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REPORTS

DATE:

FEB 1995

PRODUCED WATER PIPELINE RELEASE INVESTIGATION
DUNNAWAY DRAW (MARTHA CREEK)
EDDY COUNTY, NEW MEXICO

by

RE/SPEC Inc.
4775 Indian School Road, NE
Suite 300
Albuquerque, New Mexico 87110

prepared for

Yates Petroleum Corporation
105 South 4th Street
Artesia, New Mexico 88210

February 1995

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1.0 Introduction

On January 3, 1995, a produced water leak occurred in the Yates Petroleum Corporation's buried eight-inch pipeline which passes beneath Dunnaway Draw*, a tributary to Rocky Arroyo, northwest of Carlsbad, New Mexico. The approximate coordinates of the release are the SE¼, NE¼, SW¼ of Section 25, T21 S, R23 E, Eddy County. The reported loss from the pipeline was estimated at 350 barrels of produced water. The net loss estimated by the company after recovering 200 barrels by vacuum truck in the vicinity of the leak and pumping from the ponded area in Dunnaway Draw was approximately 150 barrels. The leak was reported to the N.M. Oil Conservation Division (OCD) in Artesia, the U.S. Bureau of Land Management in Carlsbad, and the National Response Center. Follow-up information was provided to EPA Region VI in Dallas on January 13 to comply with NPDES General Permit requirements for notification of produced water releases. The pipe failed due to the lodging of a rock in a pressure reducing value which subsequently malfunctioned causing a rupture in the line. Two water analyses taken from the pipeline within 60 days prior to the release averaged 7,125 mg/L total dissolved solids.

Subsequent to the release, RE/SPEC Inc. (RSI) was retained to investigate the severity of subsurface soil contamination at the location, and to evaluate the potential for groundwater quality impacts. Site visits were made on January 16 and 21, 1995. Soil sampling was performed during the January 21 visit. This report presents a summary of the investigation and results of soil sampling performed at the site.

* The name of the east-west watercourse where the spill occurred is Dunnaway Draw. The spill was originally reported occurring in Martha Creek which is an east-west drainage emptying into Dunnaway Draw immediately upstream of the spill location. The watercourse name was apparently was misread as Martha Creek when the spill was reported to the regulatory agencies. The actual name of the watercourse will be used in this report.

2.0 Hydrogeologic Setting

The leak location in Dunnaway Draw (Figure 1) is located in West Central Eddy County approximately 18 miles west of Carlsbad and 1 mile upstream of the confluence of Dunnaway Draw and Rocky Arroyo. Rocky Arroyo continues east then northeastward approximately 14 miles and drains into the Pecos River immediately downstream of Brantley Dam. The spill site is at a surface elevation of approximately 3750 ft. and located on the south side of an area of relatively low relief known as Indian Basin. Rocky Arroyo trends east-west through the area as a braided watercourse with some channels separated from each other by greater than 1000 ft. of gently rolling topography. Immediately to the southeast of the site the topography steepens as the surface rises to an elevation greater than 4600 ft. on some areas of Azotea Mesa. Channels cut into water resistant rock form steep banks or 40 to 60 ft. cliffs upstream in Martha Creek and Dunnaway Draw.

Watercourses in this area are dry except in direct response to precipitation. Precipitation is infrequent; average yearly rainfall in this area is about 16 inches (Hendrickson and Jones, 1952), occurring mainly in the form of light showers in the winter and thunderstorms during the summer months which can be locally heavy. The presence of cobbles and large rocks in the watercourses such as Rocky Arroyo attest to the high energy runoff produced by the large storms.

Near-surface geology of the area includes the Permian Queen Formation and Quaternary alluvium. The Queen Formation** outcrops on the surface in the area except where overlain by alluvium in the drainageways. The Queen in other areas has been mapped as having a lower sandstone member, a middle dolomite member and an upper sandstone member (Bjorklund and Motts, 1959). The upper member is named the Shattuck member and can be found several miles downstream of the site in Rocky Arroyo at the base of the Seven Rivers hills. Along Dunnaway Draw the Queen consists of a dolomite with some interbedded clastic materials. Large blocks of dolomite several feet wide on a side had been dislodged from the south side cliff face and fallen to the channel. Where overlying material had been removed from the base of the cliff, the channel bottom was a planar surface of dolomite with little sediment or alluvial cover. To the north, the 15 to 20 ft. wide channel is bounded by alluvial material which rises 30 to 40 ft. high in the 1500 ft. interval which separates Dunnaway Draw from Rocky Arroyo 1,500 ft.

The regional dip of the rocks in the Guadalupe Mountains is east and southeast with a dip generally less than 3°. However, the beds dip more steeply than the topographic surface leading to the exposure of progressively younger rocks at the surface eastward. Numerous minor flexures in the mountains cause dips in various directions and, locally, rocks can dip towards arroyos, indicating structural control for some drainageways. North of the Guadalupe Mountains, the dip is generally eastward from the Sacramento Mountains to the Pecos River.

** To the north of the site, the Queen and Seven Rivers were listed as members of the Chalk Bluff formation. In the Carlsbad area they are mapped as separate formations (Hendrickson and Jones, Bjorklund and Motts, and others).

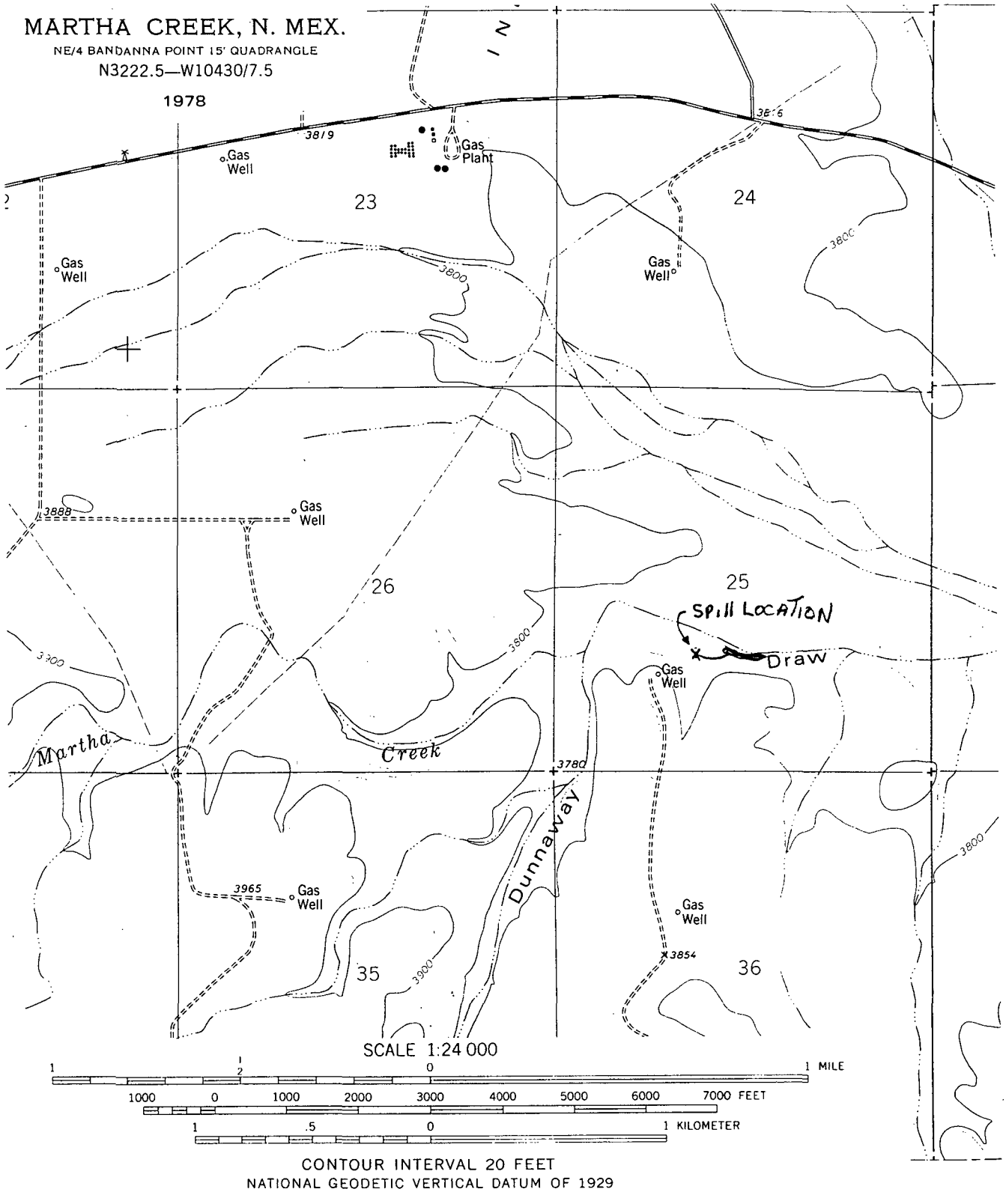

Figure 1. Location Map of Dunnaway Draw Produced Water Release Site and Vicinity

The groundwater potentiometric surface beneath the site is at an estimated depth of between 110 to 120 feet. The depth was estimated from hydrologic data collected by Marathon Oil as part of their natural gas condensate recovery efforts and provided to the NM OCD. There is conflicting information on the direction of groundwater movement in the area. Hendrickson and Jones (Plate 3) show the general direct of groundwater in the deeper aquifers as northeast while Bjorklund and Motts (1959, Figure 26), show groundwater present in the Queen in Rocky Arroyo as migrating easterly, moving into and commingling with water in the overlying alluvium, and discharging at Indian Big Springs (NW¼, Section 27, T21S, R24E) about four miles downstream from the site. More recent data provided by Marathon to the OCD shows groundwater moving northeasterly in the vicinity of their groundwater monitor wells near the Indian Basin Gas Plant.

The dolomite member of the Queen recharges water to the subsurface in its outcrop area through joints, fractures, and numerous cavities along unconformities in brecciated zones. The process of recharge is probably accelerated along well developed, major drainages such as Rocky Arroyo containing alluvium which receives and temporarily stores water during runoff events. The coarse granular material readily transmits water and discharges it through fractures and joints in the underlying dolomite to a deeper water table. The sandstone and finer grained clastics of the lower Queen act as retarding beds which allow a considerable saturated thickness of water to be stored for use as a high quality water supply. The rapidity of recharge of water through the alluvium to the Queen likely creates a localized area of groundwater mounding beneath Rocky Arroyo. The groundwater mound would be observed as a linear feature generally following the surface direction of the arroyo and contain water at a slightly higher elevation than groundwater on either side.

Groundwater in the area is provided from wells completed in several zones in the Queen and from the alluvium. Deep wells are completed in the Queen at the Indian Basin Gas Plant and some other nearby ranches. Bjorklund and Motts also report on several shallow wells in perched Queen water within two miles north of Rocky Arroyo. The alluvium is most likely to contain water at downstream locations near Indian Big Spring. Hear Rocky Arroyo narrows and becomes confined in a canyon between Azotea Mesa on the south and Seven Rivers Hills on the north. Due to the easterly regional dip, the less permeable sandstones of the Shattuck member are exposed close to and at the surface which forces groundwater to pass upwards through the alluvium and surface at Indian Big Springs. One alluvial well (NE¼, NE¼, Section 29, T21S, R24E) upgradient from the spring supplies sufficient water to allow large volume commercial sales for drilling, road construction, etc. No water wells are located within 1000 ft. of the leak location.

3.0 Field Investigation and Results

The field investigation by RSI consisted of a brief site visit by David Boyer on January 16, 1995, followed by a return visit to collect soil samples on January 21.

On January 16 David Boyer met Norbert McCaw of Yates onsite and walked the length of the spill site. Liquid from the break flowed down a lessor channel of Dunnaway Draw for a distance of about 300 ft. until merging with the main channel. The water flowed a short distance upstream, a longer distance downstream, and eventually ponded in three depressions in the main channel. The total combined length of affected area in the main Dunnaway Draw channel was approximately 250 ft. No fluids reached Rocky Arroyo.

The spill chronology provided by Yates shows them being notified of the leak by Marathon at approximately 12:15 p.m. January 3. The producing wells were shut-in and the upstream valve shut off by 1:00 p.m. At 2:00 p.m. a backhoe arrived to excavate soil around the leak and vacuum trucks arrived at 3:00 p.m. to pump water from around the trench dug to expose the pipe. At 4:00 p.m. a portable pump and line were laid to the standing pools to pump out ponded water. On January 4 and 5, the nutrient rich sorbent "Oilgator" was sprayed across the site from the break location to the last downstream pooled area. Light rain and snow fell intermittently at the location on January 5.

Little surface evidence of the spill was seen during the January 16 visit. Some slight staining was seen on rocks which had been in contact by the fluid. A hydrocarbon odor was noticed on soil 1 to 2" deep when disturbed. The area was cleaned to the extent that only a very observant person would have noticed that a spill occurred.

At the request of Yates, a second visit was made by David Boyer on January 21 accompanied by Ron Parsons of RE/SPEC. Using a hand auger, soil samples were obtained for hydrocarbon analyses at three locations in Dunnaway Draw and in the tributary drainage that channeled the produced water from the leak to Dunnaway Draw. Auger refusal occurred at 8 in. or less at all sampling locations in Dunnaway Draw. During the visit, green shoots of Bermuda grass were observed sprouting through soil on the north side and bottom of the channel. No standing water was observed in either the tributary channel or Dunnaway Draw.

Analysis of soil samples collected during the site visit on January 21 (Table 1) detected no, or only minor, concentrations of the volatile aromatic organic compounds benzene, toluene, ethyl-benzene, and xylene (BTEX). Benzene was not detected in any compound at a detection level of 0.05 milligram per kilogram (mg/kg) or lower. The highest total BTEX value was 0.068 mg/kg in hole 3. The highest Total Petroleum Hydrocarbon concentration was 595 mg/kg in hole 1A.

The produced water pipeline had been sampled within the previous 60 days for organic hydrocarbon constituents and general water chemistry characteristics. Therefore, no additional samples were obtained from the pipeline for analysis for inclusion in this report. A summary of the results of the earlier water sampling is provided in Table 2.

Table 1. Soil Data Summary -- Dunnaway Draw Soil Sampling

Sample No.	Depth (in.)	Soil Location	Odor	Benzene (mg/kg)	Toluene (mg/kg)	Ethyl-Benzene (mg/kg)	Xylenes (mg/kg)	Total BTEX (mg/kg)	TPH (mg/kg)
1 A	0 - 6	Located in channel bottom at entry of side tributary that discharged wastewater.	Slight at top	ND @ 0.001	ND @ 0.001	ND @ 0.001	0.0084	0.0084	595
1 B	6 - 8	Same as above. Auger refusal at 8 in.	None	ND @ 0.001	0.0013	ND @ 0.001	0.0066	0.0079	122
2	0 - 6	Middle pool area; base of south cliff approximately 75 ft. downstream	None	ND @ 0.05	ND @ 0.05	ND @ 0.05	ND @ 0.05	ND @ 0.05	50
3	0 - 3	Lower pool area; north side of channel; north of ledge outcrop	Slight	ND @ 0.05	ND @ 0.05	ND @ 0.05	0.068	0.068	281
4	0 - 6	Approximately 40 ft. up tributary drainage	None	ND @ 0.05	ND @ 0.05	ND @ 0.05	ND @ 0.05	ND @ 0.05	28

Notes:

Collection Date January 21, 1995

TPH: Total Petroleum Hydrocarbons by USEPA Method 418.1.

All samples clayey silt to silty clay, dark brown with roots from Bermuda grass. Green shoots starting to protrude from north side and bottom of draw.

N.M. OCD Standards for soil remediation conditions at this location: Benzene 10 mg/kg, Total BTEX 50 mg/kg, TPH 5000 mg/kg.

Table 2. Water Quality Data Summary -- Yates Produced Water

Sample Date	Sample Identification	TDS (mg/L)	Calcium + Magnesium (mg/L)	Sodium + Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethyl-Benzene (mg/L)	Xylenes (mg/L)	TPH (mg/L)
11/09/94	Pipeline Produced Water	5,410	604	1,378	1,380	1,920	--	--	--	--	--
12/01/94	Pipeline Produced Water	8,840	633	2,632	3,510	1,930	2.12	4.14	<0.200	2.17	0.160
--	NMWQCC Ground Water Standards	1000	--	--	250	600	0.01	0.75	0.75	0.62	--

Notes:
NMWQCC - New Mexico Water Quality Control Commission (standards shown for comparision purposes)
TPH - Total Petroleum Hydrocarbons

4.0 Discussion

4.1 Soils

The pipeline leak released water containing elevated concentrations of both organic and inorganic constituents into a generally dry surface and subsurface environment. A number of circumstances occurred that minimized the impact of these constituents on surface and subsurface soil and sediments, and ultimately on the groundwater.

The leak was detected quickly allowing only a minimal volume of water to be released to the surface and flow down to Dunnaway Draw. As calculated using Yates production records and the time elapsed from detection of the leak to pipeline shutoff. an estimated 350 barrels of wastewater was released to the environment. The net loss of fluids was estimated at 150 barrels. A number of mechanisms occur on the surface and in the shallow subsurface to naturally attenuate these constituents.

When traveling on the surface and passing through near-surface unsaturated materials, the mass of dissolved organic constituents in the water will be attenuated through volatilization, sorption on clays and other fine-grained materials, and decomposition through biological and chemical reactions. Benzene, especially, is subject to decomposition through these commonly occurring mechanisms. Such decomposition is enhanced when the original source of the hydrocarbons (such as petroleum condensate) is not present to continually replenish hydrocarbons decomposed by these mechanisms. The several areas of pooled water in the short reach of Dunnaway Draw volatilized a greater amount of organic constituents due to its shallow depth (1 to 1.5 ft.) than would a single pool of greater depth.

The short residence time of the fluids before recovery also minimized impacts on the soils and sediment in the channel bottom. The sampling results detected no significant concentrations of BTEX volatiles and only moderately elevated concentrations of TPH. NM OCD "Guidelines for Remediation of Leaks, Spills and Releases" (August 13, 1993) provide remediation goals using a ranking system that includes depth to groundwater, distance to a perennial surface water body, and distance to the nearest water supply well. Using the guidance and the information discussed in Section 2 above, benzene would be required to be remediated to less than 10 mg/kg, total BTEX to less than 50 mg/kg, and TPH to less than 5000 mg/kg. The values for all three constituents are considerably lower than the target cleanup levels indicating that soils and sediments do not pose a continuing contamination threat needing remediation.

4.2 Groundwater Movement

The shallow depth of pooled fluids and quick action by Yates to remove ponded liquid also minimized the amount of hydraulic head available as a driving force for infiltration into the channel bottom. No doubt some seepage occurred through joints and fractures in the dolomite lining the bottom of the watercourse. However, seepage was less than would have occurred if

significant coarse sediment had been present. In the latter case, the water would have saturated the material and drained continuously to the lower zone until free water in alluvial material was depleted.

Groundwater at the spill site is at an estimated depth of approximately 110 to 120 feet, based on information in Marathon reports provided to OCD. The most recent quarterly report by Marathon shows Queen groundwater trending northeasterly at approximately right angles to the Rocky Arroyo channel north of the Yates produced water release location (Figure 2). The shallow alluvial groundwater is moving southeasterly in the section of arroyo north of the Dunnaway Draw spill location (Figure 3).

The bottom of Rocky Arroyo is the geologic equivalent of a sieve. Water discharged into the alluvial sediments drains quickly through the joints and fractures in the dolomite down to the saturated zone of the Queen. Some alluvial wells completed by Marathon that showed fluids when drilled are dry except in response to runoff. Queen wells near Rocky Arroyo that are completed in zones having joints and fractures connected to the shallow aquifer will respond rapidly to runoff in Rocky Arroyo.

Dunnaway Draw is a lesser tributary drainage to Rocky Arroyo and it is unlikely that subsurface joints and fractures have developed solution pathways as significant as those found in Rocky Arroyo. Therefore, water entering solution openings will be somewhat retarded in downward movement and probably exhibit a greater lateral spread as fluid moves along and down bedding planes and predominant fracture patterns. This may well cause the bulk of the seeped fluid to migrate eastward along the regional dip before coming in contact with Queen groundwater.

Because water drains downward from Rocky Arroyo to the underlying Queen, a linear groundwater mound oriented in the surface direction of the channel above may have been created under the arroyo. Groundwater along the mound would contain water at a slightly higher elevation than groundwater on either side. This would cause a localized gradient reversal and changes in the direction of groundwater movement at the location of the mound. Any groundwater moving northeastward from the area of the spill in Dunnaway Draw would undergo a change in direction to the east, since it can't migrate upgradient in the vicinity of the groundwater mound.

The one deep Queen monitor well (MW-70) located on the south side of the arroyo apparently shows this effect. Groundwater in the well is 0.23 ft. lower than the water level elevation in MW-57 located directly to the northeast (i.e. downgradient), but immediately adjacent to Rocky Arroyo. The elevated groundwater elevation in MW-57 with respect to MW-70 on the south side can be interpreted as a classic response in an arid region of a groundwater system to surface recharge.

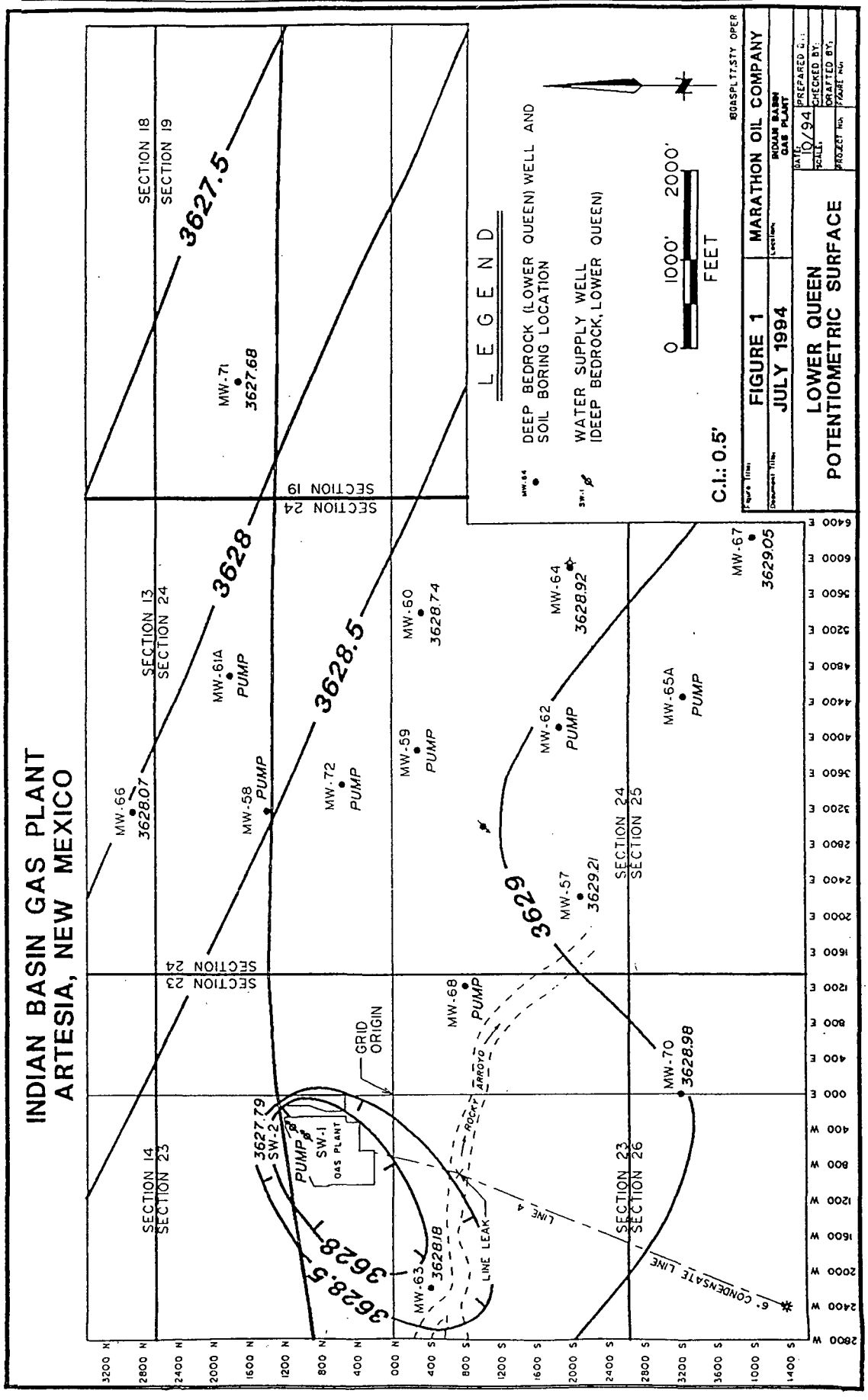

Figure 2. July 1994 Lower Queen Potentiometric Surface (From Marathon 11/94 report to NMOCD)

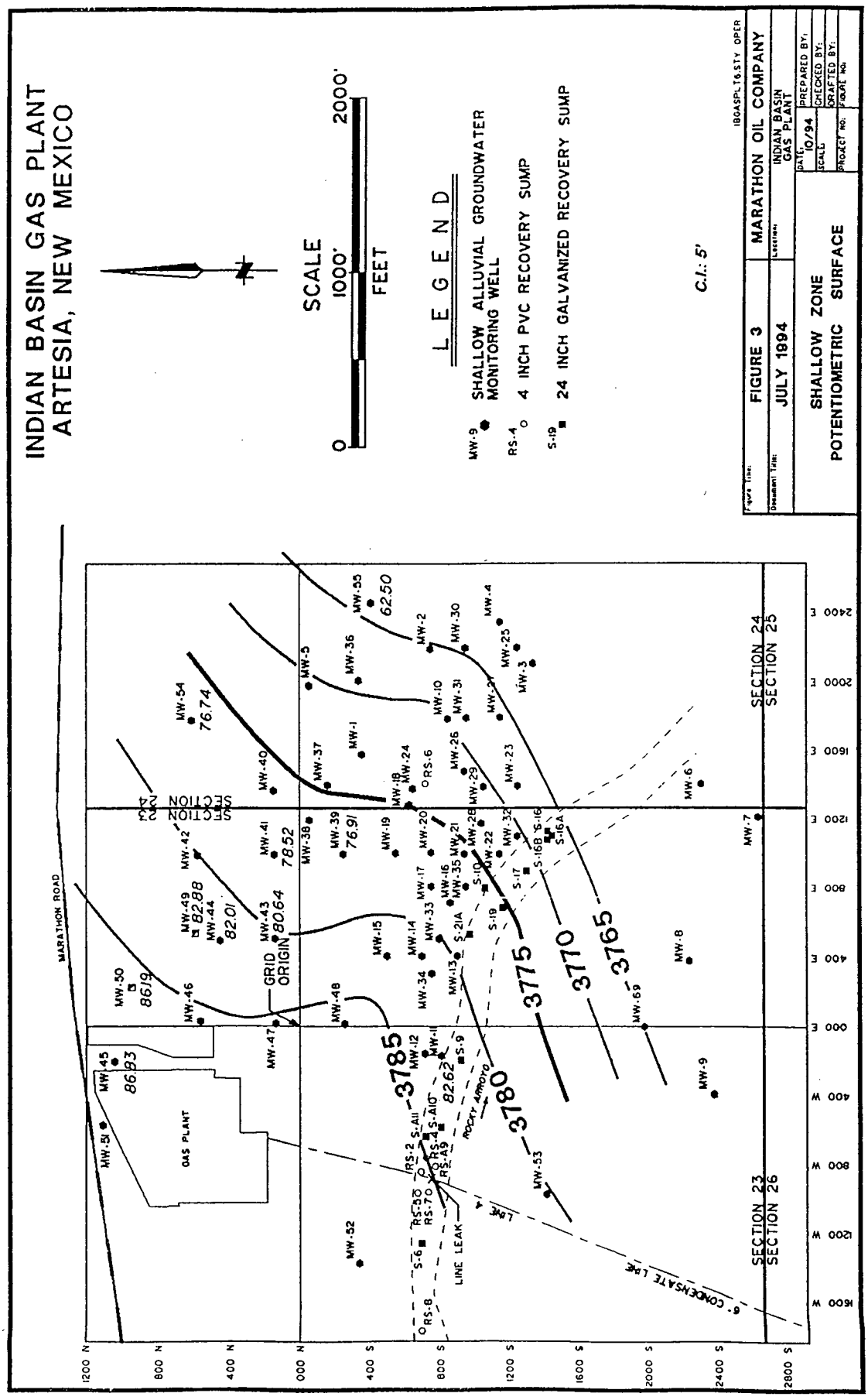

Figure 3. July 1994 Shallow Zone Potentiometric Surface (From Marathon 11/94 report to NMOCD)

Concern has been expressed to Yates about the proximity of the Dunnaway Draw leak to Marathon's Monitor Well 67 which is located approximately 3000 ft. northeast of the spill and ponded area in Dunnaway Draw. Although the Marathon monitor well appears downgradient from the spill location, the geologic and hydrologic factors discussed above will minimize the likelihood of spill impact on this or other Marathon monitor wells.

4.3 GroundWater Quality

The quality of two produced water samples taken from the Yates pipeline after the Stinking Draw spill averaged 2,445 mg/L (PPM) chlorides. Chloride, which is a conservative constituent and does not react with sediments or other constituents in normal groundwater, has concentrations of approximately 20 mg/L in the shallow/Queen aquifer system in the vicinity of the spill . A simple mixing equation can be used to calculate the volume of water necessary to reduce the concentration to 250 mg/L, the New Mexico Water Quality Control Commission groundwater standard which can be used as a water quality guide:

$$C_f = \frac{C_1V_1 + C_2V_2}{V_1 + V_2}$$

where:

C_f = Final chloride concentration of 250 mg/L,
C_1 = Average chloride concentration of produced water = 2,445 mg/L,
V_1 = Estimated volume of produced water not recovered = 150 barrels,
C_2 = Approximate chloride concentration of groundwater = 20 mg/L,
V_2 = Volume of groundwater necessary to reduce concentration to 250 mg/L.

Using the values shown above, and assuming all 150 barrels not recovered migrated to groundwater, water quality would be maintained in groundwater if the produced water mixes with at least 60,125 gallons (1,432 bbl's) of groundwater. If the length of the ponded area is approximately 250 ft. and water is assumed to seep uniformly along this length and mix completely to a depth of 5 ft. in an aquifer having a porosity of 5%, the resultant aquifer volume would measure 250 ft. by 5 ft. by 129 ft.

Of course, this water would not mix instantaneously nor is the actual mixing depth or porosity known. The example is mainly to illustrate the relatively small volume of water necessary to reduce the concentrations to acceptable levels for the 150 barrels lost. Calculations can be performed to determine actual possible concentration and time impacts on MW-67, if any. Such calculations are commonly made using various groundwater modeling techniques but would require more information than is currently available.

The area of the spill was reported to have received rainfall during a storm event that occurred only several days following the spill. The fresh water no doubt infiltrated the subsurface and diluted the water from the spill, thereby further reducing impacts on groundwater.

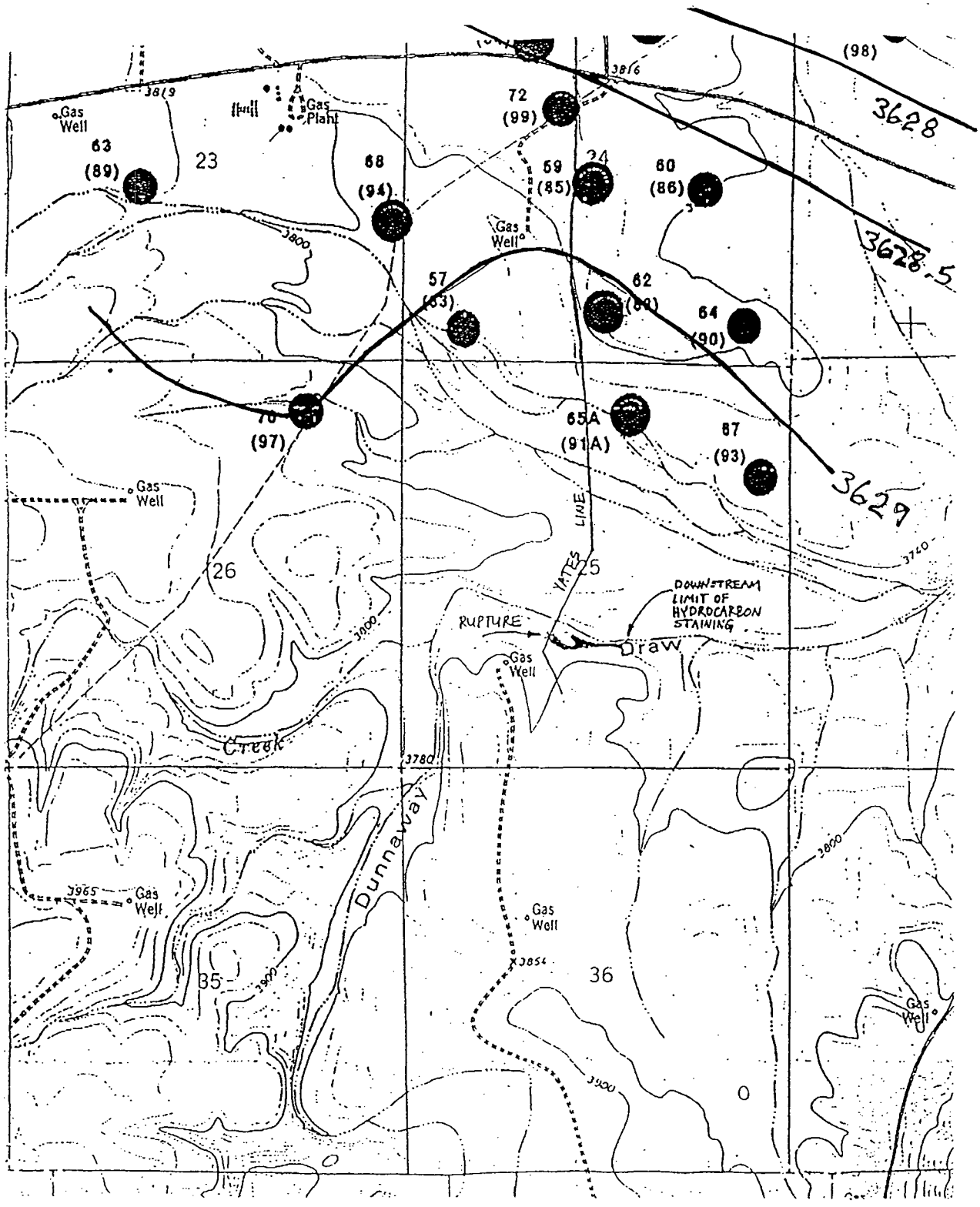

Figure 4. Dunnaway Draw Spill Location, Marathon Monitor Wells and Groundwater Elevation Contours

5.0 Conclusions

1. Soil sampling data taken within three weeks of the pipeline leak and surface release show only residual hydrocarbon contamination well below NM OCD's guidelines for soil remediation. Therefore, no soil remediation is necessary or recommended.

2. The relatively small net volume of fluid released to the subsurface makes it unlikely that groundwater will be affected by the leak except in the immediate area of the ponded sediments, if there.

3. If groundwater immediately adjacent to the release area has been impacted, any such impact would be mitigated by attenuation of organic constituents through sorption, volatilization, and biodegradation, and by hydrodynamic dispersion.

4. Flow-related circumstances make impacts unlikely at any operations currently conducted by Marathon. These include a probable groundwater recharge mound in the Queen formation beneath Rocky Arroyo, lesser development of joints and fractures as solution channels in the smaller Dunnaway Draw, and movement of spill contaminants easterly and downdip in the unsaturated zone past the location of Marathon's wells prior to contacting Queen groundwater. Other factors include the relatively small volume of spill fluids; 3000 ft. distance to the nearest monitor well, attenuation of organic constituents by sorption, volatilization, and biodegradation in the unsaturated zone; and these attenuation mechanisms, plus hydrodynamic dispersion, in the groundwater.

5. If necessary to satisfy agency concerns, these conclusions can be bolstered by performing groundwater modeling. The modeling could be performed using a range of parameters to simulate the most conservative scenario. The modeling should be performed in lieu of actual groundwater monitoring unless the results indicate that such monitoring is necessary.

6.0 References

1. Bjorklund, L.J., and W.S. Motts, 1959. "Geology and Water Resources of the Carlsbad Area, Eddy County, New Mexico," U.S.G.S. Open-file Report, December.

2. Hendrickson, G.E. and R.S. Jones, 1952. "Geology and Ground-Water Resources of Eddy County, New Mexico", Ground-Water Report 3, N.M. Bureau of Mines and Mineral Resources, Socorro, 169 pages, 4 plates.

3. Marathon Oil Co., 1994. "Quarterly Monitoring Report to NMOCD, Indian Basin Gas Plant", February

4. Marathon Oil Co., 1994. "Quarterly Monitoring Report to NMOCD, Indian Basin Gas Plant", November

5. New Mexico Oil Conservation Division, 1993. "Guidelines for Remediation of Leak, Spills and Releases", August, 15 p.

Appendix A

Soil Analytical Results

iml

Inter-Mountain Laboratories, Inc.

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Phone (409) 776-8945 FAX (409) 774-4705

Organics Laboratory
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Mr. David Boyer
RE/SPEC
4775 Indian School Road
NE Ste. 300
Albuquerque, New Mexico 87110-3927

February 9, 1995

Dear Mr. Boyer,

OnJanuary 24, 1995, five soil samples and one trip blank were received, cool and intact, by Inter-Mountain Laboratories - College Station. Analyses for BTEX and TPH were performed as requested on the accompanying chains of custody.

It is the policy of this laboratory to employ, whenever possible, preparatory and analytical methods which have been approved by regulatory agencies. The methods used in the analysis of the sample reported here are found in "Test Methods for Evaluating Solid Waste", SW-846, USEPA, Final Update I, July 1992. All reports in this package reference the methods utilized.

Quality Control reports have been included for your information and use. These reports appear at the end of the analytical package and may be identified by title. If there are any questions regarding the information presented in this package, feel free to call at your convenience.

Sincerely,

Ulonda M. Rogers
Volatiles Supervisor

RESP0201

CHAIN OF CUSTODY RECORD

Inter- Mountain Laboratories, Inc.

Client/Project Name	Project Location	ANALYSES / PARAMETERS
YATES / MARTHA DRAW	ARTESIA, NM	
Sampler: (Signature)	**Chain of Custody Tape No.**	
A G Boyd		

Sample No./ Identification	Date	Time	Lab Number	Matrix	No. of Containers	BTEX 8020	TPH			Remarks
Hole # 1 A	1/21/95	1525		Soil	1	✓	✓			0695600201
" 1 B	"	1530			1	✓	✓			0695600202
Hole # 2	"	1540			1	✓	✓			203
" 3	"	1545			1	✓	✓			204
" 4	"	1555			1	✓	✓			205
TRIP Blank	—	—		Water	1	✓				206
										samples received cool & intact NLM.

Relinquished by: (Signature)	Date	Time	Received by: (Signature)	Date	Time
A G Boyd	1/23/95	1530			
Relinquished by: (Signature)	**Date**	**Time**	**Received by: (Signature)**	**Date**	**Time**
Relinquished by: (Signature)	**Date**	**Time**	**Received by laboratory: (Signature)**	**Date**	**Time**
			Kathy Z Mott	1/24/95	1230

Inter-Mountain Laboratories, Inc.

9090

☐ 1633 Terra Avenue, Sheridan, Wyoming 82801, Telephone (307) 672-8945

☐ 1714 Phillips Circle, Gillette, Wyoming 82716, Telephone (307) 682-8945

☐ 2506 West Main Street, Farmington, NM 87401, Telephone (505) 326-4737

☐ 910 Technology Blvd. Suite B, Bozeman, Montana 59715, Telephone (406) 586-8450

☐ Route 3, Box 256, College Station, TX 77845, Telephone (409) 776-8945

☒ 3304 Longmire Drive, College Station, TX 77845, Telephone (409) 774-4999

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BTEX
AROMATIC VOLATILE ORGANICS

Client:	RE/SPEC		
Project Name:	Yates Petroleum / Martha Draw	Report Date:	02/02/95
Sample ID:	Hole #1A	Date Sampled:	01/21/95
Sample Number:	0695G00201	Date Received:	01/24/95
Sample Matrix:	Soil	Date Extracted:	02/02/95
Preservative:	Cool	Date Analyzed:	02/02/95
Condition:	Intact	Time Analyzed:	10:18 AM

Analyte	Concentration (ug/Kg)	Detection Limit (ug/Kg)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-xylene	1.1	1.0
o-xylene	7.3	1.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	97%	75 - 125%
Bromofluorobenzene	104%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments:

J. L. Lehmann
Analyst

Review

imL

Inter-Mountain Laboratories, Inc.

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TPH
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Client:	**RE/SPEC**		
Project:	Yates Pertroleum/Martha Draw	Report Date:	02/05/95
Sample ID:	Hole #1A	Date Sampled:	01/21/95
Laboratory ID:	0695G00201	Date Received:	01/24/95
Sample Matrix:	Soil	Date Extracted:	02/02/95
Preservative:	Cool	Date Analyzed:	02/02/95
Condition:	Intact		

Parameter	Concentration (mg/Kg)	Detection Limit (mg/Kg)
Total Recoverable Petroleum Hydrocarbons	595	25

ND - Parameter not detected at stated detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

Analyst

Review

imi

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BTEX
AROMATIC VOLATILE ORGANICS

Client:	RE/SPEC		
Project Name:	Yates Petroleum / Martha Draw	Report Date:	02/02/95
Sample ID:	Hole #1B	Date Sampled:	01/21/95
Sample Number:	0695G00202	Date Received:	01/24/95
Sample Matrix:	Soil	Date Extracted:	02/02/95
Preservative:	Cool	Date Analyzed:	02/02/95
Condition:	Intact	Time Analyzed:	4:00 PM

Analyte	Concentration (ug/Kg)	Detection Limit (ug/Kg)
Benzene	ND	1.0
Toluene	1.3	1.0
Ethylbenzene	ND	1.0
p,m-xylene	1.3	1.0
o-xylene	5.3	1.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	99%	75 - 125%
Bromofluorobenzene	95%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments:

Analyst J. L. Lehmann

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TPH
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Client:	**RE/SPEC**		
Project:	Yates Pertroleum/Martha Draw	Report Date:	02/05/95
Sample ID:	Hole #1B	Date Sampled:	01/21/95
Laboratory ID:	0695G00202	Date Received:	01/24/95
Sample Matrix:	Soil	Date Extracted:	02/02/95
Preservative:	Cool	Date Analyzed:	02/02/95
Condition:	Intact		

Parameter	Concentration (mg/Kg)	Detection Limit (mg/Kg)
Total Recoverable Petroleum Hydrocarbons	122	10

ND - Parameter not detected at stated detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

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BTEX
AROMATIC VOLATILE ORGANICS

Client:	RE / SPEC		
Project Name:	Yates Petroleum / Martha Draw		
Sample ID:	Hole #2	Report Date:	02/01/95
Sample Number:	0695G00203	Date Sampled:	01/21/95
Sample Matrix:	Soil	Date Received:	01/24/95
Preservative:	Cool	Date Extracted:	02/01/95
Condition:	Intact	Date Analyzed:	02/01/95
		Time Analyzed:	1:05 PM

Analyte	Concentration (ug/Kg)	Detection Limit (ug/Kg)
Benzene	ND	50
Toluene	ND	50
Ethylbenzene	ND	50
p,m-xylene	ND	50
o-xylene	ND	50

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	98%	75 - 125%
Bromofluorobenzene	99%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments:

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TPH
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Client:	**RE/SPEC**		
Project:	Yates Pertroleum/Martha Draw	Report Date:	02/05/95
Sample ID:	Hole #2	Date Sampled:	01/21/95
Laboratory ID:	0695G00203	Date Received:	01/24/95
Sample Matrix:	Soil	Date Extracted:	02/02/95
Preservative:	Cool	Date Analyzed:	02/02/95
Condition:	Intact		

Parameter	Concentration (mg/Kg)	Detection Limit (mg/Kg)
Total Recoverable Petroleum Hydrocarbons	50	10

ND - Parameter not detected at stated detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

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BTEX
AROMATIC VOLATILE ORGANICS

Client:	RE / SPEC		
Project Name:	Yates Petroleum / Martha Draw		
Sample ID:	Hole #3	Report Date:	02/01/95
Sample Number:	0695G00204	Date Sampled:	01/21/95
Sample Matrix:	Soil	Date Received:	01/24/95
Preservative:	Cool	Date Extracted:	02/01/95
Condition:	Intact	Date Analyzed:	02/01/95
		Time Analyzed:	2:27 PM

Analyte	Concentration (ug/Kg)	Detection Limit (ug/Kg)
Benzene	ND	50
Toluene	ND	50
Ethylbenzene	ND	50
p,m-xylene	ND	50
o-xylene	68	50

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	97%	75 - 125%
Bromofluorobenzene	99%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments:

Analyst J. L. Lehmann

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TPH
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Client:	**RE/SPEC**		
Project:	Yates Pertroleum/Martha Draw	Report Date:	02/05/95
Sample ID:	Hole #3	Date Sampled:	01/21/95
Laboratory ID:	0695G00204	Date Received:	01/24/95
Sample Matrix:	Soil	Date Extracted:	02/02/95
Preservative:	Cool	Date Analyzed:	02/02/95
Condition:	Intact		

Parameter	Concentration (mg/Kg)	Detection Limit (mg/Kg)
Total Recoverable Petroleum Hydrocarbons	281	10

ND - Parameter not detected at stated detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

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BTEX
AROMATIC VOLATILE ORGANICS

Client:	RE / SPEC		
Project Name:	Yates Petroleum / Martha Draw		
Sample ID:	Hole #4	Report Date:	02/01/95
Sample Number:	0695G00205	Date Sampled:	01/21/95
Sample Matrix:	Soil	Date Received:	01/24/95
Preservative:	Cool	Date Extracted:	02/01/95
Condition:	Intact	Date Analyzed:	02/01/95
		Time Analyzed:	3:06 PM

Analyte	Concentration (ug/Kg)	Detection Limit (ug/Kg)
Benzene	ND	50
Toluene	ND	50
Ethylbenzene	ND	50
p,m-xylene	ND	50
o-xylene	ND	50

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	97%	75 - 125%
Bromofluorobenzene	99%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments:

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TPH
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Client:	**RE/SPEC**		
Project:	Yates Pertroleum/Martha Draw	Report Date:	02/05/95
Sample ID:	Hole #4	Date Sampled:	01/21/95
Laboratory ID:	0695G00205	Date Received:	01/24/95
Sample Matrix:	Soil	Date Extracted:	02/02/95
Preservative:	Cool	Date Analyzed:	02/02/95
Condition:	Intact		

Parameter	Concentration (mg/Kg)	Detection Limit (mg/Kg)
Total Recoverable Petroleum Hydrocarbons	28	10

ND - Parameter not detected at stated detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

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BTEX
AROMATIC VOLATILE ORGANICS

Client:	RE / SPEC		
Project Name:	Yates Petroleum / Martha Draw		
Sample ID:	Trip Blank	Report Date:	02/01/95
Sample Number:	0695G00206	Date Sampled:	NA
Sample Matrix:	Water	Date Received:	01/24/95
Preservative:	Cool, HCl	Date Extracted:	02/01/95
Condition:	Intact, pH < 2	Date Analyzed:	02/01/95
		Time Analyzed:	11:13 AM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-xylene	ND	1.0
o-xylene	ND	1.0

ND - Analyte not detected at stated detection limit.

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	100%	75 - 125%
Bromofluorobenzene	88%	70 - 120%

Reference:

Method 5030, Purge and Trap.
Method 8020, Aromatic Volatile Organics.
SW-846, Test Methods for Evaluating Solid Waste, United States Environmental Protection Agency, Final Update I, July 1992.

Comments:

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QUALITY CONTROL REPORT - METHOD BLANK
VOLATILE AROMATIC HYDROCARBONS

Sample Number: MB0201V1
Sample Matrix: Water

Report Date: 02/01/95
Date Analyzed: 02/01/95
Time Analyzed: 9:23 AM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-Xylene	ND	1.0
o-Xylene	ND	1.0

ND - Analyte not detected at stated detection limit

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	99%	75 - 125%
Bromofluorobenzene	97%	70 - 120%

Reference: Method 5030, Purge and Trap
Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I,
United States Environmental Protection Agency, July 1992.

Comments:

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QUALITY CONTROL REPORT - METHOD BLANK
VOLATILE AROMATIC HYDROCARBONS

Sample Number: MB0202V1
Sample Matrix: Water

Report Date: 02/02/95
Date Analyzed: 02/02/95
Time Analyzed: 9:34 AM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-Xylene	ND	1.0
o-Xylene	ND	1.0

ND - Analyte not detected at stated detection limit

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	97%	75 - 125%
Bromofluorobenzene	103%	70 - 120%

Reference: Method 5030, Purge and Trap
Modified Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I,
United States Environmental Protection Agency, July 1992.

Comments:

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QUALITY CONTROL REPORT - METHOD BLANK
VOLATILE AROMATIC HYDROCARBONS

Sample Number: MB0202V2
Sample Matrix: Water

Report Date: 02/02/95
Date Analyzed: 02/02/95
Time Analyzed: 9:36 AM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	1.0
Toluene	ND	1.0
Ethylbenzene	ND	1.0
p,m-Xylene	ND	1.0
o-Xylene	ND	1.0

ND - Analyte not detected at stated detection limit

Quality Control:	Surrogate	Percent Recovery	Acceptance Limits
	a,a,a-Trifluorotoluene	101%	75 - 125%
	Bromofluorobenzene	99%	70 - 120%

Reference: Method 5030, Purge and Trap
Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I,
United States Environmental Protection Agency, July 1992.

Comments:

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QUALITY CONTROL REPORT - METHOD BLANK
VOLATILE AROMATIC HYDROCARBONS

Sample Number: MB0201ME1
Sample Matrix: Water

Report Date: 02/01/95
Date Analyzed: 02/01/95
Time Analyzed: 9:59 AM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	50
Toluene	ND	50
Ethylbenzene	ND	50
p,m-Xylene	ND	50
o-Xylene	ND	50

ND - Analyte not detected at stated detection limit

Quality Control:	Surrogate	Percent Recovery	Acceptance Limits
	a,a,a-Trifluorotoluene	98%	75 - 125%
	Bromofluorobenzene	97%	70 - 120%

Reference: Method 5030, Purge and Trap
Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I,
United States Environmental Protection Agency, July 1992.

Comments: 100 uL of purge and trap grade methanol added to reagent water.

Analyst J. L. Lehmann

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QUALITY CONTROL REPORT - METHOD BLANK
VOLATILE AROMATIC HYDROCARBONS

Sample Number: MB0202ME1
Sample Matrix: Water

Report Date: 02/02/95
Date Analyzed: 02/02/95
Time Analyzed: 10:11 AM

Analyte	Concentration (ug/L)	Detection Limit (ug/L)
Benzene	ND	50
Toluene	ND	50
Ethylbenzene	ND	50
p,m-Xylene	ND	50
o-Xylene	ND	50

ND - Analyte not detected at stated detection limit

Quality Control:	Surrogate	Percent Recovery	Acceptance Limits
	a,a,a-Trifluorotoluene	99%	75 - 125%
	Bromofluorobenzene	98%	70 - 120%

Reference: Method 5030, Purge and Trap
Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I,
United States Environmental Protection Agency, July 1992.

Comments: 100 uL of purge and trap grade methanol added to reagent water.

Analyst J. L. Lehmann

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QUALITY CONTROL REPORT - BLANK SPIKE
VOLATILE AROMATIC HYDROCARBONS

Sample Number:	BS0201V1	Report Date:	01/29/95
Sample Matrix:	Water	Date Sampled:	NA
Preservative:	NA	Date Received:	NA
Condition:	NA	Date Extracted:	02/01/95
		Date Analyzed:	02/01/95
		Time Analyzed:	10:36 AM

Analyte	Spike Added (ug/L)	Sample Result (ug/L)	Spike Result (ug/L)	Percent Recovery	Accept-ance Limit
Benzene	1.0	ND	1.0	97%	39-150%
Toluene	1.0	ND	0.8	82%	46-148%
Ethylbenzene	1.0	ND	1.0	100%	32-160%
p,m-Xylene	2.0	ND	2.1	104%	50-150%
o-Xylene	1.0	ND	1.0	98%	50-150%

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	99%	75 - 125%
Bromofluorobenzene	97%	70 - 120%

Reference: Method 5030, Purge and Trap
Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I, United States Environmental Protection Agency, July 1992.

Comments:

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QUALITY CONTROL REPORT - MATRIX SPIKE
VOLATILE AROMATIC HYDROCARBONS

Sample Number:	0695G00201 SPIKE	Report Date:	02/02/95
Sample Matrix:	Soil	Date Sampled:	01/21/95
Preservative:	Cool	Date Received:	01/24/95
Condition:	Intact	Date Extracted:	02/01/95
		Date Analyzed:	02/02/95
		Time Analyzed:	2:55 PM

Analyte	Spike Added (ug/Kg)	Sample Result (ug/Kg)	Spike Result (ug/Kg)	Percent Recovery	Accept-ance Limit
Benzene	94	ND	92	97%	39-150%
Toluene	94	ND	91	97%	46-148%
Ethylbenzene	94	ND	96	101%	32-160%
p,m-Xylene	188	ND	203	108%	50-150%
o-Xylene	94	ND	112	119%	50-150%

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	98%	75 - 125%
Bromofluorobenzene	99%	70 - 120%

Reference: Method 5030, Purge and Trap
Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I, United States Environmental Protection Agency, July 1992.

Comments:

Analyst J. L. Lehmann

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QUALITY CONTROL REPORT - MATRIX SPIKE DUPLICATE
VOLATILE AROMATIC HYDROCARBONS

Sample Number:	0695G00201 SPK DUP	Report Date:	02/02/95
Sample Matrix:	Soil	Date Sampled:	01/21/95
Preservative:	Cool	Date Received:	01/24/95
Condition:	Intact	Date Extracted:	02/01/95
		Date Analyzed:	02/02/95
		Time Analyzed:	3:32 PM

Analyte	Spike Recovery (%)	Duplicate Recovery (%)	Percent Difference
Benzene	97%	93%	4%
Toluene	97%	95%	2%
Ethylbenzene	101%	103%	2%
p,m-Xylene	108%	101%	6%
o-Xylene	119%	106%	12%

Quality Control:

Surrogate	Percent Recovery	Acceptance Limits
a,a,a-Trifluorotoluene	97%	75 - 125%
Bromofluorobenzene	99%	70 - 120%

Reference: Method 5030, Purge and Trap
Method 8020, Aromatic Volatile Organics
SW-846, Test Methods for Evaluating Solid Waste, Final Update I, United States Environmental Protection Agency, July 1992.

Comments:

J. L. Lehmann
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QUALITY CONTROL REPORT - METHOD BLANK
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Sample ID: Method Blank
Laboratory ID: MB 051
Sample Matrix: Soil
Preservative: N/A
Condition: N/A

Report Date: 02/05/95
Date Extracted: 02/02/95
Date Analyzed: 02/02/95

Parameter	Concentration (mg/Kg)	Detection Limit (mg/Kg)
Total Recoverable Petroleum Hydrocarbons	ND	10

ND - Parameter not detected at stated detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

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QUALITY CONTROL REPORT - BLANK SPIKE
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Sample ID:	Blank Spike	Report Date:	02/05/95
Laboratory ID:	BSPK 052	Date Sampled:	NA
Sample Matrix:	Soil	Date Received:	NA
Preservative:	N/A	Date Extracted:	02/02/95
Condition:	N/A	Date Analyzed:	02/02/95

Parameter	Spike Added (mg/Kg)	Sample Result (mg/Kg)	Spiked Sample Result (mg/Kg)	Percent Recovery
Total Recoverable Petroleum Hydrocarbons	469	ND	332	71%

ND - Parameter not detected at established detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

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QUALITY CONTROL REPORT - MATRIX DUPLICATE
TOTAL RECOVERABLE PETROLEUM HYDROCARBONS

Sample ID:	Matrix Duplicate	Report Date:	02/05/95
Laboratory ID:	0495H00899/0695G00412 Dup	Date Sampled:	01/26/95
Sample Matrix:	Soil	Date Received:	01/25/95
Preservative:	Cool	Date Extracted:	02/03/95
Condition:	Intact	Date Analyzed:	02/02/95

Parameter	Sample Result (mg/Kg)	Duplicate Result (mg/Kg)	Percent Difference
Total Recoverable Petroleum Hydrocarbons	261	233	11%

ND - Parameter not detected at established detection limit

Reference: Method 418.1 - Petroleum Hydrocarbons, Total Recoverable Chemical Analysis of Water and Waste, United States Environmental Protection Agency, 1978.
Method 3550A: Ultrasonic Extraction, Test Methods for Evaluating Solid Waste, 3rd Edition, Final Update I, USEPA, July 1992.

Comments:

Analyst

Review