GW - 40

REPORTS

YEAR(S):

1986

REPORT ON
ENVIRONMENTAL INVESTIGATIONS AT GIANT INDUSTRIES, INC. BLOOMFIELD REFINERY BLOOMFIELD, NEW MEXICO

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1.0 EXECUTIVE SUMMARY

At the request of Montgomery & Andrews, Geoscience Consultants, Ltd. (GCL) has performed an environmental audit, is conducting site investigations and is evaluating various options for remedial action at Giant Industries, Inc. (Giant) Bloomfield Refinery. The environmental audit, based on a records search and interviews with past and present employees, has identified 10 areas where observed or potential hydrocarbon-stained soil may exist. Site investigations in these areas included exploratory excavations and drilling/sampling of 18 boreholes (most of which have been completed as wells). Site investigations at the closed refinery are continuing as required to define potential problem areas.

Giant has always operated the Bloomfield Refinery according to well-accepted, industry-wide standards for environmental protection. Although past operating practices may not have met today's standards which are presently followed at Giant's facilities, the past practices were consistent with existing regulatory mandates and with industry standards. The extensive work performed to date and the additional work proposed herein demonstrate Giant's commitment to environmental protection and regulatory compliance.

To date, Giant has removed over 4500 cubic yards of soil from 4 areas: two tank-drain pits, the spill-recovery tank and the abandoned burn pit. The soil is being stored in bermed areas which are underlain by shale bedrock and where shallow ground water does not exist. These sites will be employed for biodegradation of hydrocarbons in the soil. After all soil sample analyses are evaluated, an appropriate biodegradation method will be selected and the method will be applied to treat such soils.

Following the selection of an appropriate hydrocarbon biodegradation method, Giant will proceed to treat the excavated soils. The biodegradation sites are environmentally sound areas for storage and treatment due to the depth to ground water, the low permeability of the underlying shale and minimal risk of stormwater run-on or runoff in these areas.

Ground water investigations reveal 3 areas of possible ground water degradation. First, an isolated and apparently "perched" zone of ground water exists under the abandoned burn pit. This water is probably derived from septic-tank discharges and/or leaks in underground fire-lines. This ground water appears to contain traces of benzene, toluene, ethylbenzene and xylenes (BTEX) at the sub-ppm level. A possible contaminant source is the abandoned "burn pit". The second area of possible ground water degradation is the southwest corner of the refinery. The potential sources of this degradation are the buried storm water catchment areas. The third area of possible degradation is north of the truck dispatching office, where a recent (1985) line leak released diesel fuel. Monitor wells in the diesel spill area have detected free product in three wells; however, numerous wells within 50 feet show only trace amounts of free hydrocarbons. Based upon presently available borehole data, degradation of ground water in all three areas appears to be localized. Test pumping has documented low hydraulic conductivities throughout the refinery which demonstrate that any potentially degraded ground water is not migrating rapidly from its source.

What about lined unlined [illegible]?

Diesel recovery operations are in progress in the diesel-spill area, and additional wells are planned. Initially a one-pump system was employed to recover hydrocarbons. However, after preliminary analysis of a pump test that was conducted in the diesel spill area, a two-pump system was installed and is presently being field tested. All produced hydrocarbons and water are being stored in above ground storage tanks. Analysis of data collected during the field testing of the recovery system will permit the design and installation of a more effective hydrocarbon recovery system.

Chemical analyses show that no chlorinated hydrocarbons are present in soil or ground water at the Bloomfield refinery. Based upon documented past and present operations, chlorinated solvents in the soil or ground water are not expected. The lateral extent of hydrocarbon-stained soil is small and present data indicate that any potential ground water degradation is confined to the site.

?, GC in [illegible] samples

2.0 ENVIRONMENTAL AUDIT

The following data on waste management practices at the Bloomfield refinery has been compiled from employee interviews and record searches. Where possible, exact dates of operations and waste quantities disposed of in each unit have been provided. The location of each waste management unit is shown on Plate 1.

Giant has always operated their refineries pursuant to industry-wide standards for environmental protection. These standards have been and presently are in compliance with appropriate local, state and Federal regulations. As a better understanding of environmental protection evolved in the 1970's and early 1980's the industry standards changed to reflect this new awareness. Past operating practices at the Bloomfield Refinery may not have met today's standards which are presently followed at Giant's facilities; however, the past practices were fully consistent with industry-accepted practices and were compliant with appropriate regulations.

2.1 SOLID, SLUDGE AND LIQUID WASTE UNITS

2.1.1 Slop Pit

Prior to construction of the oil/water separator and evaporation pond system, all oily wastewaters were discharged to an unlined "slop pit". Located approximately 25 feet south of the area where the oil/water separator was eventually constructed, the slop pit was in operation from approximately 1973 to 1978. The pit was approximately 30 x 30 feet with an estimated depth of 10-15 feet. Quantities of wastes that were "managed"! in this unit are unknown, however, the refinery was operating at a production capacity of approximately 2000 bbls/day during that period and the existing volume of the unit was sufficient to contain all wastes. When this unit was removed from service, the liquid phase was recycled through the crude unit. Any remaining sludges were left in place and covered.

mon wells in this area?

how much water?

2.1.2 Oil/Water Separator

A concrete oil/water separator was constructed in 1977-1978 to replace the existing slop pit. The unit was 12.5 x 25 x 8 feet deep with a maximum capacity of 18,700 gallons. Accumulated sludges (mostly oil-soaked blow sand) were probably removed twice by vacuum truck during the unit's operating life. The ultimate disposal of this material by the vacuum truck operator/vender is unknown at the present time. Maybe [illegible] Lee Acres?

2.1.3 Evaporation Pond

A synthetically-lined evaporation pond was constructed in 1978 and was designed for total containment of the oil/water separator effluent. The pond was originally 50 x 50 x 15 feet deep with a total capacity of 280,500 gallons. As refinery operations continued to expand during 1979-1980, the capacity of the pond became insufficient. The evaporation pond was expanded in 1980 over an old storm-water catch basin just to the south. At this same time, the majority of the pond liner was removed because portions of it had become detached from the bottom of the pond. The evaporation pond was used to retain oil/water separator effluent until refinery operations ceased in June, 1982.

Maybe [illegible] to where is [illegible] capacity?

What about cooling towers & boiler drainage

2.1.4 Burn Pit

A "burn pit" was used to conduct fire fighting exercises in conjunction with neighboring fire departments until June, 1979 when construction of the reformer unit began. The pit was approximately 20 x 15 x 10 feet deep and exercises were scheduled on a weekly basis as weather permitted. Common practice was to partially fill the pit with water and float 1-2 barrels of crude oil on the surface. One or two gallons of gasoline were then added to help ignite the crude oil. As the oily material burned, firefighters controlled or extinguished the fire. When the unit was removed from service, all materials remaining in the pit (residues of burned hydrocarbons) were left in place and covered with fill.

2.1.5 Paraffin Pits (Tank Drain Pits)

Two unlined pits were used to dispose of water/paraffin wastes that were drained from crude Tanks 1 and 2. This practice probably dates from

1975. The pit next to Tank 1 was approximately 15 x 15 x 7 feet deep. The pit next to Tank 2 which was covered over in 1984 was approximately 10 x 10 x 7 feet deep.

2.1.6 Tank Bottom Drain Pits

During the refinery operating life, unknown quantities of unrecoverable tank bottoms were removed from six small storage tanks and buried within the containment berms. Accepted industry procedure at the time was to recycle all recoverable bottoms and physically remove small quantities of unrecoverable bottoms into the containment area and then cover them with soil.

2.1.7 Loading Dock Catch Tank

Between 1973 and 1975, an underground catch tank was installed to contain occasional product spills from the loading dock. The materials which accumulated in the tank were transferred to an above ground storage tank and were eventually fed back into the process stream.

2.1.8 Production Area Drains

From about 1973 to 1979, some hydrocarbon losses which occurred in the production areas may have washed into several low lying areas by storm water run-off. These losses may have occurred whenever units were shut down and were never a continuous release. In 1979, a drain system was installed in the production areas to capture any product or feedstock that might have been released. This was then recycled in the refinery process.

2.1.9 Storm Water Containment Areas

Several storm water containment areas (natural, closed depressions) have been identified from aerial photographs of the Bloomfield refinery. One area was located approximately 25 feet south of the evaporation pond and measured 50 feet x 30 feet. The depth of material which may have accumulated in this area is unknown. A 1978 aerial photo shows what appears to be a berm in this area. This area apparently remained "swampy" throughout much of the year. This particular area was filled in

1981
Photos don't show
pond expansion!

when the evaporation pond was expanded in 1980 and is now partially covered by the southwestern corner of the unused evaporation pond (see Section 2.1.3). Two other areas were located at the base of the slope west of the burn pit. These were filled in when the parking lot area was leveled (see Plate 1).

2.1.10 Amoco Produced Water Pit

Amoco was operating (and continues to operate) a natural gas well on the refinery property when Giant first purchased the refinery site. Prior to 1985 all produced waters were discharged to unlined pits. These pits were replaced sometime in 1985 with fiberglass tanks. Quantities of produced waters that have been discharged to these pits is unknown at this time.

2.2 SPILLS AND RELEASES

2.2.1 Spills

At the Bloomfield Refinery spills which resulted from employee error were usually entered in the responsible employee's personnel file. Interviews at the Bloomfield Refinery indicated that most spills would be found in these records. Information regarding spills at the Bloomfield Refinery is shown in Table 2-1.

2.2.2 Releases from Storage Tanks

Interviews with refinery employees indicated that several storage tanks were repaired at one time or another because seeps had developed between the bolted plates. These seeps were generally of minor quantities and the amounts which may have been lost to evaporation are unknown. Based upon interviews, Tanks 11, 12, 13, 15 and 16 were repaired. The only time frame that could be determined for these seeps was the period 1979-1982.

2.2.3 Pipe Rupture and Diesel Spill

A December product inventory showed losses of diesel in the truck loading/ fueling area. A pressure test of the pipe showed a loss of integrity and oil stained soil was noted in a localized area along the

TABLE 2-1
PRODUCT RELEASES FROM BLOOMFIELD REFINERY

	Date	Area	Quantity	Product
1)	5/10/75	Probably Loading Dock	unknown	unknown
2)	1977	Loading Dock	66 bbls	Gasoline
3)	6/24/78	Tank 23	1-2 bbl	Condensate
4)	3/27/80	Tank 28	300 bbl (recovered 178 bbl)	Regular Gasoline
5)	5/27/80	Unknown	49 bbl	Diesel
6)	5/28/80	Tank 28	424 bbl	Reformate
7)	6/14/80	Tank 24	224 bbl	Regular Gasoline
8)	8/7/80	Tank 23	1-2 bbl	Condensate
9)	9/20/80	Tank 28	1-2 bbl	Regular Gasoline
10)	12/31/80	Tank 38	340 bbl	Reformer Charge
11)	3/13/81	Tank 31	51 bbl	Premium Gasoline
12)	12/16/81	Tank 23	1 bbl	Condensate
13)	2/23/82	Tank 1 or 2	Unknown (Most would have been recovered)	Crude
14)	12/85	Loading Dock	3 bbls.	Diesel
15)	12/85-1/86	Loading Dock Area	238-476 bbls. 10,000 - 20,000 gals	Diesel

~ 1286 bbls (exclusive of new diesel spill)

~ 54,000 gals product (diesel, gasoline & reformer charge)

Known Totals: 64 - 74,000 gallons

pipe. This area was excavated and a rupture was discovered. The rupture was fixed and the pipe pressure tested. Again, an integrity loss was indicated. This pipe has leaked an undetermined volume of product and has been replaced.

Estimated date of leak and [illegible] leak until discovery?

3.0 SITE INVESTIGATIONS

Plate 1 shows the locations of trenches, pits and boreholes excavated to date. Plate 2 illustrates the trenches in the burn-pit area, and Figure 3-1 shows the materials observed in the slop pit and storm water areas. Logs of borings and completion details for wells are included in Appendix A.

The available chemical analyses show that chlorinated hydrocarbons are not present in soil or ground water at the Bloomfield Refinery. Heavy metals analyses show very low concentration levels. Metals are not expected to be present in soil or ground water because the degradation is a result of the presence of hydrocarbons. However, selected samples are presently being analyzed for heavy metals.

what about VOA?

3.1 METHOD OF INVESTIGATION

3.1.1 SOIL SAMPLING METHODS

Soil samples were collected in clean mason jars or VOA vials and sealed with chain-of-custody tape pursuant to strict EPA protocols. In sandy areas, a steam-cleaned hand auger was generally employed to obtain shallow and deep soil samples. In rocky areas, a steam-cleaned backhoe was employed to excavate trenches permitting personnel to sample the soil. In most instances where trenches or pits were constructed with a backhoe, composite samples were taken from various locations within the pit or trench in addition to discrete samples from these same locations. Most composite samples were sent out for analysis and discrete samples were retained under refrigeration to ensure that specific problem areas could be identified if composite samples showed high levels of contamination.

Lead in hyd, [illegible]?

After the initial sampling was completed to characterize the constituents in the soils, the trenches were backfilled.

After excavation of hydrocarbon-stained soils from four areas, GCL personnel obtained samples from the underlying soil material to insure that a "clean-closure" was accomplished. All these areas will be

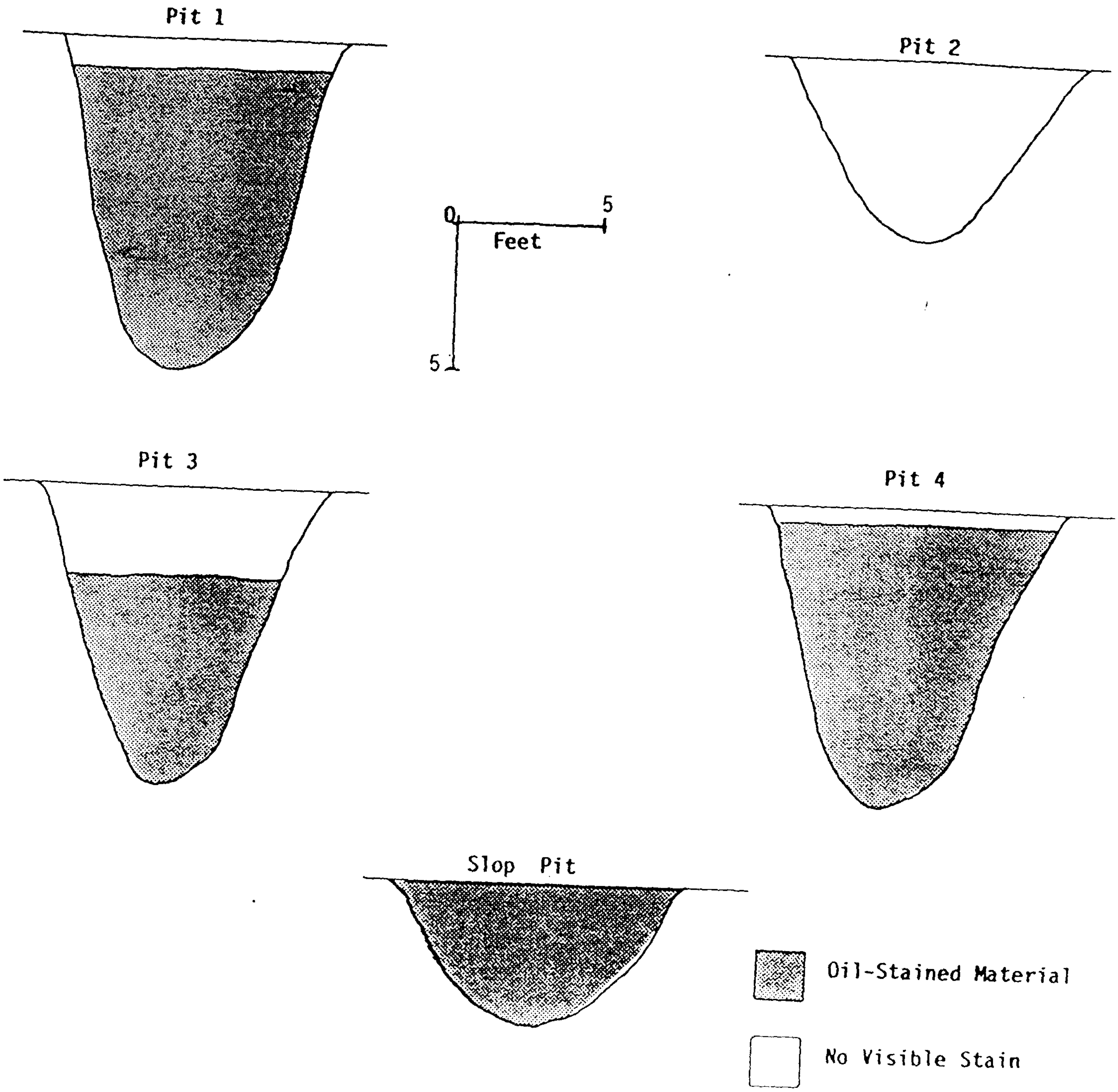

FIGURE 3-1

Sketch Cross-Sections of Exploratory Pits
In Storm-Water Containment Area (1-4) and Slop-Pit Area

backfilled after receipt of analytical results. Some areas have been backfilled due to logistical (traffic) considerations.

3.1.2 Ground Water Sampling Methodology

A hollow-stem auger was employed to install all 2-inch monitoring wells. For wells GBR-11, 18, 16 and 13 all down hole tools and monitor well equipment as well as the rig were steam cleaned to prevent cross contamination. In other areas where hydrocarbon-stained soil was apparent, the equipment was not steam-cleaned.

The 5-inch product recovery well was installed using air rotary methods. A foam drilling fluid was required to insure the stability of the borehole for the 5-inch well.

All wells were developed using air lifting, surging and bailing techniques until the water produced was relatively free and clear of silt and sand.

Prior to obtaining ground water samples, three casing volumes were purged from each well. Samples were collected in a steam-cleaned stainless steel bailer and placed into appropriate containers for analysis. Strict chain-of-custody procedures were employed, and samples were shipped on ice to the appropriate laboratories.

3.2 SOIL INVESTIGATIONS

3.2.1 Burn-Pit Area

Previous investigations by GCL indicated that leachate from a septic tank to the east of the burn pit may have flowed through the burn pit and exited as a "seep" on the west side of the topographic bench on which the burn pit was constructed (Plate 1). Additionally, some water may have originated from possible leaks in an underground fireline that runs north-south along the eastern edge of the burn pit. Use of the fireline and the laundry facilities which discharge to the septic tank has been discontinued.

Where is Septic tank [illegible]

As seen in Plate 2 (cross section B-B'), a zone of ground water (presumably perched) exists in a sandstone stratum, approximately 5 feet below the base of the burn-pit fill. The ground water encountered under the burn pit had a hydrocarbon odor and a thin (<1/8 inch) film of product. Two ground water samples were collected from this area (Table 3-1). This perched water has an upper-surface elevation of approximately 5405 feet, as opposed to a water-level elevation of 5363 feet in well GBR-5, located 175 feet to the southwest. This steep ground water gradient (1 foot in 4) could not be stable without substantial, continuous recharge, and no such recharge source is present. This difference of 42 feet in elevation over a lateral distance of 175 feet denotes that the ground water under the burn pit is "perched" on an impermeable layer. The location of the "burn pit seep", relatively high on the sloped area west of the burn pit, is consistent with this perched groundwater zone hypothesis. GCL installed a 2.0" well in this ground water zone, located at the western edge of the burn pit (see Section 3.3.1).

Seven soil samples were taken from the burn pit area. The stained area observed in the aerial photograph (Plate 1) represents a thin (1-4 inch) layer of oil-stained soil. Thicker accumulations of stained soil (1-4 feet) were found in the central 250-300 square feet of the burn pit (Plate 2). Preliminary analyses of this soil material (Table 3-2 and Appendix B) show that oil and grease and low levels of PAH's are the primary constituents of concern. Approximately 2000 cubic yards of hydrocarbon-stained soil have been removed from the area that begins at the seep and extends east to the burn pit.

Visual and organoleptic observations of the material presently exposed by the excavation indicate that all of the hydrocarbon-stained soil has been removed to the bermed sites. If analysis of samples taken from the underlying material corroborate the lack of visual hydrocarbon-staining, the pit will be backfilled with clean fill.

TABLE 3-1
SAMPLE LOCATIONS, NUMBERS AND TYPES

Location	Number	Type	Container	LAB	Disposition
Burn Pit	8604011440	S	500 ml glass	AAL	3
Burn Pit	8604011441	S	500 ml glass	AAL	3
Burn Pit	8604011442	S	500 ml glass	AAL	3
Burn Pit	8604011443	S	500 ml glass	AAL	3
Burn Pit	8604011444	S	500 ml glass	AAL	3
Burn Pit	8604011445	S,C	500 ml glass	AAL	2
Burn Pit	8604011434	GW	2, 40 ml VOA	AAL	1
Burn Pit	8604031410	S	55 gal drum	GCL	3
Background	8604031430	S	55 gal drum	GCL	3
"Slop Pit"	8604031000	S	500 ml glass	AAL	3
"Slop Pit"	8604031001	S	500 ml glass	AAL	3
"Slop Pit"	8604031002	S	500 ml glass	AAL	3
"Slop Pit"	8604031003	S	500 ml glass	AAL	3
"Slop Pit"	8604031054	S	500 ml glass	AAL	3
"Slop Pit"	8604021100	S	500 ml glass	AAL	3
"Slop Pit"	8604021110	S	500 ml glass	AAL	3
"Slop Pit"	8604021106	S	500 ml glass	AAL	3
"Slop Pit"	8604031115	S,C	500 ml glass	AAL, RMA	2
Pit #1	8604021554	S	500 ml glass	AAL	3
Pit #1	8604021556	S	500 ml glass	AAL	3
Pit #1	8604021557	S	500 ml glass	AAL	3
Pit #1	8604021600	S	500 ml glass	AAL	3
Pit #1	8604021602	S	500 ml glass	AAL	3
Pit #1	8604021605	S,C	500 ml glass	AAL	2
Pit #2	8604021545	S	500 ml glass	AAL	3
Pit #2	8604021546	S	500 ml glass	AAL	3
Pit #2	8604021550	S,C	500 ml glass	AAL	2
Pit #3	8604021612	S	500 ml glass	AAL	3
Pit #3	8604021614	S	500 ml glass	AAL	3
Pit #3	8604021616	S	500 ml glass	AAL	3
Pit #3	8604021618	S,C	500 ml glass	AAL	2
Pit #4	8604021624	S	500 ml glass	AAL	3
Pit #4	8604021626	S	500 ml glass	AAL	3
Pit #4	8604021628	S	500 ml glass	AAL	3
Pit #4	8604021630	S	500 ml glass	AAL	3
Pit #4	8604021635	S,C	500 ml glass	AAL, RMA	2

TABLE 3-1 Continued

	Location	Number	Type	Container	LAB	Disposition
	GBR-11	8604030845	GW	2, 40 ml VOA	AAL	1
	GBR-11	8604011413	S	1, 40 ml VOA	AAL	4
	GBR-11	8604011412	S	1, 40 ml VOA	AAL	1
	GBR-13	8604021500	S	500 ml glass	AAL	3
	GBR-13	8604021510	S	500 ml glass	AAL	3
	GBR-13	8604021515	S	500 ml glass	AAL	3
	GBR-13	8604021516	S,C	500 ml glass	AAL	2
	GBR-13	8605091550	GW	2, 40 ml VOA	AAL	1
	GBR-18	8605090955	GW	2, 40 ml VOA	AAL	1
	GBR-20	8605091040	GW	2, 40 ml VOA	AAL	1
	GBR-21	8605091700	GW	1, 40 ml VOA	AAL	1
	GBR-22	8605091350	GW	2, 40 ml VOA	AAL	1
	GBR-23	8604181810	GW	1, 40 ml VOA	AAL	1
	GBR-24	8604181810	GW	1, 40 ml VOA	AAL	1
	GBR-24	8605091625	GW	1, 40 ml VOA	AAL	1
	GBR-25	8605091210	GW	2, 40 ml VOA	AAL	1
Where?	Steel Well	8605091140	GW	1, 40 ml VOA	AAL	1
	Burn Pit	8605091410	S	2, 40 ml VOA	RMA	5
	Burn Pit	8605091420	S	2, 40 ml VOA	RMA	5
	Burn Pit	8605091430	S	2, 40 ml VOA	RMA	5
	Burn Pit	8605091450	S	2, 40 ml VOA	RMA	5
	BP Seep	8510241435	S,GW	2, 40 ml VOA	AAL	6
	GBR-5	8601231410	GW	1, 40 ml VOA	AAL	6
where?	Aban. Well	8601231300	GW	3, 40 ml VOA	AAL	6
	NTD Pit	8512181220	S	2, 40 ml VOA	AAL	1
	API Pond	8512191020	S	1, 40 ml VOA	AAL	1
	API Pond	8512191021	S	1, 40 ml VOA	AAL	1
	API Pond	8512191022	S	1, 40 ml VOA	AAL	1
	Pit #2	8512191157	S	1, 40 ml VOA	AAL	1
	Pit #2	8512191158	S	1, 40 ml VOA	AAL	1
	Pit #2	8512191159	S	1, 40 ml VOA	AAL	1
which one	AMOCO PW	8512181500	S	1, 40 ml VOA	AAL	1
	GBR-1	8512200850	S	1, 40 ml VOA	AAL	1
	GBR-1	8512200900	S	1, 40 ml VOA	AAL	1
	GBR-1	8512200916	S	1, 40 ml VOA	AAL	1
	GBR-2	8512201046	S	1, 40 ml VOA	AAL	1
	GBR-5	8512201240	S	1, 40 ml VOA	AAL	1
	GBR-5	8512191410	S	1, 40 ml VOA	AAL	1
which one	AMOCO PW	8512191459	S	1, 40 ml VOA	AAL	1
where	TD #2	8512191200	S	1, 40 ml VOA	AAL	1
	TD #2	8512191201	S	1, 40 ml VOA	AAL	1
	TD #2	8512191202	S	1, 40 ml VOA	AAL	1
	API Pond	8512191430	S	1, 40 ml VOA	AAL	1
	API Pond	8512191440	S	1, 40 ml VOA	AAL	1
	API Pond	8512191450	S	1, 40 ml VOA	AAL	1

TABLE 3-1 (Continued)

Abbreviations: GBR, monitor well; NTD, north tank drain pit; TD, tank drain pit; PW, produced water pit; BP, burn pit

Type: S, soil; C, composite sample; GW, ground water

Lab: AAL, Assaigai Analytical laboratories; RMA, Rocky Mountain Analytical

Disposition: 1, Scan for volatiles; 2, Analyze for volatiles, PAH's and Phenols; 3, hold; 4, broken in transit; 5, Analyze by EPA Method 602; 6, WQCC parameters, scan and EP Toxicity

TABLE 3-2
RESULTS OF AVAILABLE CHEMICAL ANALYSES
(units in ug/g except where noted)

SOILS

	8604021635 (Pit 4)	8604031115 (Slop Pit)	8512181220 (NTD Pit)	8512191020 (API Pond)
Benzene	100 (2)*	ND (8)*	<0.01 (0.01)	<0.01 (0.01)
Ethyl benzene	9000 (900)*	ND (20)*	<0.01 (0.01)	<0.1 (0.1)
Toluene	270 (4)*	ND (50)*	<0.01 (0.01)	<0.1 (0.1)
Xylenes	-	-	<0.01 (0.01)	<0.1 (0.1)
Xylene, m	84000 (12000)*	670 (20)*	-	-
Xylenes, o & p	37000 (24000)*	880 (40)*	-	-
Oil & grease	-	-	-	-

SOILS (CONTINUED)

	8512191021 (API Pond)	8512191022 (API Pond)	8512191157 (TD #2 Pit)	8512191158 (TD #2 Pit)
Benzene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Ethyl benzene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Toluene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylenes	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylene, m	-	-	-	-
Xylenes, o & p	-	-	-	-
Oil & grease	-	-	-	-

-	Not Analyzed for this Parameter
ND	Not Detected
*	units ug/Kg
	detection limits in parentheses

TABLE 3-2 (Continued)
RESULTS OF AVAILABLE CHEMICAL ANALYSES
(units are ug/g except where noted)

SOILS (CONTINUED)

	8512191159 (TD #2 Pit)	8512191500 (AMOCO PW Pit)	8512200850 (GBR-1)	8512200900 (GBR-1)
Benzene	<0.01 (0.01)	<0.01 (0.01)	9.37 (0.01)	<0.01 (0.01)
Ethyl benzene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Toluene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylenes	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylene, m	-	-	-	-
Xylenes, o & p	-	-	-	-
Oil & grease	-	-	4000 (0.01)	800 (0.01)

SOILS (CONTINUED)

	8512200916 (GBR-1)	8512201046 (GBR-2)	8512201240 (GBR-5)	8512201410 (GBR-5)
Benzene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	3.9 (0.01)
Ethyl benzene	<0.01 (0.01)	<0.01 (0.01)	<0.1 (0.1)	<0.01 (0.01)
Toluene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylenes	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylene, m	-	-	-	-
Xylenes, o & p	-	-	-	-
Oil & grease	3000 (0.1)	1600 (0.1)	2000 (0.1)	3000 (0.1)

-	Not Analyzed for this Parameter
ND	Not Detected
*	units ug/Kg
	detection limits in parentheses

TABLE 3-2 (Continued)
RESULTS OF AVAILABLE CHEMICAL ANALYSES
(units in ug/g except where noted)

SOILS (CONTINUED)

	8512191459 (AMOCO PW Pit)	8512191200 (TD #2)	8512191201 (TD #2)	8512191202 (TD #2)
Benzene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Ethyl benzene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Toluene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylenes	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylene, m	-	-	-	-
Xylenes, o & p	-	-	-	-
Oil & grease	-	-	-	-

SOILS (CONTINUED)

	8512191430 (API Pond)	8512191440 (API Pond)	8512191450 (API Pond)
Benzene	3.04 (0.01)	3.80 (0.01)	4.10 (0.01)
Ethyl benzene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Toluene	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylenes	<0.01 (0.01)	<0.01 (0.01)	<0.01 (0.01)
Xylene, m	-	-	-
Xylenes, o & p	-	-	-
Oil & grease	-	-	-

} Diff't location than API Pond # 1020, 21 & 22?

-	Not Analyzed for this Parameter
ND	Not Detected
*	units ug/Kg
	detection limits in parentheses

TABLE 3-2 (Continued)
(units in ug/Kg except where noted)

SOILS

	8604021635 (Pit 4)	8604031115 (Slop Pit)
Acenaphthene	ND (1000)	ND (1000)
Acenaphthylene	ND (1000)	ND (1000)
Anthracene	ND (100)	ND (100)
Benzo(a)anthracene	ND (200)	ND (200)
Benzo(a)pyrene	ND (200)	ND (200)
Benzo(b) fluoranthene	ND (100)	ND (100)
Benzo(g,h,i)perylene	ND (200)	ND (200)
Benzo(K)fluoranthene	ND (100)	ND (100)
Chrysene	ND (300)	ND (300)
Dibenzo(a,h)anthracene	ND (500)	ND (500)
Fluoranthene	ND (2000)	ND (2000)
Fluorene	150 (100)	ND (100)
Indeno(1,2,3-cd)pyrene	ND (100)	ND (100)
Naphthalene	1500 (500)	300 (500)
Phenanthrene	ND (500)	ND (500)
Pyrene	ND (2000)	ND (2000)
Phenolics	ND (1)*	ND (1)*

What depth? (composite sample, p. 13)

* units mg/Kg
ND Not Detected
\- Not Analyzed for this Parameter
detection limit in parentheses

TABLE 3-2 (Continued)
(units in mg/l)

GROUNDWATER

oct 8

	8504151545 (GBR-13)	860411434 (Burn Pit)	8604010845 (GBR-11)	8510241435 (Burn Pit Seep)	1430, 1452 (0.01)(0.01)
Benzene	0.042 (0.01)	? 511 (0.0001)	0.0097 (0.0001)	5.23 (0.01)	4.1, 2.2
Ethyl benzene	0.011 (0.01)	0.048 (0.0001)	0.0027 (0.0001)	3.16 (0.01)	.020 .08
Toluene	0.025 (0.01)	0.103 (0.0001)	0.0141 (0.0001)	<0.01 (0.01)	ND .110
Xylenes	0.099 (0.01)	1.518 (0.001)	0.0142 (0.001)	3.25 (0.01)	.[illegible] .08
Oil & grease	-	-	-	EDC? -	— .008 Jn<.01

detection limit in parentheses
- Not analyzed for this Parameter

TABLE 3-2 (Continued)
(units in mg/l except where noted)

	8510241435 (Burn Pit Seep) Ground Water	8510241435 (Burn Pit Seep) Sludge (EP TOX)
As	<0.050 (0.050)	<0.050 (0.050)
Ba	<1.0 (1.0)	2.0 (1.0)
Cd	<0.010 (0.010)	<0.010 (0.010)
Cr	<0.050 (0.050)	<0.050 (0.050)
Hg	<0.002 (0.002)	<0.002 (0.002)
Se	<0.010 (0.010)	<0.010 (0.010)
Ag	<0.050 (0.050)	<0.050 (0.050)
Pb	<0.050 (0.050)	<0.050 (0.050)
NO_3 as N	<0.01 (0.01)	
PCB	1.0 (1.0)*	
$C Cl_4$	<0.001 (0.001)	
1,2-dichloroethane	<0.001 (0.001)	
1,1-dichloroethylene	<0.001 (0.001)	
Tetrachloroethylene	<0.001 (0.001)	
TCE	<0.001 (0.001)	
Phenols	0.4 (0.001)	
Cl	98.0 (0.1)	
Fe	32.0 (0.05)	
Cu	<0.01 (0.01)	
Mn	1.19 (0.005)	
SO_4	9.0 (0.1)	
TDS	1258.0 (1.0)	
pH	7.5 (0.01)	
Methylene Chloride	<0.001 (0.001)	

* units ppm

3.2.2 Slop-Pit Area

Uncertainties regarding the locations of underground pipes prevented extensive exploratory trenching or well construction in the slop-pit area. One exploratory backhoe pit was dug in what is believed to be the center of that area. Any underground lines in that area should lie 6 or more feet below the surface; therefore the backhoe pit was excavated to approximately 5.5 feet (Figure 3-1). Oil-stained soil was observed to total depth, with darker staining in the 2 to 4 foot depth interval. A total of 9 samples were collected in this area (Table 3-1).

3.2.3 Storm-Water Area

This area is located south and east of the office, immediately west of the "seep" (Plate 1). Excavation and sampling of 4 backhoe pits (see Figure 3-1 and Plate 1) indicates that hydrocarbon-stained soil exists in an area of approximately 15,000 square feet, to a depth of at least 10 feet. GCL collected 18 samples in this area from 4 backhoe pits. As Table 3-1 shows, these samples were shipped to analytical laboratories and many results are still pending.

In December, 1985, a location in the parking lot below and southwest of the burn-pit was selected to advance a deeper borehole (see Plate 1). This borehole (GBR-5) was intended to sample ground water in a location downgradient from the burn pit and the refinery. As seen in the drill cuttings (Appendix A), an unexpected zone of apparent hydrocarbon-stained soil up to 50 feet thick was encountered. Based upon auger cuttings, this zone extended from just below the surface to the water table at 33 feet and for 15 to 20 feet below the water table. Continuous coring of similar areas indicates that "clean" sediments may exist between surface soil contamination and documented soil discoloration at the ground water/unsaturated zone interface. Analyses of soil samples show that benzene up to 3.9 ppm exists at total depth (55 feet).

3.3 GROUND WATER INVESTIGATIONS

In order to characterize the general ground water regimes at the Bloomfield Refinery, and to investigate the nature and extent of potential ground water contamination, a total of 18 boreholes have been drilled. Of these, 13 were completed as wells. GBR-1 through GBR-4 were boreholes advanced in the burn pit area to define the nature and extent of the pit. These borings did not encounter ground water and were not completed as wells. They were plugged with bentonite and abandoned. GBR-11 and GBR-18 are 2 inch galvanized-steel wells with 10 foot screens. GBR-5, GBR-13, GBR-20, GBR-22, GBR-23, GBR-25 and GBR-26 are 2 inch PVC monitor wells. GBR-27 is a 5.0 inch PVC product-recovery well in the area of the diesel spill (see Section 3.2.4). GBR-24 and GBR-21 are completed as dual wells to permit discrete sampling of ground water below documented free product. GBR-12 was to be completed as a well but auger refusal above the water table precluded the installation of a well. GBR-16 was completed as a 2 inch PVC monitor well in the burn pit area but was removed during the excavation of the pit. Logs of all borings are included in Appendix A, and locations are shown in Plate 1.

mw2, 17 Borings

3.3.1 Downgradient Wells (GBR-11 and GBR-12)

Borehole GBR-11 was drilled as a potential site for a 2.0 inch, stainless-steel monitor well installed in accordance with RCRA standards. Following the discovery of hydrocarbon stain and odor in a layer of sand overlapping the top of the water table, GCL elected to complete this borehole as a 2.0 inch galvanized-steel well (see Appendix A). Preliminary water samples had a hydrocarbon odor, and exhibited a few free-floating droplets of product. No continuous free layer of product was detected. The report from Assaigai Analytical Laboratories indicates that volatile aromatic hydrocarbons (BTEX) are present in trace amounts, and do not exceed NMWQCC standards (See Appendix B). Barely - Benz 0.0097!

Borehole GBR-12 was also drilled as a potential 2.0 inch RCRA well. Auger refusal was encountered in hard shale at 42 feet, before ground water was reached, therefore, a well will not be installed in this area. No significant hydrocarbon staining or odor was observed in cuttings.

3.3.2 Burn-Pit Area (GBR-16)

Following the discovery of free ground water beneath the burn pit (see Section 3.1.1), a 2.0 inch PVC well was installed in a location immediately west (downgradient) of the pit itself (see log of GBR-16, Appendix A). This well was installed in a 25 foot deep borehole, and screened from 10 to 20 feet. This borehole was advanced through backfill in the western end of the east-west trench (see 3.1.1). On April 11, 1986 a sample was bailed from the well and found to contain no visible free hydrocarbons. Chemical analyses of ground water are presented in Appendix B.

It was necessary to remove this well during the week of May 1, 1986 as part of the excavation of the hydrocarbon-stained soil in the burn pit area.

3.3.3 Exploratory Boreholes (GBR-5, GBR-13 and GBR-20)

Borehole GBR-5 was originally drilled on 12/20/85, and secured as an open hole. Some oil stain was noted from the surface to the water table at 33 feet. The hole was re-entered on 4/3/86 and re-drilled to the original total depth of 55 feet. Following an unsuccessful attempt to install 5.0 inch PVC casing, 2.0 inch PVC casing was installed (see Appendix A). Following initial development to remove drilling mud, the well did not recover to its original water level. Remedial work will be conducted on this well and a representative sample of ground water obtained.

Borehole GBR-13 was also drilled as an exploratory hole. Oil-stained sand was encountered at a depth of 35 feet, coincident with the water-table depth of 35.5 feet. Following an unsuccessful attempt to complete this well with 5 inch PVC casing, it was completed as a 2 inch PVC well (Appendix A). Because volatile organic constituents are removed by the air-lift development methods used, GCL field personnel elected to postpone sampling of this well and GBR-5 until the week of April 14, 1986. A hydrocarbon-like odor was noted in cuttings from below the water table, and a sample of these cuttings is being analyzed for volatile hydrocarbon constituents. Analyses of ground water samples are presented in Appendix B.

GBR-20 was completed as a 2 inch PVC well in an area immediately downgradient from the storm water catchment area below the "seep" from the abandoned burn pit. Ground water analyses are pending.

3.3.4 Upgradient Well (GBR-18)

GBR-18 was drilled in bedrock in the area west of the fresh-water pond on the north side of the refinery property. This site is presumed to be upgradient from all Giant facilities. ?

Moisture was noted in cuttings from a depth of 33 feet to total depth (48 feet) but, due to the shaley nature of bedrock at this site, no free water was observed in the borehole. A 2.0 inch galvanized screen and pipe were placed in the hole, and the well was securely covered without backfilling. The well was completed in late April, 1986, and analytical results of ground water samples are pending. An additional upgradient well (GBR 17) will be installed in the arroyo alluvium northwest of the refinery in May or early June, 1986.

3.3.5 Diesel Spill Area (GBR-21 through GBR-27)

In early 1986, inventory records indicated a loss of diesel fuel may have occurred at the refinery. Pipes and tanks were tested, and a leak in an underground pipe was discovered and immediately repaired. The leak was in a pipe leading from an above-ground storage tank to the truck refueling rack. A record review indicates that more than 10,000 gallons of product may have been lost.

Giant began immediate steps to evaluate, contain and recover lost diesel product. A total of 7 boreholes were drilled to ground water. Four PVC monitor wells (2 inch), one 5 inch PVC diesel recovery well and two dual completion wells were installed in this area. Location of these wells are shown in Plate 1 and Plate 3. Several of the wells showed free product layers ranging from less than 1/8 inch to 7 feet. The 5 inch recovery well (GBR-27) was drilled in the apparent center of the product lens. Following development, this well contained approximately 7 feet of free product.

In order to facilitate design of a product recovery system, GBR-27 was test-pumped during the week of May 1, 1986. The pump test showed that pumping rates as low as 1 gallon per minute (gpm) rapidly evacuated the well casing. Therefore, a low discharge, 24-hour pump test was conducted and results are presently being evaluated. The test pumping of GBR-27 produced water and product (both of which were stored in above-ground storage tanks). During the test a marked response in the observation well 12 feet away was noted: the water level rose. Apparently the pumping well removed enough product that the observation well was "unloaded" and the water level was permitted to rise.

During the test pumping up to 25 feet of drawdown was measured and a product layer over 10 feet thick accumulated in the well. Initially a single-pump recovery system was installed to recover product. A dual-pump product-recovery system is now in place and operating. Both the recovered product and produced water are being stored in above-ground storage tanks for eventual product separation and recovery. Drawdown in adjacent wells has been and is currently being monitored to refine the transmissivity and storage values which will be determined by analysis of the pump test. When these data are available, a more comprehensive and efficient recovery system will be designed, installed and operated.

Ground water samples have been collected from all well locations. Because wells which showed significant diesel contamination were typically completed as dual completion wells, ground water samples were taken from the deep completion only. This permits a more representative sample for analysis of dissolved constituents because the sampling apparatus does not contact any hydrocarbon product.

4.0 PRELIMINARY REMEDIAL ACTION PLANS

GCL is developing and implementing a comprehensive plan to deal with soil and potential ground water degradation which may have resulted from past practices, and to address the problem of the diesel spill. Ongoing investigations of soils and ground water are proceeding in conjunction with remedial action plans for the areas of known degradation. A schedule for the investigation and remedial action has been previously submitted to NMOCD. This schedule has been revised due to recent work and is presented in Appendix C.

4.1 HYDROCARBON-STAINED SOIL REMEDIAL ACTION

The general strategy for dealing with hydrocarbon-stained soils involves removal by excavation, transport to a bermed storage/treatment area on the refinery site, evaluation of several methods of biological treatment and implementation of the selected treatment option.

4.1.1 Excavation, Removal and Storage

During the last week of April, 1986, excavation and removal of hydrocarbon-stained soils began at four locations at the Bloomfield Refinery. These included the northern drain pit located to the west of crude Tank 1, the drain pit located between Tanks 23 and 2, the spill recovery tank located just to the east of the north loading rack, and the abandoned burn pit. Visibly and organoleptically-detectable hydrocarbon-stained soil was removed with earth-moving equipment (backhoes, front-end loaders and bulldozers) and transported by dump truck to two bermed storage areas on the east side of the refinery property (Plate 1). Following removal of as much stained material as possible, the excavations were inspected and sampled. Excavations at the northern drain pit have completely removed all evidence of staining. Soil samples were collected along the base of the southern wall and in the bottom of the excavation. A sample of water that was encountered at a depth of about 15 feet, and which is ponded in the northeast corner of the excavation, was also collected.

Sample analysis?

Excavations of the drain pit between Tanks 23 and 2 succeeded in removing the majority of stained soil. There are, however, stringers of stained material which continue to appear in the southern edge of the pit and which appear to extend under the foundation of Tank 2 on the eastern side. It is not practical, feasible or necessary to totally remove all material. Samples were collected along the southern, eastern and western pit walls in areas of varying or no visible staining in order to determine the range of residual hydrocarbon concentration.

Excavation of the loading dock catch tank also appeared to remove the vast majority of hydrocarbon-stained soils. Some hydrocarbon-stained material will be left in place because it continues underneath the concrete slab at the loading rack and also appears to lie beneath the piping networks which service the loading rack. This material can be left in place because it is protected from infiltration by the overlying concrete slab. Samples were collected along the northwest corner, the center of the northern pit wall and the center of the southern pit wall in an attempt to provide data on possible ranges of hydrocarbon concentration.

Removal of soil at the burn pit was begun on May 1, 1986. The operator started his excavation at the seep and began removing hydrocarbon-stained soils as he moved eastward, back towards the main pit area. The material had a noticeable hydrocarbon odor. Excavation of the burn pit area was completed by May 9, 1986. The pit area excavation has been left open until confirmation analyses can be completed.

|| Still open?
OCL
visit
to be scheduled

4.1.2 Sampling and Analysis

The sampling methodology and disposition of samples of soils were described in Section 3.1.1. After excavation of the hydrocarbon-stained soil, samples were collected from the underlying soil to ensure that a "clean closure" had been achieved. Preliminary analytical results indicate that PAHs and metals are not present in significant quantities. Because volatile organic compounds are the parameters of primary concern, samples of underlying material were shipped to Rocky Mountain Analytical Laboratory for analysis of:

- Benzene
- Toluene
- Ethylbenzene
- Xylenes

If the final analyses of contaminated soil show that other parameters are significantly elevated, the underlying material will be analyzed for these parameters as well.

A visual and organoleptic evaluation of the underlying material demonstrated that all of the visibly stained soil which could be excavated has been removed to the storage/biodegradation sites. Unless the analytical results show elevated constituents, further excavation of soil material is not anticipated. Following receipt of soil analyses, the excavations will be backfilled and graded to prevent excessive run-on and runoff.

4.1.3 Design of Remedial Action

Approximately 4500 cubic yards of soil have been removed from the four excavations. This material has been transported to two vacant, bermed areas located at the northern edge of the eastern tank battery (Plate 1). The two areas have an approximate surface area of 3.1 acres and can effectively hold 5,000 cubic yards of material spread 1 foot thick. These sites were chosen as storage/biodegradation sites because:

- usable ground water in this area should be quite deep (greater than 75 feet deep) and borehole and outcrop data demonstrate that shale bedrock is present under these sites
- the berms will effectively prevent runoff and run on of storm water
- these areas have not been used in any refinery operation and the effectiveness of the proposed biodegradation can be effectively monitored by obtaining shallow soil samples

Biodegradation of oily wastes has had a long and successful history in the petroleum refinery industry. It has been well established by the American Petroleum Institute and others that naturally occurring soil microbes have the capability of degrading oily waste fractions under a variety of mass loadings and climatological and site situations (See Appendix D).

In recent years, certain groups have begun to examine the kinetics and pathways of biodegradation of specific organic constituents which are commonly encountered in petroleum wastes. Many of these studies (see Simms, Utah State University, Appendix D) have focused on compounds which are considered to be recalcitrant to biodegradation and very persistent in the environment. In all cases, the evidence has shown that even these resistant compounds can be degraded by naturally occurring organisms in relatively short periods, albeit, often with careful monitoring and adjustment of soil moisture and nutrient content. These studies also show that biodegradation of oily wastes will occur over longer periods without the addition of any nutrients or water.

GCL is currently investigating a treatment option that involves the use of naturally occurring microorganisms to biodegrade the hydrocarbons in the soil. In order to facilitate the active growth of bacteria within the soil, oxygen, nitrogen, phosphorous and microbes must be added to the material. Water may also need to be added on a periodic or regular basis. In order to meet the above criteria, a simple biodegradation method will be employed.

To permit oxygen to enter the material, the soil will be spread out to an average thickness of one foot. Oxygen should enter the soil due to the large grain size of the material. Periodic tilling of the soil may be required to enhance oxygen transfer.

The addition of raw manure will provide an excellent source of nitrogen, phosphorous and microbes. The manure will be mixed with the soil as it is spread onto the biodegradation site. Periodic dosing with fertilizer and/or additional microbes (with sewage, sludge or additional manure) may be required.

It may be necessary to add water to sustain biologic activity. Enough water will be added to maintain proper soil moisture conditions but not to generate leachate. Water will be added only during the active degradation season (summer) when evaporation rates are highest. Table 4-1 shows the calculated potential evaporation deficit for the Bloomfield area. Water added to the treatment zone (including rainfall) will not exceed the calculated potential evaporation. Water produced in conjunction with the diesel product recovery program may be utilized for this purpose. If trace amounts of organic compounds are detected in this produced water, the soil biodegradation site will provide treatment of this produced water in addition to soil treatment.

Good
but
who
do it ?

Presently available data do not permit final design of the soil remedial action. After analytical results are evaluated, the thickness of the treatment zone, the required amount of manure, the water requirements, etc. will be determined and detailed plans and specifications will be developed.

4.2 PRODUCT RECOVERY

General investigations of site hydrogeology and preliminary analysis of pump test data indicate that significant quantities of spilled diesel fuel may be recovered from the subsurface. The diesel fuel now resides in a plume floating on the surface of unconfined ground water at an approximate depth of 30 feet below the land's surface (Plate 3). The portion of the plume which is potentially recoverable ranges from 0.5 feet to greater than 7 feet in diesel thickness and may measure approximately 200 by 50 feet (Plate 4). The long axis of the plume is oriented approximately southwest (Plates 3 and 4). These dimensions are based upon available data and are uncertain in some areas, particularly on the southwestern end of the plume.

Station Bloomfield **County** San Juan **Index No.** 1063

Latitude 36°43' **Longitude** 108°00' **Elevation** 5400ft

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Precip													
Years of record	36	36	32	32	32	33	32	33	35	34	36	36	27
Mean	.45	.76	.63	.72	.53	.52	1.19	1.27	.98	.75	.55	.59	9.35/ 8.94
Temp													
Years of record	36	35	31	32	31	31	32	32	33	33	33	35	26
Mean	25.8	34.1	42.0	49.6	56.5	67.7	72.4	72.3	62.0	51.8	37.7	28.2	51.2/ 50.0
PE	.34	.51	1.24	2.35	3.96	6.49	7.58	6.79	3.90	2.14	.69	.37	36.36
Surplus	.11	.25										.22	.58
Deficit			.61	1.63	3.43	5.97	6.39	5.52	2.92	1.39	.14		28.00

Table 4-1 Climatological data showing potential evaporation deficit, Bloom field area (Gabin, V. L., and Lesperance, L.E., New Mexico Climatological Data, 1850-1975, W.K. Summers and Associates)

Phase 2 of the product-recovery program will involve drilling and completing 4 or 5 additional 5 or 6-inch wells in addition to the existing recovery well (GBR-27). The first of the proposed wells will be drilled in the area where plume definition is least certain (southwest end of the plume). Information collected as each well is drilled will aid in the more precise definition of the plume, and this information will be used by GCL's site representative to select the exact locations for subsequent recovery wells.

4.2.1 Plume Volume, Geometry and Hydrogeologic Parameters

Available information indicates that 10,000-20,000 gallons of diesel fuel may have been released, and is presently hosted in the porous, weathered sandstone underlying the site. Sandstone pores previously filled with ground water are now occupied by a two-phase mixture of water and diesel. Assuming that the weathered sandstone porosity is 25%, and that approximately one half of that 25% volume is now filled with diesel, 12% of the sandstone's original volume is now filled with diesel. This percentage is the proportional saturation.

The volume occupied by 20,000 gallons of diesel (a worst case scenario) is approximately 2,700 cubic feet; dividing this volume by the proportional saturation (0.12) gives plume volume of 22,500 cubic feet. If the diesel plume has an average thickness of 2.5 feet the plume should have an area of approximately 9,000 square feet.

Based on available data, the thickest portion of the plume appears to be elliptical in plan, with a long-axis dimension of about 200 feet and a width of about 50 feet (Plates 3 and 4). This geometry is determined by data from existing wells and from the known behavior of petroleum-product plumes in similar geohydrologic environments.

On April 30, 1986 GCL personnel conducted a pump test of the existing recovery well (GBR-27). Preliminary analysis of the resulting time-drawdown data from the pumped well and adjacent wells indicates that the ground water zone under the plume has a transmissivity ranging from 15 to

For our calculations for GBR-14

$T = K b = 100\ \text{gpd/ft}$

$$K = \frac{T}{b} = \frac{100\ \cancel{\text{gpd}}/\cancel{\text{ft}}\left(\frac{.1337\ \text{ft}^3}{\cancel{\text{gal}}}\right)}{30\ \cancel{\text{ft}}}\left(\frac{\text{m}}{3.28\ \text{ft}}\right)$$

$$= .14\ \text{m/day}$$

For G.S.

$T = 60\ \text{gpd/ft}$

$$K = \frac{\left(60\ \text{gpd}/\cancel{\text{ft}}\right)\left(\frac{.1337\ \text{ft}^3}{\cancel{\text{gal}}}\right)}{30\ \text{ft}}\left(\frac{\text{m}}{3.28\ \text{ft}}\right) = .06\ \text{m/day}$$

$T = 15\ \text{gpd}/\cancel{\text{ft}}$

$K = .02\ \text{m/day}$

well log for GBQ-27 shows very fine to medium grained SS.
also from Todd's G.W. Hydrology the conductivity is in the range of silt and shale

60 gallons per day per foot. This value is typical of fine-grained, silty, "tight" sandstones such as the Nacimiento Formation. Transmissivity data is necessary to determine the optimal spacing and locations of the recovery wells.

As a well is pumped, the adjacent water table is drawn down, forming a "cone of depression" around the well. Product which floats on top of the ground water then flows into this depression and is concentrated there. In order to efficiently recover the maximum amount of product, the recovery wells will be designed and located so that their cones of depression overlap. This ensures that all recoverable product that lies between the wells will be collected.

Pump-test data and preliminary models indicate that a 6-inch recovery well, pumped at 1 gallon per minute, will have an effective "capture radius" of 30 to 50 feet. If the plume has an area of approximately 9,000 square feet, then 4 to 6 recovery wells may be required.

4.2.2 Product-Recovery System

The system for recovery of product must address 3 issues: the cost-effective recovery of the maximum amount of free product, the prevention of any further migration of product, and the safe and environmentally sound treatment or disposal of the potentially contaminated ground water removed during recovery operations.

As discussed in Section 4.2.1, from 4 to 6 wells on 50-foot centers should be adequate to recover most of the product. This assumes that the plume size is approximately 9,000 square feet, and has not laterally migrated to a large extent. The borehole data and the low transmissivity of the saturated zone support this hypothesis.

To assure that all recovery wells are placed in optimum locations, the following field plan will be used. The first well will be drilled near the anticipated southwestern end of the plume (Plate 4). Following completion and development, the product thickness (if any) will be determined by bailing or by using a tape with indicator paste. If little or no product is observed the second well will be drilled approximately half way between the first well and GBR-27, and tested for product in the same manner.

Based on the results obtained from the first 2 wells, sites for an additional 2 or 3 wells will be selected. We anticipate locating a total of 4 wells (including GBR-27) along the long axis of the plume, and 2 wells along the short axis near the thickest part of the plume. Following the installation of these wells it may be necessary to install several additional wells to totally contain the plume. Two air-driven displacement pumps will be installed in each well; one will pump water to depress the water table and the other will pump product for recovery (Figure 4-1).

As water and product are removed from the ground, the product phase will be diverted to on-site tanks for storage and/or treatment. The water produced may be contaminated with hydrocarbons. During the initial phases of recovery-system testing, produced water will be stored in on-site tanks. This water will then be sampled and analyzed for appropriate organic pollutants.

If the produced water is contaminated above WQCC standards, 2 options will be evaluated. First, using the water to keep the biodegradation site moist to optimize bacterial action. A second, less desirable option, would be to air-strip the produced water to remove the organic contaminants, then discharge the water.

TDS
& discharge
Act

The above plans for produced water disposal are, of course, dependent upon the final design of both the product-recovery and biodegradation systems. No decisions on these options can be made until more specific data is available on volumes of soil for biodegradation, volumes and contaminant levels in produced ground water, and the efficiencies of the product recovery and biodegradation systems.

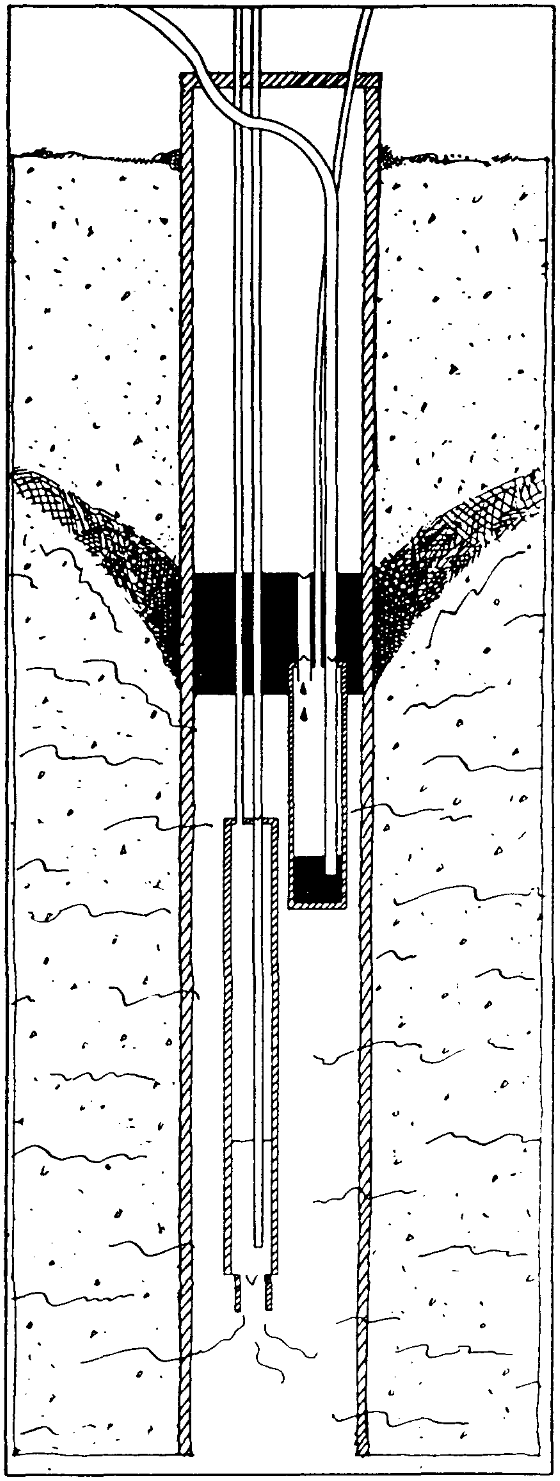

Figure 4-1 Typical 2 pump air displacement product recovery system.

5.0 REGULATORY CONSIDERATIONS

Pursuant to the proposed remedial actions, Giant may need to discharge water produced in concert with the product recovery system. Giant will be treating hydrocarbon-stained soil in a controlled area pursuant to an environmentally-sound treatment plan.

Because the documented degradation resulted from past activities consistent accepted industry practices, Giant proposes that NMOCD regulate the remedial actions under 1-203 of the WQCC Regulations. This would permit an expedient review and would not result in the loss of this summer's biodegradation season.

APPENDIX A

MONITOR WELL LITHOLOGIC LOGS AND COMPLETION DIAGRAMS

GBR 6-10, 14, 15 AND 17 WERE ORIGINALLY
PROPOSED BUT MAY NOT BE DRILLED

Where planned
To be located?

Shown on map but no log -
not drilled?

#17 log?
#19 log

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-1

¼ NE ¼ NW ¼ NW ¼ S 27 T 29 R 12 State New Mexico

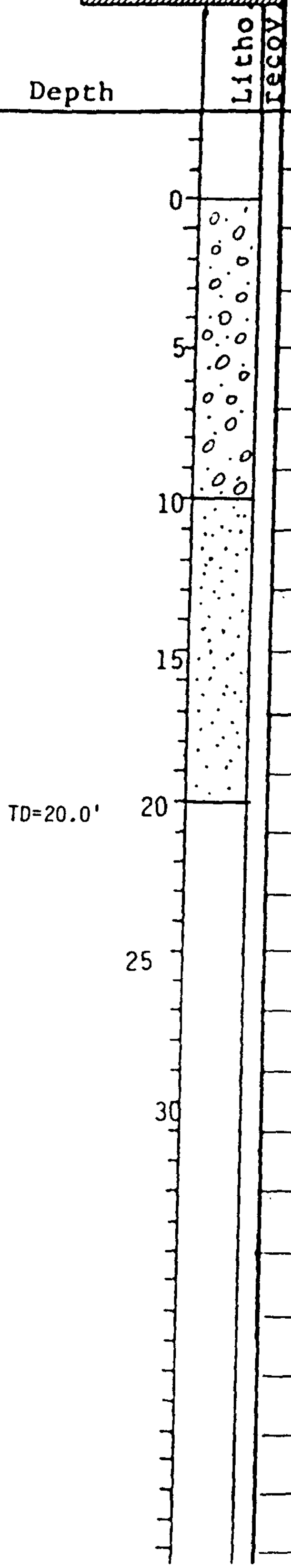
County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5414' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled With Hollow-Stem Auger (CME-55)



Samples/Footage	Lithology/Remarks
	0.0-10.0 (10.0') FILL: very coarse cobbles and small boulders of quartzite w/sand and gravel; dark gray; dark hydrocarbon stain and odor below 2.5'; damp.
8512200850/10.0' 8512200900/15.0'	10.0-20.0' (20.0') SANDSTONE : yellow-gray brown; silty and poorly sorted; fine-med grained; damp' faint hydrocarbon odor 10.0-15.0' dryer with no odor 15.0'-20.0'.
8512200916/20.0'	Borehole located on N side of old burn pit; 90.0' 165° to south fire hydrant' borehole backfilled w/cuttings and bentonite plug

85122000850 : 1 VOA, cuttings
8512200900 : 1 VOA, 1 Whirlpack, split spoon
8512200916 : 1 VOA, 1 Whirlpack, split spoon

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-2

____ ¼ NE ¼ NW ¼ NW ¼ S 27 T 29 R 12 State New Mexico

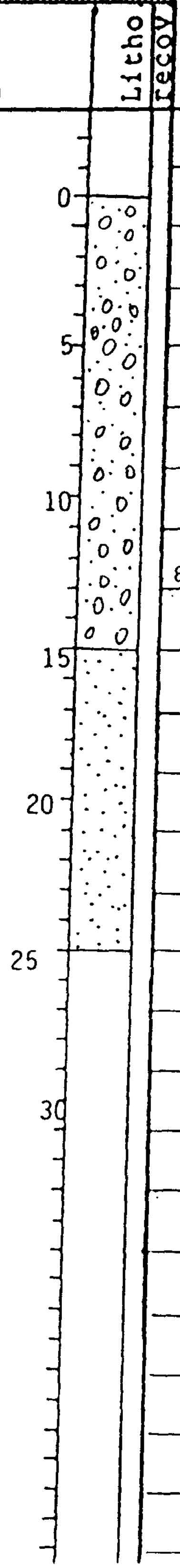
County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5414' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow-Stem Auger (CME_55)



TD=25.0 '

Samples/Footage	Lithology/Remarks
	0.0'-15.0' (15.0') FILL: very coarse cobbles and small boulders of quartyite w/sand and gravel; faint hydrocarbon odor 5.0'-10.0'; strong hydrocarbon odor 10.0'-15.0'; free water level encountered @ 10.0'; Hydrocarbon stains 5.0'-15.0".
8512201046/12.5'	
	15.0'-25.0' (10.0') SANDSTONE : grades from medium gray (15.0 17.5') to yellow gray (17.5'-25.0'); strong hydrocarbon odor and some stains 15.0'-17.5'; faint odor and no stain 17.5'-25.0'; sand is fine-med grained, poorly sorted, silty; wet to 25.0'.
	Borehole located in center of old burn pit; 73.0', 148° to south hydrant; borehole backfilled with cuttings and bentonite plug @ bottom and @ top of water.
	8512201046 : 1 VOA, 1 whirlpack, cuttings

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR-3

¼ NE ¼ NW ¼ NW ¼ S 27 T 29 R 12 State New Mexico

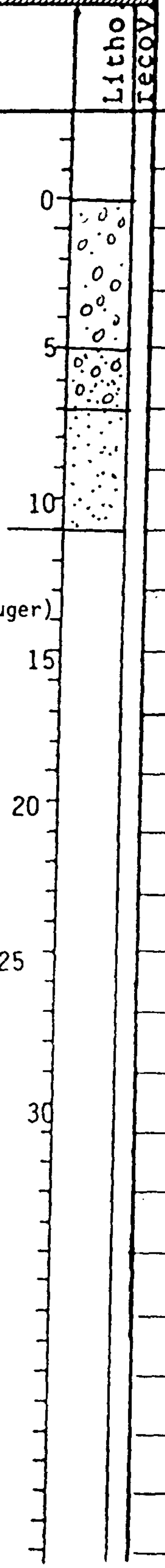
County San Juan Contractor Western Technolgy

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5414' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow- Stem Auger (CME-55)



TD=12.5'
(Refused auger)

Samples/footage	Lithology/remarks
	0.0'-5.0' (5.0') FILL: very coarse cobbles and small boulder of quartyite; some sand and gravel; gray-gray brown; dry; faint hydrocarbon odor.
	5.0'-7.5' (2.5') SANDY FILL: sand & gravel with some cobbles and boulders; browish gray; damp; faint hydrocarbon odor.
	7.5'-12.5' (5.0') SANDSTONE: yellow-brown; fine grained; poorly sorted and silty; damp; very faint hydrocarbon odor; no stain.
	Borehole located 51.0', 136' to south hydrant; backfilled w/ cuttings and bentonite plug @ bottom. Probably at or near south edge of burn pit.

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR-4

¼ NE ¼ NW ¼ NW ¼ S 27 T 29 R 12 State New Mexico

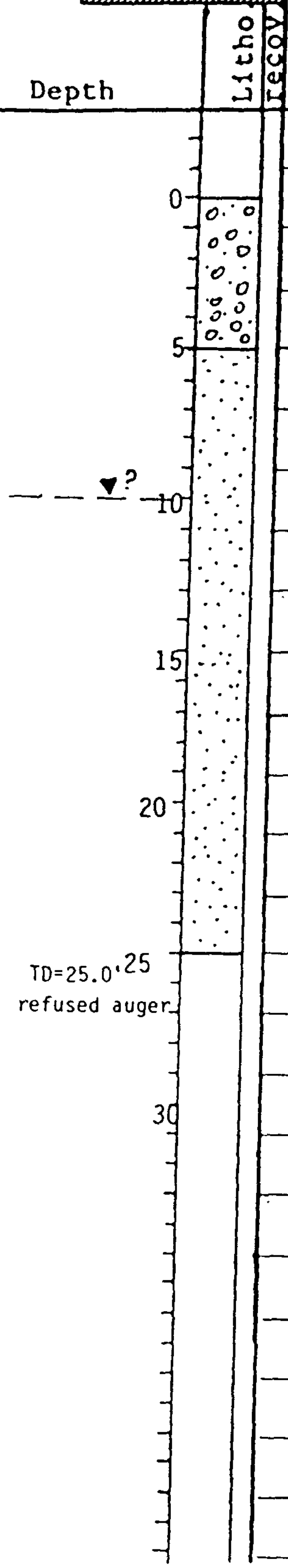
County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J C Hunter

Elevation 5414' topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow-Stem Auger (CME-55)



Samples/footage	Lithology/remarks
	0.0'-5.0' (5.0') FILL: Very coarse cobbles and small boulder brown-gray; dry, faint hydrocarbon odor; no stain.
	5.0'-25.0' (20.0') SAND and STONE : gray-brown; soft and loose 5.0'-13.0', becomes harder and cosolidated 13.0'-25.0'; damp fron 5.0'-10.0'; saturated 10.0'-25.0'; hydrocarbon odor and some stain 5.0' - 25.0'; water level poorly defined, about 10.0'.
	Located 97.0', 138° to south hydrant; backfilled with cuttings and bentonite plug @ bottom.

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-5

____ ¼ ____ ¼ ____ ¼ ____ ¼ S____ T____ R____ State New Mexico

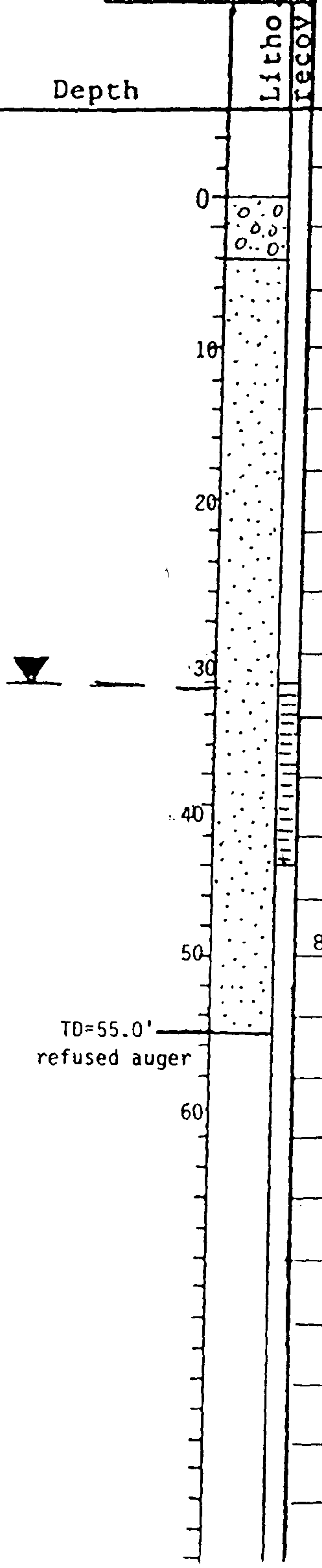
County San Juan Contractor Western Technology

Spud Date 12/20/85 Completion Date 12/20/85

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5390'topo Spud In (Fm.) Fill and/or Animas Fm.

Remarks Drilled with Hollow-Stem Auger (CME-55)



Samples/footage	Lithology/remarks
	0.0'-5.0' (5.0') FILL: Very coarse cobbles and small boulders of quartyite; minor sand and gravel; dark gray with strong oily hydrocarbon stain and odor, dry-moist.
8512201240/20.0'	5.0'-55.0' (50') SANDSTONE: dark gray-yellow gray; fine grained; poorly sorted; silty; strong hydrocarbon stain and odor 5.0'-25.0'; faint stain and some odor 25.5'- 55.0' ; water level at approximately 33.0', odor persists in saturated sand to total depth.
8512201410/55.0'	
	Borehole covered and left open for later ground water sampling. Located below SW corner of south pad. Completed as 2.0" piezometer 4/4/86, screen 30-45 feet
	8512201240 : 1VOA, 1 whirlpack, cuttings
	8512201410 : 1VOA, 1 whirlpack, cuttings

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR-11

¼ SW ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

County San Juan Contractor Western Technologies

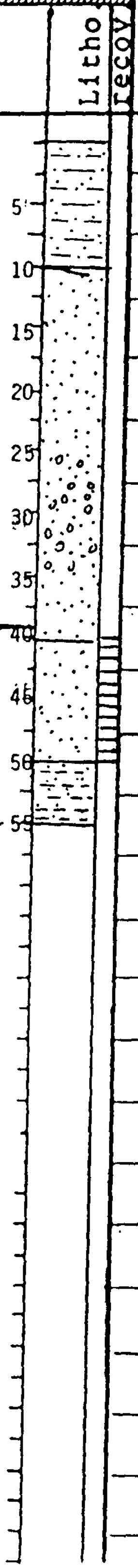
Spud Date 4/1/86 Completion Date 4/1/86

Logs Run Lithology from cuttings Logged By J.C. Hunter

Elevation 5388'(gilog topo) Spud In (Fm.) Nacimiento (Tertiary)

Remarks Drilled w/HSA, completed as galv. steel piezometer (2.0") 80.7', 245 to N end of "GIANT" sign

Depth



5348.25
W.L.
39.75
4/2/86
0800

TD@ 55

0'-10' (10') SILTY SAND : med. yellow-brown(10yr 5/4); fine to med grained, poorly sorted, rounded to subrounded, no stain or odor.

10'-40' (30') SAND: med brown (5yr 4/4); med to coarse grained, med. sorted, subround to angular, no stain or odor.

25'-35': Quarteite and granite pebbles, subrounded, 1/8" -1".

40'-50' (10') SAND: Light olive gray (5y 6/1) to olive gray (5y 4/1) med grained, subangular, med sorted; distinct hydrocarbon stain and odor

50'-55' (5') CLAYED SAND: Dark yellow brown (10yr 4/2); med grained sand with streaks of blackish red (5r 2/2) to med gray (NG) sticky wet clay; med hydrocarbon odor.

Completed as 2.0" galv steel piezometer
TD=57.2 from top of pipe, stickup=2.7
Screen from 40'-50', 5' blank on bottom
Screen packed w/washed sand, bentonite plug (½sack) @30-35'

50'7"
10' 1½' H2O

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 12

¼ ¼ ¼ ¼ S T R State New Mexico

County San Juan Contractor Western Technologies

Spud Date 4/2/86 Completion Date 4/3/86

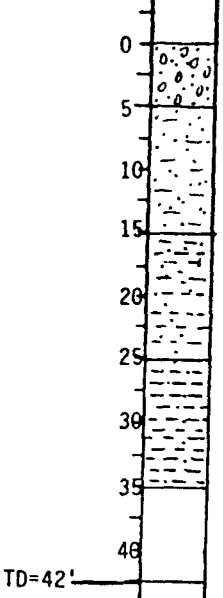
Logs Run Lithology from cuttings Logged By Nicholas

Elevation Spud In (Fm.)

Remarks

Auger Refused @ 42"

Depth | Litho | recov



0-5' GRAVEL: ½" -12" cobbles predominately quartzite poorly sorted, subrounded to subangular.

5'-15' SILTY SAND: moderate yellowish brown, (10yr 5/4), fine to med grained, moderately well sorted.

15'-25', CLAYED SILTY SAND: light olive gray, (5y6/1), fine to med. grained, moderately well sorted.

25'-35' SILTY CLAY: dark yellowish brown, (10yr 4/2)

No cuttings would come up hole after 35'

Auger Refused at 42'

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WELL LOGGING FORM

Page_____of_____

Client Montgomery & Andrews Well Number GBR 13

____¼____¼____¼____¼ S____ T____ R____ State New Mexico

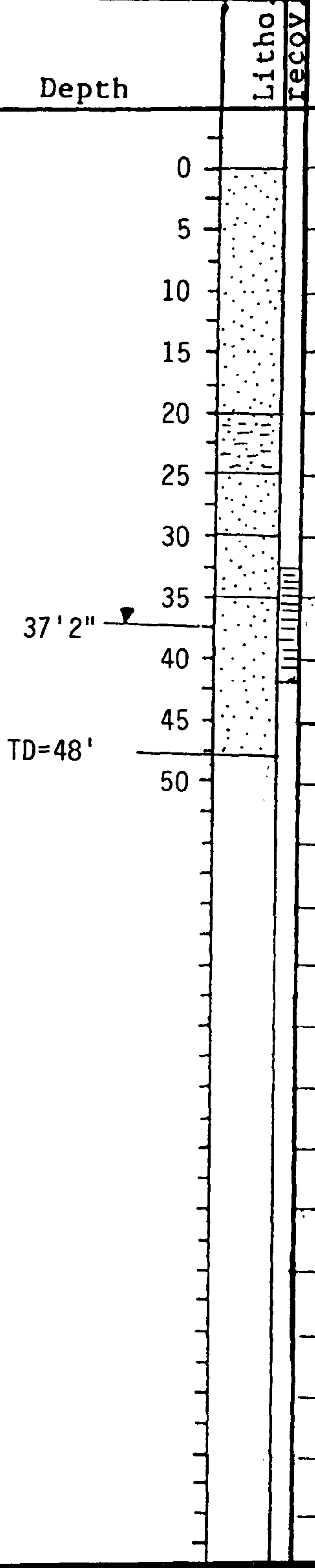
County San Juan Contractor Western Technologies

Spud Date________ Completion Date________

Logs Run Lith. from cuttings and cores Logged By J. Hunter

Elevation 5392' topo Spud In (Fm.) Nacimiento

Remarks NW corner, South parking area



0-20'	sand:	moderate yellowish brn, med to fine grained
20-25'	clayey sand:	mod brown, very fine sand with stringers of yellowish gray clay
25-30'	sand:	mod brown to yellowish brown, fine-med gr., poorly sorted, locally clayey
30-35'	oil-stained (?) sand:	mod gray to yel gray, fine gr., faint HC odor, stain increases w/depth
35-48'	sand/sandstone:	mod yel brn to yel brn, very fine gr; poorly sorted, silty

Completed as 2.0" PVC piezometer, screen 32'-42'.

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WELL LOGGING FORM

Page____ of ____

Client Montgomery & Andrews Well Number GBR 16

____ ¼ ____ ¼ ____ ¼ ____ ¼ S____ T____ R____ State New Mexico

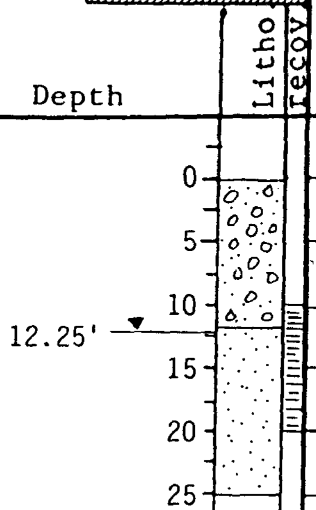
County San Juan Contractor Western Technologies

Spud Date____ Completion Date____

Logs Run Lith. from cuttings and cores Logged By____

Elevation 5414 topo Spud In (Fm.) Fill

Remarks w end of burn pit



0-12' Fill: Gray to brn gry, very coarse boulders, cobbles and sand, local HC stain & odor

12-25' Sandstone: mod yel brn, fine gr, very poor sorted, subrounded, mod HC odor

Completed as 2.0" PVC piezometer, screen 10-20'.

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WELL LOGGING FORM

Page ______ of ______

Client Montgomery & Andrews Well Number GBR 18

____ ¼ ____ ¼ ____ ¼ ____ ¼ S ____ T ____ R ____ State New Mexico

County San Juan Contractor Western Technologies

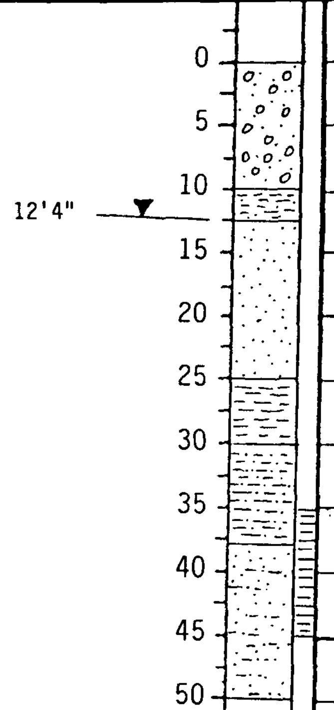
Spud Date ______ Completion Date ______

Logs Run Lith from cuttings and cores Logged By ______

Elevation ______ Spud In (Fm.) ______

Remarks drilled w/ HSA

Depth Litho Recov.



0-10' (10') fill; very coarse cobbles, some sand and gravel

10'-12.5' (2.5') sandy shale, yellowish brn

12.5-25' (12.5') sandstone: yellowish brn, med to fine grained poorly sorted

25'-30' shale: brn gry to rd brn, fissile, clayey, damp

30-38' siltstone: gry brn to brn gry; clayey, same thin, irregular sand stringers 1/4"-1/2"; moist

38-50' silty sandstone: yel brn to yel gry, very fine grained, poorly sorted, locally clayey

Completed as 2.0" galv. steel piezometer, screen 35'-45'.

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR 20

NW ¼ SE ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

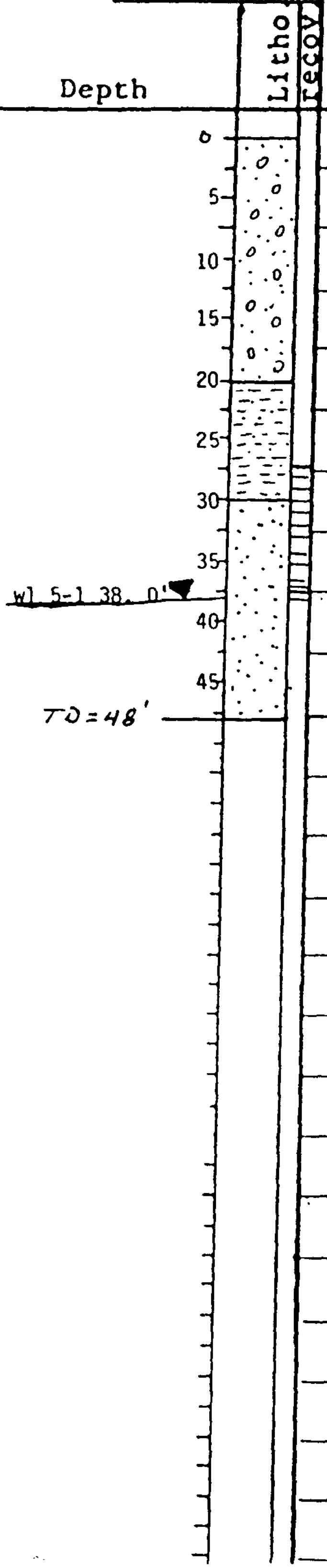
County San Juan Contractor WesternTechnologies

Spud Date 4/18/86 Completion Date 4/18/86

Logs Run lithology from cuttings Logged By Nicholas

Elevation 5394'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, no continous sampler used.



0-20' (20') SAND & GRAVEL : Moderate yellowish brown (10yr 5/4), med to coarse grained sand with 5%-30% gravel (½"-2"), No HC Odor.

20-30' (10') SILTY CLAY: Med light gray (N6) to med dark grey (N4), fine to med grained with some silt, hard drilling at 34', no HC ODOR.

Lower zone leg?
30-48'?

Completed as 2" PVC Piezometer
Stickup 1' 10" TD 43'10" from top of casing
Screened interval 27'-37'
Sand to 25', Bentonite 2/3 Bag @ 25'
Backfill to 6', Bentonite 1/3 Bag @ 6'

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR 21

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

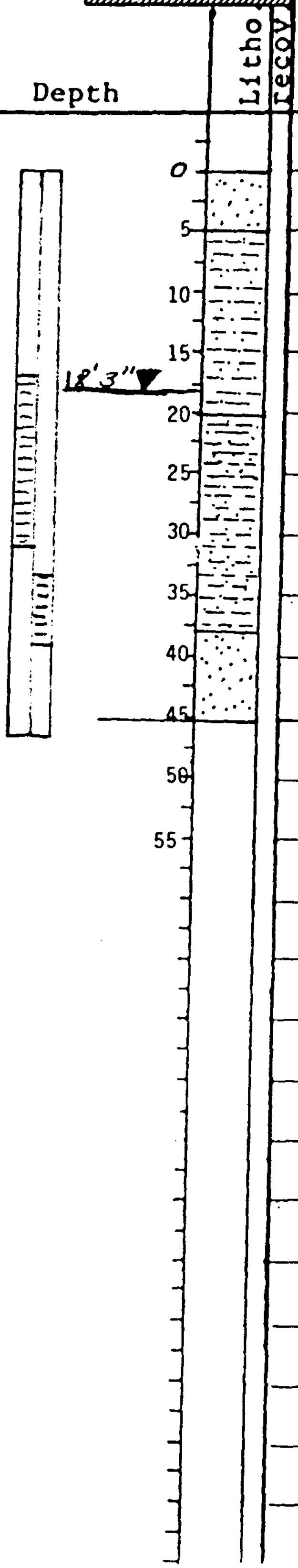
County San Juan Contractor Western Technologies

Spud Date 4/15/86 Completion Date 4/16/86

Logs Run Lithology from cuttings Logged By B Nicholas

Elevation 5398'(topo) Spud In (Fm.) Nacimiento

Remarks
Drill with HSA, completed as 2' PVC Piezometer



0'-5' (5') SAND: Brown, fine to med grained

5'-20' (15') SILTY SAND : Brown, med to coarse grained with minor small cobbles.

20'-38' (18') SANDY SHALE: Brown, fine grained, grades to yellowish brown at 25'. HC ODOR.

38'-46' (8') SANDSTONE : Med. bluish gray (5B5/1), med to coarse grained with local small cobbles (½"-1½") HC ODOR and sheen in sampler.

Dual Completion as 2" PVC Piezometer
Stickup 3'3" TD 40'3" and 41'3" from top of casing
Screened intervals 17-32' and 33-38'
Caved in to 6', Bentonite (3/4 Bag) @ 6'
Bentonite (¼Bag)@ 2'

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 22

NE ¼ NW ¼ NW ¼ NW ¼ S___ T___ R___ State New Mexico

County San Juan Contractor Western Technologies

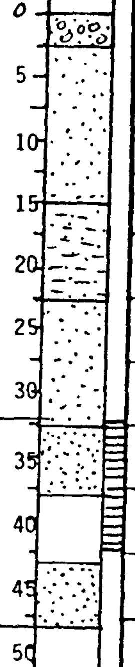
Spud Date 4/15/86 Completion Date 4/16/86

Logs Run Lithology from cuttings Logged By Hicks/Nicholas

Elevation 5394.5"(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, continous sampler and spit spoon used completed as 2' PVC Piezometer

Depth | Litho | recov



4/16 32'8"

TO = 48'

0-2.5' (2.5') SAND & GRAVEL FILL: Brown, some HC odor from surface spills

2.5'-15.0' (12.5') SAND: Med yellowish brown (10yr5/4) (2.5'-12.5') grades to Lt. brown at 12.5'(5yr5/6), med grained, well sorted contains gravels (12/5'-15.0') HC Odor

15.0-22.5' (7.5) CLAYED SAND: Brown, grades to dark brown at 17.5', some clay balls increasing with depth, HC odor.

22.5'-32.5' (10') SAND : Brown, fine to med grained, well sorted, clean , some clay from (22.5'-27.5'), black stained sand at 30', HC Odor.

32.5'-38.0' (5.5') SANDSTONE: Green to yellow green, consolidated grades to yellow brow at 36.5'.

38'-43' (5') No Returns.

43'-48' SANDSTONE: gray, med to coarse grained, no HC odor

Completed as 2' PVC Piezometer
Stickup 3'5" TD 49.5' from top of casing
Screen from 32'-42', 4' blank on bottom
Sand to 32', Backfill to 26', 3/4 Bag Bentonite @ 26'
Backfill to 2', 1/4 Bag Bentonite @2'

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR 23

SW ¼ NE ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

County San Juan Contractor Western Technologies

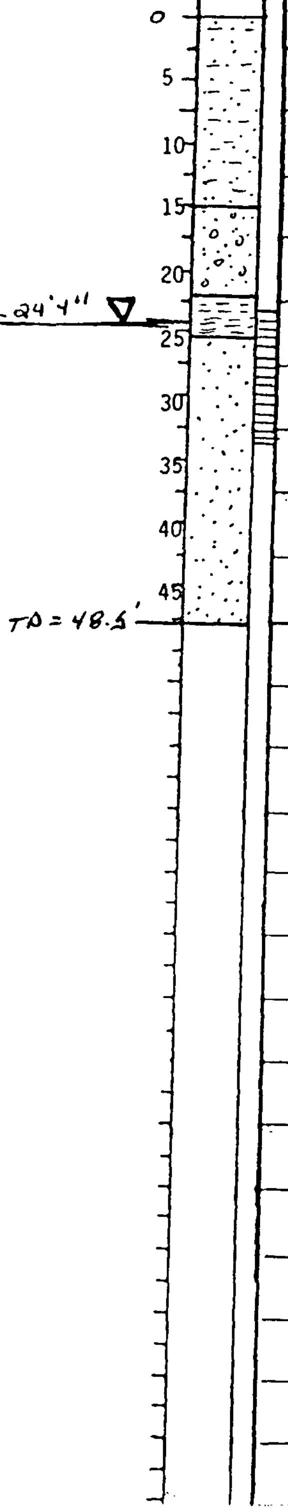
Spud Date 4/16/86 Completion Date 4/16/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5401'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled With Hsa, continous sampler used 22'-48.5'

Depth | Litho | recov



0-15' (15') SILTY SAND: med yellowish brown (10yr5/4), very fine grained, with small amounts of cobbles (½"-1"), grades coarser at 10', HC Odor.

15'-22' (7') SAND & GRAVEL: Med yellowish brown(10yr 5/4) to pale brown (5yr 5/2), med to coarse grained sand with cobbles (¼"-3"), HC Odor

22'-26' (4') SHALE: Grayish Brown (5yr 3/2) to yellowish grey (5y7/2), localized sand lenses, some weathering in shale, no HC Odor.

26'-48.5' (22.5) SANDSTONE: Weathered, light olive gray (5y5/2) from 26-27', med lt gray (N6) to med gray (N5), fine to med grained, slight HC odor(?) from 26'-27'.

Completed as 2" PVC Piezometer
Stickup 3' TD 41'10" from top of casing
Screen from 23'10" to 33'10" 5' Blank on Bottom
Sand to 23', 2/3 Bag Bentonite @ 23', Backfill to 5', 1/3 Bag Bentonite at5'

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR 24

NW ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R 12 W State New Mexico

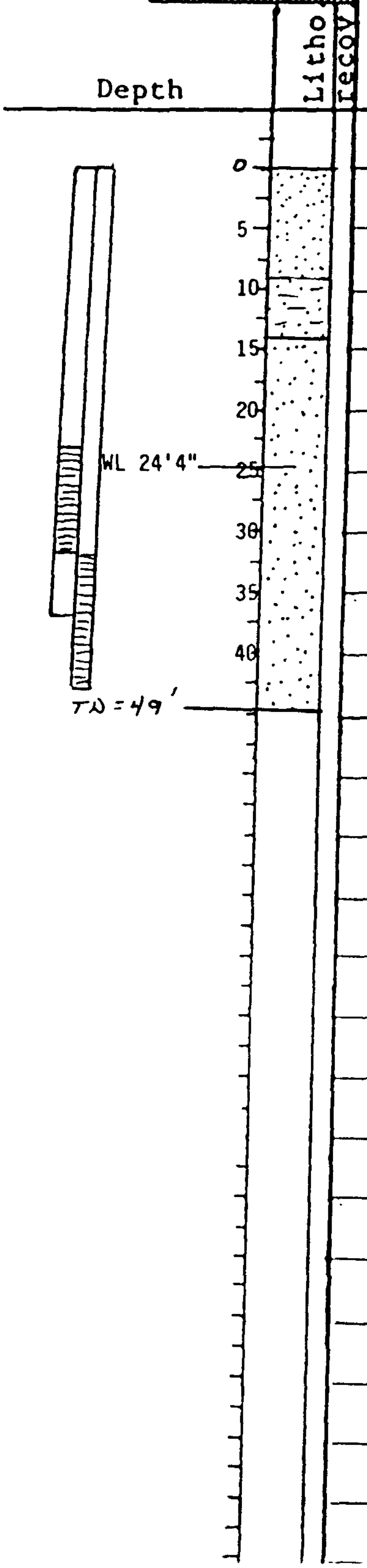
County San Juan Contractor Western Technologies

Spud Date 4/17/86 Completion Date 4/17/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5395'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, continous sampler used from 9'-49'



0'-9' (9') SAND : Moderate yellowish brown, (10yr5/4), med to coarse grained, No HC Od

9'-14' (5') SILTY SANDSTONE: Moderate yellowish brown (10vr 5/4) to olive gray (5y4/1) weathered, very fine to fine grained, No HC Odor.

14'-49' (35') SANDSTONE: lt olive grey (5y 6/1), fine grained, contains minor gravels @ 28' (1"-1½"), HC Odor at 29'

Dual Completion as 2' PVC Piezometer
Stickup 3'3" TD41'3" and 46'3" from top of casing
Screened intervals 23-33' and 33'-43'
Caved to 33', sand to 22', Bentonite 2/3 Bag
@22', Backfill to 6', Bentonite 1/3 Bag @ 6'.

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WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number CBR 25

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R 12W State New Mexico

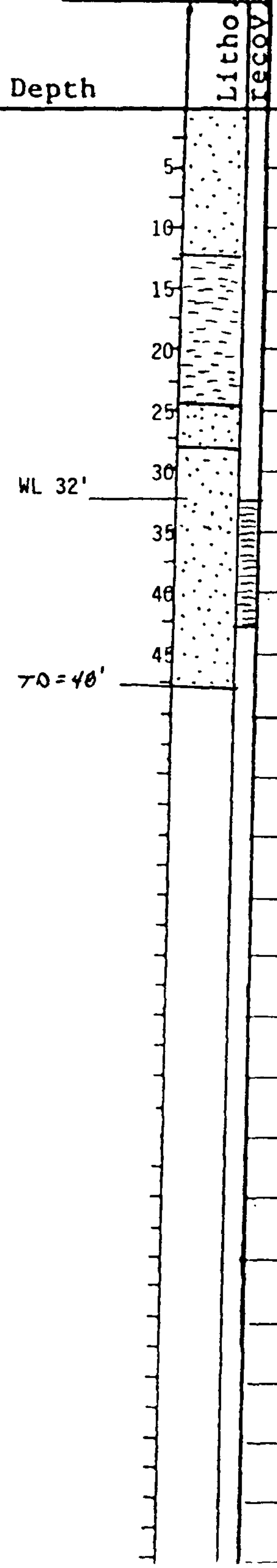
County San Juan Contractor Western Technologies

Spud Date 4/17/86 Completion Date 4/18/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5395'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with HSA, used continous sampler from 17'-48'



0'-17' (17') SAND: Med yellowish brown (10yr5/4) , med to coarse grained with some sma
cobbles from 5'-17', HC Odor

17'-24' (7') SHALE: Dark yellowish brown, (10yr4/2), with pale yellowish orange
stringers (10yr8/6) from 23'-24', soft . slight HC Odor

24'-28' SANDSTONE': Moderate yellowish brown (10yr5/4) with streaks of dark yellowish
orange (10yr 6/6), fine to med grained, weathered, NO HC odor.

28'-48' SANDSTONE: Ranges in color from lt gray (N7), to moderate yellowish brown
(10yr5/4) from 28-33', greenish gray (5G6/1) to dark yellowish orange
(10yr6/6) from 33'-43', med to coarse grained, grades coarser at 38', conta
grades to lt gray (N7) at 43',contains small cobbles from 28-43', shale
stringers from 43-48', no HC odor

Completed as 2" PVC Piezometer
Stickup 2' 0" TD 50' to top of casing
Screened interval 33-43', caved to 35', sand to 23'
Bentonite 2/3 Bag @ 23', Backfill to 6'
Bentonite 1/3 Bag at 6'

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WELL LOGGING FORM

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Client Montgomery & Andrews Well Number GBR 26

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R 12 W State New Mexico

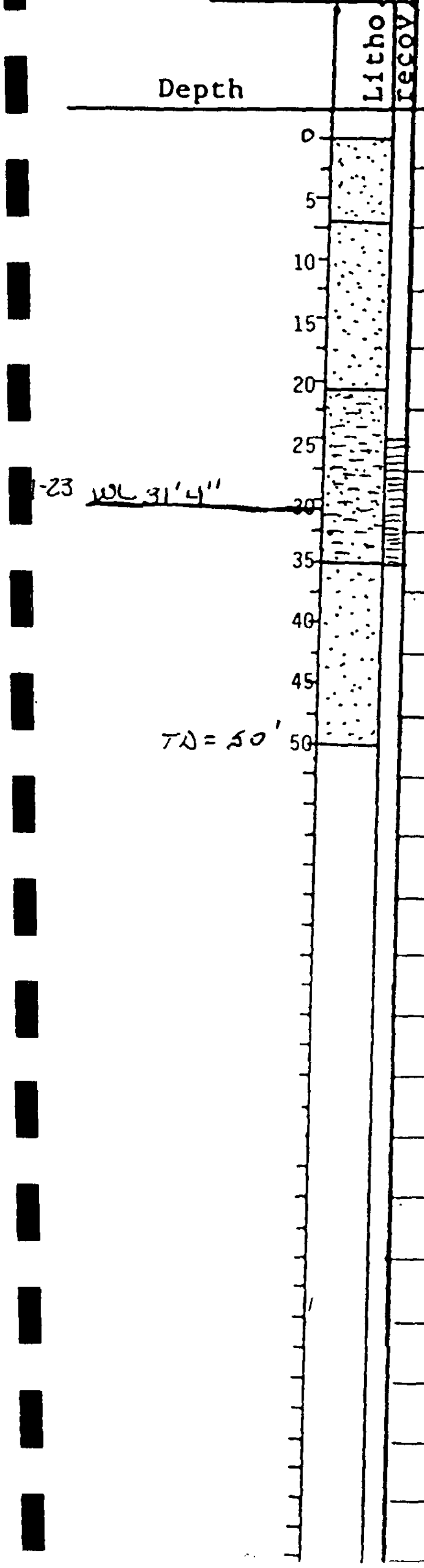
County San Juan Contractor PSI Western Technologies

Spud Date 4/18/86 Completion Date 4/18/86

Logs Run lithology from cuttings Logged By Nicholas

Elevation 5396' Spud In (Fm.) Naco.oemtp

Remarks Drilled with Hsa, continous sampler was not used.



0-7' (7') SAND : moderate yellowish brown (10yr5/4), med to fine grained, well sorted, no HC odor

7'-21' (14') SAND: HC stained, ranges from med dark gray (N4), grayish black (N2), to med gray (N5), fine to med grained, contains cobbles at 15', clay lenses from 12'-15' strong HC odor

21'-35' (14') CLAYED SAND: HC stained, ranges in color from med gray (N5) to grayish black (N2), very fine to fine grained, moist, HC odor.

35'-50' (15') SANDSTONE: med dark gray (N4), fine to med grained with some clay, wet HC odor.

Completed as 2" PVC Piezometer
Stickup 1'6" TD 41'6" from top of casing
Screened interval 25-35', caved to 26',
Sand to 23', Bentonite @23 2/3 Bag, Backfill to
5', Bentonite 1/3 Bag at 5'

Geoscience Consultants, Ltd

WELL LOGGING FORM

Page 1 of 1

Client Montgomery & Andrews Well Number GBR 27

NE ¼ NW ¼ NW ¼ NW ¼ S 27 T 29N R12W State New Mexico

County San Juan Contractor Beeman Brothers

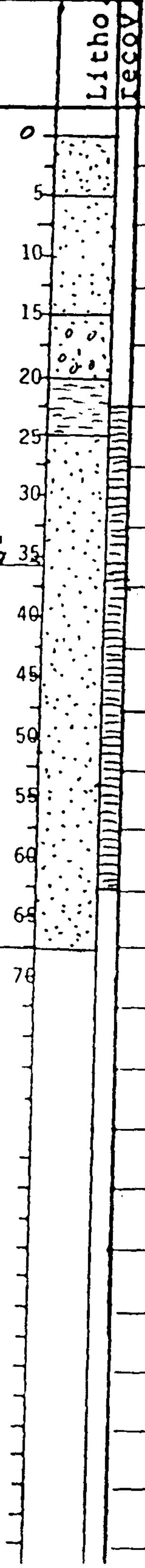
Spud Date 4/23/86 Completion Date 4/23/86

Logs Run Lithology from cuttings Logged By Nicholas

Elevation 5397'(topo) Spud In (Fm.) Nacimiento

Remarks Drilled with Air Rotary, completed as 5" PVC Well

Depth



WL 5-2 35'10" ▽

TD=67'

0-5' (5') SAND: Grayish orange (10yr7/4); fine to coarse grained, no HC odor

5-15' (10') SAND: Mod yellowish brown (10yr5/4); fine to med grained with some silt, contains some cobbles at 13', (2-3%)

15-20' (5') SAND & GRAVEL : Mod yellowish brown (10yr5/4) ; fine to med grained with some silt, contains 30% gravels

20-25' (5') SHALE: Dusky yellow (5y6/4)

25-67' (42') SANDSTONE: Lt gray (N7), very fine to med grained, grades to mod yellowish brown (10yr5/4) from 32'-34'

Completed as 5" PVC well
Stickup 1'4" TD 68'4" from top of casing
Screen from 22-62' , 5' Blank on Bottom
Sand to 18', Bentonite (1sack) 1 18'

Where was diesel first located when drilling?

APPENDIX B

CHEMICAL ANALYSES

SAMPLE LOCATIONS, NUMBERS AND PAGE NUMBER FOR CHEMICAL ANALYSES

Location	Number	Type	Page(s)	LAB	Disposition
Burn Pit	8604011440	S	--	AAL	3
Burn Pit	8604011441	S	--	AAL	3
Burn Pit	8604011442	S	--	AAL	3
Burn Pit	8604011443	S	--	AAL	3
Burn Pit	8604011444	S	--	AAL	3
Burn Pit	8604011445	S,C	10	AAL	2
Burn Pit	8604011434	GW	10	AAL	1
Burn Pit	8604031410	S	--	GCL	3
Background	8604031430	S	--	GCL	3
"Slop Pit"	8604031000	S	--	AAL	3
"Slop Pit"	8604031001	S	--	AAL	3
"Slop Pit"	8604031002	S	--	AAL	3
"Slop Pit"	8604031003	S	--	AAL	3
"Slop Pit"	8604031054	S	--	AAL	3
"Slop Pit"	8604021100	S	--	AAL	3
"Slop Pit"	8604021110	S	--	AAL	3
"Slop Pit"	8604021106	S	--	AAL	3
"Slop Pit"	8604031115	S,C	NR,1-4	AAL, RMA	2
Pit #1	8604021554	S	--	AAL	3
Pit #1	8604021556	S	--	AAL	3
Pit #1	8604021557	S	--	AAL	3
Pit #1	8604021600	S	--	AAL	3
Pit #1	8604021602	S	--	AAL	3
Pit #1	8604021605	S,C	NR	AAL	2
Pit #2	8604021545	S	--	AAL	3
Pit #2	8604021546	S	--	AAL	3
Pit #2	8604021550	S,C	NR	AAL	2
Pit #3	8604021612	S	--	AAL	3
Pit #3	8604021614	S	--	AAL	3
Pit #3	8604021616	S	--	AAL	3
Pit #3	8604021618	S,C	NR	AAL	2
Pit #4	8604021624	S	--	AAL	3
Pit #4	8604021626	S	--	AAL	3
Pit #4	8604021628	S	--	AAL	3
Pit #4	8604021630	S	--	AAL	3
Pit #4	8604021635	S,C	NR,1-4	AAL, RMA	2

Location	Number	Type	Page(s)	LAB	Disposition
GBR-11	8604030845	GW	10	AAL	1
GBR-11(41’)	8604011413	S	--	AAL	4
GBR-11(40’)	8604011412	S	10	AAL	1
GBR-13(35’)	8604021500	S	--	AAL	3
GBR-13(40’)	8604021510	S	--	AAL	3
GBR-13(50’)	8604021515	S	--	AAL	3
GBR-13 (35’-50’)	8604021516	S,C	NR	AAL	2
GBR-13	8504151545	GW	5	AAL	1
GBR-13	8605091550	GW	NR	AAL	1
GBR-18	8605090955	GW	NR	AAL	1
GBR-20	8605091040	GW	NR	AAL	1
GBR-21	8605091700	GW	NR	AAL	1
GBR-22	8605091350	GW	NR	AAL	1
GBR-23	8604181810	GW	NR	AAL	1
GBR-24	8604181800	GW	NR	AAL	1
GBR-24	8605091625	GW	NR	AAL	1
GBR-25	8605091210	GW	NR	AAL	1
Steel Well	8605091140	GW	NR	AAL	1
Burn Pit	8605091410	S	NR	RMA	5
Burn Pit	8605091420	S	NR	RMA	5
Burn Pit	8605091430	S	NR	RMA	5
Burn Pit	8605091450	S	NR	RMA	5
BP Seep	8510241435	S,GW	6	AAL	6
GBR-5	8601231410	GW	NR	AAL	6
Aban. Well	8601231300	GW	NR	AAL	6
Aban. Well	8601231310	GW	NR	AAL	1
NTD Pit	8512181220	S	8	AAL	1
API Pond	8512191020	S	8	AAL	1
API Pond	8512191021	S	8	AAL	1
API Pond	8512191022	S	8	AAL	1
TD Pit #2	8512191157	S	8	AAL	1
TD Pit #2	8512191158	S	8	AAL	1
TD Pit #2	8512191159	S	8	AAL	1
AMOCO PW	8512181500	S	8	AAL	1
GBR-1	8512200850	S	8	AAL	1
GBR-1	8512200900	S	8	AAL	1
GBR-1	8512200916	S	8	AAL	1
GBR-2	8512201046	S	9	AAL	1
GBR-5(20’)	8512201240	S	9	AAL	1
GBR-5(55’)	8512191410	S	9	AAL	1
AMOCO PW	8512191459	S	9	AAL	1

Location	Number	Type	Page(s)	LAB	Disposition
TD #2	8512191200	S	9	AAL	1
TD #2	8512191201	S	9	AAL	1
TD #2	8512191202	S	9	AAL	1
API Pond	8512191430	S	9	AAL	1
API Pond	8512191440	S	9	AAL	1
API Pond	8512191450	S	9	AAL	1

Type: S, soil; C, composite sample; GW, ground water

Lab: AAL, Assaigai Analytical laboratories; RMA, Rocky Mountain Analytical

* Both aromatic & halogenated?

Disposition: 1, Scan for volatiles; 2, Analyze for volatiles, PAH's and Phenols; 3, hold; 4, broken in transit; 5, Analyze by EPA Method 602; 6, WQCC parameters, scan and EP Toxicity

which method?

Page: NR Analyses not received
- sample held

SAMPLE DESCRIPTION INFORMATION

for

Geoscience Consultants, Ltd.

RMA Sample No.	Sample Description	Sample Type	Date Sampled	Date Received
61315-01	8604021635 PIT 4 COMPOSITE	SOIL	-	04/09/86
61315-02	8604031115 SLOP PIT COMPOSITE	SOIL	-	04/09/86

May 8, 1986

ANALYTICAL RESULTS

for

Geoscience Consultants, Ltd.

PURGEABLE ORGANICS METHOD 602

Parameter	Units	61315-01		61315-02	
Benzene	ug/kg	100	(2)	ND	(8)
Ethylbenzene	ug/kg	9000	(900)	ND	(20)
Toluene	ug/kg	270	(4)	ND	(50)
Xylene, m	ug/kg	84000	(12000)	670	(20)
Xylenes, o & p	ug/kg	37000	(24000)	880	(40)

ND = Not detected. Detection limits in parentheses.

ANALYTICAL RESULTS

for

Geoscience Consultants, Ltd.

METHOD 610 PNA

Parameter	Units	61315-01		61315-02	
Acenaphthene	ug/kg	ND	(1000)	ND	(1000)
Acenaphthylene	ug/kg	ND	(1000)	ND	(1000)
Anthracene	ug/kg	ND	(100)	ND	(100)
Benzo(a)anthracene	ug/kg	ND	(200)	ND	(200)
Benzo(a)pyrene	ug/kg	ND	(200)	ND	(200)
Benzo(b)fluoranthene	ug/kg	ND	(100)	ND	(100)
Benzo(g,h,i)perylene	ug/kg	ND	(200)	ND	(200)
Benzo(k)fluoranthene	ug/kg	ND	(100)	ND	(100)
Chrysene	ug/kg	ND	(300)	ND	(300)
Dibenzo(a,h)anthracene	ug/kg	ND	(500)	ND	(500)
Fluoranthene	ug/kg	ND	(2000)	ND	(2000)
Fluorene	ug/kg	150	(100)	ND	(100)
Indeno(1,2,3-cd)pyrene	ug/kg	ND	(100)	ND	(100)
Naphthalene	ug/kg	1500	(500)	300	(500)
Phenanthrene	ug/kg	ND	(500)	ND	(500)
Pyrene	ug/kg	ND	(2000)	ND	(2000)

ND = Not detected.   Detection limits in parentheses.

ANALYTICAL RESULTS

for

Geoscience Consultants, Ltd.

PRIORITY POLLUTANT INORGANIC PARAMETERS

Parameter	Units	61315-01	61315-02
Phenolics	mg/kg	ND (1)	ND (1)

ND = Not detected. Detection limits in parentheses.

ASSAIGAI
ANALYTICAL
LABORATORIES

TO: Geoscience Consultants Ltd.
Attn: Randy Hicks
500 Copper N.W. Suite 325
Albuquerque, NM 87102

DATE: 24 April 1986
0629

SAMPLE ID: 8504151545 GBL-13

ANALYTE	ANALYTICAL RESULTS	NOMINAL DETECTION LIMIT
Benzene	0.042 mg/l	0.01 mg/l
Toluene	0.025 mg/l	0.01 mg/l
Ethylbenzene	0.011 mg/l	0.01 mg/l
Xylenes	0.099 mg/l	0.01 mg/l

.601

REFERENCE: "Test Methods for the Examination of Solid Waste Physcial/ Chemical Methods", USEPA, SW 846, EMSL-Cincinnati, 1982.

An invoice for services is enclosed. Thank you for contacting Assagai Laboratories.

Sincerely,

Jennifer V. Smith

Jennifer V. Smith, Ph.D.
Laboratory Director

ASSAIGAI
ANALYTICAL
LABORATORIES Sampled 85/10/24

TO: Geoscience Consultants, Ltd.
500 Copper N.W. Suite 325
Albuquerque,NM 87102

DATE: 8 January 1986
1559 Revised
Page 1 of 2

Seep @ Bloomfi

ANALYTE	SAMPLE ID/ANALYTICAL RESULTS		NOMINAL DETECTION LIMITS
	Water 851024 1435	Sludge EP TOX	
As	<0.050 mg/l	<0.050 mg/l	0.050 mg/l
Ba	<1.0 mg/l	2.0 mg/l	1.0 mg/l
Cd	<0.010 mg/l	<0.010 mg/l	0.010 mg/l
Cr	<0.050 mg/l	<0.050 mg/l	0.050 mg/l
Hg	<0.002 mg/l	<0.002 mg/l	0.002 mg/l
Se	<0.010 mg/l	<0.010 mg/l	0.010 mg/l
Ag	<0.050 mg/l	<0.050 mg/l	0.050 mg/l
Pb	<0.050 mg/l	<0.050 mg/l	0.050 mg/l
NO 3 as N	<0.01 mg/l		0.01 mg/l
Benzene	5.23 mg/l		0.01 mg/l
Toluene	<0.01 mg/l		0.01 mg/l
Ethyl Benzene	3.16 mg/l		0.01 mg/l
Xylenes	3.25 mg/l		0.01 mg/l
PCB	1.0 ppm		1.0 ppm
C Cl 4	<0.001 mg/l		0.001 mg/l
1,2-dichloroethane	<0.001 mg/l		0.001 mg/l
1,1-dichloroethylene	<0.001 mg/l		0.001 mg/l
Tetrachloroethylene	<0.001 mg/l		0.001 mg/l
TCE	<0.001 mg/l		0.001 mg/l
Phenols	0.4 mg/l		0.001 mg/l
Cl	98.0 mg/l		0.1 mg/l
Fe	32.0 mg/l		0.05 mg/l
Cu	<0.01 mg/l		0.01 mg/l
Mn	1.19 mg/l		0.005 mg/l
SO 4	9.0 mg/l		0.1 mg/l
TDS	1258.0 mg/l		1 mg/l
pH	7.5		0.01
Methylene Chloride	<0.001 mg/l		0.001 mg/l

REFERENCES: 1."Standard Methods for the Examination of Water and Wastewater", 15th Edition, APHA, N.Y., 1980.

2. EPA Method 608

An invoice fore services is enclosed. Thank you for contacting Assaigai Laboratories.

Sincerely,

Jennifer V. Smith

Jennifer V. Smith, Ph.D.
Laboratory Director

ASSAIGAI
ANALYTICAL
LABORATORIES

TO: Geoscience Consultants, Ltd.
500 Copper N.W. Suite 325
Albuquerque,NM 87102

DATE: 17 January 1986
1884
Page 1 of 3

ANALYTE	SAMPLE ID/ANALYTICAL RESULTS		
	8512181220 NTD Pit	8512191020 API Pond 0.5' (center)	8512191021 API Pond 1.0' (center)
Benzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Xylenes	<0.01 ug/g	<0.1 ug/g	<0.01 ug/g
Ethylbenzene	<0.01 ug/g	<0.1 ug/g	<0.01 ug/g
Toluene	<0.01 ug/g	<0.1 ug/g	<0.01 ug/g
Scan	ND *	Many Peaks	ND *
	8512191022 API Pond 2.0' (center)	8512191157 TD Pit #2 0.5'	8512191158 TD Pit #2 3.0'
Benzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Xylenes	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Ethylbenzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Toluene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Scan	ND *	ND *	ND *
	8512191159 TD Pit #2 5.0'	8512191500 Amoco PW Pit	8512191530 BACKGROUND
Benzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Xylenes	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Ethylbenzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Toluene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Scan	ND *	ND *	ND *
	8512200850 GBR-1 10.0'	8512200900 GBR-1 15.0'	8512200916 GBR-1 20.0'
Benzene	9.37 ug/g	<0.01 ug/g	<0.01 ug/g
Xylenes	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Ethylbenzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Toluene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Scan	1 peak≈100 ug/g	ND *	ND *
Oil & Grease	4000.0 ug/g	800.0 ug/g	3000.0 ug/g
Moisture	**	9.4 %	8.7 %

ANALYTE	SAMPLE ID/ANALYTICAL RESULTS		
	8512201046 GBR-2 12.5'	8512201240 GBR-5 20.0'	8512201410 GBR-5 55.0'
Benzene	<0.01 ug/g	<0.01 ug/g	3.9 ug/g
Xylenes	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Ethylbenzene	<0.01 ug/g	<0.1 ug/g	<0.01 ug/g
Toluene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Scan	small peaks each <1.0 ug/g	Many Peaks	1 peak≈50 ug/g
Moisture	16.0 %	7.8 %	18.8 %
Oil & Grease	1600.0 ug/g	2000.0 ug/g	3000.0 ug/g
	8512191459 AMOCO PW Pit 1.0'	8512191200 3'N of TD#2 0.5'	8512191201 3'N of TD#2 3.0'
Benzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Xylenes	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Ethylbenzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Toluene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Scan	ND *	ND *	ND *
	8512191202 3'N of TD#2 5.0'	8512191430 API Pond (S) 1.0'	8512191440 API Pond (E) 2.0'
Benzene	<0.01 ug/g	3.04 ug/g	3.80 ug/g
Xylenes	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Ethylbenzene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Toluene	<0.01 ug/g	<0.01 ug/g	<0.01 ug/g
Scan	ND *	1 peak=15 ug/g	1 peak≈50 ug/g
	8512191450 API pond (N) 2.0'		NOMINAL DETECTION LIMITS
Benzene	4.10 ug/g		0.01 ug/g
Xylenes	<0.01 ug/g		0.01 ug/g
Ethylbenzene	<0.01 ug/g		0.01 ug/g
Toluene	<0.01 ug/g		0.01 ug/g
Scan	1 peak ≈ 15 ug/g		1.0 ug/g
Oil & Grease			0.1 ug/g

* ND = None Detected
** = Did not receive

REFERENCE: "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", USEPA, SW 846, EMSL-Cincinnati, 1982.

Assaigai Analytical Labs TO: Geoscience Consultants Ltd. 0546

SAMPLE ID/ ANALYTICAL RESULTS

ANALYTE	8604011412 GBR-11 Soil	8604011434 BURN PIT H2O	8604010845 GBR-11 H2O	8604011445 BURN PIT SOIL	BURN PIT SOIL Composite 8604011440 8604011441 8604011442 8604011443 8604011444	NOMINAL DETECTION LIMITS
Benzene	<0.1 ug/g	? 511 mg/l	0.0097 mg/l	<1.0 ug/g		0.1 ug/g 0.0001 mg/l
Toluene	<0.1 ug/g	0.103 mg/l	0.0141 mg/l	85 ug/g		0.1 ug/g 0.0001 mg/l
Ethyl benzene	<0.1 ug/g	0.048 mg/l	0.0027 mg/l	42 ug/g		0.1 ug/g 0.0001 mg/l
Xylenes	<1.0 ug/g	1.518 mg/l	0.0142 mg/l	36 ug/g		1.0 ug/g 0.001 mg/l
Napthalene				<0.005 ug/g		0.005 ug/g
Anthracene				0.044 ug/g		0.03 ug/g
Phenanthracene				0.043 ug/g		0.03 ug/g
Benzo(b)fluoranthene				<0.03 ug/g		0.03 ug/g
Benzo(k)fluoranthene				<0.03 ug/g		0.03 ug/g
Benzo(a)pyrene				<0.03 ug/g		0.03 ug/g
Fluoranthene				0.094 ug/g		0.03 ug/g
1-Methyl Napthalene				<0.005 ug/g		0.005 ug/g
Pyrene				<0.020 ug/g		0.020 ug/g
Fluorene				<0.020 ug/g		0.020 ug/g
2-Nitro phenol						0.03 ug/g
Phenol					<1 ug/g	1 ug/g
Cresol					<1 ug/g	1 ug/g
2,4-Dimethyl phenol					<1 ug/g	1 ug/g
2,4-Dinitro phenol					<1 ug/g	1 ug/g
4-Nitro phenol					<1 ug/g	1 ug/g
4,6-Dinito-o-cresol					<1 ug/g	1 ug/g
Ammonia as N					12.25 ug/g	0.01 ug/g
Orthophosphate as P					0.5 ug/g	0.01 ug/g
Oil & Grease					29,200 ug/g	0.1 ug/g
pH					6.8	0.01

APPENDIX C

SCHEDULE OF THE INVESTIGATIONS AND REMEDIAL ACTIONS

WORK PLAN FOR SOIL AND GROUND WATER INVESTIGATIONS AND REMEDIAL ACTION DESIGN
BLOOMFIELD REFINERY

DECEMBER 1985

Shallow Soil Sampling Areas Of Potential Contamination

- The Amoco gas well site with its associated produced water pits
- The oil/water separator and lined evaporation pond for refinery wastewater
- Tank drain pits located at crude storage tanks #1, #2 and #3
- An abandoned burn pit and leach field for septic tanks
- Use fully steam cleaned hand auger to sample at 1, 3, 5 and 10 foot depths (soil conditions permitting) at the above sites and two background sites
- Identify areas where deep drilling may be required

DECEMBER 1985 - APRIL 1986

Burn Pit Remedial Design

- Define exact location of buried burn pit through aerial photography and site survey
- Define extent of contaminated soil by drilling and trenching
- Take soil and ground water samples for confirmation analyses

APRIL 1-18

Deep Soil Coring In Areas Of Potential Soil Contamination

- Employ hollow stem auger with coring system to carefully examine unsaturated zone in selected areas
- Collect representative samples of unsaturated and saturated zone lithologies
- Install 2-inch, PVC or galvanized steel wells to determine ground water chemistry and gradients
- Analyze selected soil and ground water samples
- Bore piezometer holes and complete 2" PVC piezometers around the diesel spill area
- Measure water levels and determine product thickness
- Complete lithologic logs of boreholes and completion diagrams
- Purge and develop all wells by air lifting
- Using a clear bailer and/or oil/water indicating paste determine product thickness in ground water and record ground water levels
- Perform slug-recovery tests on selected piezometers to roughly determine aquifer characteristics

APRIL 21-MAY 15 DATA EVALUATION/TEST PUMPING

- Model pump test to determine pump test parameters, expected drawdown, number and location of observation wells
- Drill 5 inch well for aquifer test pumping
- Update water table map
- Construct product thickness map
- Evaluate lithologic data
- Determine location of recovery wells
- Conduct aquifer test at pumping rate and duration determined by computer modeling
- Excavate contaminated soil areas and remove soil to treatment areas

MAY 15-JUNE 30

- Finish any additional 2" piezometer installations
- Input pump-test data into aquifer model for development of several remedial-action scenarios at diesel spill area
- Drill and complete any required recovery wells for free floating product

MAY 30-JULY 30

- Design remedial action for any soil and/or ground water contamination (if required)

APPENDIX D

PUBLICATIONS ON LAND TREATMENT OF OILY WASTES

LAND DISPOSAL OF WASTES CONTAINING POLYNUCLEAR AROMATIC COMPOUNDS

Ronald C. Sims
Utah Water Research Laboratory
Utah State University
Logan, UT 84322

ABSTRACT

This research project investigated the treatment potential of soil systems for polynuclear aromatic compounds (PAHs) identified in wastes from industrial and municipal sources. A protocol for obtaining the soil assimilative capacities of PAH compounds, including transformation of mutagenic characteristics was developed. The protocol included: (1) incubation, (2) characterization/identification, and (3) determination of mutagenic potential. The protocol involved interfacing high performance liquid chromatography (HPLC) for compound and metabolite characterization with the Ames Salmonella typhimurium mammalian microsome mutagenicity assay for determination of genotoxic potential of PNA compounds and transformation products in single constituent systems and in complex waste:soil mixtures.

Kinetics of transformation were related to PAH structure. The range of half-lives was similar for low and high soil loadings (19-190 days) while the initial soil concentration varied over a range of 0.07 to 147 ppm. The initial rate of degradation varied by a factor of 2000. Results of engineering management options suggest that it may be possible to influence the degradation rates of PAH constituents with pH amendment, analog enrichment, complex substrate amendment, and moisture control. Results for mutagenicity testing indicate that the polar class fraction of PAH metabolites may be mutagenic, and may leach through soil under saturated conditions, but proceeds through a pathway of detoxification and degradation which can be controlled and managed. Results of studies obtained thus far indicate that, with a better understanding of soil:waste processes, it will be possible to accomplish safe ultimate disposal and ensure the protection of public health at reasonable cost to society.

INTRODUCTION

Land disposal was defined and approached in this study under the concept of land treatment. Hazardous waste land treatment (HWLT) can be considered as the intimate mixing or dispersion of wastes into the upper zone of the soil-plant system with the objective of microbial stabilization, detoxication, immobilization, or plant treatment. HWLT, with proper design and management, must lead to an environmentally acceptable assimilation of the waste which ensures protection of the public health.

Polynuclear aromatic hydrocarbons (PAH) include a group of organic priority pollutants of critical environmental and health concern due to the following characteristics: (1) chronic health effects (carcinogenicity), (2) microbial recalcitrance, (3) high bioaccumulation potential, and (4) low removal efficiencies in traditional wastewater treatment processes (2). PAH compounds have been identified and summarized for a variety of domestic and industrial liquid wastes and solid residues (5,7,9). Based on a comprehensive review of the literature and laboratory treatability studies, Sims and Overcash (8) summarized the behavior and fate of PAH compounds in soil systems. The potential for effective treatment and safe ultimate disposal of PAH compounds is significant with regard to land treatment.

Recently promulgated hazardous waste land treatment regulations established by the U.S. Environmental Protection Agency (40 CFR section 264) requires a permit to operate a HWLT facility. Requirements specify that hazardous constituents contained in a waste to be land treated must be degraded, transformed, and/or immobilized in the soil treatment zone. A treatment demonstration must be conducted in order to specify design and management requirements including: (1) waste application rate, (2) waste application frequency, (3) waste application method, (4) measures to control soil pH, (5) measures to increase microbial activity, (6) measures to increase chemical reaction, and (7) measures to control soil moisture.

PURPOSE

Research is needed to provide engineering design and management information for land treatment systems receiving wastes containing PAH constituents. Because of the diverse inputs of site characteristics, waste constituents, soil reactions, and assimilation capacities, development of a methodology for using information concerning the behavior and fate of PAH constituents in land treatment systems is required.

For this research effort, information was obtained concerning: (1) waste loading rates, (2) rates of degradation, (3) measures to increase microbial activity, and (4) mutagenic characteristics transformation for soil incubated priority pollutant PNA compounds. A protocol for obtaining this information was developed and evaluated. The three-step protocol included: (1) incubation, (2) characterization/ identification, and (3) determination of mutagenic potential. The protocol involved interfacing high performance liquid chromatography (HPLC) for compound and metabolite characterization with the Ames <u>Salmonella</u> <u>typhimurium</u> mammalian microsome mutagenicity assay for determination of genotoxic potential of PNA compounds and transformation products in soil.

APPROACH

Incubation

PNA compounds were incubated, singly or in a complex waste, in an environmentally controlled chamber in glass soil reactors. Environmental parameters that were controlled included temperature (25°C), light exposure (dark to prevent possible photodegradation, or light to encourage photodegradation), and soil moisture as percent field capacity.

Chemical Characterization with HPLC

Procedures for extraction and analysis of PAH compounds were based on the high performance liquid chromatography procedure for analysis of PAH compounds in water samples (4). HPLC was used with acetonitrile-water as the mobile phase, and a C-18 Perkin Elmer reverse phase column was used as the stationary phase. PAH compounds and metabolites were characterized with a UV detector at a wave length of 254 nm.

A subset of soil extracts was fractionated using a C-8 preparative Lobar size-A prepacked column. Polarity classes of degradation products were collected in acetonitrile-water, evaporated, and redissolved in dimethylsulfoxide for the Ames assay.

Mutagenicity Evaluation

The Ames *Salmonella typhimurium*/mammalian microsome mutagenicity assay (6) was used to determine the genotoxic potential of complex extracts (unfractionated) as well as parent compounds and biodegradation products obtained with the fractionation procedure described above.

Enhancement of Microbial Activity

Potential engineering management options for stimulating microbial activity include analog enrichment, complex substrate enrichment, nutrient addition, surfactant addition, pH adjustment, and moisture adjustment. The options may provide tools for increasing the rate of biodegradation of PAH constituents and therefore increasing the soil assimilative capacity for these constituents. Phenanthrene was used as an analog enrichment, at a concentration of 1000 mg/kg soil. Raw manure addition to soil reactors was the complex substrate enrichment and was calculated based on nutrient content. Nutrient addition including nitrogen and phosphorus was added as the salt solution recommended by Hoagland and Arnon (3). To investigate the effect of surfactant addition on the soil assimilative capacity for PNA constituents, Triton-100 surfactant was used at 2 ml/200 gm soil dry-weight. For pH adjustment, $CaCO_3$ was used to neutralize a Norfolk fine sandy loam (pH = 6.1); soil pH was adjusted to 7.0. The effect of soil moisture on PNA assimilation capacity was investigated with two soil moisture ranges, 20-40 percent field capacity and 60-80 percent field capacity.

Chemical and mutagenic data were subjected to analysis of variance, and when significant differences at the 5 percent level were found, Duncan's New Multiple Range Test was employed to separate means. The statistical procedures were performed using standard package programs of Statistical Analysis Systems-76 (1).

PROBLEMS ENCOUNTERED

One problem concerned the type of soil reactor/sampling approach used. Because of the difficulty of achieving completely homogeneous mixtures of soil and waste or soil and PNA compound, accurate reproducibility for results of subsampling soil from one reactor is difficult to achieve. Therefore, the entire contents of each glass soil reactor was used for each sampling event; replicate soil reactors were prepared in order to obtain samples through time. Triplicate reactors were used for each sampling event.

RESULTS

Based on a comprehensive review of the literature and on laboratory treatability studies, initial rates of transformation of PNA compounds in soil as a function of initial soil concentration based on first order kinetics are presented in Figure 1. These data were corrected for variation in temperature using an Arrhenius equation with coefficients developed from PNA data to a temperature of 20°C. Rates were normalized to micrograms PNA transformed per gram soil dry-weight per hour. The general trends shown in Figure 1 can be summarized as follows: (1) for a given PNA compound, the initial rate of degradation increases with increasing initial soil concentration, and (2) within the class of PNA compounds the initial rate of degradation decreases with increasing number of fused benzene rings (or molecular weight).

Results for PNA degradation kinetics from laboratory studies and from the literature indicate that most PNAs have reasonable, finite half-lives in soil systems at the concentrations evaluated. Kinetics of degradation were found to be related to PNA structure. Arranging PNAs by number of rings indicates that there are distinct statistically different groups of PNA compounds. The range of half-lives is similar for low and high soil loadings (19-190 days) while the initial soil concentration varies over a range of 0.07 to 147 ppm (2000 fold). However the initial rate of degradation varies by a factor of 2500.

Results of experiments with engineering management options suggest that it may be possible to influence the degradation rates of PNA compounds. The effect of several amendments on the degradation of benz(a)pyrene is presented in Table 1. The degradation of B(a)P, a five ring PNA compound which is considered to be cometabolized, i.e., cannot serve as a source of carbon and energy for the growth of microorganisms, appears to be influenced by pH adjustment and analog enrichment. Statistical analysis of the data indicated significant differences among the treatments, as shown in Table 1.

The effects of simultaneous addition of a complex substrate amendment, raw manure, and pH adjustment on degradation kinetics for a complex waste containing PAH compounds is presented in Table 2. Manure provided an inoculum of microorganisms and degradable organic carbon sources for soil microorganisms. pH of the waste: soil mixture was adjusted from 6.1 to 7.5. Results are presented for

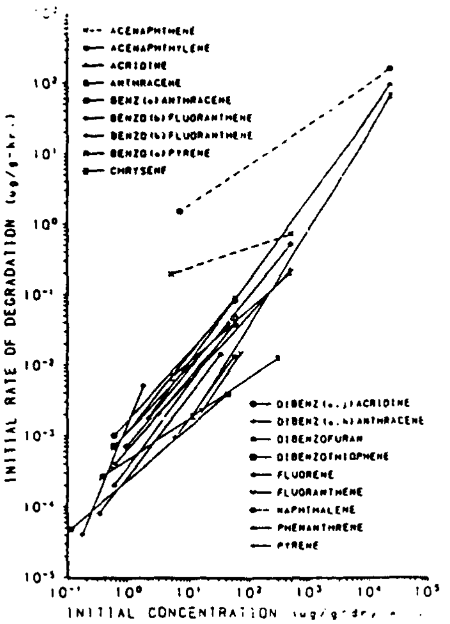


Figure 1. Rates of Transformation of PNA Compounds in Soil as a Function of Initial Soil concentrations.

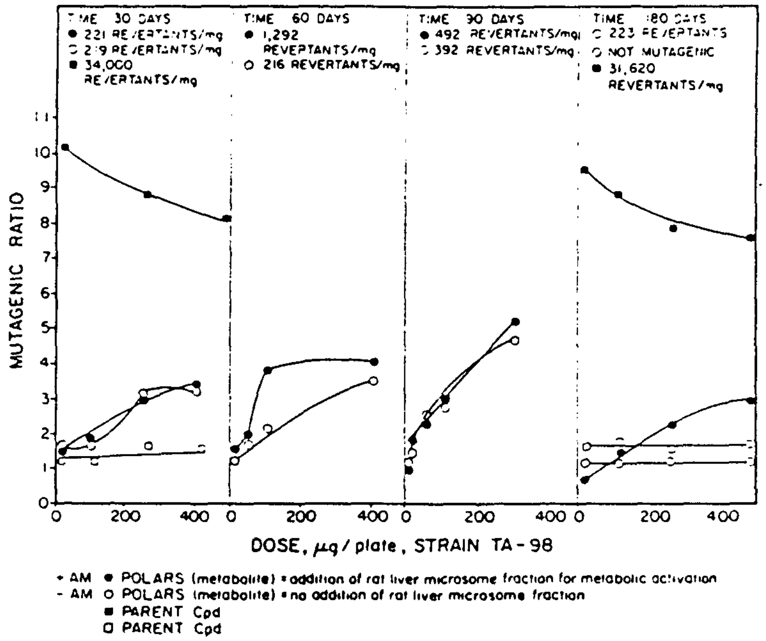


Figure 2. Mutagenicity of soil incubated B(a)P and metabolites (7).

PAH compounds identified and quantified in waste:soil mixtures without and with the amendment described.

Results presented in Table 2 indicate that degradation of all PAH compounds was affected by the amendments. PAH half-lives were greatly reduced compared with half-lives in unamended soil.

Table 1. Effect of amendments on benz(a)pyrene degradation.

Treatment	Half-life (days)
None	90 A[a]
Nutrients	81 A
pH Adjustment (5.2 to 7.4)	64 B
Surfactant	87 A
Analog enrichment with phenanthrene	64 B

[a] Values are means of three replicates. Means followed by same letter are not significant at the 0.05 level.

The effects of moisture amendment on the degradation of pure PAH compounds applied to soil batch reactors is presented in Table 3. For all three PAH compounds evaluated, degradation rates were improved by adjustment of soil moisture from 20-40 percent of field capacity to 60-80 percent. Thus results for amendment additions to PAH compounds present as individual constituents or in complex waste in soil indicate that management techniques are available for optimizing degradation kinetics.

Intermediate products formed in the degradation of PAH compounds in soil systems, as a class, proceed through a cycle of generation and degradation which complements the parent compound cycle in soil. Intermediate degradation products are generally more polar than parent PAH compounds (8), and thus are more readily transported (leached) through soil systems than parent PAH compounds. Optimization of treatment of PAH compounds, therefore,

Table 2. Effect of manure and pH amendments on PAH degradation in a complex waste incorporated into soil.

	Half-Life in Waste:Soil Mixture (days)	
PAH Compound	Without amendments	With amendments
Acenaphthylene	78	14
Acenaphthene	96	45
Fluorene	64	39
Phenanthrene	69	23
Anthracene	28	17
Fluoranthene	104	29
Pyrene	73	27
Benz(a)anthracene	123	52
Chrysene	70	42
Benzo(b)fluoranthene	85	65
Benzo(k)fluoranthene	143	74
Benzo(a)pyrene	91	69
Benzo(ghi)perylene	74	42
Dibenz(a,h)anthracene	179	70
Indeno(1,2,3-cd)pyrene	57	42

Table 3. Effect of soil moisture on PAH degradation (results presented as half-life in days).

Moisture	Anthracene	Phenanthrene	Fluroanthene
20-40% field capacity	43	61	559
60-80% field capacity	37	54	231

also requires optimizing treatment of PAH degradation products.

The Ames assay was used to determine the mutagenic potential of PAH degradation products in soil. Figure 2 presents results of laboratory studies with the PAH compound B(a)P and soil metabolites of B(a)P. It is obvious from Figure 2 that the mutagenicity of polar degradation products increases and then decreases with incubation time, or treatment time, in soil. Results also indicate that the mutagenic potential of degradation products, as a class of polar metabolites, is much less than the parent compound. A detoxication pathway is indicated for soil biodegradation (Figure 2).

The Ames assay was also used to evaluate potential mutagenicity of leachates produced in glass column leaching experiments conducted with complex wastes containing PAH compounds. Results for the Ames testing of leachates are summarized in Table 4. Results for the control leachate collected from columns without waste addition demonstrate a negative response (mutagenic ratio is less than 2.0), and therefore the leachate from soil with no complex waste addition is not mutagenic.

Table 4. Results for Ames assay testing of leachates. (Results expressed in terms of mutagenic ratio. Negative response indicated by mutagenic ratio of less than 2.0).

Treatment	Treatment Time (days)		
	0	61	91
Control[a]	1.50	1.75	1.50
Waste:Soil Mixture	1.25	4.05	1.85

[a]Control indicates soil only (no waste addition).

Results for leachate generated at the beginning of the study for the waste:soil mixture also demonstrated no mutagenicity. This result is expected since the parent PAH compounds are not highly soluble in water. PAH compounds also demonstrate high partitioning into soil organic matter (8), and the soil used in the laboratory study had a relatively high organic carbon content of 1.0 percent. Also very few PAH degradation products would be expected immediately after waste incorporation into soil.

Results for leachate generated at 61 and 91 days after initial waste incorporation into soil indicate increased mutagenicity (intoxication) followed by decreased mutagenicity (detoxication) compared with the initial waste incorporated soil. Thus polar metabolites resulting from PAH degradation in soil are mutagenic and may be transported through soil under saturated conditions. More research is required to characterize the mobility and toxicity of biodegradation products of PAH compounds in soil systems.

ACKNOWLEDGMENTS

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Disclaimer

DEGRADATION OF PETROLEUM FRACTIONS FROM OIL REFINERY WASTES - A LAND TREATMENT STUDY

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Abstract

The degradation of oil fractions was followed using the ASTM D-2007 method. The project was conducted at the Univ. of Oklahoma and funded by the U.S. EPA. The research was conducted on a ten acre tract of land by the application of API separator sludges obtained from an oil refinery processing sweet crude.

The land treatment study consisted of 50 plots of 9ft x 20ft each. The plots were of different loading rates and loading frequencies. The degradation of the oily wastes in terms of their fractions was followed with time on two plots. The study was limited to the zone of incorporation (till zone).

The results of the study showed that all fractions (asphaltenes,saturates,aromatics and polar compounds) degraded with time. During the winter months transformations among fractions was observed even though the total oil content remained constant. First order rate constants and fraction losses were computed.

Introduction

Petroleum refineries are among the top ten industrial waste generators, and the industry is among the fastest growing in the nation. The wastes generally consist of API separator sludges, slop oils; tank bottoms DAF sludges and refinery waste water. The present study was conducted using API separator sludges obtained from an oil refinery processing sweet crude. Oil refinery wastes are also a listed RCRA hazardous waste.

The present paper is a part of a large scale land treatment project conducted at the University of Oklahoma. The project was funded by the U.S. Environmental Protection Agency. The present paper focusses on the study of degradation of the oily fractions (Asphaltenes, Saturates, Polar compounds and Aromatics) by fractionating the total oil extracted from the soil-oil matrix.

Materials and Methods

The oily waste disposal site used in land treatment was a ten acre tract of land owned by the University of Oklahoma, Norman. The site consisted of 50 plots of 9ft x 20ft each. Nine control plots were established at random. The fractionation study was conducted on two plots.

The method of application, method of sampling and sample preparation are discussed in our previous paper (Bagawandoss et.al, 1984). The method of analysis of fractionation used was ASTM-D2007. The Attapulgus Clay and Silica gel used were obtained from Forcoven Products Inc., Texas.

According to the above method Asphaltenes are defined as pentane insolubles that can be separated from a solution of oil in n-pentane and may include insoluble resinous bitumens produced by the oxidation of oil. Polar compounds are material retained on adsorbent clay after percolation of the sample in a pentane eluent. Aromatics are material that on percolation passes through a column of adsorbent clay in n-pentane but adsorb on silica gel. Saturates are material that on percolation in a n-pentane eluent is not adsorbed on either the clay or silica gel.

The application rates of oil are presented in table 1. The composition of fractions in the oily sludge at each application is presented in table 2.

Results and Discussion of Fractionation

It was deemed desirable to study the degradation of individual fractions from the total oil; therefore, the oil was further fractionated into asphaltenes, saturates, aromatics and polar compounds to study the behavior of the individual fractions. The following section deals with the analysis and discussion of the data obtained for the above fractions. The losses and the rate of degradation of the fractions are evaluated and discussed. The results of fractionation of oily residues are presented in Figures 1 through 8.

Analysis of the data was performed by dividing the entire study into two time periods, Phases 1 and 2. The first time period consisted of 488 days and the second 171 days. The reason for two differnt lengths of time in Phases 1 and 2 was due to weather conditions which prevented adherence to the nominal loading frequency of once per year. In the initial phase two applications were made. The reason for two applications in Phase 1 was that plots could not be loaded with oily residues at desired loading rates without exceeding the field capacity of the soil. Following the initial application heavy rains prevented tilling of the plots; therefore, the immediate addition of the balance of the oily sludge to fulfill the desired loading rate was not possible. The remaining sludge was applied after a period of five months when the soil was tillable at point B. In Figures 1 - 8, points A to H correspond to Phase 1 and points I to K correspond to Phase 2.

Table 1 Application Rates of Oily Residues

Plot #	Application Date	% Applied
30	8/19/81	3.85
30	1/19/82	6.90
30	12/20/82	3.45
35	8/19/81	6.15
35	1/19/82	6.81
35	12/20/82	5.75

Table 2 Composition of Oily Fractions (%)

Plot #	Application Dates	Asphaltenes	Saturates	Aromatics	Polar Compounds
30	8/19/81	1.5	60.5	27.9	10.1
30	1/19/82	1.5	60.5	27.9	10.1
30	12/20/82	4.43	30.15	17.15	28.26
35	8/19/81	1.5	60.5	27.9	10.1
35	1/19/82	1.5	60.5	27.9	10.1
35	12/20/82	4.43	30.15	17.15	28.26

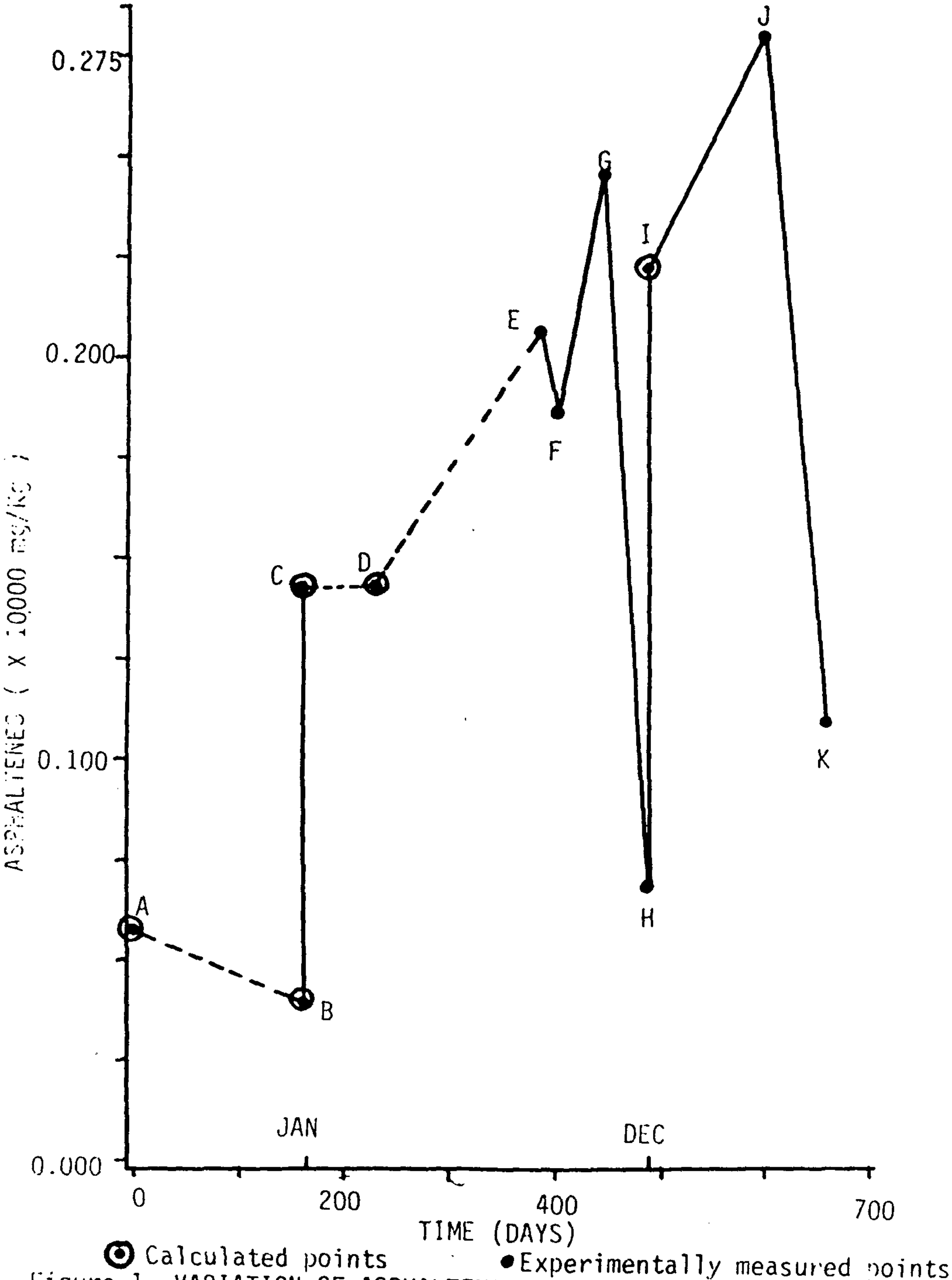

Figure 1 VARIATION OF ASPHALTENES WITH TIME - PLOT #30

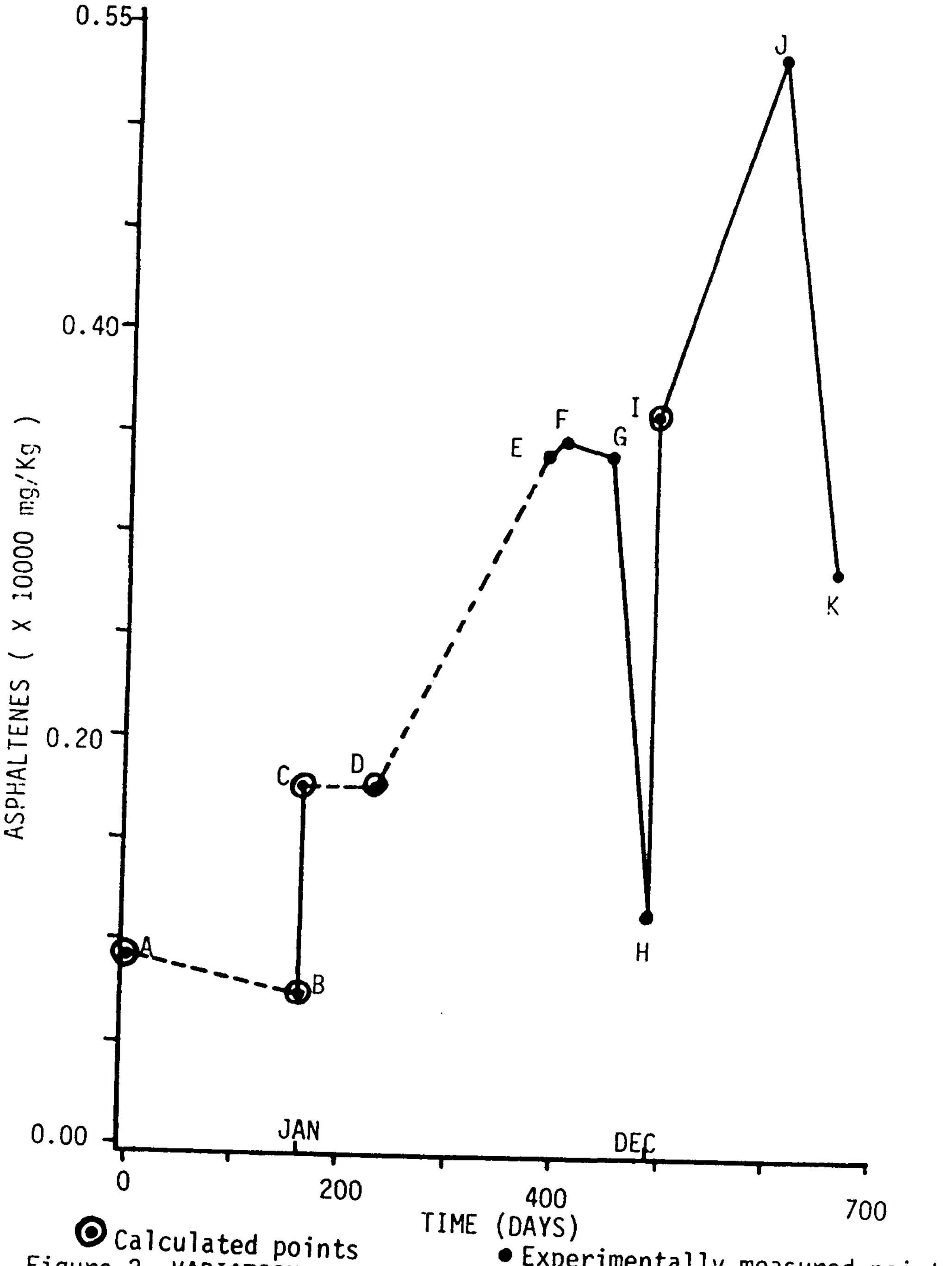

Figure 2 VARIATION OF ASPHALTENES WITH TIME - PLOT #35

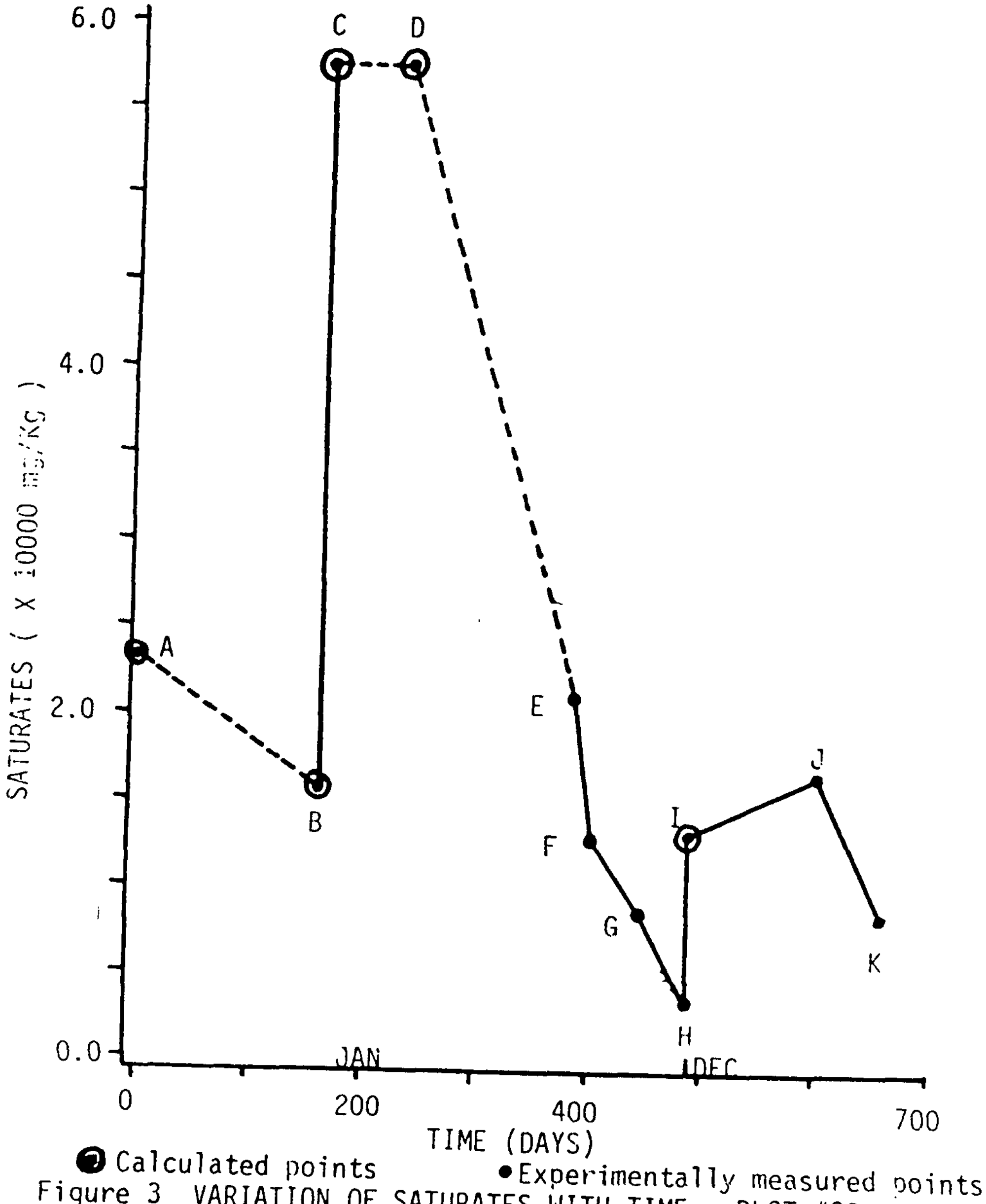

Figure 3 VARIATION OF SATURATES WITH TIME - PLOT #30

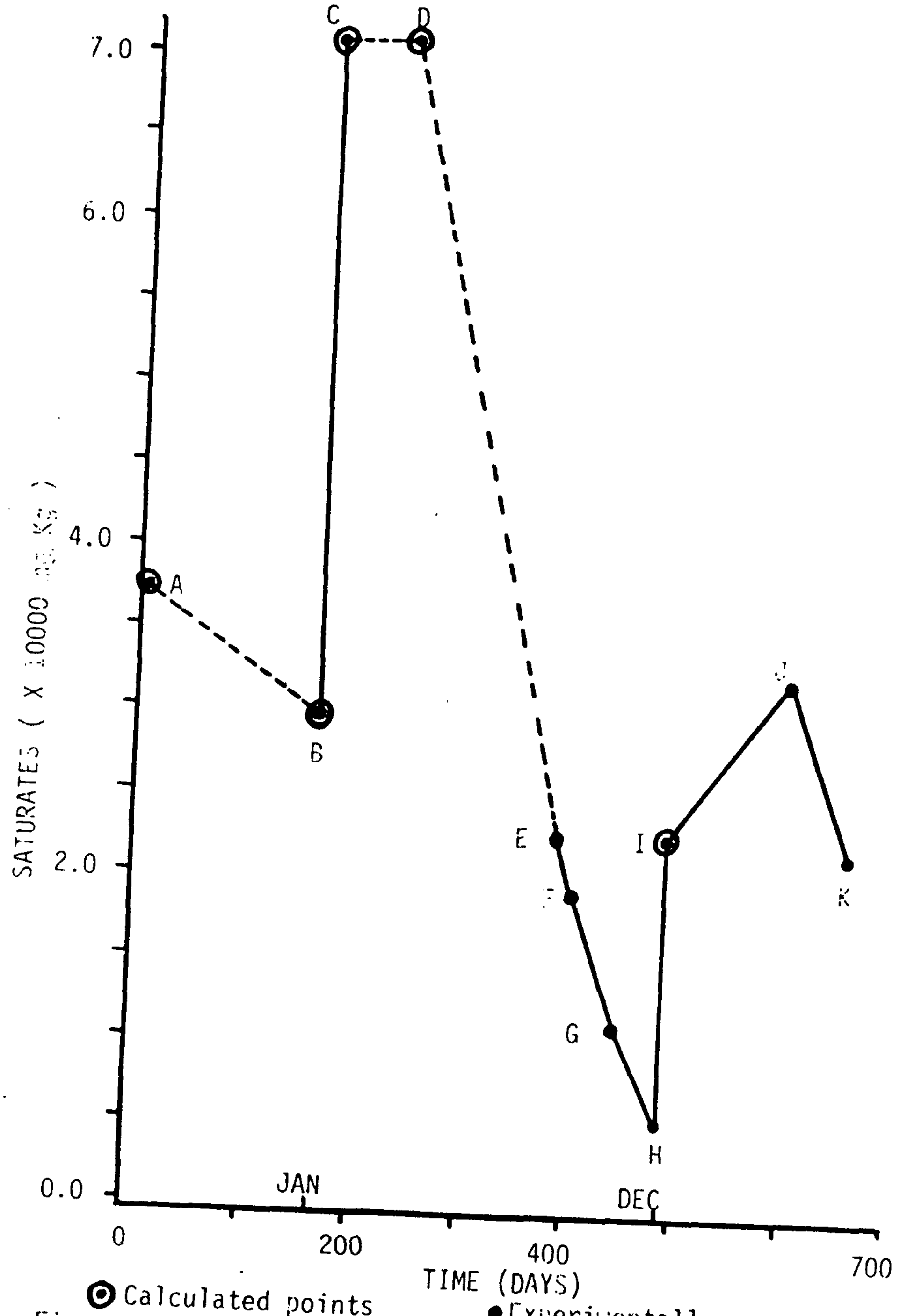

Figure 4 VARIATION OF SATURATES WITH TIME - PLOT #35

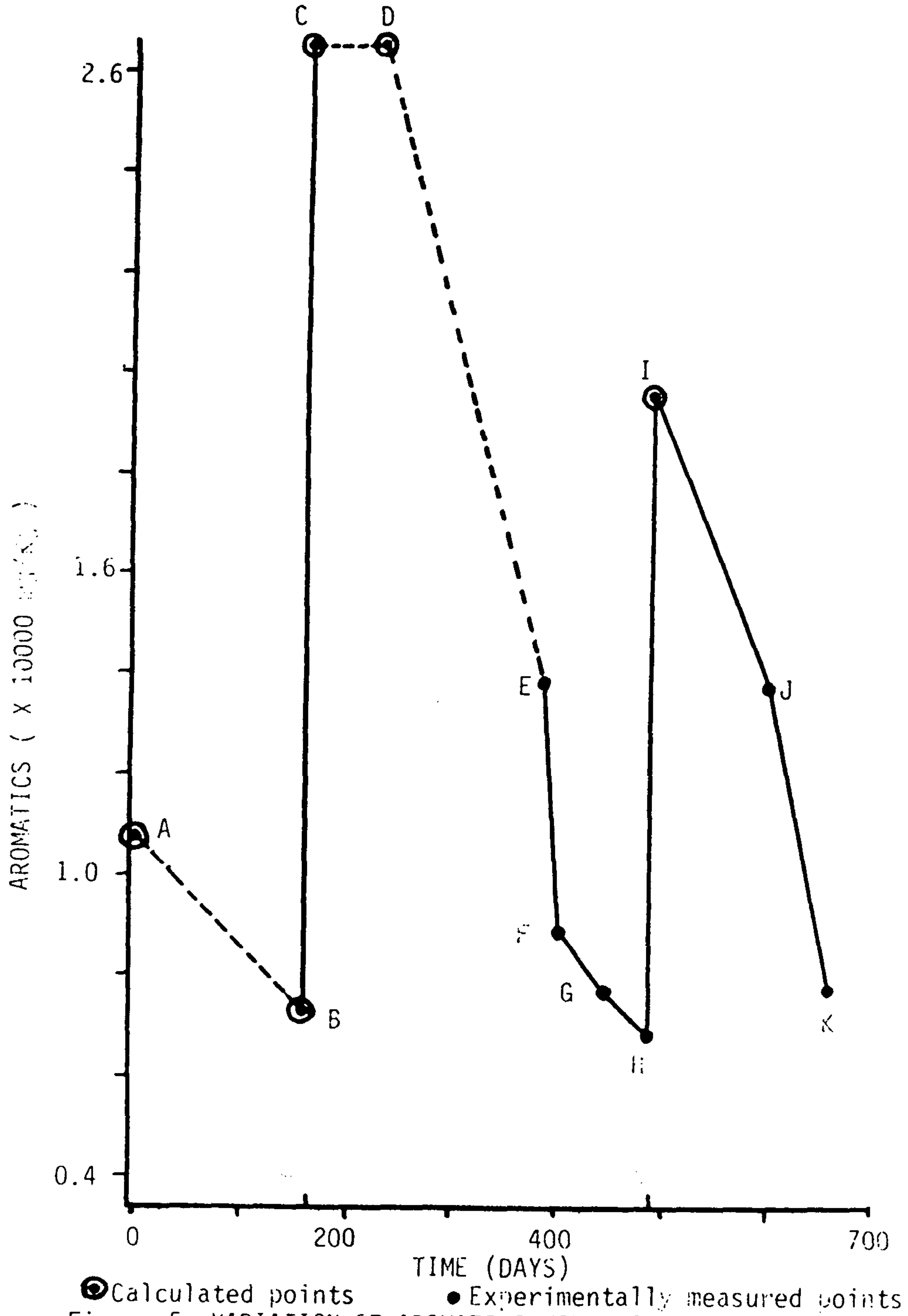

Figure 5 VARIATION OF AROMATICS WITH TIME - PLOT #30

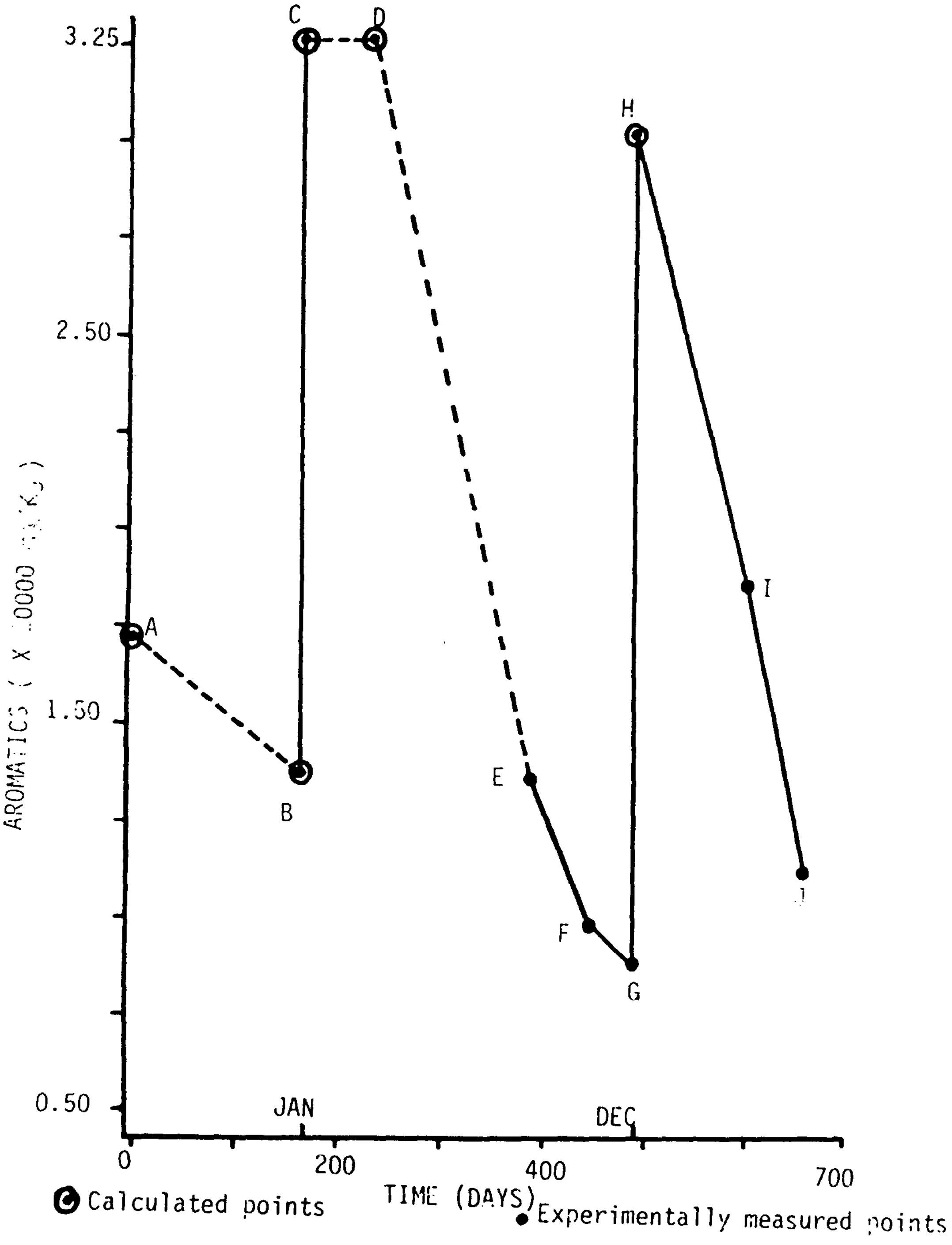

Figure 6 VARIATION OF AROMATICS WITH TIME - PLOT #35

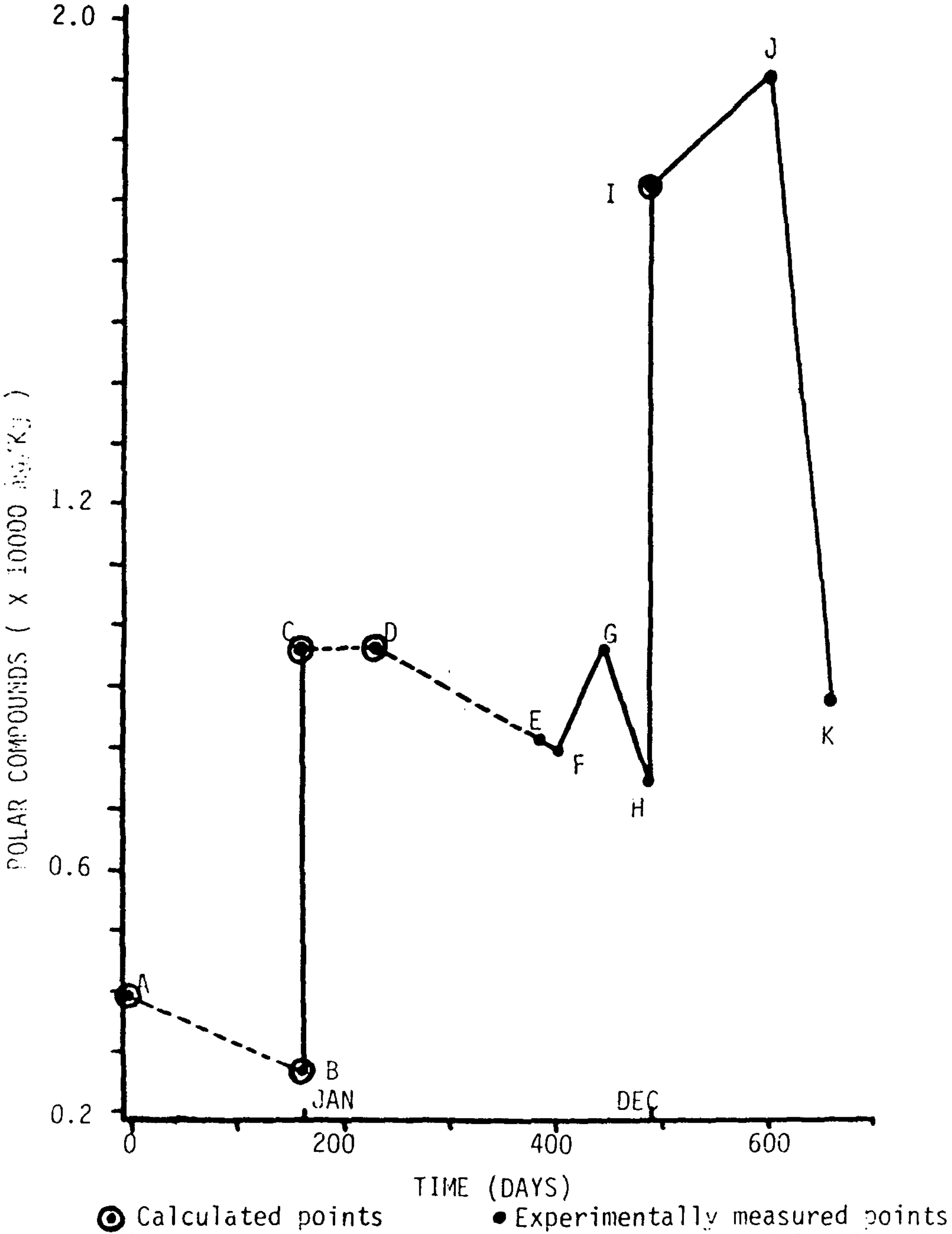

Figure 7 VARIATION OF POLAR COMPOUNDS WITH TIME - PLOT #30

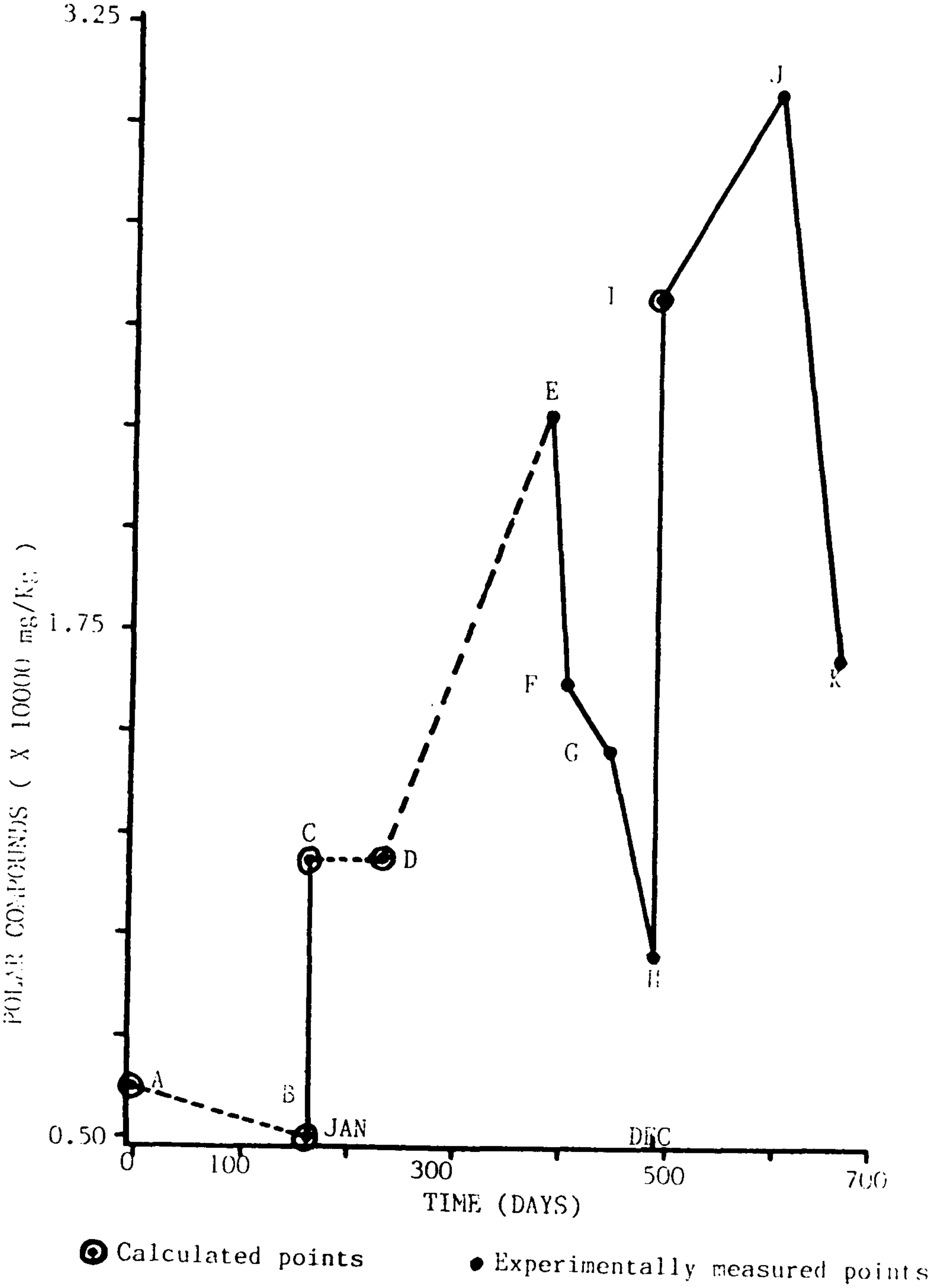

Figure 8 VARIATION OF POLAR COMPOUNDS WITH TIME - PLOT #35

During Phase 1 of the project from points A to E (excluding point E) several problems, in addition to weather conditions, were encountered in sampling, sample preparation and oil content analysis. Oil recoveries were inconsistent during Phase 1. Hence, points A to E were calculated and not experimentally measured points. Also, the dashed lines are hypothetical lines. The inconsistencies in oil recoveries were overcome by the development of new sampling, sample preparation, and oil content analysis methods. as explained in the procedures. (Bagawandoss (1984)) . From point E on all points were experimentally measured points with the exclusion of the application at point I. Point I was determined by adding the amount of oil applied and the amount of oil applied and the amount of oil remaining from the previous application at point H. The amount of sludge to be applied was determined from the oil content of the sludge, soil density and the loading rate and frequency desired.

Observation of Figures 1 and 2 show that the asphaltenic fraction (pentane insolubles) at point E was greater than the sum of the total amount of asphaltenes applied at points A and B in plots 30 and 35. A similar trend was observed during the dormancy period from points I and J. Although these increases were not expected, they can be explained. The time period during which the increases occured, coincided with cold weather and saturated soil conditions. Therefore, anoxic conditions existed with a possibility of anaerobic decomposition.

Walker et al., (1976) characterized the pentane insoluble fraction using computerized mass spectrometry as carboxylic acids, ketones, esters and porphyrins. Waksman (1927) has shown that anaerobic decomposition produces various acids, such as acetic, butyric and lactic, and alcohols, such as ethyl and butyl and in some cases acetone. Okinsky and Umbreit (1959) showed that the anaerobic decomposition of aromatic ring compounds produces acids, saturated hydrocarbons, alcohols and ketones. Evans (1977) delineated the anaerobic decomposition of the benzene nucleus under three different sets of biological conditions. The three conditions are: anaerobic photometabolism of benzoate by Athiohodaceae, anaerobic metabolism of dichlorophenol, giving rise to quinolines; and formation of quinolines observed in the presence of fungal phenoloxidase in soil (Liu et al., 1981, Rosazza 1982).

Figure 7 (plot 30) shows an increase in polar compounds from points F to G, whereas there was no increase during the same time period in plot 35 (Fig. 8). During the above time period, when an increase in polar compounds was seen in plot 30 phenol, 2 nitrophenol and pentachlorophenol, as well as benzene, nitrobenzene, andisophorone, were detected in the soil matrix. This is reported in the fate of priority pollutants section of the study on 9/10/82, which corresponds to point F in Figure 7 (Bagawandoss, 1984). The above compounds would increase the concentration of polar compounds. The characterization of priority pollutants at point G on 9/26/82 indicated the absence of phenolic compounds or benzene related compounds. Therefore, the formation of quinolines, as observed by Liu et al., (1981), to increase the polar compounds is a possibility.

Nonenzymatic transformation of aromatic and phenolic compounds (polar compound to another polar compound) into polar compounds is also possible, due to the alteration of the physico-chemical environment by variations of pH, temperature, redox potentials and other factors in the formation of Xenobiotic compounds (Rosazza). Enzymatic conversion of organic sulfur compounds to sulfoxides in sterile soils were observed (Chin et al., 1970, Rosazza 1982). Sulfoxidation of carboxin by the fungus Utilago mayolis was observed in the soil by Lyr et al., (Rosazza 1982). Therefore, formation of polar compounds in the soil can be accounted for.

Based on the above trends, the losses of the individual fractions were calculated. The results are tabulated in Table 3. The overall losses are presented in Table 4. The loss of fractions during the first phase was greater than during the second phase. Several factors were involved in affecting the difference in losses between Phases 1 and 2. Phase 1 consisted of a period of 488 days and Phase 2 of only 171 days. Since Phase 1 extended over a longer period of time than during Phase 2, the losses there were greater than Phase 2. The initial application in Phase 1 was made in August; this allowed time for degradation of the oil prior to low temperature winter conditions; whereas in Phase 2 the systen was overcome by low temperatures resulting in a period of minimal degradation.

Analysis of Figures 1 through 8 shows that degradation of fractions was the highest from points E to H and J to K. The same phenomenon was observed for the total oil content. During winter months, the land treatment system acted as a storage unit with minimal degradation.

First order empirical rate coefficients were computed for all fractions based on the fact that most biological reactions which occur are first order or psuedo first order. The rate coefficients are presented in Table 5. The magnitudes of the rate coefficients for both phases are as follows:

Asphaltenes > Saturates > Polar Compounds > Aromatics

Asphaltenes showed a greater rate constant because as the asphaltenes degraded other fractions were formed, hence, a greater net loss rate for asphaltenes. Whereas,the other fractions, even though they degraded (due to increases from the degradation of asphaltenes), showed a lower rate constant. The pentane insoluble compounds (measured as asphaltenes) built up during anoxic conditions were probably carboxylic acids, ketones, esters, aldehydes and alcohols (Walker et al., 1976). Therefore, as soon as the plots were tilled after the anoxic period, there was an immediate loss of the compounds, which were readily amenable to degradation under aerobic conditions, as shown by sharp drops in asphaltenes from G to H and J to K in Figures 1 and 2.

SUMMARY OF OIL CONTENT AND FRACTIONATION STUDY

The results of oil content and fractionation show that oil and the associated fractions degraded with time. The degradation of oil and fractions occurred predominantly in the summer and fall months. An inhibition period was observed during winter months, when there was no appreciable degradation observed for oil content, even though the

Table 3 Percent Losses of Oily Fractions

Plot #	Asphaltenes		Saturates		Aromatics		Polar Compounds	
	1	2	1	2	1	2	1	2
30	56.3	50.0	94.8	39.1	77.3	62.3	32.1	48.3
35	42.1	22.2	93.4	6.2	75.7	45.4	27.5	35.0
Mean	49.2	36.1	94.1	22.7	76.5	53.9	29.8	41.7

1 = Phase 1   2 = Phase 2

Table 4 Overall Losses of Oil Fractions

	Plot 30	Plot 35
Oil Applied (Wt.%)	14.2	18.71
Sample	2.51	5.24
Loss	11.69	13.47
% Loss	82	72
Asph. Applied	0.31	0.44
Sample	0.11	0.28
Loss	0.20	0.16
% Loss	65	36
Sat. Applied	7.53	9.57
Sample	0.84	2.17
Loss	6.69	7.40
% Loss	89	77
Arom. Applied	4.28	5.76
Sample	0.84	2.17
Loss	6.69	7.40
% Loss	83	81
Pol. Applied	2.07	2.93
Sample	0.87	1.67
Loss	1.20	1.26
% Loss	58	43

Table 5 Rate Coefficient for Oily Fractions Degradation

Plot #	Asphaltenes		Saturates		Aromatics		Polar Compounds	
	1	2	1	2	1	2	1	2
30	0.031	0.016	0.017	0.0114	0.0059	0.0097	-	0.013
35	0.026	0.011	0.014	0.0104	0.004	0.0086	0.0055	0.0104
Mean	0.0295	0.0135	0.0155	0.0124	0.00495	0.00915	0.0055	0.0117

1 = Phase 1 2 = Phase 2

individual fractions showed increases and decreases. During this period saturates, asphaltenes and polar compounds showed increases which were probably due to the anaerobic decomposition of oil. Aromatics were found to degrade even during winter months. A contribution of the degradation of aromatics to the remaining fractions as intermediate compounds is possible. Asphaltenes and polar compounds were found to degrade with time. This is contrary to the studies reported in the literature.

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CREOSOTE STUDY

Two types of soil were investigated, one highly-concentrated soil and one soil that was slightly contaminated.

250 mg. of each soil type was added to 250 ml. of basal salts medium. Polybac E was added to yield 30 ppm final concentration. The flasks were inoculated with 20 ml. of rehydrated Hydrobac and incubated with vigorous shaking at 20°C.

Samples were collected by filtering the growth medium through Whatman filter paper and analyzed via EPA method 610 or 625. Results were reported in ppm of original soil sample.

The shake flask test was initiated on May 16, 1984 and all references to days of treatment are relative to that date.

RESULTS:

Low Concentration Sample: Significant degradation was observed between untreated and treated samples at 6 days. Significant decreases in all PNA-type compounds were observed in the treated sample after 6 days of incubation (See Figures 1 & 2). After 14 days of incubation, the concentration of compounds in treated samples also decreased. After 14 days, the untreated sample resulted in concentrations that were lower than the 0 hr, untreated sample, but in most cases, the concentration of compounds in the untreated, 14-day sample were higher than the concentration of compounds in the treated 14-day sample (See Figures 3 & 4). These increased concentrations may be best explained by differences in acuity of analytical methods employed. Although some volatilization may have occurred during the 14-day incubation period, it is most likely that biodegradation by organisms existing in the contaminated soil became metabolically active in the nutrient-rich basal salts medium. As a result, these indigenous microorganisms metabolized many of the PNA compounds present in the sample. Also, the interactive effects of ultraviolet radiation, photolysis and other abiotic effects most likely played a role in the decrease of these compounds. Microorganisms of various morphological types were observed in all samples by phase-contrast microscopy after 14 days of incubation.

After 55 days of treatment (Figures 9 & 10), additional metabolism of the compounds was observed. In some particular compounds there were apparent increases in concentration. This is most likely attributed to either analytical acuity (low-level concentration determinations via EPA method 610 is somewhat variable), the passage of some larger compounds through intermediates or desorption of the compounds by the organisms. The most likely reason is due to analytical acuity. Notwithstanding this, all samples exhibited signs of high levels of microbial activity.

High Concentration Levels: The levels of compounds observed in the highly concentrated, untreated soil at 0 days of incubation are shown in Figure 5. Figure 6 indicates a higher constituent concentration after 6 days of treatment than at the beginning of the test in Figure 5. The increase is due to several factors. The concentrations shown are soluble concentrations. All samples were filtered prior to analysis and any components which did not immediately solubilize will not appear in the analysis. Subsequently, the microbes began to produce surfactants, which in conjunction with mechanical agitation of the test flasks, caused a complete solubilization of the material. Thus, the apparent soluble concentration increased while the total concentration in all likelihood decreased. Figure 7 indicates substantial microbial activity was occurring at this time. After 14 days of incubation, the levels of compounds in untreated samples decreased; again, most likely because of some volatilization, photolysis and other abiotic factors, and because of significant metabolic activity of indigenous organisms (Figures 7 & 8). These incubated samples also exhibited microbiological activity when viewed under the phase-contrast microscope. In most cases, the levels of compounds observed in the highly concentrated, treated sample at 14 days were lower than the compound in the 14-day, untreated sample. Also, compounds were lower in the 14 day treated sample, than in the 6 day treated sample.

Analysis after 55 days of treatment (Figures 11 & 12) showed a marked reduction from the concentrations observed after 14 days treatment. There is no apparent inhibition of metabolic activity due to the high levels of creosote present. It would be expected that the microbial degradation would proceed to completion. Additionally, the untreated sample showed continuing decreases in concentrations, as would be expected. It is, however, proceeding at a lower rate than the treated sample.

It is our belief that significant microbiological activity has resulted in biodegradation and therefore, decreases in the PNA compounds analyzed. An abundance of microorganisms were observed in all shake flasks examined. These observations lead us to believe that the toxicity of the samples did not prohibit growth.

In an adjunct study, the degradation of creosote in a soil matrix is being examined. Samples from this soil plot have been used in Polybac Corporation's proprietary Rapid Toxicity Test. We have observed that the creosote-contaminated soil exerts a slight toxic effect upon organisms contained in Hydrobac, but this level of toxicity is quite low.

FIGURE 1
Low Concentration Soil, Untreated
0 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	1000
acenaphthylene	<1000
acenaphthene	<2000
fluorene	740
phenanthrene	1600
anthracene	280
fluoranthene	560
pyrene	330
benzo(a) anthrancene	690
chrysene	720
benzo(b)fluoranthene	36
benzo(k)fluoranthene	25
benzo(a)pyrene	53
dibenzo(a,h)anthracene	<1000
benzo(g,h,i)perylene	<200
indeno(1,2,3-c,d)pyrene	<100

Reference #18341-2

FIGURE 2
Low Concentration Soil, Treated
6 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	<50
acenaphthylene	<50
acenaphthene	<100
fluorene	130
phenanthrene	180
anthracene	90
fluoranthene	230
pyrene	220
benzo(a) anthrancene	38
chrysene	22
benzo(b)fluoranthene	5.3
benzo(k)fluoranthene	<5.0
benzo(a)pyrene	<5.0
dibenzo(a,h)anthracene	<20
benzo(g,h,i)perylene	18
indeno(1,2,3-c,d)pyrene	< 5.0

Reference #18394-2

FIGURE 3
Low Concentration, Treated
14 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	< 100
acenaphthylene	<100
acenaphthene	<200
fluorene	<20
phenanthrene	<4.0
anthracene	<2.0
fluoranthene	120
pyrene	130
benzo(a) anthrancene	150
chrysene	45
benzo(b)fluoranthene	5.3
benzo(k)fluoranthene	4.7
benzo(a)pyrene	7.0
dibenzo(a,h)anthracene	<20
benzo(g,h,i)perylene	<20
indeno(1,2,3-c,d)pyrene	<20

Reference #18441-2

FIGURE 4
Low Concentration, Untreated
14 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	<100
acenaphthylene	<100
acenaphthene	<200
fluorene	<20
phenanthrene	22
anthracene	11
fluoranthene	240
pyrene	250
benzo(a) anthrancene	40
chrysene	45
benzo(b)fluoranthene	12
benzo(k)fluoranthene	6.8
benzo(a)pyrene	13
dibenzo(a,h)anthracene	<20
benzo(g,h,i)perylene	<20
indeno(1,2,3-c,d)pyrene	<10

Reference #18441-1

FIGURE 5
High Concentration Soil, Untreated
0 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	35,000
acenaphthylene	<1,000
acenaphthene	2,000
fluorene	8,800
phenanthrene	23,000
anthracene	4,400
fluoranthene	11,000
pyrene	9,800
benzo(a) anthrancene	1,400
chrysene	1,800
benzo(b)fluoranthene	850
benzo(k)fluoranthene	630
benzo(a)pyrene	1,000
dibenzo(a,h)anthracene	630
benzo(g,h,i)perylene	780
indeno(1,2,3-c,d)pyrene	96

Reference #18341-3

FIGURE 6
High Concentration Soil, Treated
6 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	67,000
acenaphthylene	8,700
acenaphthene	25,000
fluorene	18,000
phenanthrene	40,000
anthracene	6,000
fluoranthene	16,000
pyrene	16,000
benzo(a) anthrancene	3,500
chrysene	3,900
benzo(b)fluoranthene	1,400
benzo(k)fluoranthene	800
benzo(a)pyrene	1,600
dibenzo(a,h)anthracene	<1,900
benzo(g,h,i)perylene	<860
indeno(1,2,3-c,d)pyrene	1,000

Reference #18394-1

FIGURE 7
High Concentration, Treated
14 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	15,000
acenaphthylene	<10,000
acenaphthene	<20,000
fluorene	14,000
phenanthrene	33,000
anthracene	1,400
fluoranthene	22,000
pyrene	40,000
benzo(a) anthrancene	8,700
chrysene	3,200
benzo(b)fluoranthene	1,700
benzo(k)fluoranthene	830
benzo(a)pyrene	3,000
dibenzo(a,h)anthracene	<2,000
benzo(g,h,i)perylene	<2,000
indeno(1,2,3-c,d)pyrene	1,000

Reference #18441-4

FIGURE 8
High Concentration, Untreated
14 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	24,000
acenaphthylene	<10,000
acenaphthene	<20,000
fluorene	16,000
phenanthrene	34,000
anthracene	1,700
fluoranthene	22,000
pyrene	43,000
benzo(a) anthrancene	7,700
chrysene	2,200
benzo(b)fluoranthene	1,600
benzo(k)fluoranthene	930
benzo(a)pyrene	3,200
dibenzo(a,h)anthracene	<2,000
benzo(g,h,i)perylene	<2,000
indeno(1,2,3-c,d)pyrene	<1,000

Reference #18441-3

FIGURE 9
Low Concentration Soil, Treated
55 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	<100
acenaphthylene	<100
acenaphthene	<200
fluorene	<20
phenanthrene	<10
anthracene	<5.0
fluoranthene	170
pyrene	66
benzo(a) anthrancene	22
chrysene	70
benzo(b)fluoranthene	20
benzo(k)fluoranthene	12
benzo(a)pyrene	14
dibenzo(a,h)anthracene	<10
benzo(g,h,i)perylene	<10
indeno(1,2,3-c,d)pyrene	9.0

Reference #18788-1

FIGURE 10
Low Concentration Soil, Untreated
55 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	<100
acenaphthylene	<100
acenaphthene	<200
fluorene	<20
phenanthrene	<10
anthracene	<5.0
fluoranthene	340
pyrene	190
benzo(a) anthrancene	75
chrysene	200
benzo(b)fluoranthene	40
benzo(k)fluoranthene	40
benzo(a)pyrene	40
dibenzo(a,h)anthracene	<10
benzo(g,h,i)perylene	24
indeno(1,2,3-c,d)pyrene	25

Reference #18788-2

FIGURE 11
High Concentration, Treated
55 days

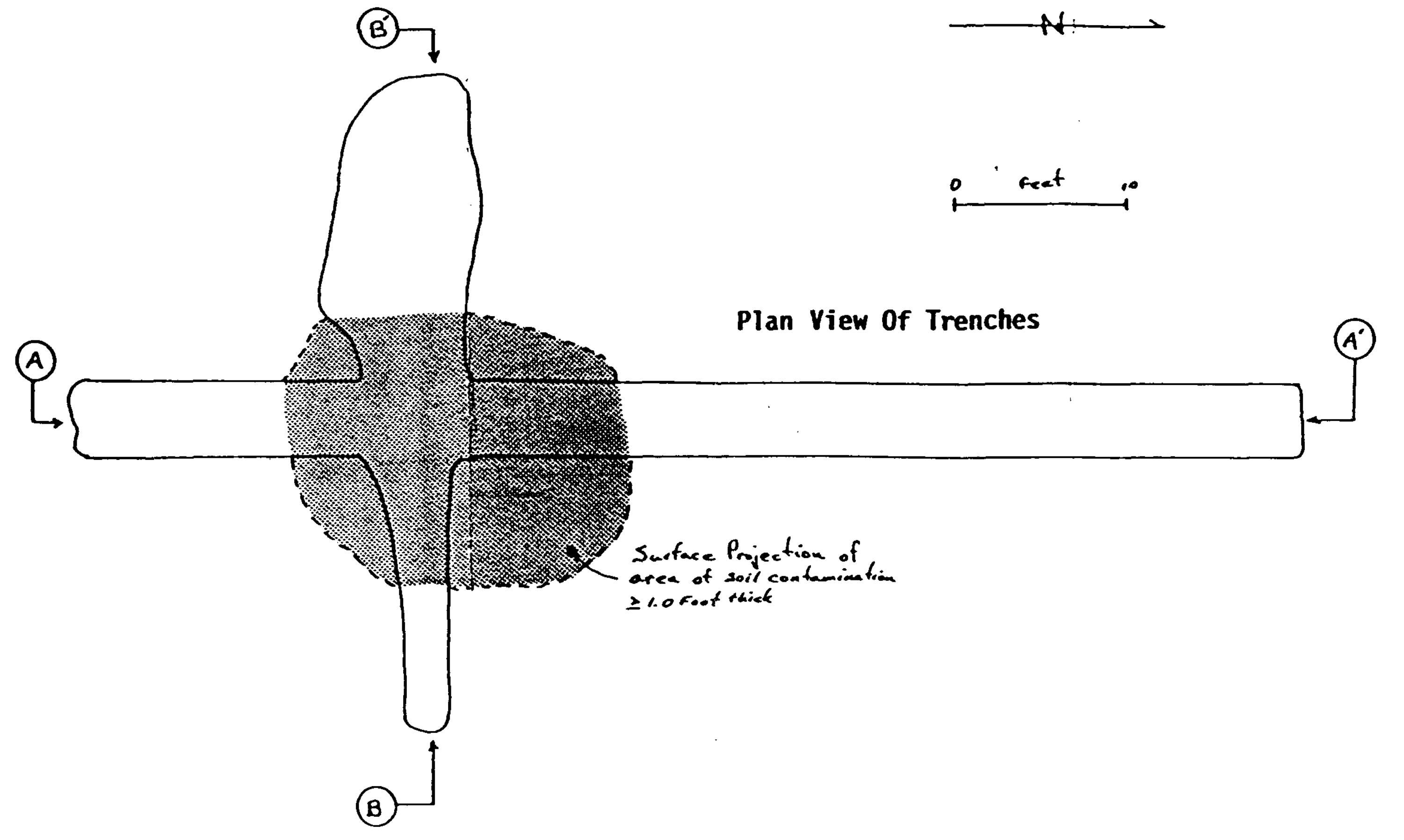
PNA COMPOUND	ug/gm(ppm)
naphthalene	<1,000
acenaphthylene	<1,000
acenaphthene	<2,000
fluorene	<200
phenanthrene	<100
anthracene	180
fluoranthene	1,700
pyrene	550
benzo(a) anthrancene	170
chrysene	600
benzo(b)fluoranthene	130
benzo(k)fluoranthene	100
benzo(a)pyrene	110
dibenzo(a,h)anthracene	<100
benzo(g,h,i)perylene	<100
indeno(1,2,3-c,d)pyrene	<100

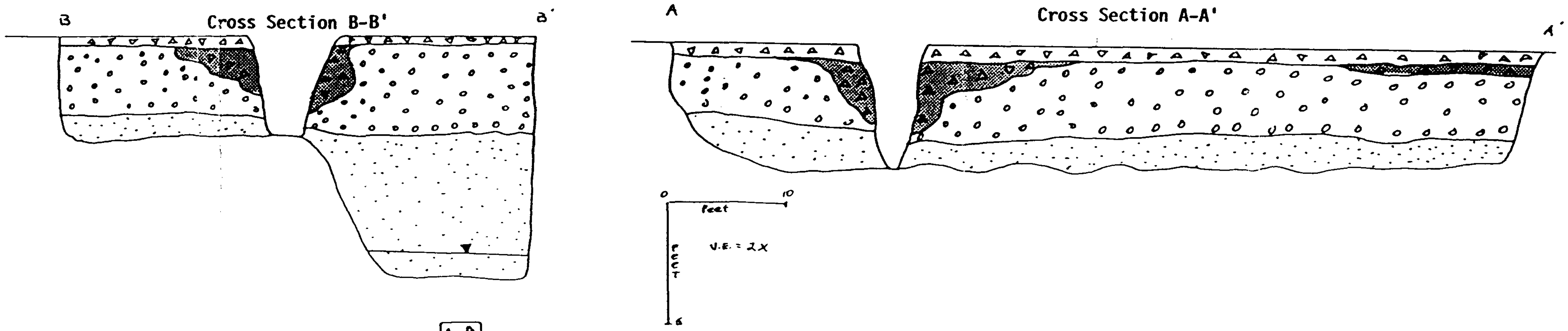
Reference #18788-3

FIGURE 12
High Concentration, Untreated
55 days

PNA COMPOUND	ug/gm(ppm)
naphthalene	<1,000
acenaphthylene	<1,000
acenaphthene	2,000
fluorene	5,000
phenanthrene	17,000
anthracene	1,300
fluoranthene	6,200
pyrene	2,300
benzo(a) anthrancene	1,000
chrysene	1,800
benzo(b)fluoranthene	550
benzo(k)fluoranthene	360
benzo(a)pyrene	440
dibenzo(a,h)anthracene	170
benzo(g,h,i)perylene	290
indeno(1,2,3-c,d)pyrene	340

Reference #18788-4





- ▵ Artificial Fill
- ⁘ Cobbles and Boulders
- ░ Sand and Sandstone
- ▓ Hydrocarbon Stain

PLATE 2
Plan and Sections of Trenches
In The Burn Pit Area

May '86 Report

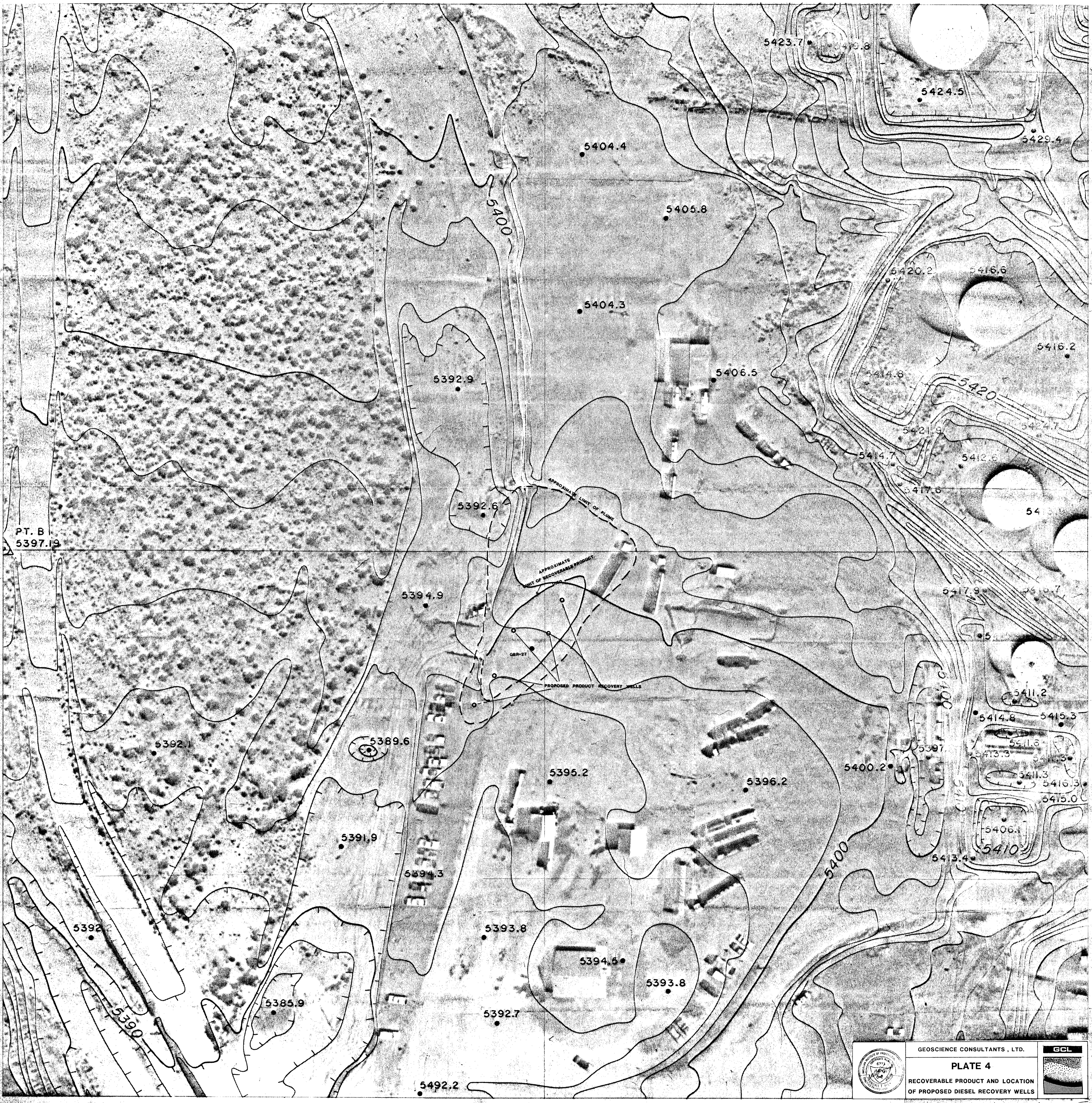


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PLATE 4

RECOVERABLE PRODUCT AND LOCATION OF PROPOSED DIESEL RECOVERY WELLS

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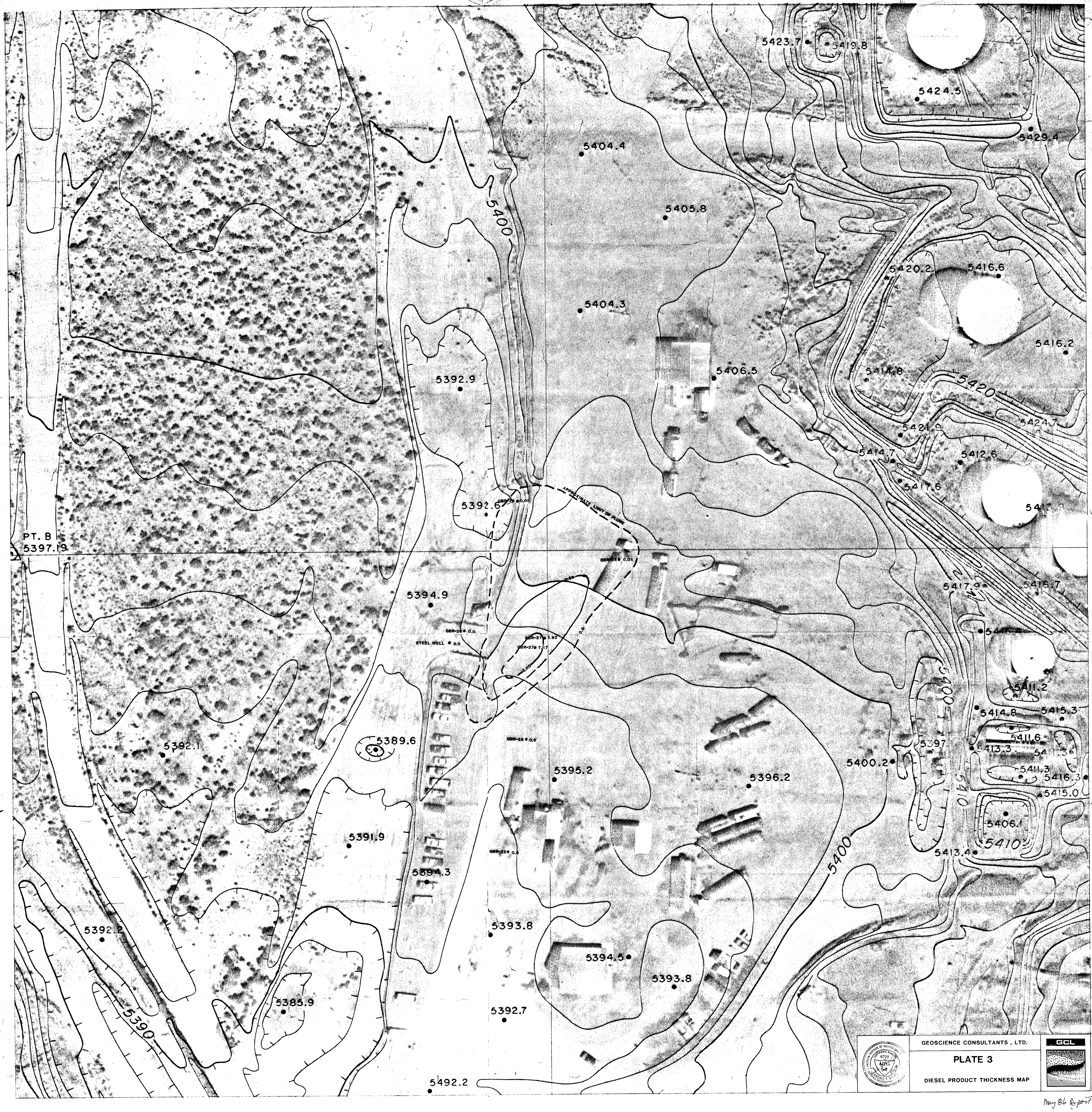

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PLATE 3

DIESEL PRODUCT THICKNESS MAP

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