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STAGE 1 & 2 WORKPLANS

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PROPOSED REMEDIAL INVESTIGATION WORK PLAN

Prepared for:

REXENE

Office of Environmental Affairs
5005 LBJ Freeway
Occidental Tower, 5th Floor
Dallas, Texas 75244

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1.0 Introduction

This work plan describes the subsurface investigation program to be conducted at the former Brickland Refinery site currently owned by Rexene Corporation (Rexene). The primary objective of this investigation is to better characterize free product and soil contamination at the site and determine appropriate soil remediation requirements. A second objective is to obtain additional groundwater information to determine if groundwater remediation is necessary.

1.1 Site Location and History

The former Brickland Refinery site is located in Sunland Park, New Mexico near the city of El Paso, Texas. The 35-acre site was operated as a petroleum refinery from 1933 to 1958. Virtually all of the processing equipment and buildings associated with refinery operations have been removed from the site. Disposal and leakage of petroleum products and refinery wastes have resulted in soil and groundwater contamination at the site.

Previous investigations by Eder Associates (Eder 1990), conducted prior to Geoscience Consultants, Ltd. (GCL) involvement with this project, have proven to be more qualitative than quantitative. The data, while being generally accurate and adequate for detection and early assessment, lacks sufficient detail in specific data required for a remedial design. For example, earlier investigations predicted that a significant quantity of free-phase floating product would be present at this site; however only localized areas of free product were found during remedial investigations performed by GCL. The GCL investigations discussed in this report were, and will be, conducted to refine the existing conceptual model of contamination in soil and groundwater.

1.2 Summary of Recent Investigations by GCL

1.2.1 Site Hydrogeology

To support the design of a free product recovery system as an interim remedial action, GCL implemented a confirmatory field investigation with the intent of mapping the free-phase floating product plume predicted by Eder. This investigation, performed by GCL in October and December of 1993, consisted of well point installation and hand-auger borings that were designed to identify areas of free-phase floating product and provide detailed descriptions of subsurface lithologies. GCL's investigation provided additional information regarding the interpretation of site hydrogeology and the occurrence of hydrocarbons in the subsurface.

The site is underlain by fine-grained fluvial sediments deposited by the recent and ancestral Rio Grande, which are capped by river dredge spoils, asphalt and concrete. The predominant subsurface lithologies are very fine sands with varying amounts of clay and silt. Interlayered clay and clay-rich silty and/or sandy units occur locally beneath the site.

Shallow groundwater at the site is encountered at depths ranging from 3 to 10 feet beneath the surface. Much of the shallow groundwater is found in thin layers of fine sands and silty sands that occur within finer, clay-rich sands, silty sands and sandy clays. The clay-rich sediments have a relatively low permeability whereas the fine sandy units yield water freely. A more continuous and homogeneous sandy unit occurs beneath much of the site at varying depths below 5 feet. This sandy unit is typically more transmissive than the shallower units.

1.2.2 Free Product Distribution

GCL investigation results determined that free-phase floating product is not as widespread as suggested by the results of the Eder Investigation (Eder 1990). Floating product appeared to occur primarily in the southern portion of the site where the former wastewater ponds were located. Additionally, free product may be trapped in thin lenses of saturated sands throughout the site. Much of the hydrocarbons that are still present are probably sorbed to the fine grained material that occurs beneath the site. It is possible that much of the product released at the site has historically been diluted and degraded, which may account for the low concentrations of dissolved-phase groundwater contamination found in monitoring wells at the site and the lack of observed contaminant migration into the adjacent Rio Grande.

1.2.3 Groundwater Flow

The potentiometric surface was determined using two separate data sets. The first set of groundwater elevations was contoured using only the data from well points completed in the upper three to five feet of the shallow aquifer. This data set was selected because it gives the best interpretation for the surface of groundwater which is most likely to control the movement of free-phase floating product. The second data set of groundwater elevations included information from monitor wells completed in the upper ten feet of the shallow aquifer. This data set was selected because the well screens penetrated into the deeper, and more continuous and homogeneous river sediments beneath the site. The potentiometric surface associated with the deeper sand unit is expected to more strongly influence the migration of dissolved-phase contaminants. Differences between the two data sets reflect the heterogeneous nature of the sediments underlying the site, the projected configuration of the underlying bedrock to the west and south of the site, and the presence of locally semi-confined hydraulic conditions within the saturated zone underlying the site.

Results of the hydrogeologic investigation indicate that the hydraulic gradient is very shallow and that the groundwater flow direction ranges from south-southeast to west (plates A and B). Flow direction in the upper unconfined portion of the aquifer (based on water level elevations from the first data set) differ from the flow directions based on water level elevations obtained from wells completed deeper in the shallow aquifer. Two different flow patterns exist. Plate A shows that shallow groundwater beneath the site flows toward the southwest in the northern portion of the site. It flows to the west, and directly away from the Rio Grande, in the southern portion of the site. The Rio Grande is a losing stream based on water table configuration. This configuration of the shallow water table would tend to drive any existing free-phase floating product to the south and southwestern portion of the site. This is in fact the location of the site where the largest volume of floating product was confirmed.

Plate B shows that the direction of groundwater flow for the locally semi-confined deeper portion of the shallow aquifer (which also includes the upper portion) is to the south. It also shows that beneath the eastern site boundary, groundwater flows southeast toward the river. Deeper waters of the shallow aquifer are recharging the river due to geologic constrictions imposed by the sharp narrowing of the basin near the southern portion of the site. The deeper groundwater flow direction explains the presence of dissolved phase hydrocarbons found in MW-6S.

1.2.4 Conclusions from Preliminary GCL Investigations

Based on this preliminary investigation, GCL now believes that no interim remedial action is warranted for the site since no imminent hazard from free product contamination appears to exist. The purpose of this proposed remedial investigation is to provide the specific data required for design of soil remedial actions that may be implemented for the site. It is also recommended that quarterly sampling of selected monitoring wells and water level monitoring of all monitor wells and well points be implemented to provide supporting data for the design of any soil and groundwater remedial actions.

2.0 Purpose and Objective

The purpose for performing a remedial investigation at the former Brickland Refinery site is to generate data that will aid in the selection and design of the appropriate technology for remediation of petroleum contamination at the site. In addition, the investigation is designed to provide data for developing the appropriate site clean-up standards for petroleum-contaminated soils. The impact of the contaminated soils on groundwater will be evaluated and the groundwater sampling in this proposed investigation will be used to gather information to assess the need for additional groundwater investigations and remediation. If the need for groundwater remediation is confirmed, additional work may be required to complete the design and implementation of a groundwater system. Whenever possible, monitor well design and locations will be selected so that they may be converted to recovery wells at a later date in order to save time and costs, should a groundwater clean-up prove to be necessary.

Potential soil treatment technologies applicable to the Brickland site have been identified by GCL. The following applicable technologies for soil treatment were identified:

Solidification/Stabilization
Soil Washing
Bioremediation
Capping
Long Term Monitoring

In order to determine the site-specific applicability of each technology, specific analyses of selected samples of site soils will be required. The specific data objectives of this investigation are to determine the following:

- Locations, depths and thicknesses of the clay layers
- Clay type (ie. kaolinite, montmorillonite, etc...)
- Clay cation exchange capacity (CEC)
- Horizontal and vertical hydraulic conductivity of the clay unit (ft/day)
- Capillary Moisture Relationship
- Type of petroleum contamination in soils (ie. gasoline, diesel, fuel-oil, etc...)
- Depth and location of petroleum contaminated soils
- Soil grain size distribution
- Total organic carbon
- Characterization of indigenous soil bacteria (ie. nutrients, heterotrophs, hydrocarbon degraders, PAH degraders)

- Nutrients
- Soil density
- Soil pH
- Moisture content
- Humic content
- Metals concentrations
- Volatile organic concentrations
- Semi-volatile organic concentrations

To accomplish these objectives, soil borings will be augured, test trenches will be excavated and soil samples will be collected for analysis. The following sections elaborate on the investigative methods that will be used to meet these data objectives.

3.0 Investigation Methods

Five test trenches are planned; however, one additional trench may be included as an option if field conditions warrant. These test trenches will provide access for sample collection and will also provide for a better visual observation of the relationship between subsurface soils, groundwater, lithology and the distribution and extent of contamination. GCL has also proposed that 14 soil borings be drilled in order to characterize the subsurface lithology and collect the samples necessary to meet the data quality objectives of this investigation plan. Groundwater monitor wells will be installed in four borings to refine the existing interpretation of site hydrogeology, and to determine if free-phase floating product is present. In addition, well points will be adjusted and/or installed to assist in this interpretation.

Selected analyses will be conducted to characterize the physical and chemical properties of subsurface soils and to further refine the nature and extent of subsurface contamination. Plate C shows the proposed locations for test trench excavations and soil borings. These sampling locations were selected in areas of the site that are believed to have the most significant contamination and/or will provide the most significant data for site characterization. These areas also represent the most probable locations for any potential active soil and/or groundwater remediation that would be implemented.

3.1 Test Trenches

Test trenches will be excavated using a backhoe fitted with a 3-foot bucket. Trench dimensions will be approximately 4 feet wide, 6 to 8 feet long and approximately 12 feet deep, depending on groundwater level. The trenches will be excavated and sloped to prevent side-wall cave in. Trench excavations will proceed at approximately 2-foot intervals to allow for visual observation of the subsurface and the collection of samples as specified in table 1. Upon completion of the investigation, the trenches will be properly filled and compacted.

3.2 Soil Borings

A drill rig with all-terrain capability (or provisions for all terrain access) equipped with a 6.125 inch OD X 2.75 inch ID continuous-flight hollow-stem auger will be used to drill the boreholes. At locations where monitor wells or well points are proposed, auger flights appropriate for 4-inch ID monitor well casing and 2-inch ID well point casing will be used. Core samples will be collected using a 5 foot continuous core barrel sampler. The auger

Table 1
Former Brickland Refinery-Remedial Investigation
Sampling Analysis Summary for Soil Borings and Test Trenches

Hole/ Trench I.D.	Target Depth (ft)	Sample Interval (ft)	Analytical Strategy *																					
			1	2^a	3^a	4	5	6	7	8	9	10	11	12	13^b	14	15	16	17	18	19	20	21	22
B-1	15	0																						
		2								1														
		4																						
		6		1	1	1	1			1	1	1	1	1	1							1		
		8																				1		
		10																						
		12																						
B-2	15	0																						
		2																						
		4																						
		6												1	1						1	1		
		8						1	1													1		
		10																						
		12																						
B-3	15	0																						
		2																						
		4	1																					
		6	1											1	1									
		8	1			1	1				1	1	1	1										
		10	1																					
		12	1																					
B-4	15	0																						
		2								1						1								
		4														1								
		6								1				1	1	1							1	
		8														1								
		10														1								
		12														1	1	1						
B-5	15	0																						
		2																						
		4																						
		6		2D	1									1	1							1		
		8																	1	1		1		
		10																						
		12																						
B-6	15	0																						
		2																						
		4																						
		6												1	1						1	1		
		8																	1	1				
		10																						
		12																						
B-7	15	0																						
		2	1																					
		4	1																					
		6	1											1	1									
		8	1								1	1	1	1										
		10	1																					
		12	1																					
B-8	15	0																						1
		2																						
		4																						
		6				1	1	1	1					1	1							1		
		8																						
		10																						
		12																						
B-9	15	0																						
		2	1																					
		4	1																					
		6	1											1	1									
		8	2D				1															1		
		10	1																					
		12	1																					
B-10	15	0																						
		2																						
		4																						
		6		1	1					1				1	1									
		8																	1	1		1		
		10																						
		12																						

Table 1
Former Brickland Refinery-Remedial Investigation
Sampling Analysis Summary for Soil Borings and Test Trenches

Hole/ Trench I.D.	Target Depth (ft)	Sample Interval (ft)	Analytical Strategy *																					
			1	2[a]	3[a]	4	5	6	7	8	9	10	11	12	13[b]	14	15	16	17	18	19	20	21	22
B-11	15	0																						1
		2	1													1								
		4	1													1								
		6	1	1	2D									1	1	1							1	
		8	1			1	1			2D	1	1	1	1		1								
		10	1													1								
		12	1													1								
B-12	15	0																						
		2																						
		4																						
		6												1	1									
		8						1	1											1	1			
		10																						
		12																						
B-13	15	0																						
		2																						
		4																						
		6												1	1									
		8								1												1		
		10																						
		12															1	1						
B-14	15	0																						
		2																						
		4																						
		6																						
		8	1	1	1			1	1					1	1							1		
		10																						
		12																						
TR-1	12																							
									1															
				1	2D								1	1										
									2D															
TR-2	12	0																						
		2																						
		4																						
		6		1	1								1	1										
		8																						
		10																						
		12																						
TR-3	12	0																						
		2								1														
		4																						
		6		2D	1					1			1	1										
		8																						
		10																						
		12																						
TR-4	12	0																						
		2								1														
		4																						
		6		1	1					1				1	1									
		8																						
		10																						
		12																						
TR-5	12	0																						1
		2								1														
		4																						
		6		1	1					1				1	1									
		8																						
		10																						
		12																						
Trip Blanks					4																			
Field Blanks				3	3																			
Rinsate Samples				3	3																			
Total Samples			26	18	22	4	5	4	4	17	4	4	4	19	19	12	2	2	3	3	3	13	2	2

Table 1
Former Brickland Refinery-Remedial Investigation
Sampling Analysis Summary for Soil Borings and Test Trenches

Analytical Strategy Codes:

(1) TPH (EPA 418.1)
(2) PAH (EPA 8270A)
(3) BTEX (EPA 8020)
(4) TOC (EPA 415.1)
(5) Soil pH (EPA 9045)
(6) TCLP-Benzene (EPA 1311)
(7) TCLP-Metals (EPA 1311)
(8) RCRA Metals
(9) Background Heterotrophic Bacteria (Sect. 9215)[c]
(10) Volatile Hydrocarbon Utilizers (Sect. 9215)[c]
(11) Non-Volatile Hydrocarbon Utilizers (Sect. 9215)[c]
(12) Macronutrient Analysis (Hach Field Kit)
(13) Lithology (USCS)
(14) Particle Size Distribution (Laser)
(15) Saturated Horizontal Hydraulic Conductivity (ASTM -D-2434)
(16) Saturated Vertical Hydraulic Conductivity (ASTM-D-2434)
(17) CEC (Absorbed Water)
(18) Clay Type (X-Ray Diffraction)
(19) Humic Content (ASTM-D-2974)
(20) Moisture Content (ASTM-D-2216-80)
(21) Capillary Moisture Relationship (ASTM-D-2325)
(22) Dry Bulk Density (API RP-40)

[a] Field screen all intervals with PID and submit samples with highest concentration for laboratory analysis.

[b] Record lithologic description for entire depth of hole or trench.

[c] Method Reference: Standard Method for the Examinations of Water and Wastewater, 17th Edition, 1989.

[D] Include duplicate sample

will be advanced at intervals of 5 feet to facilitate removal of the continuous core sampling tube for lithologic logging and sample collection.

The total depth of the soil borings will be determined in the field, but are not expected to exceed 15 feet (possibly deeper for monitor wells). In some borings the total depth could be as shallow as 5 or 6 feet. If auger refusal conditions are encountered, drilling will be stopped. Auger refusal conditions will be verified by the American Society for Testing and Materials (ASTM) Method D-1586. This method specifies that refusal is met when a standard 2-inch OD split barrel sampler driven by a 140 pound weight dropped 2.5 feet will not penetrate 6 inches in 50 impacts.

The locations of the proposed borings are shown on plate C. Some of these borings will be completed as monitor wells and/or well points and the remainder will be properly plugged and abandoned.

3.3 Well Points/Monitor Wells

During recent investigations, GCL installed well points in zones of suspected soil contamination in order to define the nature and extent of the contamination and the occurrence of free-phase floating product. These well points were installed at varying depths, with well screens placed either across the air-water interface or several feet beneath the water table. The screened interval of several well points installed below the groundwater table will be elevated to allow measurement of the air-water interface and to aid in location of free-phase product. Each well screen will be elevated by raising the well point casing up through the ground until the desired elevation is reached. Also, a few well points will be driven deeper to provide more information on groundwater movement in deeper portions of the shallow aquifer. The well points to be adjusted are listed below and are shown on plate C.

Adjust Upward		Adjust Deeper
WP-1	WP-9	WP-2
WP-3	WP-10	WP-18
WP-4	WP-16	WP-22
WP-5	WP-17	
WP-6	WP-21	
WP-8	WP-24	

New well points are planned to be installed adjacent to borings B-12 and B-13.

Conversion of four soil borings to monitoring wells is planned to enhance the monitoring capability of the existing network. One monitor well will be placed toward the center section of the site and another will be placed near MW-6S to investigate for free-phase and dissolved phase contaminants. In addition, two monitoring wells will be installed in soil borings B-12 and B-13 at the southwestern end of the site to investigate the theory that free-phase product has collected in this area. Monitoring well installations will be designed so that they may be easily converted to recovery wells if groundwater remediation is determined to be necessary. Soil borings planned for conversion to monitoring wells are identified on plate C.

4.0. Sampling and Analysis

4.1 Sample Collection

Sample collection and analysis will be conducted in accordance with table 1, which outlines the sampling location and type of analyses to be performed. Sampling and analysis will be conducted using accepted protocols that will be documented in a site sampling and analysis plan. Sample collection and analysis strategies may vary from those presented in table 1, depending on field conditions. A brief description of the various analytical parameters and the rationale for their selection is found in the following pages.

4.1.1 Borehole Sampling

A continuous core, clear Lexan sampling tube (minimum 2-inch ID) will be used to collect samples while drilling. Upon reaching the desired sampling depth (approximately every 4 or 5 feet) drilling will stop and the sampling tube will be retrieved. The core will be photographed and described as to lithologic character. Decisions for sample collection will be made based on visual and/or photoionization detector (PID) screening. Again, the type of samples to be collected will vary by borehole location and will be in accordance with table 1.

4.1.2 Test Trench Sampling

When the total depth of the test trench is reached, the exposed subsurface will be logged for lithology, as well as visually scanned to determine the most appropriate depth and stratigraphic layer from which samples should be obtained. Samples will be collected with 6-inch long, open tube stainless steel samplers and then properly containerized. Personnel entry into the trench for sampling will be avoided by using extension tools for sample collection.

4.1.3 Monitor Well Sampling

Prior to sample collection at least 2 to 3 well casing volumes of groundwater should be purged from monitor wells before sampling.

All wells will be purged with a submersible pump. Samples will be collected upon full recovery of the well. If full recovery exceeds 3 hours, samples will be collected as soon as sufficient water volume is available. It is anticipated that purge volumes will vary from approximately 14 to 54 gallons and that a maximum pumping rate of 2.0 gpm can be attained. To prevent aeration and possible volatilization of contaminants pumping will be controlled so that groundwater does not cascade back into the well. Low pumping rates are preferred since it may prevent disturbance to the zone of stagnation immediately above the well screen and serve to provide a sample of groundwater representative of the aquifer.

To ensure that a sample of fresh formation water from the surrounding aquifer is collected the following pumping procedure will be used:

- Set the intake of the pump such that it is below the static water level and near the center of the screened interval.
- Start the pump and monitor drawdown in the well with a water level probe that has been previously deployed down the well.
- Maintain the pump intake at a level approximately 5 feet below the declining water table. When drawdown stabilizes, the pump intake can be maintained at that level until the desired purge volume has been removed. If however, drawdown continues and the water level approaches within 1 foot of the pump intake, the pumping rate should be reduced until drawdown stabilizes. The water level in this circumstance will be maintained at or near the top of the well screen.
- As groundwater is being purged from the well the total volume being purged will be tracked by filling 2-gallon buckets until the total volume to be purged is obtained.

Some general, sampling procedures that should be followed include:

- Avoid placing clean sampling equipment directly on the ground to prevent cross-contamination. Pump hose lines must not contact soil during sampling.
- Slowly lower sampling equipment into the well to prevent degassing of the water, prevent mixing of the stagnant water column above the well screen and damage to the equipment.
- When floating product is encountered in the well it should be removed as completely as possible to prevent contamination of the sampling pump. Free product should be bailed slowly to prevent excessive mixing of the product with the underlying water column.

- Sample wells from the least to most suspected or apparent contamination; this will reduce cross-contamination analytical artifacts.

4.2 Sample Analysis for Soils

The following analyses will be performed. The data derived from these analyses will provide the necessary information for selecting and designing a potential remedial action for the site. A summary of the analyses required to support a particular remedial technology is provided in table 2.

4.2.1 Lithology/Particle Size Distribution

The lithology will be thoroughly documented to provide a stratigraphic description of the subsurface. The Unified Soil Classification System (USCS) will be used. This information, in conjunction with other geotechnical analyses, will provide an accurate description of the physical subsurface conditions for the design and installation of ex-situ and in-situ remedial technologies, as applicable.

Samples for particle size distribution analyses will be collected from two boreholes as indicated in table 1. Samples from each borehole will be collected at two-foot intervals over the total depth of the hole. The samples will be collected with a Lexan tube continuous core barrel sampler while drilling the soil borings with a hollow-stem auger. The Lexan tube will be cut and capped prior to shipment to the laboratory. A laser particle size method will be used for particle size distribution analysis.

4.2.2 Capillary Moisture Relationship

These samples will be collected using the continuous core barrel sampler. The samples will be collected in accordance with the sampling outline presented in table 1. The analyses will generate data for developing a soil moisture characteristic curve that will provide information on the behavior of fluids in the subsurface.

4.2.3 Horizontal and Vertical Saturated Hydraulic Conductivity

This analysis will be performed on samples identified in table 1 via the constant head method according to ASTM D-2434. It will provide data on the potential flow of water

Table 2
Soil Analyses Required for Screening Soil Treatment Technologies

Analyses Soil Treatment Technology	Analytical/Method Code *																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Solidification/ Stabilization	X	X	X	X	X	X	X	X						X			X	X		X		
Soil Washing	X	X	X	X	X									X						X		
Bioremediation	X	X	X	X	X			X	X	X	X	X	X		X	X			X	X	X	
Capping	X	X	X			X	X	X							X		X		X			X
Long Term Monitoring	X	X	X			X	X	X														

***Analytical/Method Code:**

(1) TPH (EPA 418.1)
(2) PAH (GPA 8270A)
(3) BTEX (EPA B020)
(4) TOC (EPA 415.1)
(5) Soil pH (EPA 9045)

(6) TCLP-Benzene (EPA 1311)
(7) TCLP-Metals (EPA 1311)
(8) RCRA Metals
(9) Background Heterotrophic Bacteria
(10) Volatile Hydrocarbon Utilizers

(11) Non-Volatile Hydrocarbon Utilizers
(12) Macronutrient Analysis (Hach Field Kit)
(13) Lithology (USCS)
(14) Particle Size Distribution (Laser)
(15) Horizontal Hydraulic Conductivity (ASTM D-2434)

(16) Vertical Hydraulic Conductivity (ASTM D-2434)
(17) CEC (Absorbed Water)
(18) Clay Type (X-Ray Diffraction)
(19) Humic Content (ASTM D-2974)
(20) Moisture Content (ASTM D-2216-80)
(21) Capillary Moisture Relationship (ASTM D-2325)
(22) Dry Bulk Density (API RP-40)

through the subsurface and is necessary for remedial actions that may require dewatering or the extraction or injection of groundwater.

4.2.4 Soil Moisture Content

Soil moisture content analyses will be conducted according to table 1 to determine the amount of interstitial water present in sediments. Drier soils may strongly adsorb organic constituents, making contaminant removal more difficult. Organic constituents are more easily desorbed when water competes with them for adsorption sites. ASTM method D-2216-80 will be used for this analysis.

4.2.5 Clay Type and Humic Content

Samples identified in table 1 will be analyzed for clay type and humic content. Clay type definition (kaolinite, montmorillonite, etc) will give an indication of sorption characteristics, especially for metals, which could possibly be treated by solidification and stabilization. An x-ray diffraction method will be used for this analysis. Humic content can indicate the type of bacteria that might thrive in site soils and can be useful in developing potential bioremediations. It will also provide data on compaction for a possible capping alternative. ASTM method D-2974 will be used for this analysis.

4.2.6 Cation Exchange Capacity

Samples to be submitted for cation exchange capacity (CEC) analyses are summarized in table 1. CEC is expressed as the number of milliequivalents of cations that can be exchanged in a sample with a dry mass of 100g. The standard test for CEC involves: (1) adjustment of pH to 7.0; (2) saturation of the sample with NH_4^+ by mixing with ammonium acetate; (3) removal of adsorbed NH_4^+ by leaching with a sodium chloride (NaCl) solution, where sodium replaces NH_4^+; and (4) evaluation of the NH_4^+ content of the leaching solution. CEC data are used to evaluate the degree of sorption onto clay minerals that can affect the efficiency and success of both in-situ and ex-situ remedial technologies.

4.2.7 Total Organic Carbon

Total organic carbon (TOC) offers a measure of both natural and anthropogenic organic matter in soils. TOC together with total petroleum hydrocarbon analysis testing offers a gross indication of overall contamination of a sample. Samples for TOC analyses are identified in table 1. And will be conducted according to EPA Method 415.1

4.2.8 Total Petroleum Hydrocarbons

Total petroleum hydrocarbons (TPH) is a measure of the aromatic, aliphatic and paraffinic components of hydrocarbons. The desired carbon range is often specified in advance; or both methods EPA 8015 modified and EPA 418.1 can be used to define the full range of hydrocarbon constituents present. TPH offers an estimate of overall contamination present without specific compound identification. Samples to be submitted for TPH analyses are identified in table 1.

4.2.9 Background Heterotrophic Bacteria

Heterotrophic plate counts are used for estimating the number of viable heterotrophic bacteria in soil and groundwater. This test will be performed according to the methods described in Section 9215 of "Standard Methods for the Examination of Water and Wastewater", using R2A medium (Difco), in conjunction with the spread plate procedure (Section 9215C). For determining oil and grease and petroleum degrading bacteria, a minimal salts medium exposed to dodecane vapors as the sole carbon source for growth will be used. Samples to be submitted for heterotrophic plate counts are identified in table 1.

4.2.10 Volatile and Non-Volatile Hydrocarbon Utilizers

This test determines if the population of microorganisms indigenous to the soil can be increased in number by the addition of nutrient amendments and oxygen to levels necessary for site remediation. Further, the test establishes the feasibility of bioremediation by measuring the quantity of target compounds biologically degraded in a defined time under optimal conditions (with excellent aeration and excess nutrients). A 20% degradation of the target compounds within 6 weeks is considered to be the minimum accepted level of degradation for a successful remedial screening test. Samples will be evaluated for both volatile and non-volatile hydrocarbon degradation activity, as identified in table 1.

4.2.11 Macronutrient Analyses

The levels of soil macronutrients (ammonia NH_3; nitrate NO_3; and phosphate PO_4) present in the composite soil samples identified in table 1 will be determined using a Hach field kit.

For NH_3, PO_4, and NO_3 analyses, soil extracts will be prepared by adding 5 grams of the composite soil samples to 25 ml of water. After the addition of 50 mg of $CaCO_4$ (for NO_3 125 mg of carbon decolorizing agent will also be added), the mixture will be shaken vigorously at room temperature for 20 minutes. Assays will be performed on supernatants following centrifugation and filtration. For each assay, standard curves will be prepared and spiked soil samples tested to determine the efficiency of the soil extraction procedure.

4.2.12 Soil pH

An aliquot of soil will be mixed with tap water, agitated vigorously and then the particulate matter allowed to settle. The pH of the aqueous phase will be measured using a Bechmann combination electrode. Samples to be submitted for pH analysis are identified in table 1. Soil pH is a characteristic used to evaluate the potential for metal migration as well as bioremediation potential.

4.2.13 Dry Bulk Density

Dry bulk density will be determined by weighing 10 grams of the composite soil sample into a beaker and allowing the soil to bake at 110°C for 24 hours. The beaker and soil are weighed again, after allowing sufficient cooling time and the loss in weight (moisture) calculated. Samples to be analyzed for dry bulk density are summarized in table 1. Dry bulk density data are used in estimating soil volume and expansion for alternatives that utilize excavation and backfilling.

4.2.14 PAH, BTEX, RCRA Metals Analyses

Analyses for polynuclear aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene and xylene (BTEX) and RCRA metals will provide concentration data regarding the presence of specific compounds that may require treatment. Analyses for PAH and BTEX samples will be performed by EPA methods 8270A and 8020, respectively. Constituent-specific concentrations will be used as indicators of current site conditions and as a means of identifying general areas of the site that may require different remedial approaches.

4.2.15 Toxicity Characteristic Leaching Procedure

The toxicity characteristic leaching procedure (TCLP) provides a measure of contaminant leachability. This is especially useful for determining whether contaminants are a threat to groundwater, the type of landfill that would be required for the disposal of contaminated soils (if necessary), and for establishing soil clean-up standards. Samples to be submitted for TCLP analyses are summarized in table 1. Each TCLP extract will be analyzed for benzene and RCRA metals.

4.3 Sample Analysis for Groundwater

The following analytical methodologies selected for groundwater samples from the site require specific sample acquisition techniques, which are described below.

4.3.1 Halogenated and Aromatic Volatile Organics Samples (EPA Method 601/602)

Method 601/602 samples consist of three 40 mL glass vials containing concentrated HCl as a preservative to lower the pH of the sample to less than 2. The preservative will be added by sample management personnel prior to delivery of the sample containers to the field. Samples will be collected using a submersible pump, with a recommended pump rate of 200-300 mL/minute. The septum vial should be filled until it is just overflowing. Cap the vial, invert and tap vial on hand. If a bubble exists, discard the sample and repeat the sampling. Do not attempt to add additional sample to a vial containing a bubble. Samples will be placed in an ice-filled cooler immediately following collection.

4.3.2 Base/Neutral/Acid (BNA) Organic Compounds (EPA Method 625)

BNA samples consist of a 1,000 mL amber glass bottle with a teflon lined cap. Groundwater is placed in the container using a submersible pump as described in the Method 601/602 sampling procedure discussed above. Bottles should be completely filled so that head-space is minimized. Caps must be securely closed. No preservative other than cooling to 4 degrees Centigrade (C) immediately after collection is required.

4.3.3 Total Petroleum Hydrocarbons (TPH) Samples (EPA Method 418.1)

TPH samples consist of 1,000 mL glass bottle containing H_2SO_4 as a preservative to lower the pH to less than 2. The preservative will be added by sample management personnel prior to delivery of the sample containers to the field. Bottles will be capped with a teflon lined septum. Groundwater is placed in the container using a submersible pump as described in the Method 601/602 sampling procedure discussed above. Bottles should be completely filled so that headspace is minimized. Caps must be securely closed. Samples will be placed in an ice-filled cooler immediately following collection.

4.3.4 (CAM) Metals Samples

Unfiltered metal samples of groundwater will be obtained from new monitoring wells. Unfiltered samples, if obtained by the method described above, require less handling, produce fewer sampling artifacts (contamination unrelated to the true quality of the groundwater), and include potentially mobile colloidal-associated metal contaminant fractions that would otherwise be eliminated by filtration.

Unfiltered total metals samples consist of one 500 mL polyethylene container containing concentrated HNO_3 as a preservative to lower the pH of the sample to less than 2. The preservative will be added by sample management personnel prior to delivery of the sample containers to the field. Samples will be placed in an ice-filled cooler immediately following collection.

5.0 Schedule

It is anticipated that completion of the Remedial Investigation of the former Brickland refinery will require a period of approximately four weeks. Field work is tentatively scheduled to begin in May 1994. Reporting of investigation findings and results is expected to require at least 12 weeks from the time field work is completed.

6.0 References

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