DOE/RMOTC-020154

**DEGRADATION OF TOTAL PETROLEUM
HYDROCARBON AND BTEX COMPOUNDS IN
PRODUCED WATER**

INTERIM REPORT

November 16, 2001 - January 10, 2002

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Approved by:

RMOTC Manager

Date

L.M. Jackson

**PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY/ROCKY MOUNTAIN
OILFIELD TESTING CENTER**

**Work Performed Under Rocky Mountain Oilfield
Testing Center (RMOTC) CRADA No. 2001-010**

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Abstract

Petroleum Environmental Technologies, LLC entered into a Cooperative Research and Development agreement with the Rocky Mountain Oilfield Testing Center to an in-situ pit treatment demonstration and produced water treatment demonstration. The purpose of the test is to demonstrate the degradation of petroleum hydrocarbon compounds in soil and aqueous matrices where ECOSAFE™ is applied to enhance the degradation of these contaminants.

ECOSAFE™ is a mixture of nutrients that blends natural sequestrants, surfactants, and emulsifying agents. It is 100% biodegradable, is not harmful to marine/aquatic life and safely treats and degrades organic based contaminants. ECOSAFE™ uses a reduction-oxidation reaction to degrade the targeted organic compound. This reaction reduces the target compound to nitrates, oxygen, carbon dioxide and water. Another important aspect of this technology is the simultaneous treatment of the contaminated soil and ground water. The ECOSAFE™ solution penetrates into the soil. The solution emulsifies and degrades the organic compounds by breaking them up into suspended particles. These particles repeal each other thereby change the molecular structure of the organic compound. The compound in effect becomes water-soluble. The result is a mixture of dissolved oxygen, carbon dioxide, and nitrates using the hydrogen of water as catalytic agent.

Introduction

Petroleum Environmental Technologies, LLC., a Floridian Corporation relocating to Casper, Wyoming, contracted with the Rocky Mountain Oilfield Testing Center (RMOTC) of Casper, Wyoming to demonstrate an in-situ application of the non-hazardous product ECOSAFE™. Along side the full-scale field trial, a bench scale produced water experiment was conducted. The bench test was intended to demonstrate the ability of ECOSAFE™ to treat total petroleum hydrocarbon and BTEX compounds in produced water column while simultaneously treating the soil matrix.

The data presented in this report was collected from November 16, 2001 to January 10, 2002. This report will detail the materials and methods used to conduct the test, test procedures, laboratory results, and conclusions.

Experimental Design

Two 55-gallon drums were recycled from the chemical storage yard and cleaned for this test. The drums were filled with fluid retrieved from a pit located at the Water Disposal Facility. The fluid was a mixture of water, oil and other unknown waste products. There was no special preparation of the fluid prior to filling the drums.

The drums were placed side by side on a pallet. For each drum, air injection tubing was inserted into 1" bunghole located on top of the drum. The 2" bunghole was used to introduce the fluid to the drum. (See Appendix C).

The fluid was extracted from the Water Disposal Facility pit using a vacuum truck and transported to the PET test site. The fluid was discharged from the truck through a 10" hose into the 2" bunghole on top of the drums. There was no filter applied to the end of the hose. Each drum received approximately 40 gallons of fluid. Approximately 10-15 gallons of void space was left inside each drum to allow for potential overflow when the air injection cycle began.

Samples of the fluid column inside both drums was collected and analyzed to establish a baseline level of petroleum compounds. This fluid was collected using a 1.5" x 36" disposable bailer. The retrieval capacity of the bailer was approximately 1 liter. The bailer was inserted through the 2" bunghole directly into the fluid column. The samples collected from each drum were analyzed for Total Petroleum Hydrocarbon content using EPA Method 418.1, Diesel Range Organics using EPA Method 8015B Modified and Volatile Organic Compounds Suite (Benzene, Toluene, Ethylbenzene, Xylene) using EPA Method 8021B.

Next, one gallon of ECOSAFE™ solution was added to each drum using a hand pump to dispense the product into the drum. A 24 inch stainless-steel pipe was inserted vertically into the 1" bunghole of each drum. The pipe was perforated at 3 inch spacing along the length of the pipe to facilitate even agitation of the fluid. Air was injected into each drum at an average rate between 90 psi and 120 psi. The air compressor ran 24 hours a day. It cycled on when the pressure fell to 90 psi and cycled off when the pressure reached 120 psi.

On the 55th day of the test, a second set of samples was collected from each drum. These samples were analyzed for Total Petroleum Hydrocarbon content using EPA Method 418.1, Diesel Range Organics using EPA Method 8015B Modified and BTEX (Benzene, Toluene, Ethylbenzene, Xylene) Soils using EPA Method 8021B. Results for both sampling events are listed in Table 1. Full laboratory analysis reports are contained in Appendix A.

Discussion

The purpose of this bench test was to demonstrate the ability of ECOSAFE™ to degrade petroleum hydrocarbon and BTEX compounds in the water phase. The experiment does not compare a control set to a treated or test set. Instead, it provides an example of petroleum hydrocarbon and BTEX degradation in a controlled experiment to the degradation of those same compounds found in the water phase of the in-situ pit treatment in which ECOSAFE™ was mixed with produced water and injected into the soil column.

The analyses parameters chosen for this test were important to demonstrate and document key functions of this technology. (1) A general presence of petroleum hydrocarbons should be established using a test method widely accepted by most state regulatory agencies, (2) Test for specific hydrocarbons, in particular those longer chain hydrocarbon chains (C₁₀-C₂₈). (3) Test for those compounds that represent a risk to public health and the environment because they are relatively soluble in water and can diffuse rapidly once introduced into an aquifer (volatile organic compounds).

EPA Test Method 418.1, Total Petroleum Hydrocarbons is widely used as a general measure of the presence of crude oil or petroleum product in water and soils. TPH is defined as the measurable amount of petroleum-based hydrocarbon in an environmental media. While TPH provides an overall concentration of petroleum hydrocarbons in a media, it is not a direct indicator of the risk. Other analysis or information should be used to relate TPH concentrations to risk. During this test, ECOSAFE™ significantly reduced the measurable amount of petroleum hydrocarbons in the water phase. In one case, over a 90% reduction was realized from baseline levels in 55 days of treatment. (See Table 1 and Appendix B)

EPA Method 8015 Modified reports the concentration of purgeable and extractable hydrocarbons, which are also sometimes referred to as gasoline and diesel range organics (i.e., GRO and DRO). Purgeable hydrocarbons are measured by purge-and-trap gas chromatography (GC) analysis using a flame ionization detector (FID), while the extractable hydrocarbons are analyzed by GC following extraction with a solvent and subsequent concentration of the extract by evaporation. While more detailed information is generated by this method (e.g., GC chromatograms), the results are most frequently reported as single numbers for purgeable and extractable hydrocarbons. For the purposes of this report, DRO measurements are given as a single number, however full chromatograms are contained in Appendix A.

Test analyses reveals virtually one hundred percent of the diesel range organics (C₁₀-C₂₈) were degraded in the drums and almost fifty percent were degraded in the water phase of the in-situ pit treatment test. (See Table 1 and Appendix B) The nearly fifty-percent degradation of

DRO is noteworthy because the levels were small to begin. Furthermore, the bioavailability of the compounds may have been limited by age and weathering.

Often, further degradation of these extractable hydrocarbons is hard to achieve under natural attenuation scenarios. This stall in the degradation pathway is known as "bottle-necking." It is most often attributed to decreased bioavailability for further microbial degradation, sorption or solubilization of the hydrocarbon molecule. A key function of ECOSAFE™ technology is its ability to breakthrough the bottleneck stage and continue to make the organic compounds bioavailable for treatment.

EPA Method 8021B measures the BTEX chemicals (Benzene, Toluene, Ethylbenzene, and Xylenes). These are volatile monocaromatic hydrocarbons. They are considered one of the major causes of environmental pollution because of widespread occurrences of leakage from underground petroleum storage tanks and spills at petroleum production wells, refineries, pipelines, and distribution terminals. The results of the BTEX analysis provide important documentation that ECOSAFE™ effectively reduces the presence of these water soluble compounds. Baseline concentrations of these compounds were reduced to below the practical quantitative limit of 0.5 µg/L after treatment. (See Table 1 and Appendix B) It should be noted that this test did not quantify what percent of the BTEX compounds volatilized and what percent were degraded by treatment.

Summary

Three analytical methods were used to measure levels of petroleum hydrocarbon in produced water from the in-situ pit treatment and a separate drum test in which fluid was treated with ECOSAFE™. EPA Method 418.1 is an accepted method by most regulatory agencies for measuring hydrocarbon content in soils and water. This method is widely observed as a screening tool rather than a quantitative representation of specific hydrocarbon content. Thus, variations in analysis results can be expected. In this test, analysis results showed an 83% reduction of total petroleum hydrocarbon content from treatment in the pit, 73% reduction in Drum No. 1 and a 99% reduction in Drum No. 2.

Specific analysis for diesel range organics (C₁₀-C₂₈) illustrates significant reduction of these compounds in Drum No. 1 and No. 2 by 99%. Percent degradation was not as high for the pit sample, however baseline levels were low to begin and the bioavailability of these compounds may have been affected by age and weathering.

Perhaps the compounds of greatest concern are the BTEX compounds in the drum test. These compounds are highly soluble in water and difficult to treat thereby posing a major risk to public health and the environment. Analysis for the BTEX suit showed 99% reduction of these compounds from baseline levels to non-detectable levels after treatment with ECOSAFE™.

Laboratory analyses results are summarized below in Table 1. Full laboratory reports are contained in Appendix A.

Matrix: Produced Water (Pit)							
Date	418.1 (mg/L)	8015B DRO (mg/L)	Benzene (µg/L)	Ethyl- benzene (µg/L)	M+P Xylenes (µg/L)	o-Xylene (µg/L)	Toluene (µg/L)
11/19/01	61.0	35.0					
12/4/02	9.9	18.0					
% Reduction	83%	48%					
Matrix: Water Disposal Facility Mixture (Drum #1)							
Date	418.1 (mg/L)	8015B DRO (mg/L)	Benzene (µg/L)	Ethyl- benzene (µg/L)	M+P Xylenes (µg/L)	o-Xylene (µg/L)	Toluene (µg/L)
11/16/01	2,980.0	5,980.0	27.0	30.0	72.0	68.0	27.0
1/10/02	760.0	670.0	>0.5*	>0.5*	>0.5*	>0.5*	>0.5*
% Reduction	73%	99%	<26.5/ 27.0	<29.5/ 30.0	<71.5/ 72.0	<67.5/ 68.0	<26.5/ 27.0
Matrix: Water Disposal Facility Mixture (Drum #2)							
Date	418.1 (mg/L)	8015B DRO (mg/L)	Benzene (µg/L)	Ethyl- benzene (µg/L)	M+P Xylenes (µg/L)	o-Xylene (µg/L)	Toluene (µg/L)
11/16/01	98,000.0	7,100.0	35.0	34.0	86.0	79.0	39.0
1/10/02	4,100.0	1,100.0	>0.5*	>0.5*	>0.5*	>0.5*	>0.5*
% Reduction	99%	99%	<34.5/ 35.0	<29.5/ 34.0	<85.5/ 86.0	<78.5/ 79.0	<38.5/ 39.0

*POL-Chemicals that are not detected in a particular sample below a certain limit. This limit usually will be the practical quantitation limit for the chemical in that sample.

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References

Using TPH In Risk-Based Corrective Action, by John B. Gustafson, Shell, Development Company, <http://www.epa.gov/swcrust1/rbdm/tphrbca.htm>, 3/28/02.

BTEX Metabolism Metapathway Map,
http://umbbd.ahc.umn.edu/BTEX/BTEX_map.html, 3/28/02.

Chapelle, Francis H., Robertson, John F., Landmeyer, James E., Bradley, Paul M., Methodology for Applying Monitored Natural Attenuation to Petroleum Hydrocarbon-Contaminated Ground-Water Systems with Examples from South Carolina, U.S. Geological Survey Water-Resources Investigations Report 00-4161, <http://toxics.usgs.gov/pubs/wri004161/index.html>, 3/28/02.

Deuel, Lloyd E., Jr., Holliday, George H., Soil Remediation for the Petroleum Extrastion Industry, PennWell Publishing Company, 1994.

K.J. McCarthy, Uhler, A.D., and Stout, S.A., "Weathering affects petroleum ID." *Soil & Groundwater Cleanup*, August/September (1998).

Total Petroleum Hydrocarbon Working Groups Series, Volume 5 Human Health Risk-Based Evaluation of Petroleum Release Sites: Implementing the Working Group Approach, Press (1999).

Sublette, Kerry L., Ph.D., The University of Tulsa, Continuing Engineering and Science Education, Fundamentals Of Bioremediation Of Hydrocarbon Contaminated Soils, March 506, 2001, Tulsa, Oklahoma.

APPENDIX A

LABORATORY ANALYTICAL REPORT

Client: U.S. Department of Energy
Project: RMOTC
Lab ID: C02010299 001
Client Sample ID: RMOTC #1

Report Date: 01/21/02
Collection Date: 01/10/02 14:20
Date Received: 01/10/02
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/		Method	Analysis Date / By
				RL	QCL		
VOCS							
Benzene	ND	ug/L		250		SW8021B	01/12/02 02:33 / jlr
Ethylbenzene	ND	ug/L		250		SW8021B	01/12/02 02:33 / jlr
m,p-Xylenes	ND	ug/L		250		SW8021B	01/12/02 02:33 / jlr
o-Xylene	ND	ug/L		250		SW8021B	01/12/02 02:33 / jlr
Toluene	ND	ug/L		250		SW8021B	01/12/02 02:33 / jlr
Sum: Trifluorotoluene	92.7	%REC			80-120	SW8021B	01/12/02 02:33 / jlr
Matrix interference caused increase in RL							
ORGANIC CHARACTERISTICS							
Diesel Range Organics (DRO)	670	mg/L		100		SW8016M as D	01/18/02 16:27 / dj
Total Petroleum Hydrocarbons	780	mg/L		100		E418.1	01/21/02 11:41 / dj

Report Definitions: ND - Not detected at the reporting limit
MCL - Maximum contaminant level

QCL - Quality control limit
RL - Analyte reporting level

TEACHSHEET CASE NO.
102150000002

002010238 001A 0.17DROH. 4HC.DRO-APLW.

G:\4HC\HP\10117DROH.20R

002010238 001A 0.17DROH. 4HC.DRO-APLW.

002010238 001A 0.17DROH. 4HC.DRO-APLW.

LABORATORY ANALYTICAL REPORT

Client: US Department of Energy
Project: RMOTC
Lab ID: C02010299-002
Client Sample ID: RMOTC Drum #2

Report Date: 01/21/02
Collection Date: 01/10/02 14:30
Date Received: 01/10/02
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/		Method	Analysis Date / By
				RL	QCL		
VOCS							
Benzene	ND	ug/l		250		SW8021B	01/12/02 03:51 / jlr
Ethylbenzene	ND	ug/L		250		SW8021B	01/12/02 03:51 / jlr
m,p-Xylenes	ND	ug/L		250		SW8021B	01/12/02 03:51 / jlr
o-Xylene	ND	ug/L		250		SW8021B	01/12/02 03:51 / jlr
Toluene	ND	ug/L		250		SW8021B	01/12/02 03:51 / jlr
Sum Trifluorotoluene	93.3	%REC			80-120	SW8021B	01/12/02 03:51 / jlr
Matrix interference caused increase in RL							
ORGANIC CHARACTERISTICS							
Diesel Range Organics (DRO)	1100	mg/L		1000		SW8015M as D	01/18/02 17:10 / dj
Total Petroleum Hydrocarbons	4100	mg/L		10		E418.1	01/21/02 11:41 / dj

**Report
Definitions:**

ND = Not detected at the reporting level
MCL = Maximum contaminant level

QCL = Quality control limit
RL = Analyte reporting level

TRANSMISSION CASE NO.

1109570103

0020-0298-002A-3117DROH, \$HC-DRO-APIW, (1.13)
C:\GROHPI\0117DROH.21R

7.10	n-Decane
8.13	
8.36	
9.14	n-Dodecane
9.73	
10.24	
10.45	n-Tetradecane
11.11	
11.40	
11.69	n-Hexadecane
12.25	
12.78	
13.29	n-Octadecane
13.77	n-Eicosane
14.23	
14.57	n-Docosane
15.00	
15.50	n-Tetracosane
16.00	
16.27	n-Hexacosane
16.64	
16.99	n-Octacosane
17.34	
17.69	
18.03	
18.33	
18.59	
18.83	
19.25	
20.25	
21.22	
21.46	
22.50

LABORATORY ANALYTICAL REPORT

Client: US Department of Energy
Project: RMOTC Test Pit #1
Lab ID: C01110584-001
Client Sample ID: RMOTC Drum #1

Report Date: 12/01/01
Collection Date: 11/16/01 14:47
Date Received: 11/16/01
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/ RL		Method	Analysis Date / By
				RL	QCL		
VOCs							
Benzene	27	ug/L		5.0		SW8021B	11/27/01 19:38 / jlr
Ethylbenzene	30	ug/L		5.0		SW8021B	11/27/01 19:38 / jlr
m-p-Xylenes	72	ug/L		5.0		SW8021B	11/27/01 19:38 / jlr
o-Xylene	68	ug/L		5.0		SW8021B	11/27/01 19:38 / jlr
Toluene	27	ug/L		5.0		SW8021B	11/27/01 19:38 / jlr
ORGANIC CHARACTERISTICS							
Total Petroleum Hydrocarbons	2900	mg/L		1000		E418.1	11/20/01 12:50 / dj

Report Definition: ND - Not detected at the reporting limit
MCL - Maximum contaminant level

QCL - Quality control limit
RL - Analyte reporting level

TRACKING NO. PAGE NO.
11584R00002

LABORATORY ANALYTICAL REPORT

Client: US Department of Energy
Project: RMOTC Test Pit #1
Lab ID: C01110584-002
Client Sample ID: RMOTC Drum #2

Report Date: 12/01/01
Collection Date: 11/16/01 15:00
Date Received: 11/16/01
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/		Method	Analysis Date / By
				RL	QCL		
VOCS							
Benzene	35	ug/L		25		SW8021B	11/27/01 20:57 / jlr
Ethylbenzene	34	ug/L		25		SW8021B	11/27/01 20:57 / jlr
m+p-Xylenes	86	ug/L		25		SW8021B	11/27/01 20:57 / jlr
o-Xylene	79	ug/L		25		SW8021B	11/27/01 20:57 / jlr
Toluene	39	ug/L		25		SW8021B	11/27/01 20:57 / jlr
ORGANIC CHARACTERISTICS							
Total Petroleum Hydrocarbons	38000	mg/L		1.0		E418.1	11/20/01 15:44 / dj

Report Definitions: ND - Not detected at the reporting limit.
MCL - Maximum contaminant level

QCL - Quality control limit
RL - Analyte reporting level

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11534R00000

LABORATORY ANALYTICAL REPORT

Client: US Department of Energy
Project: RMOTC Test Pit #1
Lab ID: C01110584-003
Client Sample ID: RMOTC Drum #1

Report Date: 12/01/01
Collection Date: 11/17/01 09:15
Date Received: 11/16/01
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/		Method	Analysis Date / By
				RL	QCL		
ORGANIC CHARACTERISTICS							
Diesel Range Organics	5900	mg/L		5000		SW8015M as D	11/27/01 02:38 / dj

**Report
Definitions:**

ND - Not detected at the reporting limit
MCL - Maximum contaminant level

QCL - Quality control limit
RL - Analyte reporting level

TRACKING NO. PAGE NO.
11584R000064

00110584-0038-1126DRO-4, 3HC-DRO-W-API, (C 5000)
G-ORC:HP11126DROH.16K

9.75
7.67 n-Decane
8.52
9.17
9.56 n-Dodecane
9.90
10.00
10.45
10.64 n-Tetradecane
11.02
11.26
11.85 n-Hexadecane
12.41
12.91 n-Octadecane
13.45
13.93 n-Eicosane
14.38
14.83 n-Docosane
15.25
15.87 n-Tetraacosane
16.05
16.44 n-Hexacosane
16.80
17.15 n-Octacosane
17.52
17.71
17.82
18.19
18.45
18.85
19.21
20.59

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11584R00005

LABORATORY ANALYTICAL REPORT

Client: US Department of Energy
Project: RMOTC Test Pit #1
Lab ID: C01110584-004
Client Sample ID: RMOTC Drum #2

Report Date: 12/01/01
Collection Date: 11/17/01 09:15
Date Received: 11/16/01
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/		Method	Analysis Date / By
				RL	QCL		
ORGANIC CHARACTERISTICS							
Diesel Range Organics	7100	mg/L		5000		SW8015M as D	11/27/01 04:03 / dj

Report Definitions: ND - Not detected at the reporting limit
MCL - Maximum contaminant level

QCL - Quality control limit
RL - Analyte reporting level

TRACKING NO. PAGE NO.
11586R00005

00110584-0048 1126DROH 5HC-DRO-W-APL (115000)

----- G4ORG:HP113126DRO-K18R

7.05
7.89 n-Decane
8.02
8.36
8.52
9.07
9.28 27 n-Dodecane
9.98
10.10 9.98
10.58 18 n-Tetradecane
10.84 10.58
11.28
11.82
11.82 n-Hexadecane
12.43
12.94 12.94 n-Octadecane
13.44
13.83 n-Eicosane
14.89
14.89 n-Docosane
15.26
15.67 n-Tetracosane
16.08
16.44 n-Hexacosane
16.80
17.19 n-Octacosane
17.52
17.82
18.12
18.48
18.72
19.02
19.22
19.42
19.72
20.02

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11584R00007

QA/QC Summary Report

Expanded format available on request

Client: US Department of Energy

Project: RMOTC Test Pit #1

Report Date: 12/03/01

Work Order: C01110584

Analyte	Result	Units	PQL	%REC	Low Limit	High Limit	%RPD	RPDLimit	Qual
Method: E416.1			Batch: 011120A-HC-TPH-HR-W						
Sample ID: MBLK1_011120A	MBLK								11/20/01 12:50
Total Petroleum Hydrocarbons	0.3418	mg/L	1.0						J
Sample ID: MBLK1_011120AMS	MS								11/20/01 12:50
Total Petroleum Hydrocarbons	5.154	mg/L	1.0	103	70	130			
Sample ID: MBLK1_011120AMSD	MSD								11/20/01 12:50
Total Petroleum Hydrocarbons	5.122	mg/L	1.0	102	70	130	0.631	20	
Method: SW8015M as D			Batch: 544						
Sample ID: MB-544	MBLK								11/26/01 18:47
Diesel Range Organics	ND	mg/L	1.0						
Sum: o-Terphenyl			0.10	82.5	75	125			
Sample ID: C01110608-004BMS	MS								11/26/01 22:22
Diesel Range Organics	20	mg/L	10	100	60	140			
Sum: o-Terphenyl			1.0	252	75	125			J5
Sample ID: C01110608-004BMSD	MSD								11/26/01 23:04
Diesel Range Organics	20	mg/L	10	100	60	140	0	20	
Sum: o-Terphenyl			1.0	252	75	125	0	10	J8

Qualifiers: ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank

S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits

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TRACKING NO. PAGE NO.

11596R00000

QA/QC Summary Report

Expanded format available on request.

Client: US Department of Energy

Project: RMOTC Test Pit #1

Report Date: 12/03/01

Work Order: C01110584

Analyte	Result	Units	PQL	%REC	Low Limit	High Limit	%RPD	RPDLimit	Qual
Method: SW8021B									
Batch: R5189									
Sample ID: MBLK_1127HP205P	MULT								11/27/01 13:19
Benzene	ND	ug/L	0.50						
Ethylbenzene	ND	ug/L	0.50						
m+p-Xylenes	ND	ug/L	0.50						
Methyl tert-butyl ether (MTBE)	ND	ug/L	2.0						
o-Xylene	ND	ug/L	0.50						
Toluene	ND	ug/L	0.50						
Sum: Trifluorotoluene			0.50	90.4	80	120			
Sample ID: C01110664-003AMS	MS								11/27/01 18:20
Benzene	436	ug/L	25	86.6	70	130			
Ethylbenzene	477	ug/L	25	94.5	70	130			
m+p-Xylenes	1010	ug/L	25	94.3	70	130			
Methyl tert-butyl ether (MTBE)	738	ug/L	100	2.75	70	130			S
o-Xylene	486	ug/L	25	92.3	70	130			
Toluene	461	ug/L	25	90.8	70	130			
Sum: Trifluorotoluene			25	91.6	70	130			
Sample ID: C01110664-003AMSD	MSD								11/27/01 18:58
Benzene	437	ug/L	25	86.4	70	130	0.229	20	
Ethylbenzene	475	ug/L	25	94.1	70	130	0.420	20	
m+p-Xylenes	1011	ug/L	25	94.4	70	130	0.0990	20	
Methyl tert-butyl ether (MTBE)	734	ug/L	100	2.55	70	130	0.543	20	S
o-Xylene	487	ug/L	25	92.1	70	130	0.205	20	
Toluene	460	ug/L	25	90.6	70	130	0.217	20	
Sum: Trifluorotoluene			25	90.4	70	130	0	20	

Qualifiers: ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
B - Analyte detected in the associated Method Blank

S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits

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11584R00069

LABORATORY ANALYTICAL REPORT

Client: US Department of Energy
Project: Not Indicated
Lab ID: C01120064-001
Client Sample ID: RMOTCPit #1

Report Date: 12/13/01
Collection Date: 12/04/01 11:30
Date Received: 12/04/01
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/		Method	Analysis Date / By
				RL	QCL		
ORGANIC CHARACTERISTICS							
Diesel Range Organics	18	mg/L		10		SW8015M as D	12/06/01 20:36 / dj
Total Petroleum Hydrocarbons	9.9	mg/L		1.0		E418.1	12/05/01 15:41 / dj

Report
Definitions:

ND - Not detected at the reporting limit
MCL - Maximum contaminant level

QCL - Quality control limit
RL - Analyte reporting level

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12065R00302

001*20064-001A 1206DROH SF-C-DRO W API (7.10)
G:\ORG\HPI\1206DROH 14R

24.53	
22.72	
21.54	
20.74	
19.92	
19.08	
18.24	
17.40	
16.56	n-Octadecane
15.72	
14.88	n-Hexadecane
14.04	
13.20	
12.36	n-Tetradecane
11.52	
10.68	
9.84	n-Dodecane
9.00	
8.16	
7.32	
6.48	
5.64	
4.80	
3.96	
3.12	
2.28	
1.44	
0.60

LABORATORY ANALYTICAL REPORT

Client: US Department of Energy
Project: Not Indicated
Lab ID: CQ1110592-001
Client Sample ID: RMOTC P&I No.1

Report Date: 11/28/01
Collection Date: 11/19/01 13:18
Date Received: 11/19/01
Matrix: AQUEOUS

Analyses	Result	Units	Qual	MCL/		Method	Analysis Date / By
				RL	QCL		
ORGANIC CHARACTERISTICS							
Diesel Range Organics	35	mg/L		10		SW8015M as D	11/26/01 23:47 / d
Sulf. o-Terphenyl	250	%REC	D		75-125	SW8015M as D	11/26/01 23:47 / d
ORGANIC CHARACTERISTICS							
Total Petroleum Hydrocarbons	6*	mg/L		10		E418.1	11/20/01 12:21 / d

Report: NTD - Not detected at the reporting limit
Definitions: MCL - Maximum contaminant level

QCL - Quality control limit
RL - Analyte reporting level

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11592R00002

C01110592-001A; 1126DRCH; SHC-DRO W API (1.10)
G:\016GAP\11130DRCH.12R

74.44	
23.78	
22.95	
22.84	
22.50	
22.41	
22.31	
22.21	
22.11	
22.01	
21.91	
21.81	
21.71	
21.61	
21.51	
21.41	
21.31	
21.21	
21.11	
21.01	
20.91	
20.81	
20.71	
20.61	
20.51	
20.41	
20.31	
20.21	
20.11	
20.01	
19.91	
19.81	
19.71	
19.61	
19.51	
19.41	
19.31	
19.21	
19.11	
19.01	
18.91	
18.81	
18.71	
18.61	
18.51	
18.41	
18.31	
18.21	
18.11	
18.01	
17.91	
17.81	
17.71	
17.61	
17.51	
17.41	
17.31	
17.21	
17.11	
17.01	
16.91	
16.81	
16.71	
16.61	
16.51	
16.41	
16.31	
16.21	
16.11	
16.01	
15.91	
15.81	
15.71	
15.61	
15.51	
15.41	
15.31	
15.21	
15.11	
15.01	
14.91	
14.81	
14.71	
14.61	
14.51	
14.41	
14.31	
14.21	
14.11	
14.01	
13.91	
13.81	
13.71	
13.61	
13.51	
13.41	
13.31	
13.21	
13.11	
13.01	
12.91	
12.81	
12.71	
12.61	
12.51	
12.41	
12.31	
12.21	
12.11	
12.01	
11.91	
11.81	
11.71	
11.61	
11.51	
11.41	
11.31	
11.21	
11.11	
11.01	
10.91	
10.81	
10.71	
10.61	
10.51	
10.41	
10.31	
10.21	
10.11	
10.01	
9.91	
9.81	
9.71	
9.61	
9.51	
9.41	
9.31	
9.21	
9.11	
9.01	
8.91	
8.81	
8.71	
8.61	
8.51	
8.41	
8.31	
8.21	
8.11	
8.01	
7.91	
7.81	
7.71	
7.61	
7.51	
7.41	
7.31	
7.21	
7.11	
7.01	
6.91	
6.81	
6.71	
6.61	
6.51	
6.41	
6.31	
6.21	
6.11	
6.01	
5.91	
5.81	
5.71	
5.61	
5.51	
5.41	
5.31	
5.21	
5.11	
5.01	
4.91	
4.81	
4.71	
4.61	
4.51	
4.41	
4.31	
4.21	
4.11	
4.01	
3.91	
3.81	
3.71	
3.61	
3.51	
3.41	
3.31	
3.21	
3.11	
3.01	
2.91	
2.81	
2.71	
2.61	
2.51	
2.41	
2.31	
2.21	
2.11	
2.01	
1.91	
1.81	
1.71	
1.61	
1.51	
1.41	
1.31	
1.21	
1.11	
1.01	
0.91	
0.81	
0.71	
0.61	
0.51	
0.41	
0.31	
0.21	
0.11	
0.01	

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11592R00003

APPENDIX B

Figure 1 Lab Analysis Results for Drum No. 1

Figure 2 Lab Analysis Results for Drum No. 2

Figure 3 Analysis Results from RMOTC Pit - Produced Water Matrix

APPENDIX C

1

2

3

Basic Set-up of Proton Test
(drawing not to scale)