)ether	ND	1.0	mg/kg
bis(2-Chloroisopropyl)ether	ND	1.0	mg/kg
bis(2-Ethylhexyl)phthalate	ND	5.0	mg/kg
Butylbenzylphthalate	ND	1.0	mg/kg
Chrysene	ND	1.0	mg/kg
Di-n-Butylphthalate	ND	5.0	mg/kg
Di-n-Octylphthalate	ND	5.0	mg/kg
Dibenz(a,h)anthracene	ND	1.0	mg/kg
Dibenzofuran	ND	1.0	mg/kg
Diethylphthalate	ND	1.0	mg/kg
Dimethylphthalate	ND	1.0	mg/kg
Fluoranthene	ND	1.0	mg/kg
Fluorene	ND	1.0	mg/kg
Hexachlorobenzene	ND	2.0	mg/kg
Hexachlorobutadiene	ND	2.0	mg/kg
Hexachlorocyclopentadiene	ND	1.0	mg/kg
Hexachloroethane	ND	2.0	mg/kg
Indeno(1,2,3-cd)pyrene	ND	1.0	mg/kg
Isophorone	ND	1.0	mg/kg
N-Nitrosodi-n-propylamine	ND	1.0	mg/kg
N-Nitrosodiphenylamine	ND	1.0	mg/kg
Naphthalene	ND	1.0	mg/kg
Nitrobenzene	ND	1.0	mg/kg
Pentachlorophenol	ND	5.0	mg/kg
Phenanthrene	ND	1.0	mg/kg
Phenol	ND	1.0	mg/kg
Pyrene	ND	1.0	mg/kg

Continued

LAB QA/QC
EPA METHOD 8270
METHOD BLANK

Date Analyzed: 07/20/96
Lab ID: MBS96199
Matrix: Soil
Date Extracted: 07/17/96

Parameter	Result	PQL	Units

Continued

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	56	19 - 122
2-Fluorobiphenyl	53	30 - 115
2-Fluorophenol	46	25 - 121
Nitrobenzene-d5	51	23 - 120
Phenol-d6	56	24 - 113
Terphenyl-d14	45	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Analyst ____________

Reviewed ____________

LAB QA/QC
EPA METHOD 8240
BLANK SPIKE / BLANK SPIKE DUPLICATE SUMMARY

Date Analyzed: 07/17/96
Lab ID: BSS60198
Matrix: Sand
Date Extracted: 07/16/96

Original Sample Parameters

Parameter	Spike Added (mg/kg)	Sample Result (mg/kg)	Spike Result (mg/kg)	BS Recovery %	QC Limits Rec.
1,1-Dichloroethene	10	0	8.44	84	59 -172
Benzene	10	0	9.77	98	62 -137
Chlorobenzene	10	0	10.7	107	66 -142
Toluene	10	0	10.8	108	59 -139
Trichloroethene (TCE)	10	0	10.3	103	60 -133

Duplicate Sample Parameters

Parameter	Spike Added (mg/kg)	BSD Result (mg/kg)	BSD Recovery %	RPD %	QC Limits RPD	QC Limits Rec.
1,1-Dichloroethene	10	10.2	102	19	22	59 -172
Benzene	10	10.1	101	3	24	62 -137
Chlorobenzene	10	10.8	108	1	21	66 -142
Toluene	10	10.8	108	0	21	59 -139
Trichloroethene (TCE)	10	10.5	105	2	21	60 -133

Note: Spike Recoveries are calculated using zero for Sample result if Sample result was less than PQL (Practical Quantitation Level).

Spike Recovery: 0 out of 10 outside QC limits.
RPD: 0 out of 5 outside QC limits.

Analyst E.D. 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

LAB QA/QC
EPA METHOD 8270
BLANK SPIKE / BLANK SPIKE DUPLICATE SUMMARY

Date Analyzed: 07/20/96
Lab ID: BSS96199
Matrix: Soil
Date Extracted: 07/17/96

Original Sample Parameters

Parameter	Spike Added (mg/kg)	Sample Result (mg/kg)	Spike Result (mg/kg)	BS Recovery %	QC Limits Rec.
1,2,4-Trichlorobenzene	10	0	4.0	40	38 - 107
1,4-Dichlorobenzene	10	0	4.2	42	28 - 104
2,4-Dinitrotoluene	10	0	6.8	68	28 - 89
2-Chlorophenol	20	0	8.3	42	25 - 102
4-Chloro-3-methylphenol	20	0	12	60	26 - 103
4-Nitrophenol	20	0	11	55	11 - 114
Acenaphthene	10	0	6.2	62	31 - 137
N-Nitrosodi-n-propylamine	10	0	8.0	80	41 - 126
Pentachlorophenol	20	0	13	65	17 - 109
Phenol	20	0	8.3	42	26 - 90
Pyrene	10	0	5.1	51	35 - 142

Duplicate Sample Parameters

Parameter	Spike Added (mg/kg)	BSD Result (mg/kg)	BSD Recovery %	RPD %		QC Limits RPD	QC Limits Rec.
1,2,4-Trichlorobenzene	10	5.8	58	37	*	23	38 - 107
1,4-Dichlorobenzene	10	5.9	59	34	*	27	28 - 104
2,4-Dinitrotoluene	10	7.0	70	3		47	28 - 89
2-Chlorophenol	20	12	60	36		50	25 - 102
4-Chloro-3-methylphenol	20	13	65	8		33	26 - 103
4-Nitrophenol	20	12	60	9		50	11 - 114
Acenaphthene	10	6.8	68	9		19	31 - 137
N-Nitrosodi-n-propylamine	10	8.5	85	6		38	41 - 126
Pentachlorophenol	20	14	70	7		47	17 - 109
Phenol	20	12	60	36	*	35	26 - 90
Pyrene	10	5.4	54	6		36	35 - 142

Note: Spike Recoveries are calculated using zero for Sample result if Sample result was less than PQL (Practical Quantitation Level).

Spike Recovery: 0 out of 22 outside QC limits.
RPD: 3 out of 11 outside QC limits.

Analyst RPD

Reviewed

LAB QA/QC
EPA METHOD 8270
MATRIX SPIKE

Date Analyzed: 07/23/96
Lab ID: 0596H05797 SK1 0396G01319
Matrix: Soil
Date Extracted: 07/17/96

Parameter	Spike Added (mg/kg)	Sample Result (mg/kg)	Spike Result (mg/kg)	MS Recovery %	QC Limits Rec.
1,2,4-Trichlorobenzene	10	0	5.4	54	38 -107
1,4-Dichlorobenzene	10	0	5.1	51	28 -104
2,4-Dinitrotoluene	10	0	6.4	64	28 - 89
2-Chlorophenol	20	0	12	60	25 -102
4-Chloro-3-methylphenol	20	0	13	65	26 -103
4-Nitrophenol	20	0	11	55	11 -114
Acenaphthene	10	0	6.5	65	31 -137
N-Nitrosodi-n-propylamine	10	0	8.5	85	41 -126
Pentachlorophenol	20	0	12	60	17 -109
Phenol	20	0	12	60	26 - 90
Pyrene	10	0	5.1	51	35 -142

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	59	19 -122
2-Fluorobiphenyl	66	30 -115
2-Fluorophenol	60	25 -121
Nitrobenzene-d5	68	23 -120
Phenol-d6	67	24 -113
Terphenyl-d14	44	18 -137

Note: Spike Recoveries are calculated using zero for Sample result if Sample result was less than PQL (Practical Quantitation Level).

Spike Recovery: 0 out of 11 outside QC limits.

Analyst RPD

Reviewed

Inter-Mountain Laboratories, Inc.

CHAIN OF CUSTODY RECORD

Client/Project Name: GIANT REFINING CO - BLMFLD

Project Location:

Sampler: (Signature) LYNN SHELTON

Chain of Custody Tape No.:

ANALYSES / PARAMETERS

Sample No./ Identification	Date	Time	Lab Number	Matrix	No. of Containers	WQCC LIST				Remarks
96 S-0-1	7/10/96	1330		SOIL	4	X				
96 S-3-5	7/10/96	1430			4	X				
96 N-0-1	7/10/96	1011			4	X				
96 N-3-5	7/10/96	1130			4	X				
										cool + intact

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Lynn Shelton	7/10/96	5:34PM	Chris Raymer	7-10-96	173
Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Date	Time	Received by laboratory: (Signature)	Date	Time

Inter-Mountain Laboratories, Inc.

☐ 1633 Terra Avenue
Sherida Wyoming 82801
Teleph 307) 672-8945

☐ 1701 Phillips Circle
Gillette, Wyoming 82718
Telephone (307) 682-8945

☒ 2506 West Main Street
Farmington, NM 87401
Telephone (505) 326-4737

☐ 1160 Research Dr.
Bozeman, Montana 59715
Te hone (406) 586-8450

☐ 11183 SH 30
College Station, TX 77845
Telephone (409) 776-8945

☐ 3304 Longmire Drive
College Station, TX 77845
Telephone (409) 774-4999

37672

iml
Inter·Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

5 August 1996

Lynn Shelton
Giant Refining Co.
P. O. Box 159
Bloomfield, NM 87413

Mr. Shelton:

Enclosed please find the report for the samples received by our laboratory for analysis on July 11, 1996.

If you have any questions about the results of these analyses, please don't hesitate to call me at your convenience.

Sincerely,

Anna Schaerer

Anna Schaerer
Organic Analyst/IML-Farmington

Enclosure

xc: File

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

CASE NARRATIVE

Client: GIANT REFINING COMPANY
Project: Bloomfield, NM Received on: 07/16/96
Set ID: 0596H05846 # samples: 4

Suites: 8240 Standard, 8270 PAHs

Samples were received for analysis at Inter-Mountain Laboratories (IML), Bozeman, Montana. Enclosed are the results of these analyses.

Limits of detection for each instrument/analysis are determined by sample matrix effects, instrument performance under standard conditions, and dilution requirements to maintain chromatography output within calibration ranges. Quantitations have been calculated on an as received basis.

Jack Felkey
IML-Bozeman

Inter·Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client: Giant Refining Co.
Project: Bloomfield
Sample ID: 96E-0-1
Laboratory ID: 0396G01328
Sample Matrix: Soil
Condition: Cool/Intact

Date Reported: 08/05/96
Date Sampled: 07/11/96
Time Sampled: 9:45 AM
Date Received: 07/11/96

Parameter	Analytical Result	Units
Lab pH	7.6	s.u.
Fluoride	1.15	ppm
Chloride	2,582	ppm
Sulfate	2,156	ppm
Cyanide	<0.10	mg/Kg
Nitrate as Nitrogen	6.42	ppm
Trace Metals (Total)		
Aluminum	10,122	mg/Kg
Arsenic	1.16	mg/Kg
Barium	195	mg/Kg
Boron	55.8	mg/Kg
Cadmium	0.158	mg/Kg
Chromium	9.48	mg/Kg
Cobalt	5.06	mg/Kg
Copper	3 58	mg/Kg
Iron	13,097	mg/Kg
Lead	11.6	mg/Kg
Manganese	223	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	<1.00	mg/Kg
Nickel	1.16	mg/Kg
Selenium	<0.50	mg/Kg
Silver	<1.00	mg/Kg
Uranium	86.4	mg/Kg
Zinc	45.3	mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992

Comments:

Reported by ____________

Reviewed by ____________

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Giant Refining Co.		
Project:	Bloomfield		
Sample ID:	96E-3-5	Date Reported:	08/05/96
Laboratory ID:	0396G01329	Date Sampled:	07/11/96
Sample Matrix:	Soil	Time Sampled:	10:45 AM
Condition:	Cool/Intact	Date Received:	07/11/96

Parameter	Analytical Result	Units
Lab pH	7.8	s.u.
Fluoride	1.76	ppm
Chloride	1,235	ppm
Sulfate	724	ppm
Cyanide	<0.10	mg/Kg
Nitrate as Nitrogen	0.51	ppm
Trace Metals (Total)		
Aluminum	7,102	mg/Kg
Arsenic	0.527	mg/Kg
Barium	189	mg/Kg
Boron	56.9	mg/Kg
Cadmium	<0.10	mg/Kg
Chromium	7.48	mg/Kg
Cobalt	4.11	mg/Kg
Copper	2.32	mg/Kg
Iron	10,569	mg/Kg
Lead	7.69	mg/Kg
Manganese	240	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	1.05	mg/Kg
Nickel	7.38	mg/Kg
Selenium	<0.50	mg/Kg
Silver	<1.00	mg/Kg
Uranium	66.4	mg/Kg
Zinc	30.6	mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods",
SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992.

Comments:

Reported by__________ Reviewed by__________

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

lient:	**Giant Refining Co.**		
Project:	Bloomfield		
Sample ID:	96B-0-1	Date Reported:	08/05/96
Laboratory ID:	0396G01330	Date Sampled:	07/11/96
Sample Matrix:	Soil	Time Sampled:	11:45 AM
Condition:	Cool/Intact	Date Received:	07/11/96

Parameter	Analytical Result	Units
Lab pH	7.5	s.u.
Fluoride	0.77	ppm
Chloride	1,054	ppm
Sulfate	2,790	ppm
Cyanide	<0.10	mg/Kg
Nitrate as Nitrogen	14.2	ppm
Trace Metals (Total)		
Aluminum	6,199	mg/Kg
Arsenic	<0.50	mg/Kg
Barium	166	mg/Kg
Boron	55.0	mg/Kg
Cadmium	0.104	mg/Kg
Chromium	6.85	mg/Kg
Cobalt	3.84	mg/Kg
Copper	2.18	mg/Kg
Iron	9,401	mg/Kg
Lead	8.00	mg/Kg
Manganese	205	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	<1.00	mg/Kg
Nickel	7.27	mg/Kg
Selenium	<0.50	mg/Kg
Silver	<1.00	mg/Kg
Uranium	84.1	mg/Kg
Zinc	33.2	mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992.

Comments:

Reported by ____________ Reviewed by ____________

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

lient: Giant Refining Co.
Project: Bloomfield
Sample ID: 96B-3-5
Laboratory ID: 0396G01331
Sample Matrix: Soil
Condition: Cool/Intact

Date Reported: 08/05/96
Date Sampled: 07/11/96
Time Sampled: 12:30 PM
Date Received: 07/11/96

Parameter	Analytical Result	Units
Lab pH	8.2	s.u.
Fluoride	0.38	ppm
Chloride	324	ppm
Sulfate	395	ppm
Cyanide	<0.10	mg/Kg
Nitrate as Nitrogen	<0.05	ppm
Trace Metals (Total)		
Aluminum	3,266	mg/Kg
Arsenic	<0.50	mg/Kg
Barium	56.0	mg/Kg
Boron	51.9	mg/Kg
Cadmium	<0.10	mg/Kg
Chromium	3.16	mg/Kg
Cobalt	1.83	mg/Kg
Copper	3.87	mg/Kg
Iron	4,751	mg/Kg
Lead	4.99	mg/Kg
Manganese	113	mg/Kg
Mercury	<0.10	mg/Kg
Molybdenum	<1.00	mg/Kg
Nickel	3.46	mg/Kg
Selenium	<0.50	mg/Kg
Silver	<1.00	mg/Kg
Uranium	31.1	mg/Kg
Zinc		mg/Kg

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992

Comments:

Reported by__________

Reviewed by__________

Inter·Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Quality Control / Quality Assurance

Spike Analysis

Total Metals

Client:	Giant Refining	Date Reported:	08/05/96
Project:	Bloomfield	Date Sampled:	07/11/96
Lab ID:	0396G01328-31	Date Received:	07/11/96
Matrix:	Soil		
Condition:	Cool / Intact		

Spike Analysis

Parameter	Spiked Sample Result (mg/L	Sample Result (mg/L	Spike Added (mg/L	Percent Recovery
Aluminum	9.14	<0.05	10.0	91%
Arsenic	0.029	0.001	0.030	93%
Barium	1.26	0.88	0.50	92%
Boron	0.89	0.44	0.50	99%
Cadmium	0.002	<0.001	0.002	108%
Chromium	0.58	0.07	0.50	103%
Cobalt	0.47	0.03	0.50	89%
Copper	0.007	0.002	0.005	106%
Iron	9.28	<0.025	10.00	93%
Lead	0.032	0.010	0.025	106%
Manganese	1.63	1.24	0.50	98%
Mercury	0.55	<0.10	0.50	98%
Molybdenum	0.53	<0.10	0.50	105%
Nickel	0.56	0.05	0.50	103%
Selenium	0.024	0.001	0.025	92%
Silver	0.003	<0.001	0.003	108%
Uranium	0.95	0.49	0.50	102%
Zinc	0.79	0.27	0.50	109%

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992

Comments:

Reported By:

Reviewed By:

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington, New Mexico 87401

Quality Control / Quality Assurance

Known Analysis

Total Metals

Client:	Giant Refining	Date Reported:	08/05/96
Project:	Bloomfield	Date Sampled:	07/11/96
Lab ID:	0396G01328-31	Date Received:	07/11/96
Matrix:	Soil		
Condition:	Cool / Intact		

Known Analysis

Parameter	Found Result	Known Result	Units	Percent Recovery
Aluminum	0.94	1.00	mg/L	94%
Arsenic	0.009	0.010	mg/L	90%
Barium	0.91	1.00	mg/L	91%
Boron	0.95	1.00	mg/L	95%
Cadmium	0.004	0.004	mg/L	100%
Chromium	1.02	1.00	mg/L	102%
Cobalt	0.91	1.00	mg/L	91%
Copper	0.005	0.005	mg/L	100%
Iron	0.96	1.00	mg/L	96%
Lead	0.040	0.040	mg/L	100%
Manganese	1.01	1.00	mg/L	101%
Mercury	0.440	0.400	mg/L	110%
Molybdenum	1.01	1.00	mg/L	101%
Nickel	1.01	1.00	mg/L	101%
Selenium	0.010	0.010	mg/L	100%
Silver	0.004	0.004	mg/L	98%
Uranium	1.19	1.00	mg/L	119%
Zinc	1.01	1.00	mg/L	101%

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992

Comments:

Reported By: ____________ Reviewed By: ____________

Inter-Mountain Laboratories, Inc.

2506 W Main Street
Farmington New Mexico 87401

Quality Control / Quality Assurance

Blank Analysis

Total Metals

Client: Giant Refining
Project: Bloomfield
Lab ID: 0396G01328-31
Matrix: Soil
Condition: Cool / Intact

Date Reported: 08/05/96
Date Sampled: 07/11/96
Date Received: 07/11/96

Blank Analysis

Parameter	Result	Detection Limit (mg/L)
Aluminum	ND	5.00
Arsenic	ND	0.50
Barium	ND	1.00
Boron	ND	5.00
Cadmium	ND	0.10
Chromium	ND	1.00
Cobalt	ND	1.00
Copper	ND	0.10
Iron	ND	2.50
Lead	ND	0.50
Manganese	ND	1.00
Mercury	ND	0.10
Molybdenum	ND	1.00
Nickel	ND	1.00
Selenium	ND	0.50
Silver	ND	1.00
Uranium	ND	20.0
Zinc	ND	5.00

Reference: "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods", SW-846, United States Environmental Protection Agency, November, 1986.
"Test Methods for Evaluating Solid Wastes", Method 3050, SW-846, 3rd ed., November 1992.

Comments:

Reported by:__________

Reviewed by:__________

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96B-0-1
Project ID: Bloomfield, NM
Lab ID: B965848 0396G01328
Matrix: Soil

Date Reported: 07/31/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/25/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg

Continued

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client:	GIANT REFINING COMPANY		Date Reported:	07/31/96
Sample ID:	96B-0-1		Date Sampled:	07/11/96
Project ID:	Bloomfield, NM		Date Received:	07/16/96
Lab ID:	B965848	0396G01328	Date Extracted:	07/23/96
Matrix:	Soil		Date Analyzed:	07/25/96

Parameter	Result	PQL	Units
Continued			
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	90	70 - 121
omofluorobenzene	118	74 - 121
Toluene-d8	113	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992.

Analyst E. D. 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
POLYNUCLEAR AROMATIC HYDROCARBONS

Client: GIANT REFINING COMPANY
Sample ID: 96B-0-1
Project ID: Bloomfield, NM
Lab ID: B965848 0396G01328
Matrix: Soil

Date Reported: 07/29/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/26/96

Parameter	Result	PQL	Units
3-Methylcholanthrene	ND	1.0	mg/kg
Acenaphthene	ND	1.0	mg/kg
Acenaphthylene	ND	1.0	mg/kg
Anthracene	ND	1.0	mg/kg
Benzo(a)anthracene	ND	1.0	mg/kg
Benzo(a)pyrene	ND	1.0	mg/kg
Benzo(b)fluoranthene	ND	1.0	mg/kg
Benzo(g,h,i)perylene	ND	1.0	mg/kg
Benzo(k)fluoranthene	ND	1.0	mg/kg
Chrysene	ND	1.0	mg/kg
Dibenz(a,h)anthracene	ND	1.0	mg/kg
Fluoranthene	ND	1.0	mg/kg
Fluorene	ND	1.0	mg/kg
Indeno(1,2,3-cd)pyrene	ND	1.0	mg/kg
Naphthalene	ND	1.0	mg/kg
Phenanthrene	ND	1.0	mg/kg
Pyrene	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	65	19 - 122
2-Fluorobiphenyl	57	30 - 115
2-Fluorophenol	49	25 - 121
Nitrobenzene-d5	50	23 - 120
Phenol-d6	69	24 - 113
Terphenyl-d14	47	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client:	GIANT REFINING COMPANY		Date Reported:	07/31/96
Sample ID:	96B-3-5		Date Sampled:	07/11/96
Project ID:	Bloomfield, NM		Date Received:	07/16/96
Lab ID:	B965849	0396G01328	Date Extracted:	07/23/96
Matrix:	Soil		Date Analyzed:	07/25/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg

Continued

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96B-3-5
Project ID: Bloomfield, NM
Lab ID: B965849 0396G01328
Matrix: Soil

Date Reported: 07/31/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/25/96

Parameter	Result	PQL	Units
Continued			
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	94	70 - 121
ofluorobenzene	110	74 - 121
Toluene-d8	109	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

erence: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992.

Analyst E.D. 7/31/96

Reviewed

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
POLYNUCLEAR AROMATIC HYDROCARBONS

Client:	GIANT REFINING COMPANY			
Sample ID:	96B-3-5		Date Reported:	07/29/96
Project ID:	Bloomfield, NM		Date Sampled:	07/11/96
Lab ID:	B965849	0396G01328	Date Received:	07/16/96
Matrix:	Soil		Date Extracted:	07/23/96
			Date Analyzed:	07/26/96

Parameter	Result	PQL	Units
3-Methylcholanthrene	ND	1.0	mg/kg
Acenaphthene	ND	1.0	mg/kg
Acenaphthylene	ND	1.0	mg/kg
Anthracene	ND	1.0	mg/kg
Benzo(a)anthracene	ND	1.0	mg/kg
Benzo(a)pyrene	ND	1.0	mg/kg
Benzo(b)fluoranthene	ND	1.0	mg/kg
Benzo(g,h,i)perylene	ND	1.0	mg/kg
Benzo(k)fluoranthene	ND	1.0	mg/kg
Chrysene	ND	1.0	mg/kg
Dibenz(a,h)anthracene	ND	1.0	mg/kg
Fluoranthene	ND	1.0	mg/kg
Fluorene	ND	1.0	mg/kg
Indeno(1,2,3-cd)pyrene	ND	1.0	mg/kg
Naphthalene	ND	1.0	mg/kg
Phenanthrene	ND	1.0	mg/kg
Pyrene	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	62	19 - 122
2-Fluorobiphenyl	51	30 - 115
2-Fluorophenol	44	25 - 121
Nitrobenzene-d5	45	23 - 120
Phenol-d6	64	24 - 113
Terphenyl-d14	49	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst______________

Reviewed______________

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96E-0-1
Project ID: Bloomfield, NM
Lab ID: B965846 0396G01328
Matrix: Soil

Date Reported: 07/31/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/25/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	7.0	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg

Continued

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client:	GIANT REFINING COMPANY	
Sample ID:	96E-0-1	
Project ID:	Bloomfield, NM	
Lab ID:	B965846	0396G01328
Matrix:	Soil	

Date Reported:	07/31/96
Date Sampled:	07/11/96
Date Received:	07/16/96
Date Extracted:	07/23/96
Date Analyzed:	07/25/96

Continued

Parameter	Result	PQL	Units
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	89	70 - 121
romofluorobenzene	119	74 - 121
Toluene-d8	110	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

eference: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992.

Analyst E.D. 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
POLYNUCLEAR AROMATIC HYDROCARBONS

Client: GIANT REFINING COMPANY
Sample ID: 96E-0-1
Project ID: Bloomfield, NM
Lab ID: B965846 0396G01328
Matrix: Soil

Date Reported: 07/29/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/26/96

Parameter	Result	PQL	Units
3-Methylcholanthrene	ND	1.0	mg/kg
Acenaphthene	ND	1.0	mg/kg
Acenaphthylene	ND	1.0	mg/kg
Anthracene	ND	1.0	mg/kg
Benzo(a)anthracene	ND	1.0	mg/kg
Benzo(a)pyrene	ND	1.0	mg/kg
Benzo(b)fluoranthene	ND	1.0	mg/kg
Benzo(g,h,i)perylene	ND	1.0	mg/kg
Benzo(k)fluoranthene	ND	1.0	mg/kg
Chrysene	ND	1.0	mg/kg
ibenz(a,h)anthracene	ND	1.0	mg/kg
Fluoranthene	ND	1.0	mg/kg
Fluorene	ND	1.0	mg/kg
Indeno(1,2,3-cd)pyrene	ND	1.0	mg/kg
Naphthalene	ND	1.0	mg/kg
Phenanthrene	ND	1.0	mg/kg
Pyrene	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	65	19 - 122
2-Fluorobiphenyl	62	30 - 115
2-Fluorophenol	57	25 - 121
Nitrobenzene-d5	58	23 - 120
Phenol-d6	75	24 - 113
Terphenyl-d14	46	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst RRD

Reviewed

Inter·Mountain Laboratories, Inc.

1160 Research Drive
Bozeman Montana 59715

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96E-3-5
Project ID: Bloomfield, NM
Lab ID: B965847 0396G01328
Matrix: Soil

Date Reported: 07/31/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/25/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg

Continued

EPA METHOD 8240
VOLATILE ORGANIC COMPOUNDS

Client: GIANT REFINING COMPANY
Sample ID: 96E-3-5
Project ID: Bloomfield, NM
Lab ID: B965847 0396G01328
Matrix: Soil

Date Reported: 07/31/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/25/96

Parameter	Result	PQL	Units
Continued			
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	95	70 - 121
Bromofluorobenzene	110	74 - 121
Toluene-d8	109	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8260, Gas Chromatography/Mass Spectrometry for Volatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, Rev. 1, November 1992.

Analyst E.D. 7/31/96

Reviewed

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

EPA METHOD 8270
POLYNUCLEAR AROMATIC HYDROCARBONS

Client: GIANT REFINING COMPANY
Sample ID: 96E-3-5
Project ID: Bloomfield, NM
Lab ID: B965847 0396G01328
Matrix: Soil

Date Reported: 07/29/96
Date Sampled: 07/11/96
Date Received: 07/16/96
Date Extracted: 07/23/96
Date Analyzed: 07/26/96

Parameter	Result	PQL	Units
3-Methylcholanthrene	ND	1.0	mg/kg
Acenaphthene	ND	1.0	mg/kg
Acenaphthylene	ND	1.0	mg/kg
Anthracene	ND	1.0	mg/kg
Benzo(a)anthracene	ND	1.0	mg/kg
Benzo(a)pyrene	ND	1.0	mg/kg
Benzo(b)fluoranthene	ND	1.0	mg/kg
Benzo(g,h,i)perylene	ND	1.0	mg/kg
Benzo(k)fluoranthene	ND	1.0	mg/kg
Chrysene	ND	1.0	mg/kg
Dibenz(a,h)anthracene	ND	1.0	mg/kg
Fluoranthene	ND	1.0	mg/kg
Fluorene	ND	1.0	mg/kg
Indeno(1,2,3-cd)pyrene	ND	1.0	mg/kg
Naphthalene	ND	1.0	mg/kg
Phenanthrene	ND	1.0	mg/kg
Pyrene	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
2,4,6-Tribromophenol	64	19 - 122
2-Fluorobiphenyl	53	30 - 115
2-Fluorophenol	49	25 - 121
Nitrobenzene-d5	49	23 - 120
Phenol-d6	72	24 - 113
Terphenyl-d14	47	18 - 137

ND - Not Detected at Practical Quantitation Level (PQL)

Reference: Method 8270, Gas Chromatography/Mass Spectrometry for Semivolatile Organics, Test Methods for Evaluating Solid Wastes, SW-846, United States Environmental Protection Agency, November 1990.

Analyst__________

Reviewed__________

Inter-Mountain Laboratories, Inc.

1160 Research Drive
Bozeman, Montana 59715

LAB QA/QC
EPA METHOD 8240
METHOD BLANK

Date Analyzed: 07/26/96
Lab ID: MBS06205
Matrix: Sand
Date Extracted: 07/23/96

Parameter	Result	PQL	Units
1,1,1-Trichloroethane	ND	1.0	mg/kg
1,1,2,2-Tetrachloroethane	ND	1.0	mg/kg
1,1,2-Trichloroethane	ND	1.0	mg/kg
1,1-Dichloroethane	ND	1.0	mg/kg
1,1-Dichloroethene	ND	1.0	mg/kg
1,2-Dichloroethane	ND	1.0	mg/kg
1,2-Dichloropropane	ND	1.0	mg/kg
2-Butanone (MEK)	ND	5.0	mg/kg
2-Hexanone	ND	1.0	mg/kg
4-Methyl-2-pentanone (MIBK)	ND	1.0	mg/kg
Acetone	ND	5.0	mg/kg
Benzene	ND	1.0	mg/kg
Bromodichloromethane	ND	1.0	mg/kg
Bromoform	ND	1.0	mg/kg
Bromomethane	ND	1.0	mg/kg
Carbon Disulfide	ND	1.0	mg/kg
Carbon Tetrachloride	ND	1.0	mg/kg
Chlorobenzene	ND	1.0	mg/kg
Chloroethane	ND	1.0	mg/kg
Chloroform	ND	1.0	mg/kg
Chloromethane	ND	1.0	mg/kg
cis-1,3-Dichloropropene	ND	1.0	mg/kg
Dibromochloromethane	ND	1.0	mg/kg
Ethylbenzene	ND	1.0	mg/kg
m,p-Xylene	ND	1.0	mg/kg
Methylene chloride	ND	5.0	mg/kg
o-Xylene	ND	1.0	mg/kg
Styrene	ND	1.0	mg/kg
Tetrachloroethene (PCE)	ND	1.0	mg/kg
Toluene	ND	1.0	mg/kg
trans-1,2-Dichloroethene	ND	1.0	mg/kg
trans-1,3-Dichloropropene	ND	1.0	mg/kg
Trichloroethene (TCE)	ND	1.0	mg/kg

Continued

LAB QA/QC
EPA METHOD 8240
METHOD BLANK

Date Analyzed: 07/26/96
Lab ID: MBS06205
Matrix: Sand
Date Extracted: 07/23/96

Continued

Parameter	Result	PQL	Units
Vinyl Chloride	ND	1.0	mg/kg
Xylenes (total)	ND	1.0	mg/kg

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
1,2-Dichloroethane-d4	100	70 - 121
Bromofluorobenzene	106	74 - 121
Toluene-d8	105	81 - 117

ND - Not Detected at Practical Quantitation Level (PQL)

Analyst E.D. 7/31/96

Reviewed

LAB QA/QC
A METHOD 8240
LAB CONTROL SAMPLE

Date Analyzed:	07/26/96
Lab ID:	LCS96205
Matrix:	Sand
Date Extracted	07/23/96

Parameter	Spike Added (mg/kg)	Sample Result (mg/kg)	LCS Result (mg/kg)	LCS % Recovery	QC Limits Rec.
1,4-Dichlorobenzene	2.0	0	1.5	75	70 -130
1,1,2-Trichloroethane	2.0	0	2.0	100	70 -130
1,2-Dibromoethane (EDB)	2.0	0	1.8	90	70 -130
1,2-Dichloroethane	2.0	0	1.8	90	70 -130
1,2-Dichloropropane	2.0	0	1.7	85	70 -130
Benzene	2.0	0	1.8	90	70 -130
Bromoform	2.0	0	1.1	55 *	70 -130
Carbon Tetrachloride	2.0	0	1.5	75	70 -130
cis-1,3-Dichloropropene	2.0	0	1.7	85	70 -130
rachloroethene (PCE)	2.0	0	1.6	80	70 -130
ichloroethene (TCE)	2.0	0	2.0	100	70 -130
Vinyl Chloride	2.0	0	1.2	60 *	70 -130

QUALITY CONTROL - Surrogate Recovery	%	QC Limits
Bromofluorobenzene	121	74 -121
1,2-Dichloroethane-d4	94	70 -121
Toluene-d8	109	81 -117

Spike Recovery: 2 out of 12 outside QC limits.
Surrogates: Surrogate Recoveries within QC Limits.

Analyst E.D. 7/31/96

Reviewed

Appendix D

Investigation Derived Waste (IDW) Management Plan

All IDW will be properly characterized and disposed of in accordance with all federal, State, and local rules and regulations for storage, labeling, handling, transport, and disposal of waste. The IDW may be characterized for disposal based on the known or suspected contaminants potentially present in the waste. It is assumed that there are no listed wastes present in any of the planned investigation areas. Only drums containing products were stored in the drum storage areas at North Bone Yard (SWMU No. 2) and the warehouse yard (SWMU No. 18). The potentially impacted soils, which were placed in landfill (SWMU No. 18), were delisted in 1996.

A dedicated decontamination area will be setup prior to any sample collection activities. The decontamination pad will be constructed so as to capture and contain all decontamination fluids (e.g., wash water and rinse water) and foreign materials washed off the sampling equipment. The fluids will be pumped directly into suitable storage containers (e.g., labeled 55-gallon drums), which will be located at satellite accumulation areas until the fluids are disposed in the refinery wastewater treatment system upstream of the API separator. The solids captured in the decontamination pad will be shoveled into 55-gallon drums and stored at the designated satellite accumulation area pending proper characterization for off-site disposal.

Drill cuttings generated during installation of soil borings and monitoring wells will be placed directly into 55-gallon drums and staged in the satellite accumulation area pending results of the waste characterization sampling. The portion of soil cores, which are not retained for analytical testing, will be placed into the same 55-gallon drums used to store the associated drill cuttings.

The solids (e.g., drill cuttings and used soil cores) will be characterized by testing to determine if there are any hazardous characteristics in accordance with 40 Code of Federal Regulations (CFR) Part 261. This includes tests for ignitability, corrosivity, reactivity, and toxicity. If the materials are not characteristically hazardous, then further testing will be performed pursuant to the requirements of the facility to which the materials will be transported. Depending upon the results of analyses for individual investigation soil samples, additional analyses may include TPH and polynuclear aromatic hydrocarbons.

Purge water generated during groundwater sampling activities will be containerized in 55-gallons drums and then disposed in the refinery wastewater treatment system upstream of the API separator. All miscellaneous waste materials (e.g., discarded gloves, packing materials, etc.) will be placed into the refinery's solid waste storage containers for off-site disposal.