1R - 265

REPORTS

DATE:

12/11/1996

1R - 265

REPORTS

DATE:

Executive Summary

Field History

This project involves the closure of nine pits situated atop a comparatively shallow section of the Ogallala Aquifer. Eight of the pits were used for containment of fluids in upset conditions that were normally directed to on site storage and separation equipment. Satellite # 4 was similarly designed for upset conditions within the Burro Pipeline gathering system. All of the pits were constructed between 1965 and 1968. No production fluids have been directed to the pits since before 1970.

Site Investigation

Excavation

In December of 1996, Whole Earth partially excavated the Mable COM and Iva COM locations in an attempt to determine the vertical extent of contamination. We encountered high hydrocarbon concentrations down to the mechanical limits of the excavation equipment.

Coring

In January of this year, we auger drilled each location until we found either the 100 ppm TPH concentration horizon or the water table. We were able to auger into the center of four pits. On the remaining five, we were unable to do so due either to the presence of fluids within the pit or to the pit geometry. In such cases we cored atop the berm wall immediately southeast of the pit center. The location of the probe holes are noted on the attached plat maps with an asterisk.

TPH Analysis

TPH samples were analyzed at approximate 5' intervals and are included within the relevant pit detail sections of this report. The samples were extracted and analyzed in accordance with EPA Method 418.1 (modified) and Whole Earth Environmental procedures QP-06 and QP-25 (enclosed).

Volatiles and Semi-Volatiles

Seven of the locations were cored down to the upper vadose zone and samples were submitted to Environmental Labs of Texas for volatile and semi-volatile analysis under EPA Methods 8240, 8270 and 3551. The results are included within the relevant pit detail sections of this report.

Remediation Plan

A. Sohio State "A"

This pit will be excavated to a depth sufficient to achieve TPH concentrations below 100 ppm, benzene concentrations of less than 10 ppm and total BTEX concentrations of less than 50 ppm. The materials will be mixed and blended with additional topsoils obtained immediately adjacent to the location and re-deposited within the excavated area at the above cited maximum concentration levels.

B. Satellite # 4

This pit will be handled similarly to Sohio State "A" except that all free liquids and the liner will be first transported to a licensed disposal facility.

C. Vera # 1, State NBN # 1, State NBF # 1, Bell State "A" & G.S. State #1

For these five pits, we request that the OCD consider the enclosed risk based evaluations which demonstrate that the remaining contaminants will not pose a threat to present or foreseeable beneficial use of fresh waters, public health and the environment.

As described in the enclosed closure protocol QP-42, we plan to excavate all surface contaminants to a sufficient depth to achieve TPH concentrations of <10,000 ppm, and benzene concentrations of < 10 ppm. The pit surface will then be covered with an impermeable liner of at least 20 mils thickness preventing any vertical infiltration of groundwater onto the remaining contaminants. To insure that the liner is not punctured during installation, it will be "sandwiched" between two layers of fresh sand each at least 6" thick. The area above the liner will be remediated to a maximum TPH concentration of <100 ppm and a benzene concentration of <10 ppm.

We are compelled to propose this risk based plan for two reasons. First, the caliche layer above the table ranges from a minimum of 20' and a maximum of 38' in thickness. The density of the caliche makes it particularly resistant to excavation. Similarly, the rock morphology does not lend itself to passive remediation alternatives such as sparging.

The caliche does however prove to be an effective barrier to the vertical migration of BTEX components as demonstrated by the laboratory analyses included within this report. The enclosed VADSAT modeling supports the actual laboratory results in concluding that even in remaining concentrations of 10,000 ppm TPH, the contamination will not find its way to the water table.

D. Mable COM & Iva COM

The laboratory results verify that contaminates within these two pits have impacted the water table. The physical excavation of these two pits indicate that they were (in all probability) blasted during their construction. This blasting fractured the sub-strait layers and provided a migration path for the contamination to follow.

Again, the caliche layer prevents either the physical removal of the contaminated soils or passive remediation through sparging. We propose to install a draw-down well in the center of each pit and a monitoring well immediately down-gradient of the site. Tipperary will continue to remove all free products from the table and monitor the down-gradient concentrations until final closure may be affected.

We do not plan to install an impermeable barrier above the plume as we desire to leach as much of the contamination as possible into the draw-down well. We will however remediate the surface ten feet of each site to <100 ppm TPH and <10 ppm benzene to minimize any potential run-off risk.

Sohio State “A”

Legal Description

Sohio State “A”
State Lease K2371 Unit “P”
T11S-R33E-Sec.4
660’ FSL - 1,980’ FEL

Pit Description

Sohio State “A” is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage at the well location. The pit lies approximately 125 feet east of the separator in a shallow depression located off of the pad. The actual pit dimensions are 30’ X 40’ x 2’ in depth.

There is very minor surface staining and the remaining hydrocarbon fractions appear to be heavily weathered and asphaltic in texture. There are no signs of stressed vegetation surrounding the pit.

Pit History

The well was logged on August 29, 1967 and completed shortly thereafter. The well site was connected to the Burro Pipeline system before 1970 eliminating any subsequent emergency discharges into the pit.

Distance to Surface & Ground Waters

The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 33’. (See attached 7.5’ & hydro-geological plat maps.)

Closure Standards

In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. ’93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

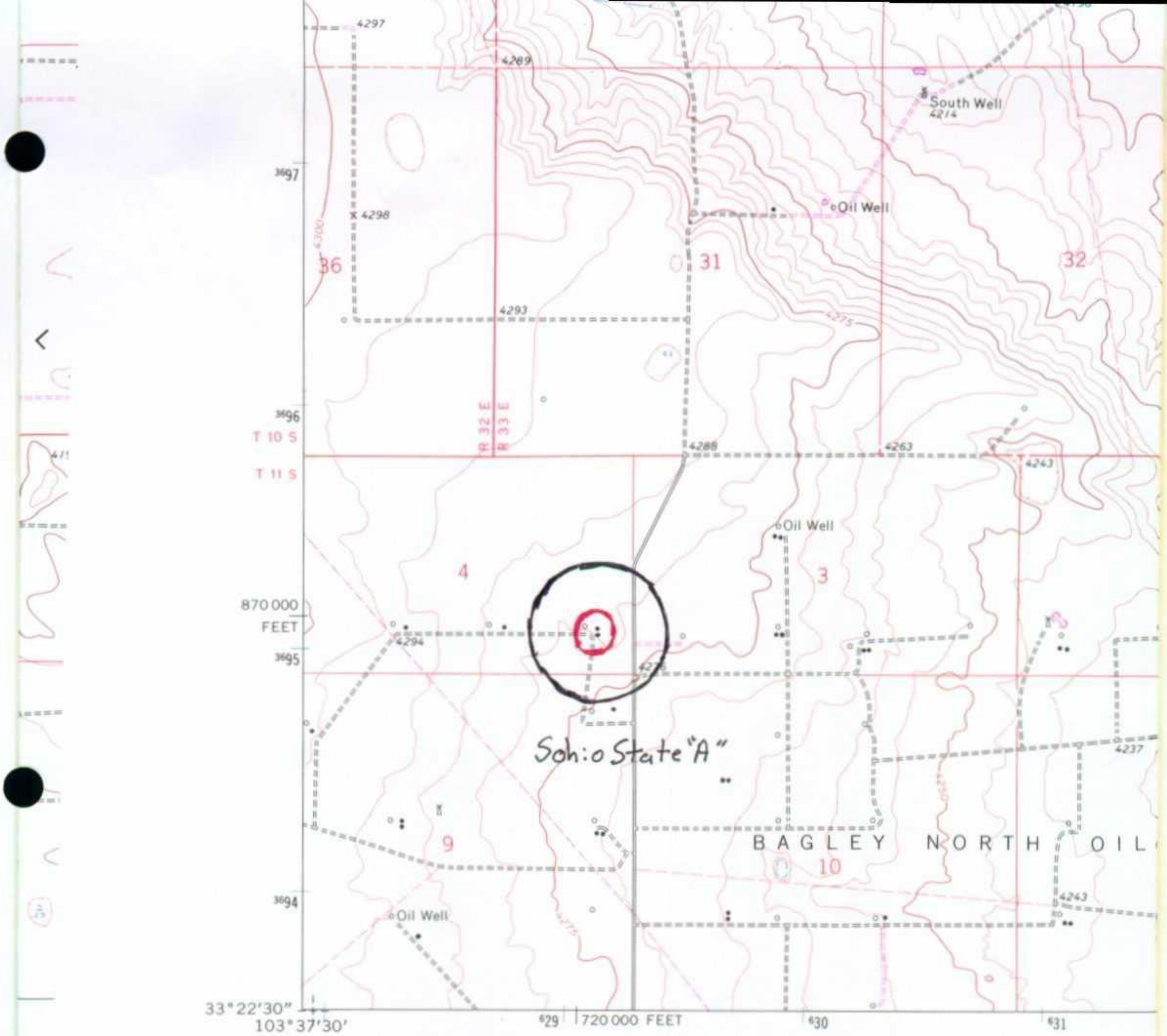
Sampling Results

On January 10, 1997, Whole Earth supervised the coring of the pit and found no reportable hydrocarbon concentrations at a depth of between 10-15’. (See attached field sampling report.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

Closure Protocol

We propose to close Sohio State "A" in accordance with the attached Protocol QP-41.

Sohio State "A"



Soh:o State "A"

(SOLDIER HILL)
5250 I SW

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1971. Field checked 1973

Projection and 10,000-foot grid ticks: New Mexico coordinate system, east zone (transverse Mercator)
1000-meter Universal Transverse Mercator grid ticks, zone 13, shown in blue
1927 North American Datum
To place on the predicted North American Datum 1983 move the projection lines 7 meters south and 46 meters east as shown by dashed corner ticks

Fine red dashed lines indicate selected fence lines

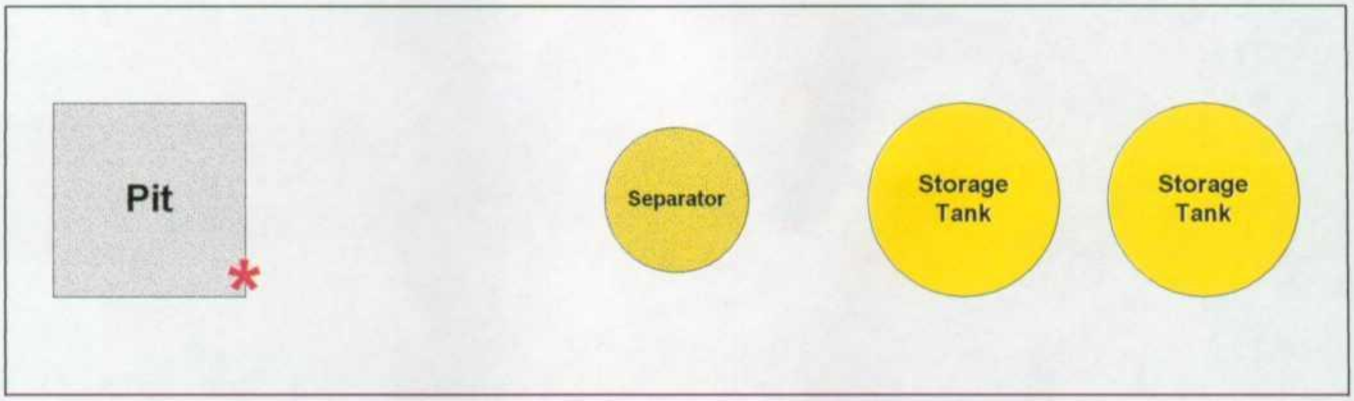
Revisions shown in purple and woodland compiled from aerial photographs taken 1982 and other sources. This information not field checked. Map edited 1984

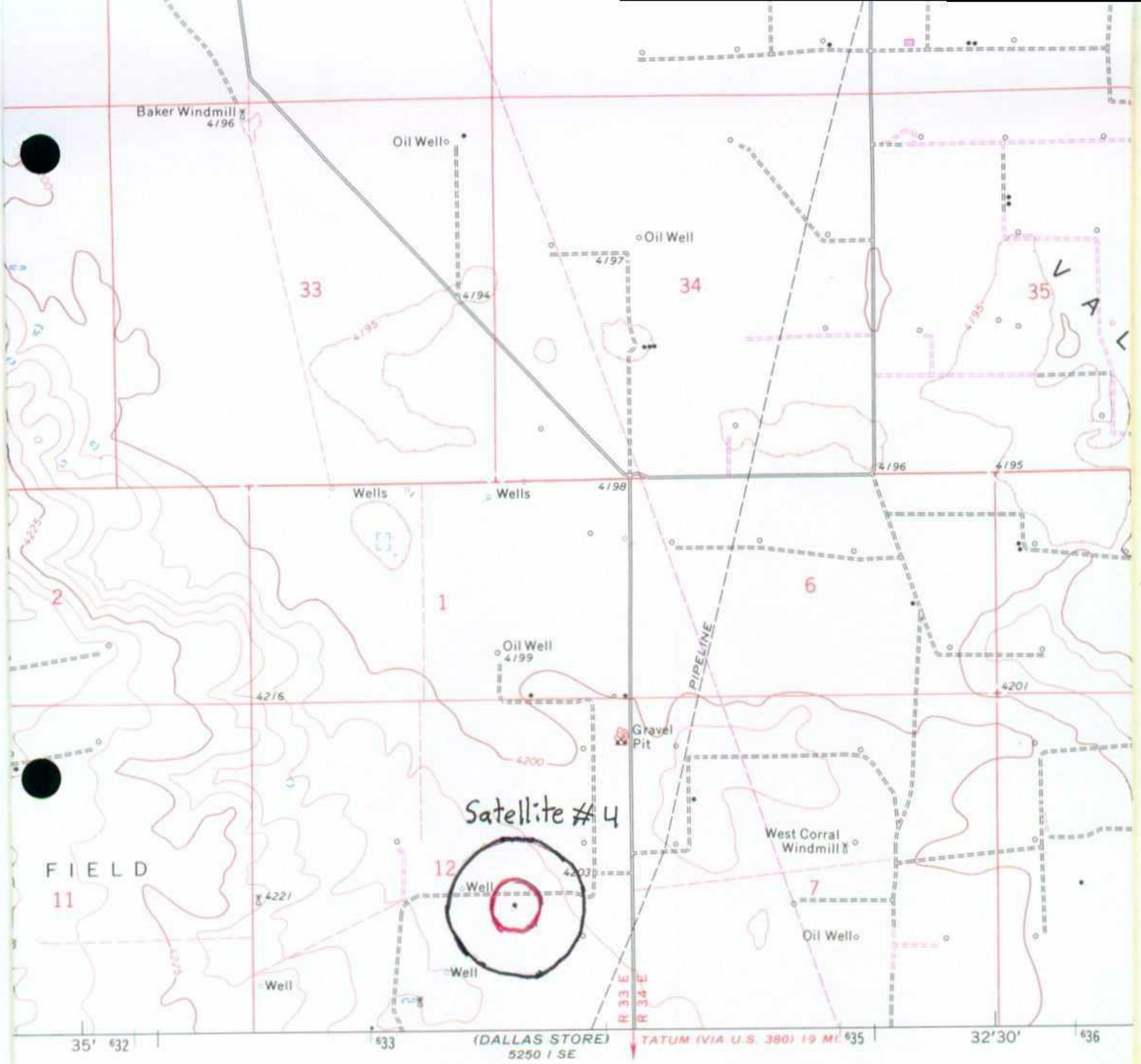
UTM GRID AND 1984 MAGNETIC NOR
DECLINATION AT CENTER OF SHEET

Satellite # 4

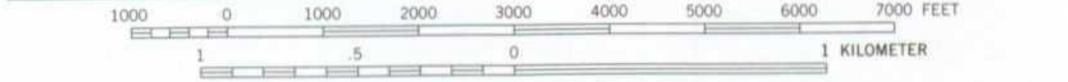
1 30 98

Satellite # 4





SCALE 1:24 000



CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

TH

QUADF

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 2

DATE: 1-10-97

DRILL START: 8:40 AM
DRILL STOP: 9:40 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: N. of NM Hwy. 380
Sohio State A

TH NUMBER: 6

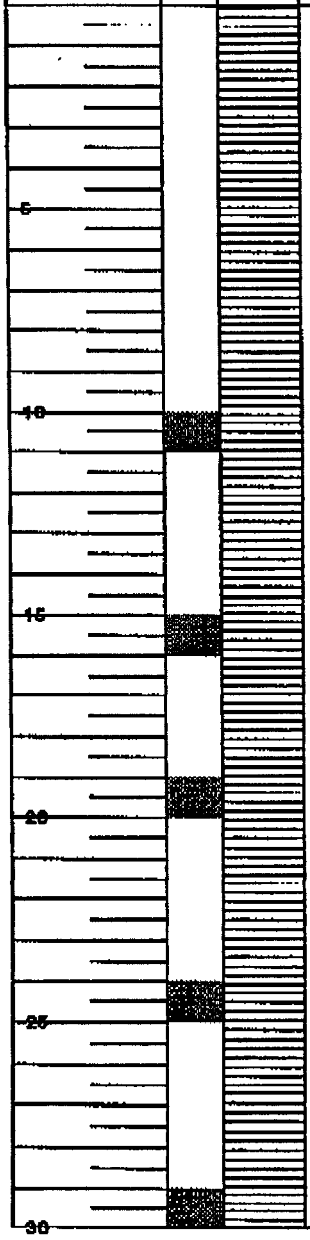
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet) | SPT | Symbol | STRATUM DESCRIPTION | Well Construction Details | PID Reading | Lab Analysis | Lab Analysis



Clay w/Caliche, Brown, Firm, Damp

Silty Clay w/Caliche, Tan, Firm, Dry

Silty Sandy Clay, Tan, Firm, Dry

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 **OF** 2

DATE: 1-10-97

DRILL START: 8:40 AM

DRILL STOP: 9:40 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: N. of NM Hwy. 380
Sohio State A

TH NUMBER: 8

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis
		▤	Silty Sandy Clay, Tan, Firm, Dry (Cont'd)				
35	▨	▤					
40	▨	▤					
			TD = ±40 ft.				
45							
50							
55							
60							

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 10, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: Sohio State "A"
Depth to Water: Unknown

Depth	10'	15'	20'	30'	
Concentration	1,120	6	7	3	

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________

Pit Remediation Protocol
Tipperary Corporation
Tatum Pit Closure Project
Sohio State "A"

1.0 Purpose

This protocol is provide a detailed outline of the steps to be employed in the remediation and final closure of the Sohio State "A" Pit.

2.0 Scope

This protocol is site specific for the Sohio Sate "A" pit.

3.0 Preliminary

Prior to any field operations, Whole Earth Environmental shall conduct the following activities:

3.1 Client Review

3.1.1 Whole Earth shall meet with cognizant personnel within Tipperary to review this protocol and make any requested modifications or alterations prior to submittal to the State of New Mexico Oil Conservation Division.

3.1.2 Changes to this protocol will be documented and submitted for final review by Tipperary Corporation prior to submittal to the Oil Conservation Division.

3.2 Oil Conservation Division Review

3.2.1 Upon client approval, this procedure will be submitted to the New Mexico Oil Conservation Division for review and comment. Recommended changes will be reviewed by the client prior to implementation.

3.2.2 Any recommended changes effecting costs will require a revised quotation to be issued to the client for approval prior to the commencement of any on-site remediation activity.

4.0 Safety

4.1 Prior to work on the site, Whole Earth shall obtain the location and phone numbers of the nearest emergency medical treatment facility. We will review all safety related issues with the appropriate Tipperary personnel, sub-contractors and exchange phone numbers.

4.2 A tailgate safety meeting shall be held and documented each day. All sub-contractors must attend and sign the daily log-in sheet.

4.3 Anyone allowed on to location must be wearing sleeved shirts, steel toed boots, and long pants. Each vehicle must be equipped with two way communication capabilities.

4.4 Prior to any excavation, the area shall be surveyed with a line finder. If lines are discovered within the area to be excavated they shall be marked with pin flags on either side of the line at maximum five foot intervals.

5.0 Excavation & Remediation

5.1 The site shall be excavated to a minimum depth of 10'. All excavated material will be deposited immediately adjacent to the pit site.

5.2 The bottom of the pit and all four side walls will be tested for TPH and BTEX concentrations using WEQP-06 and WEQP-19. Excavation will continue until such concentrations are <100 ppm TPH, <10 ppm benzene and <50 ppm total BTEX.

5.3 The excavated materials will be mixed and blended with additional topsoils obtained from the area immediately adjacent to the pit until the hydrocarbon concentrations fall below the maximum limits as described in Paragraph 5.2 of this protocol. The remediated materials will then be replaced into the excavated area, compacted and the surface contoured to provide for positive drainage.

6.0 Documentation & Reporting

6.1 At the conclusion of the pit remediation project, Whole Earth will prepare a closure report to include the following information:

- A plat map of the location showing the exact location of the pit, the dimensions prior to excavation and the actual excavated dimensions.
- Photographs of the pit prior to excavation, at the point of maximum excavation and after final closure

- Field Sampling Report to include the side wall and pit bottom TPH and BTEX concentrations after excavation.
- Field Sampling Report to include TPH and BTEX concentrations of all remediated materials deposited into the pit deposited into the pit.
- Daily calibration records of each testing instrument

Satellite # 4

Legal Description
Fee Lease
T11S-R33E-Sec.12
NE / SE

Pit Description
Satellite # 4 is described as a lined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 75 feet east of the separator within a raised berm approximately 2' in height. The actual pit dimensions are 60' X 60' x 8' in depth. The pit is covered in bird netting and the liner appears intact.

There is free product within the pit however there is no evidence of surface staining surrounding the berm. There are no signs of stressed vegetation surrounding the pit and indeed vegetation can be found extending to the edge of the liner.

The location is surrounded in perimeter fencing consisting of four string barbed wire.

Pit History
The Satellite Station was erected in late 1967 or early 1968 as part of the Burro Pipeline system. The pit was established to serve as an emergency discharge pit in the event of an upset condition within the pipeline system.

Distance to Surface & Ground Waters
The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 29'. (See attached 7.5' & hydro-geological plat maps.)

Closure Standards
In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

Sampling Results
On January 10, 1997, Whole Earth supervised the coring of the pit and found no reportable hydrocarbon concentrations to a depth of 25'. Due to the presence of free product within the pit, the coring was performed at the southeast corner, mid way up the

berm. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

Closure Protocol

We propose to close Satellite # 4 in accordance with the attached Protocol QP-44.

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2004 West Second Street, Roswell, New Mexico 88202-5158

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 1

DATE: 1-10-97

DRILL START: 10:40 AM

DRILL STOP: 11:20 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: N. of NM Hwy. 380
Satellite 4

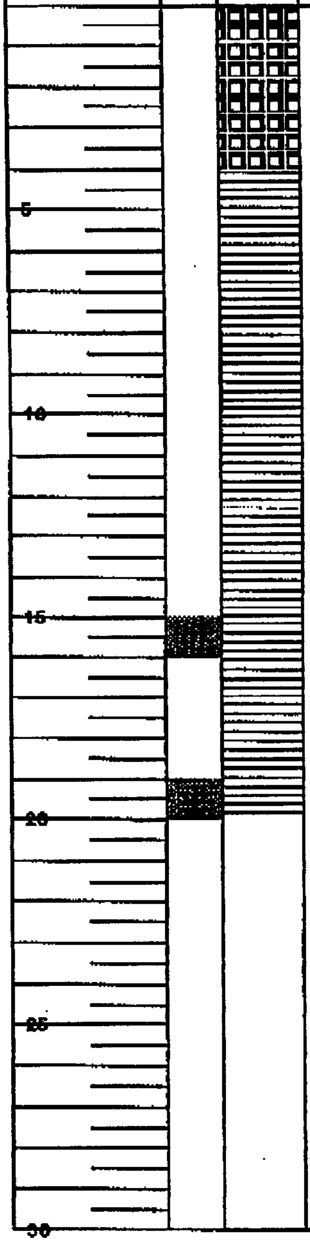
TH NUMBER: 9

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, INC.

LOGGED BY: Mort Bates



STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis	
Caliche back fill w/Silty Clay,, Brown, Firm, Damp					
Silty Clay w/Caliche, Tan, Firm, Dry					
TD = ±20 ft.					

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 10, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: Satellite # 4
Depth to Water: Unknown

Depth	10'	15'	20'	25'	
Concentration	8	26	19	8	

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________________

Pit Remediation Protocol
Tipperary Corporation
Tatum Pit Closure Project
Satellite # 4

1.0 Purpose

This protocol is provide a detailed outline of the steps to be employed in the remediation and final closure of the Tipperary Satellite # 4 Pit.

2.0 Scope

This protocol is site specific for the Satellite # 4 pit.

3.0 Preliminary

Prior to any field operations, Whole Earth Environmental shall conduct the following activities:

3.1 Client Review

3.1.1 Whole Earth shall meet with cognizant personnel within Tipperary to review this protocol and make any requested modifications or alterations prior to submittal to the State of New Mexico Oil Conservation Division.

3.1.2 Changes to this protocol will be documented and submitted for final review by Tipperary Corporation prior to submittal to the Oil Conservation Division.

3.2 Oil Conservation Division Review

3.2.1 Upon client approval, this procedure will be submitted to the New Mexico Oil Conservation Division for review and comment. Recommended changes will be reviewed by the client prior to implementation.

3.2.2 Any recommended changes effecting costs will require a revised quotation to be issued to the client for approval prior to the commencement of any on-site remediation activity.

4.0 Safety

4.1 Prior to work on the site, Whole Earth shall obtain the location and phone numbers of the nearest emergency medical treatment facility. We will review all safety related issues with the appropriate Tipperary personnel, sub-contractors and exchange phone numbers.

4.2 A tailgate safety meeting shall be held and documented each day. All sub-contractors must attend and sign the daily log-in sheet.

4.3 Anyone allowed on to location must be wearing sleeved shirts, steel toed boots, and long pants. Each vehicle must be equipped with two way communication capabilities.

4.4 Prior to any excavation, the area shall be surveyed with a line finder. If lines are discovered within the area to be excavated they shall be marked with pin flags on either side of the line at maximum five foot intervals.

5.0 Fluid Removal

Prior to any excavation, the pit fluids shall be removed by vacuum truck and transported to the Gandy / Marley, Inc. Landfarm. A shipping manifest and O.C.D. Form C-117-A shall be prepared for each load and included within the final closure report.

6.0 Excavation & Remediation

6.1 The site shall be excavated to a minimum depth of 5'. All excavated material will be deposited immediately adjacent to the pit site.

6.2 The bottom of the pit and all four side walls will be tested for TPH and BTEX concentrations using WEQP-06 and WEQP-19. Excavation will continue until such concentrations are <100 ppm TPH, <10 ppm benzene and <50 ppm total BTEX.

63 The excavated materials will be mixed and blended with additional topsoils obtained from the area immediately adjacent to the pit until the hydrocarbon concentrations fall below the maximum limits as described in Paragraph 6.2 of this protocol. The remediated materials will then be replaced into the excavated area, compacted and the surface contoured to provide for positive drainage.

7.0 Documentation & Reporting

7.1 At the conclusion of the pit remediation project, Whole Earth will prepare a closure report to include the following information:

- A plat map of the location showing the exact location of the pit, the dimensions prior to excavation and the actual excavated dimensions.
- Photographs of the pit prior to excavation, at the point of maximum excavation and after final closure
- Field Sampling Report to include the side wall and pit bottom TPH and BTEX concentrations after excavation.
- Field Sampling Report to include TPH and BTEX concentrations of all remediated materials deposited into the pit deposited into the pit.
- Daily calibration records of each testing instrument
- Shipping manifests and OCD Form C-117-A

Vera # 1

Legal Description
State Lease K3985 - Unit "E"
T11S-R33E-Sec.32
1,980' FNL - 810' FWL

Pit Description
Vera # 1 is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 120 feet north of the separator within a raised berm approximately 2' in height. The actual pit dimensions are 50' X 50' x 3' in depth. The pit is covered in bird netting and is surrounded by a four strand barbed wire fence.

There is a minor amount of free product within the pit consisting of heavily weathered asphaltic fractions however there is no evidence of surface staining surrounding the berm. There are no signs of stressed vegetation surrounding the pit.

Pit History
Vera # 1was logged on October 15, 1968 and completed shortly thereafter. Burro Pipeline was permitted in October of 1967 and was connected to the wellsite prior to 1970. All emergency discharges to the pit were discontinued prior to 1970.

Distance to Surface & Ground Waters
The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 58' as determined on January 9, 1997. (See attached 7.5', hydro-geological plat maps and boring logs.)

Closure Standards
In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

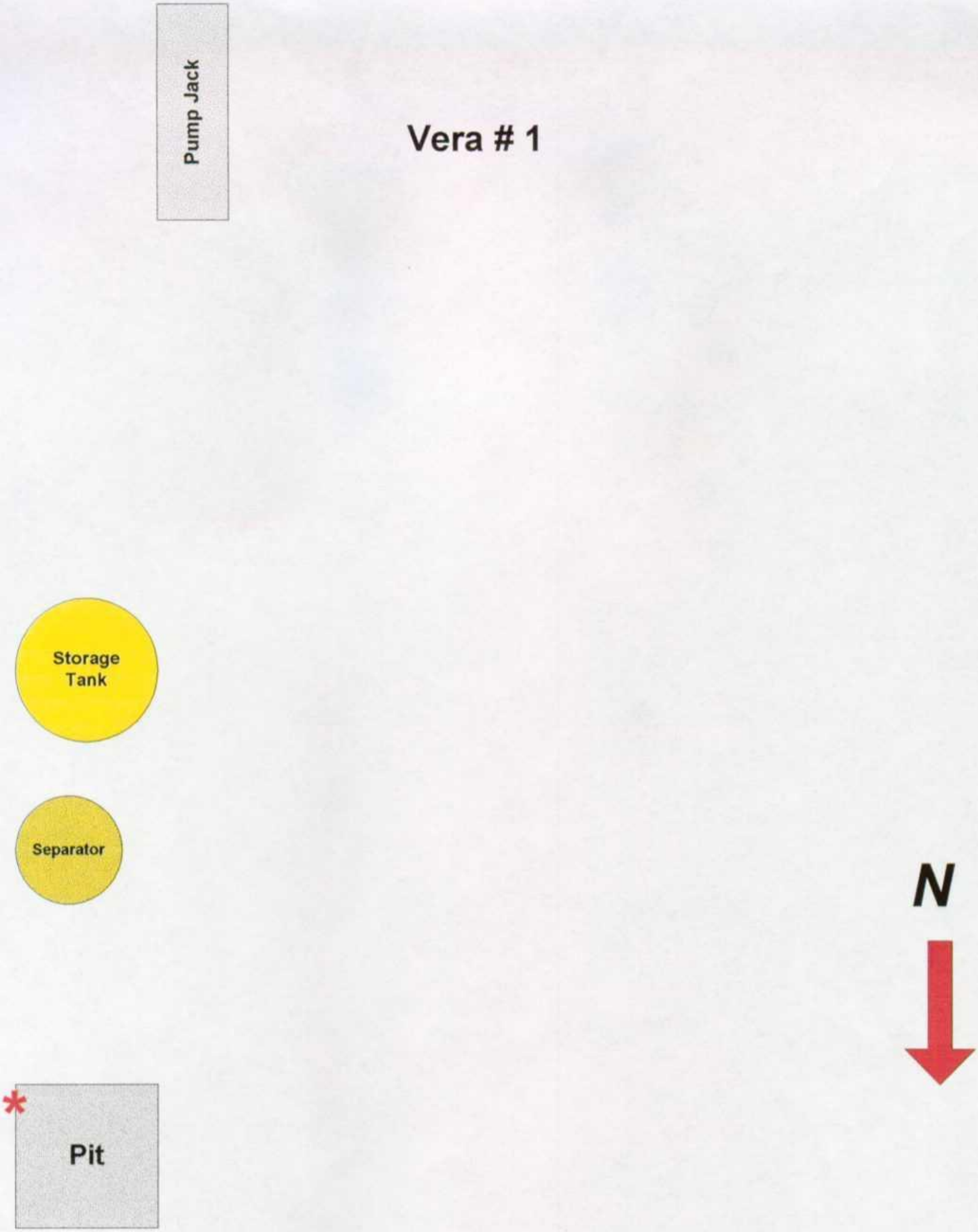
Sampling Results
On January 10, 1997, Whole Earth supervised the coring of the pit and found hydrocarbon concentrations of less than 1,000 ppm TPH at a depth of between 10-15'. Due to the presence of free product within the pit, the coring was performed at the

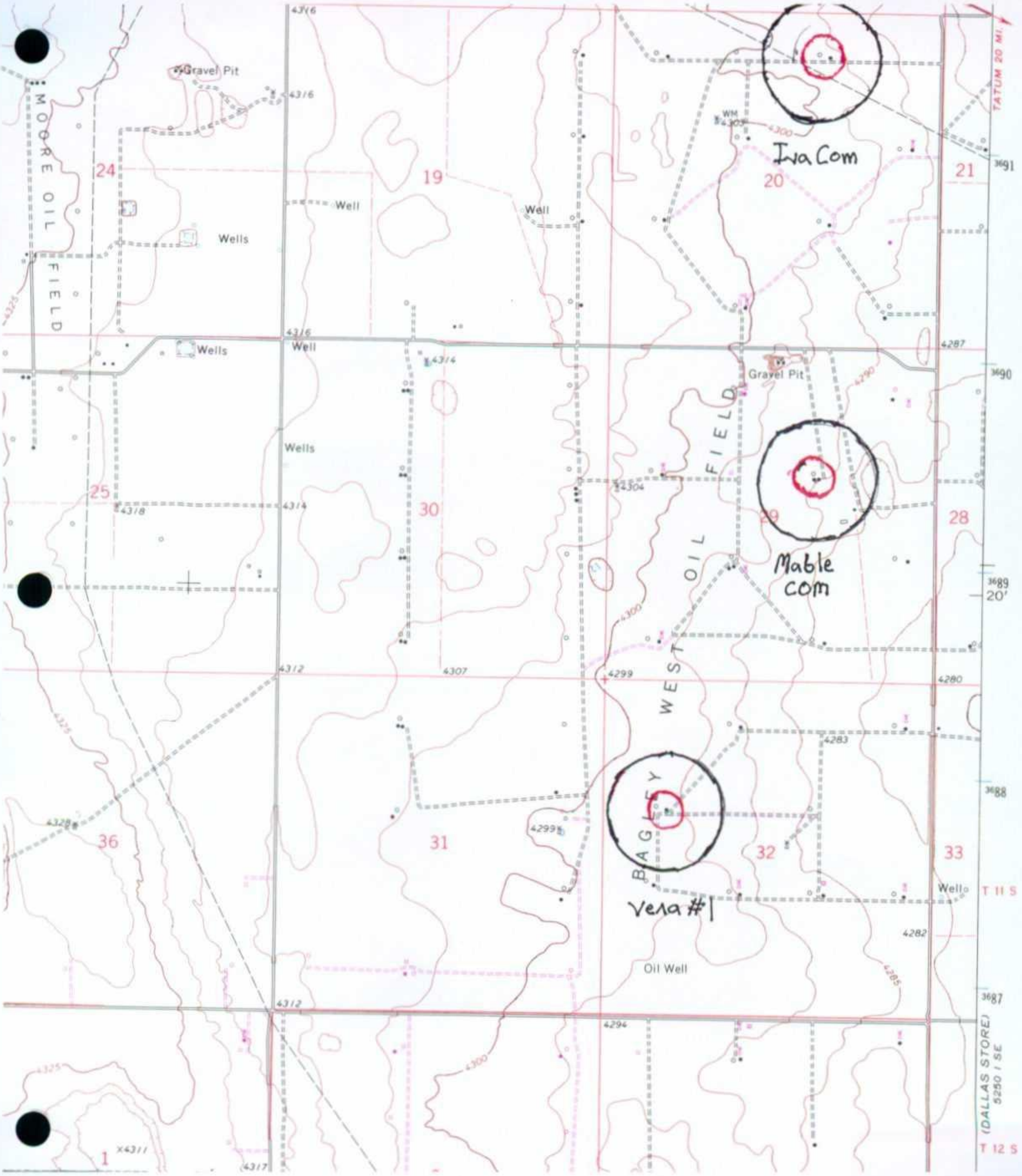
southeast corner, mid-way up the berm. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

Core samples obtained from the upper vadose zone of the aquifer revealed no detectable concentrations of volatile or semi-volatile compounds. (See attached Environmental Labs of Texas analytical reports.)

Closure Protocol
We propose to close Vera # 1 in accordance with the attached Protocol QP-42.

Vera # 1




Iva Com
Mable Com
Vera #1
MOORE OIL FIELD
BAGLEY WEST OIL FIELD
Gravel Pit
Wells
Well
Oil Well
WM
TATUM 20 MI.
(DALLAS STORE)
5250 I SE
T 11 S
T 12 S
24
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4316
4314
4318
4312
4307
4299
4304
4303
4300
4290
4287
4283
4282
4280
4285
4294
4311
4317
4325
4328
3691
3690
3689
20'
3688
3687

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3158

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental. Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 2

DATE: 1-8-97

DRILL START: 8:45 AM
DRILL STOP: 1:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
~~Iva~~ Com
Vera

TH NUMBER: 5

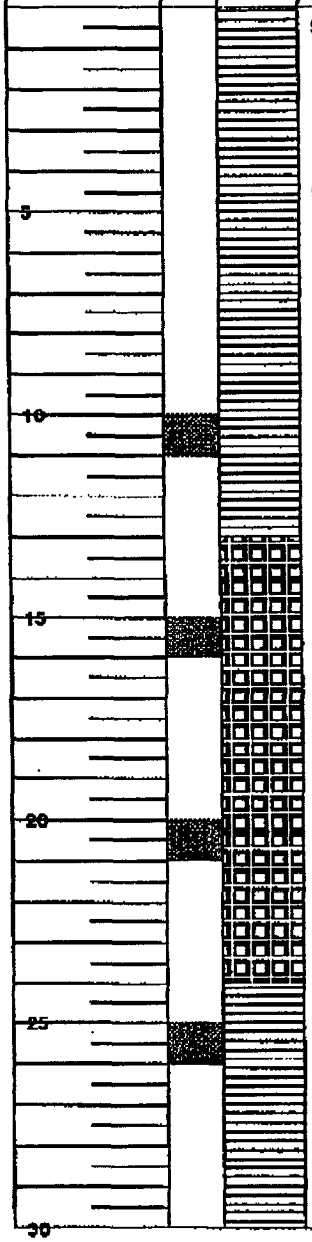
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet) / SPT / Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis	
	Silty Clay w/Caliche, Brown, Firm, Dry					
	Silty Clay w/Caliche, Tan, Firm, Dry					
	Caliche w/Silty Clay, Tan, Hard, Dry					
	Caliche, Gray, Hard, Dry					
	Silty Clay w/Caliche, Tan, Firm, Dry					



BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2004 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 OF 2

DATE: 1-9-97

DRILL START: 8:45 AM

DRILL STOP: 1:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
~~Ive~~ Com
Vera

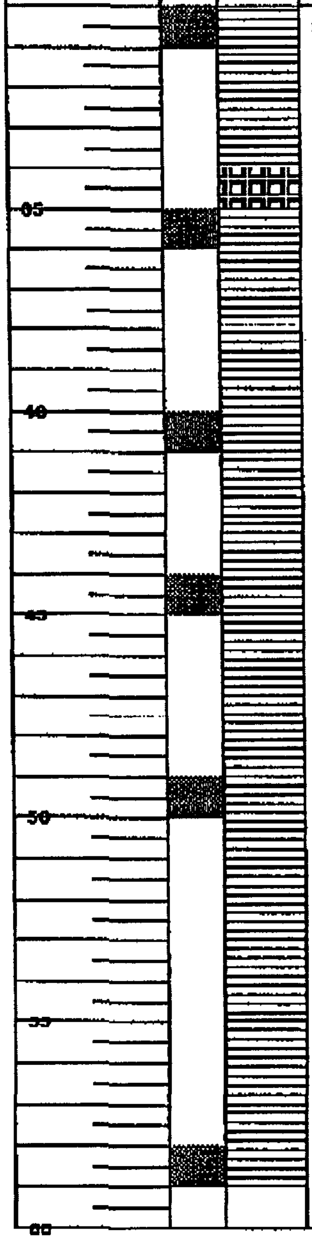
TH NUMBER: 5

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet) / SPT / Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis	
	Silty Clay w/Caliche, Tan, Firm, Dry (Cont'd) Caliche, Gray, Hard, Dry Silty Clay w/Caliche, Tan, Hard, Dry Silty Clay w/Caliche, Tan, Firm, Saturated TD = ±59 ft. Lost 35 feet of center rod with center bit. Damaged 35 feet of Auger					

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 10, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: Vera # 1
Depth to Water: 58'

Depth	10'	15'	20'	30'	35'
Concentration	156	93	127	549	748

Depth	50'				
Concentration	418				

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________________

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Bottom hole Sample

Receiving Date: 01/10/97
Sample Type: SOIL
Project : TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: VERA #1
ELT# 9910

Analysis Date: 01/19/97
Sampling Date: 01/09/97
Sample Condition: Intact/Iced

8270 COMPOUNDS	REPORTING LIMIT	SAMPLE Concentration ppm	QC	RPD	% EA	% IA
N-Nitrosodimethylamine	0.01	ND				
2-Picoline	0.01	ND				
Methyl methanesulfonate	0.01	ND				
Ethyl methanesulfonate	0.01	ND				
Phenol	0.01	ND	91	11	84	95
Aniline	0.05	ND				
bis(2-Chloroethyl)ether	0.05	ND				
2-Chlorophenol	0.05	ND		8	74	
1,3-Dichlorobenzene	0.01	ND				
1,4-Dichlorobenzene	0.01	ND	94	10	73	93
Benzyl alchohol	0.05	ND				
1,2-Dichlorobenzene	0.01	ND				
2-Methylphenol	0.01	ND				
bis(2-Chloroisopropyl)ether	0.05	ND				
4-Methylphenol/3-Methylphenol	0.01	ND				
Acetophenone	0.05	ND				
n-Nitrosodi-n-propylamine	0.01	ND		5	79	
Hexachloroethane	0.01	ND				
Nitrobenzene	0.01	ND				
N-Nitrosopiperidine	0.05	ND				
Isophorone	0.05	ND				
2-Nitrophenol	0.05	ND	93			94
2,4-Dimethylphenol	0.05	ND				
bis(2-Chloroethoxy)methane	0.01	ND				
Benzoic acid	0.1	ND				
2,4-Dichlorophenol	0.05	ND	87			96
1,2,4-Trichlorobenzene	0.01	ND		9	79	
a,a Dimethylphenethylamine	0.1	ND				
Naphthalene	0.01	ND				
4-Chloroaniline	0.05	ND				
2,6-Dichlorophenol	0.05	ND				
Hexachlorobutadiene	0.01	ND	95			97
N-Nitroso-di-n-butylamine	0.05	ND				
4-Chloro-3-methylphenol	0.05	ND	97	12	81	93

ELT# 9910

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
2-Methylnaphthalene	0.01	ND				
1,2,4,5-Tetrachlorobenzene	0.01	ND				
Hexachlorocyclopentadiene	0.01	ND				
2,4,6-Trichlorophenol	0.05	ND	86			94
2,4,5-Trichlorophenol	0.05	ND				
2-Chloronaphthalene	0.01	ND				
1,-Chloronaphthalene	0.01	ND				
2-Nitroaniline	0.05	ND				
Dimethylphthalate	0.01	ND				
Acenaphthylene	0.01	ND				
2,6-Dinitrotoluene	0.01	ND				
3-Nitroaniline	0.05	ND				
Acenaphthene	0.01	ND	97	3	81	92
2,4-Dinitrophenol	0.05	ND				
Dibenzofuran	0.05	ND				
Pentachlorobenzene	0.01	ND				
4-Nitrophenol	0.05	ND		4	80	
1-Napthylamine	0.05	ND				
2,4-Dinitrotoluene	0.01	ND		6	79	
2-Napthylamine	0.05	ND				
2,3,4,6-Tetrachlorophenol	0.05	ND				
Fluorene	0.01	ND				
Diethylphthalate	0.01	ND				
4-Chlorophenyl-phenylether	0.01	ND				
4-Nitroaniline	0.05	ND				
4,6-Dinitro-2-methylphenol	0.01	ND				
n-Nitrosodipenlamine & Diphenylam	0.01	ND	93			90
Diphenylhydrazine	0.05	ND				
4-Bromophenyl-phenylether	0.01	ND				
Phenacetin	0.05	ND				
Hexachlorobenzene	0.01	ND				
4-Aminobiphenyl	0.05	ND				
Pentachlorophenol	0.05	ND	89	6	79	95
Pentachloronitrobenzene	0.05	ND				
Pronamide	0.01	ND				
Phenanthrene	0.01	ND				
Anthracene	0.01	ND				
Di-n-butylphthalate	0.01	ND				
Fluoranthene	0.01	ND	92			95
Benzidine	0.1	ND				
Pyrene	0.01	ND		6	88	
p-Dimethylaminoazobenzene	0.01	ND				
Butylbenzylphthalate	0.01	ND				

ELT# 9910

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
Di-n- octlphthalate	0.01	ND	89			92
Benzo[b]fluoranthene	0.01	ND				
7,12-Dimethylbenz(a)anthracene	0.01	ND				
Benzo[k]fluoranthene	0.01	ND				
Benzo [a] pyrene	0.01	ND	96			91
3-Methylcholanthrene	0.01	ND				
Dibenzo (a,j) acridine	0.01	ND				
Indeno [1,2,3-cd] pyrene	0.01	ND				
Dibenz [a,h] anthracene	0.01	ND				
Benzo [g,h,i] perylene	0.01	ND				

METHOD: EPA SW 846-8270, 3551

SURROGATES	% RECOVERY
2-Fluorophenol SURR	87
Phenol-d6 SURR	79
Nitrobenzene-d5 SURR	92
2-Fluorobiphenyl SURR	96
2,4,6-Tribromophenol SURR	82
Terphenyl-d14 SURR	91

Michael R. Fowler

Michael R. Fowler

1-27-97

Date

ENVIRONMENTAL
LAB OF , INC.
"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: VERA #1

Analysis Date: 01/22/97
Sampling Date: 01/09/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9910	PQL	% IA	Method Blank	% EA
Chloromethane	ND	0.1	110	ND	
Vinyl chloride	ND	0.1	101	ND	
Bromomethane	ND	0.1	100	ND	
Chloroethane	ND	0.1	105	ND	
Trichlorofluoromethane	ND	0.1	102	ND	
Acetone	ND	0.1	100	ND	
1,1-Dichloroethane	ND	0.1	95	ND	69
Iodomethane	ND	1.0	92	ND	
Vinyl Acetate	ND	1.0	107	ND	
Carbon Disulfide	ND	0.1	100	ND	
Methylene Chloride	ND	0.1	110	ND	
trans-1,2-Dichloroethene	ND	0.1	98	ND	
1,1-Dichloroethane	ND	0.1	102	ND	
2-Butanone	3.651 —?	1.0	108	ND	
Chloroform	ND	0.1	106	ND	
1,1,1-Trichloroethane	ND	0.1	91	ND	
Carbon Tetrachloride	ND	0.1	94	ND	
Benzene	ND	0.1	96	ND	110
1,2 Dichloroethane	ND	0.1	97	ND	
Trichloroethene	ND	0.1	83	ND	108
1,2-Dichloropropane	ND	0.1	95	ND	
Dibromomethane	ND	0.1	115	ND	
Bromochloromethane	ND	0.1	124	ND	
2-Chloroethyl Vinyl ether	ND	1.0	123	ND	
4 Methyl 2-Pentanone	ND	1.0	120	ND	
cis 1,3 Dichloropropene	ND	0.1	105	ND	
Toluene	ND	0.1	96	ND	119
trans 1,3-Dichloropropene	ND	0.1	89	ND	
1,1,2-Trichloroethane	ND	0.1	98	ND	
Dibromochloromethane	ND	0.1	105	ND	
Tetrachloroethene	ND	0.1	107	ND	
Chlorobenzene	ND	0.1	98	ND	107

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Page 2 of 2

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: VERA #1

Analysis Date: 01/22/97
Sampling Date: 01/09/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9910	PQL	% IA	Method Blank	% EA
Ethylbenzene	ND	0.1	89	ND	
m&p Xylene	ND	0.1	87	ND	
o-Xylene	ND	0.1	90	ND	
Styrene	ND	0.1	95	ND	
Bromoform	ND	0.1	113	ND	
1,1,2,2-Tetrachloroethane	ND	0.1	87	ND	
1,2,3-Trichloropropane	ND	0.1	108	ND	

SYSTEM MONITORING COMPOUNDS	% RECOVERY
Dibromofluoromethane	96
Toluene-d8	100
4-Bromofluorobenzene	65

ND=<PQL

Michael R. Fowler
Michael R. Fowler

1-27-97
Date

Modeling Data Entry
Vera # 1

Control Data	Entry	U / M
Deterministic	Yes	
Monte Carlo	No	
Evaporation	No	
Biodecay	No	
Low Permeability Layer Below Contamination	No	

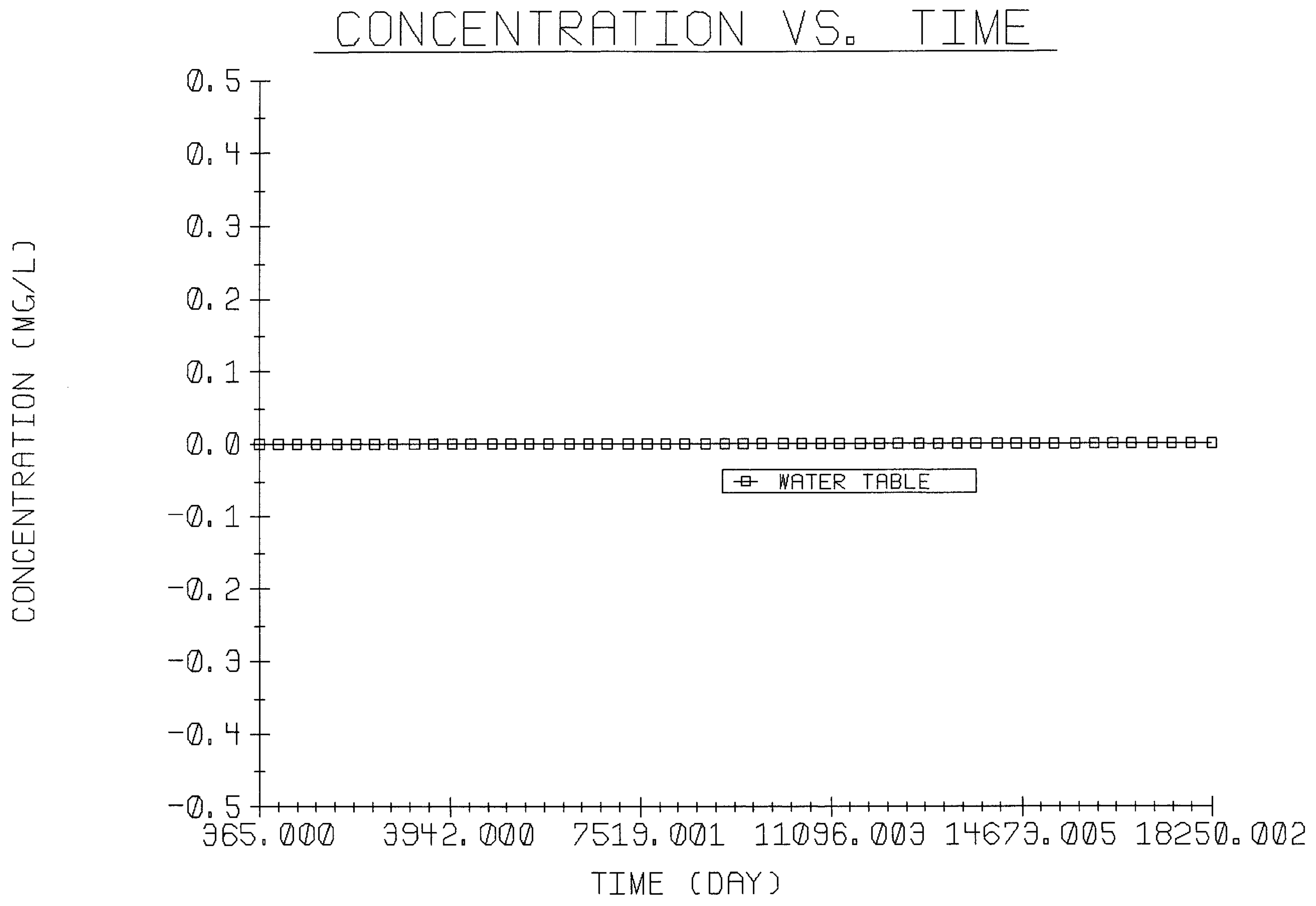
Source Data		
Waste Zone Thickness	48	ft.
Waste Zone Area	2,500	sq. ft.
Ratio of Length to Width	1	
Soil Thickness above Waste Zone	10	ft.
Contaminant Concentration in Soil / Waste Zone	10	ppm
Hydrocarbon Concentration in Soil / Waste Zone	10,000	ppm

Chemical Data	
Benzene	Yes

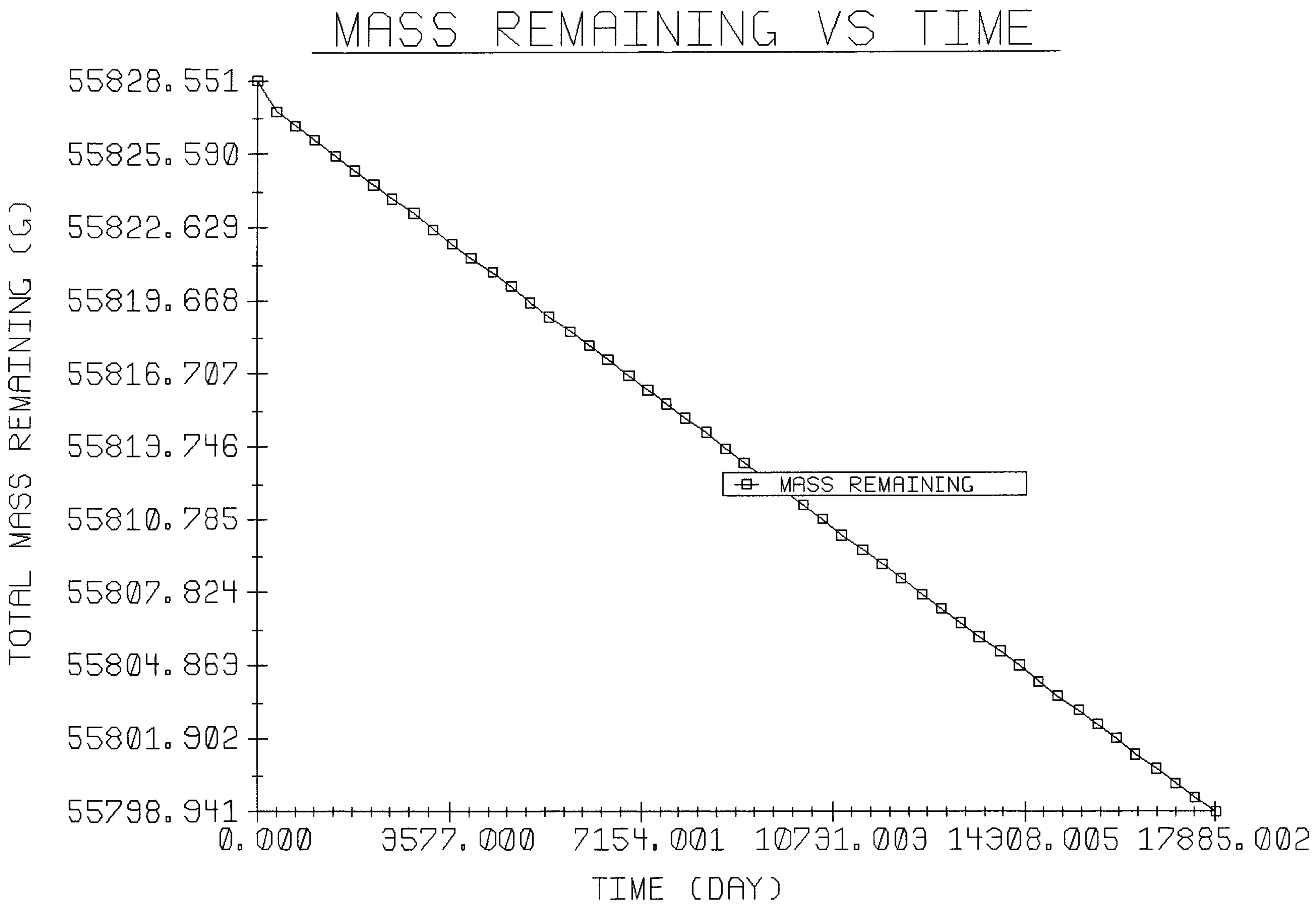
Unsaturated Zone		
Biodecay Cooefficient	0	
Organic Carbon Fraction	0	
Soil Database	Clay	
Hydrological Database	Sedimentary	
Unsaturated Zone Thickness	1	meter
Soil Database	Clay	
van Genuchten n	1.09	(Default)
Residual Water Content	0.01001	
Unsaturated Zone Dispersivity	0	Internally

Saturated Zone		
Biodecay Cooefficient	0	
Aquifer Porosity	0.2	(Default)
Organic Carbon Fraction	0	
Longitudinal Dispersivity	0	Internally
Ratio of Long. / Trans. Dispersivities	3	
Ratio of Trans. / Vert. Dispersivities	3	
Hydrological Database	Sedimentary	
Aquifer Thickness	60	ft.
Aquifer Gradient	0.00357	
Saturated Hydraulic Conductivity	0.0986	ft / day

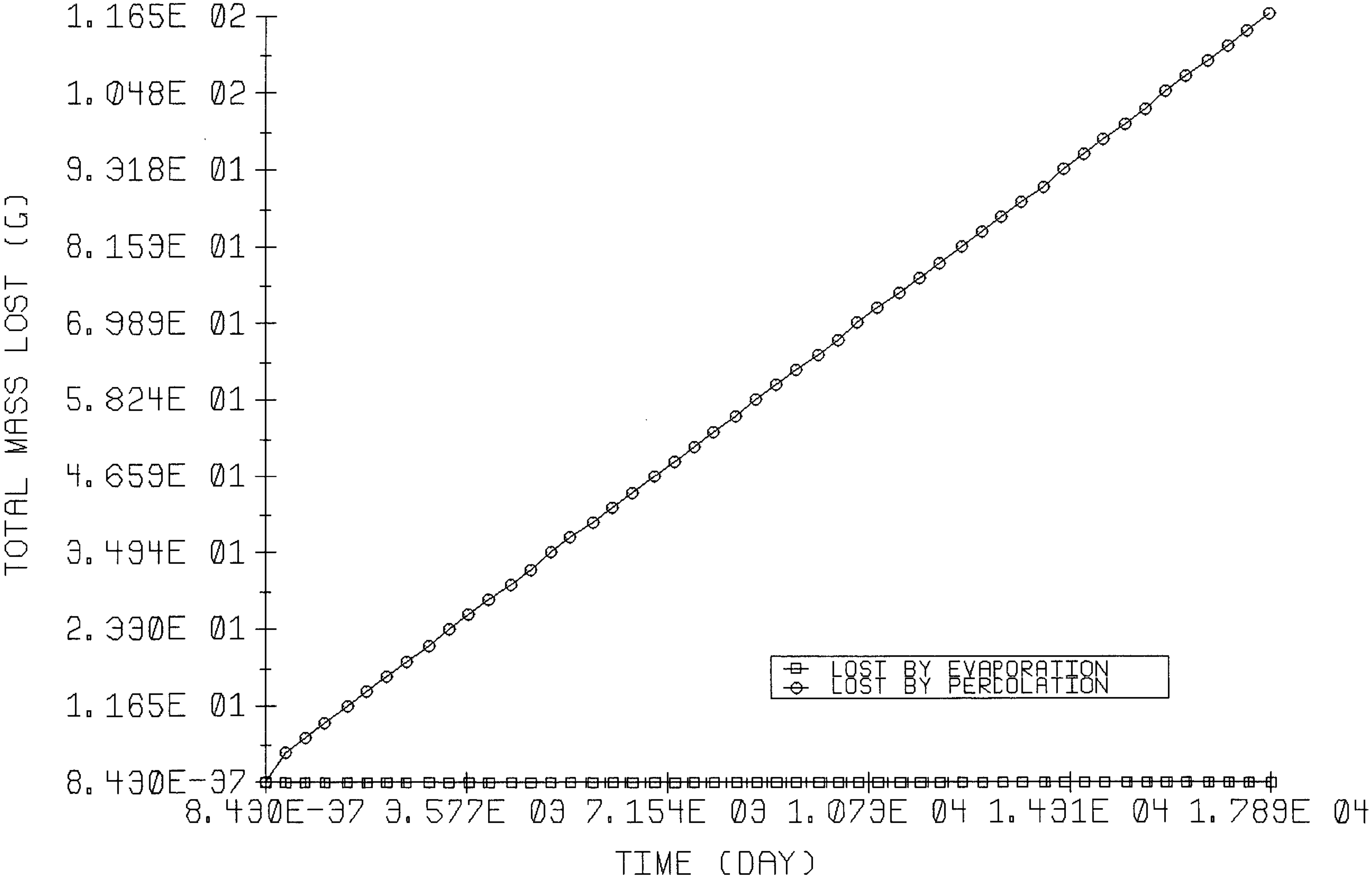
Net Infiltration Rate	0.00001	ft / day


CONCENTRATION VS. TIME
CONCENTRATION (MG/L)
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
WATER TABLE
365.000
3942.000
7519.001
11096.003
14673.005
18250.002
TIME (DAY)

Vena


MASS REMAINING VS TIME
TOTAL MASS REMAINING (G)
55828.551
55825.590
55822.629
55819.668
55816.707
55813.746
55810.785
55807.824
55804.863
55801.902
55798.941
0.000
3577.000
7154.001
10731.003
14308.005
17885.002
TIME (DAY)
MASS REMAINING

MASS LOST VS TIME



State NBN # 1

Legal Description

State Lease K2654 - Unit "N", (Oil & Gas # E2654)
T11S-R33E-Sec.16
660' FSL - 1,982.5' FWL

Pit Description

State NBN # 1 is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 50 feet north of the separator in with a raised berm approximately 2' in height. The actual pit dimensions are 50' X 60' x 3' in depth. The pit is covered in bird netting and is surrounded by a four strand barbed wire fence.

There is a minor amount of free product within the pit consisting of heavily weathered asphaltic fractions however there is no evidence of surface staining surrounding the berm. There are no signs of stressed vegetation surrounding the pit. (See attached photograph.)

Pit History

State NBN # 1 was logged in March 1965 and completed shortly thereafter. Burro Pipeline was permitted in October of 1967 and was connected to the wellsite prior to 1970. All emergency discharges to the pit were discontinued prior to 1970.

Distance to Surface & Ground Waters

The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 63' as determined on January 8, 1997. (See attached 7.5', hydro-geological plat maps and boring logs.)

Closure Standards

In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

Sampling Results

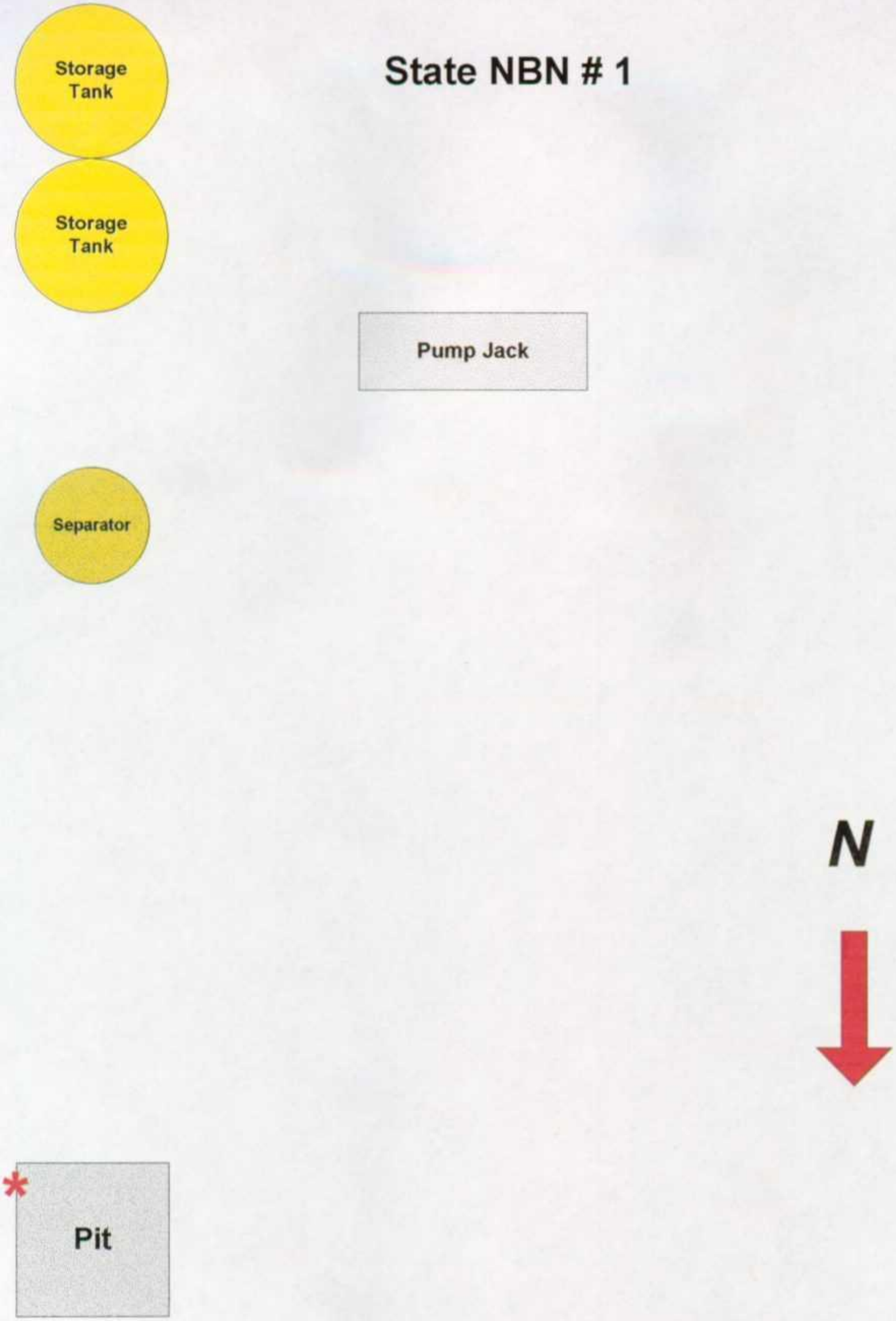
On January 10, 1997, Whole Earth supervised the coring of the pit and found hydrocarbon concentrations of less than 10,000 ppm TPH at a depth of between 10-15'. Due to the presence of free product within the pit, the coring was performed at the southeast corner, mid-way up the berm. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

Core samples obtained from the upper vadose zone of the aquifer revealed no detectable concentrations of volatile or semi-volatile compounds. (See attached Environmental Labs of Texas analytical reports.)

Closure Protocol

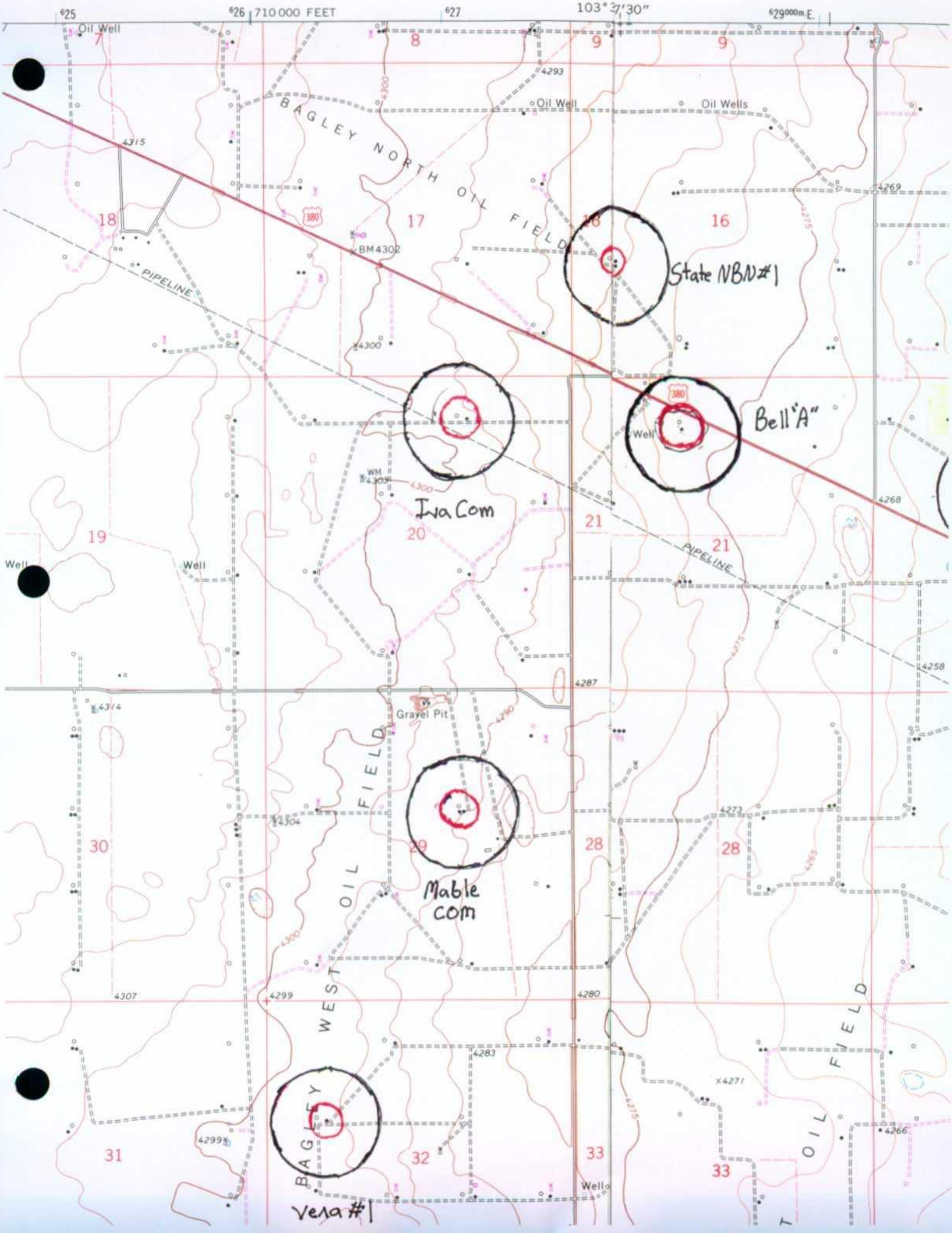
We propose to close State NBN # 1 in accordance with the attached Protocol QP-42.

State NBN # 1



NEW MEXICO—LEA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 2

DATE: 1-8-97

DRILL START: 2:50 PM
DRILL STOP: 4:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
NBN #1

TH NUMBER: 4

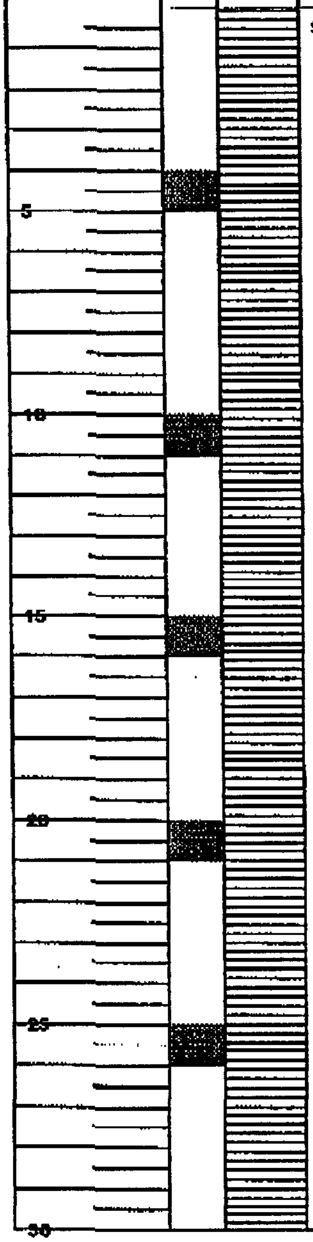
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis



Silty Clay w/Caliche, Brown, Firm, Damp

Silty Clay w/Caliche, Gray, Firm, Damp

Silty Clay, Gray-Green, Firm, Dry

Silty Clay w/Caliche, Gray-Green, Firm, Dry

Silty Clay w/Caliche, Gray/Tan, Firm , Dry

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2004 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 **OF** 2

DATE: 1-8-97

DRILL START: 2:50 PM
DRILL STOP: 4:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
NBN #1

TH NUMBER: 4

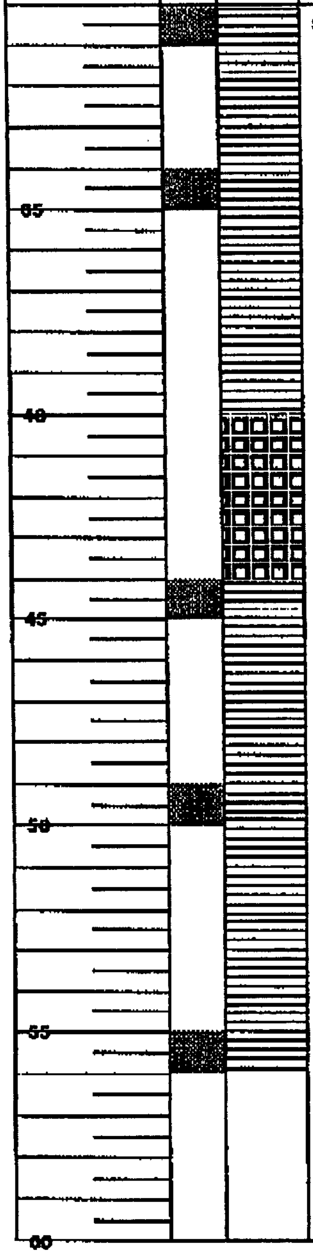
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet) | SPT | Symbol | STRATUM DESCRIPTION | Well Construction Details | PID Reading | Lab Analysis | Lab Analysis



Silty Clay w/Caliche, Gray/Tan, Firm, Dry (Cont'd)

Silty Sandy Clay w/Caliche, Tan, Firm, Damp

Caliche w/Silty Sandy Clay, Tan, Hard, Dry

Silty Sandy Clay, Tan, Loose, Moist

Silty Sandy Clay, Tan, Soft, Saturated

TD = ±56 ft.

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 10, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: State NBN # 1
Depth to Water: 63’

Depth	5’	10’	15’	25’	35’
Concentration	5,680	5,330	9,320	8,990	5,660

Depth	40’	50’			
Concentration	5,720	2,320			

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________________

ENVIRONMENTAL LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Sample Type: SOIL
Project : TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: STATE NBN #1
ELT# 9911

Analysis Date: 01/19/97
Sampling Date: 01/08/97
Sample Condition: Intact/Iced

8270 COMPOUNDS	REPORTING LIMIT	SAMPLE Concentration ppm	QC	RPD	% EA	% IA
N-Nitrosodimethylamine	0.01	ND				
2-Picoline	0.01	ND				
Methyl methanesulfonate	0.01	ND				
Ethyl methanesulfonate	0.01	ND				
Phenol	0.01	ND	91	11	84	95
Aniline	0.05	ND				
bis(2-Chloroethyl)ether	0.05	ND				
2-Chlorophenol	0.05	ND		8	74	
1,3-Dichlorobenzene	0.01	ND				
1,4-Dichlorobenzene	0.01	ND	94	10	73	93
Benzyl alchohol	0.05	ND				
1,2-Dichlorobenzene	0.01	ND				
2-Methylphenol	0.01	ND				
bis(2-Chloroisopropyl)ether	0.05	ND				
4-Methylphenol/3-Methylphenol	0.01	ND				
Acetophenone	0.06	ND				
n-Nitrosodi-n-propylamine	0.01	ND		5	79	
Hexachloroethane	0.01	ND				
Nitrobenzene	0.01	ND				
N-Nitrosopiperidine	0.05	ND				
Isophorone	0.05	ND				
2-Nitrophenol	0.05	ND	93			94
2,4-Dimethylphenol	0.05	ND				
bis(2-Chloroethoxy)methane	0.01	ND				
Benzoic acid	0.1	ND				
2,4-Dichlorophenol	0.05	ND	87			96
1,2,4-Trichlorobenzene	0.01	ND		9	79	
a,a Dimethylphenethylamine	0.1	ND				
Naphthalene	0.01	ND				
4-Chloroaniline	0.05	ND				
2,6-Dichlorophenol	0.05	ND				
Hexachlorobutadiene	0.01	ND	95			97
N-Nitroso-di-n-butylamine	0.05	ND				
4-Chloro-3-methylphenol	0.05	ND	97	12	81	93

ELT# 9911

SAMPLE

8270 COMPOUNDS	Reporting Limits	Concentration ppm	QC	RPD	%EA	%IA
2-Methylnaphthalene	0.01	ND				
1,2,4,5-Tetrachlorobenzene	0.01	ND				
Hexachlorocyclopentadiene	0.01	ND				
2,4,6-Trichlorophenol	0.05	ND	86			94
2,4,5-Trichlorophenol	0.05	ND				
2-Chloronaphthalene	0.01	ND				
1,-Chloronaphthalene	0.01	ND				
2-Nitroaniline	0.05	ND				
Dimethylphthalate	0.01	ND				
Acenaphthylene	0.01	ND				
2,6-Dinitrotoluene	0.01	ND				
3-Nitroaniline	0.05	ND				
Acenaphthene	0.01	ND	97	3	81	92
2,4-Dinitrophenol	0.05	ND				
Dibenzofuran	0.05	ND				
Pentachlorobenzene	0.01	ND				
4-Nitrophenol	0.05	ND		4	80	
1-Napthylamine	0.05	ND				
2,4-Dinitrotoluene	0.01	ND		6	79	
2-Napthylamine	0.05	ND				
2,3,4,6-Tetrachlorophenol	0.05	ND				
Fluorene	0.01	ND				
Diethylphthalate	0.01	ND				
4-Chlorophenyl-phenylether	0.01	ND				
4-Nitroaniline	0.05	ND				
4,6-Dinitro-2-methylphenol	0.01	ND				
n-Nitrosodipenlamine & Diphenylarr	0.01	ND	93			90
Diphenylhydrazine	0.05	ND				
4-Bromophenyl-phenylether	0.01	ND				
Phenacetin	0.05	ND				
Hexachlorobenzene	0.01	ND				
4-Aminobiphenyl	0.05	ND				
Pentachlorophenol	0.05	ND	89	6	79	95
Pentachloronitrobenzene	0.05	ND				
Pronamide	0.01	ND				
Phenanthrene	0.01	ND				
Anthracene	0.01	ND				
Di-n-butylphthalate	0.01	ND				
Fluoranthene	0.01	ND	92			95
Benzidine	0.1	ND				
Pyrene	0.01	ND		6	88	
p-Dimethylaminoazobenzene	0.01	ND				
Butylbenzylphthalate	0.01	ND				
Benzo [a]anthracene	0.01	ND				
3,3-Dichlorobenzidine	0.01	ND				
Chrysene	0.01	ND				
bis (2-Ethylhexyl)phthalate	0.05	ND				

ELT# 8911

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
Di-n- octlphthalate	0.01	ND	89			92
Benzo[b]fluoranthene	0.01	ND				
7,12-Dimethylbenz(a)anthracene	0.01	ND				
Benzo[k]fluoranthene	0.01	ND				
Benzo [a] pyrene	0.01	ND	96			91
3-Methylcholanthrane	0.01	ND				
Dibenzo (a,j) acridine	0.01	ND				
Indeno [1,2,3-cd] pyrene	0.01	ND				
Dibenz [a,h] anthracene	0.01	ND				
Benzo [g,h,i] perylene	0.01	ND				

METHOD: EPA SW 846-8270, 3551

SURROGATES	% RECOVERY
2-Fluorophenol SURR	89
Phenol-d6 SURR	83
Nitrobenzene-d5 SURR	96
2-Fluorobiphenyl SURR	95
2,4,6-Tribromophenol SURR	84
Terphenyl-d14 SURR	97

Michael R. Fowler
Michael R. Fowler

1-27 97
Date

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97	Analysis Date: 01/22/97
Reporting Date: 01/23/97	Sampling Date: 01/09/97
Project Name: TATUM PIT SAMPLING	Sample Type: SOIL
Project Location: WEST OF TATUM, NM	Sample Condition: C&I
Field Code: STATE NBN #1	

Volatiles EPA SW 846-8240. (ppm) Compounds	ELT# 9911	PQL	% IA	Method Blank	% EA
Chloromethane	ND	0.1	110	ND	
Vinyl chloride	ND	0.1	101	ND	
Bromomethane	ND	0.1	100	ND	
Chloroethane	ND	0.1	105	ND	
Trichlorofluoromethane	ND	0.1	102	ND	
Acetone	ND	0.1	100	ND	
1,1-Dichloroethane	ND	0.1	95	ND	69
Iodomethane	ND	1.0	92	ND	
Vinyl Acetate	ND	1.0	107	ND	
Carbon Disulfide	ND	0.1	100	ND	
Methylene Chloride	ND	0.1	110	ND	
trans-1,2-Dichloroethene	ND	0.1	98	ND	
1,1-Dichloroethane	ND	0.1	102	ND	
2-Butanone	ND	1.0	108	ND	
Chloroform	ND	0.1	106	ND	
1,1,1-Trichloroethane	ND	0.1	91	ND	
Carbon Tetrachloride	ND	0.1	94	ND	
Benzene	ND	0.1	96	ND	110
1,2 Dichloroethane	ND	0.1	97	ND	
Trichloroethene	ND	0.1	83	ND	108
1,2-Dichloropropane	ND	0.1	95	ND	
Dibromomethane	ND	0.1	115	ND	
Bromochloromethane	ND	0.1	124	ND	
2-Chloroethyl Vinyl ether	ND	1.0	123	ND	
4-Methyl 2-Pentanone	ND	1.0	120	ND	
cis 1,3 Dichloropropene	ND	0.1	105	ND	
Toluene	ND	0.1	96	ND	119
trans 1,3-Dichloropropene	ND	0.1	89	ND	
1,1,2-Trichloroethane	ND	0.1	98	ND	
Dibromochloromethane	ND	0.1	105	ND	
Tetrachloroethene	ND	0.1	107	ND	
Chlorobenzene	ND	0.1	98	ND	107

Modeling Data Entry
State NBN # 1

Control Data	Entry	U / M
Deterministic	Yes	
Monte Carlo	No	
Evaporation	No	
Biodecay	No	
Low Permeability Layer Below Contamination	No	

Source Data		
Waste Zone Thickness	48	ft.
Waste Zone Area	3,000	sq. ft.
Ratio of Length to Width	0.75	
Soil Thickness above Waste Zone	15	ft.
Contaminant Concentration in Soil / Waste Zone	10	ppm
Hydrocarbon Concentration in Soil / Waste Zone	10,000	ppm

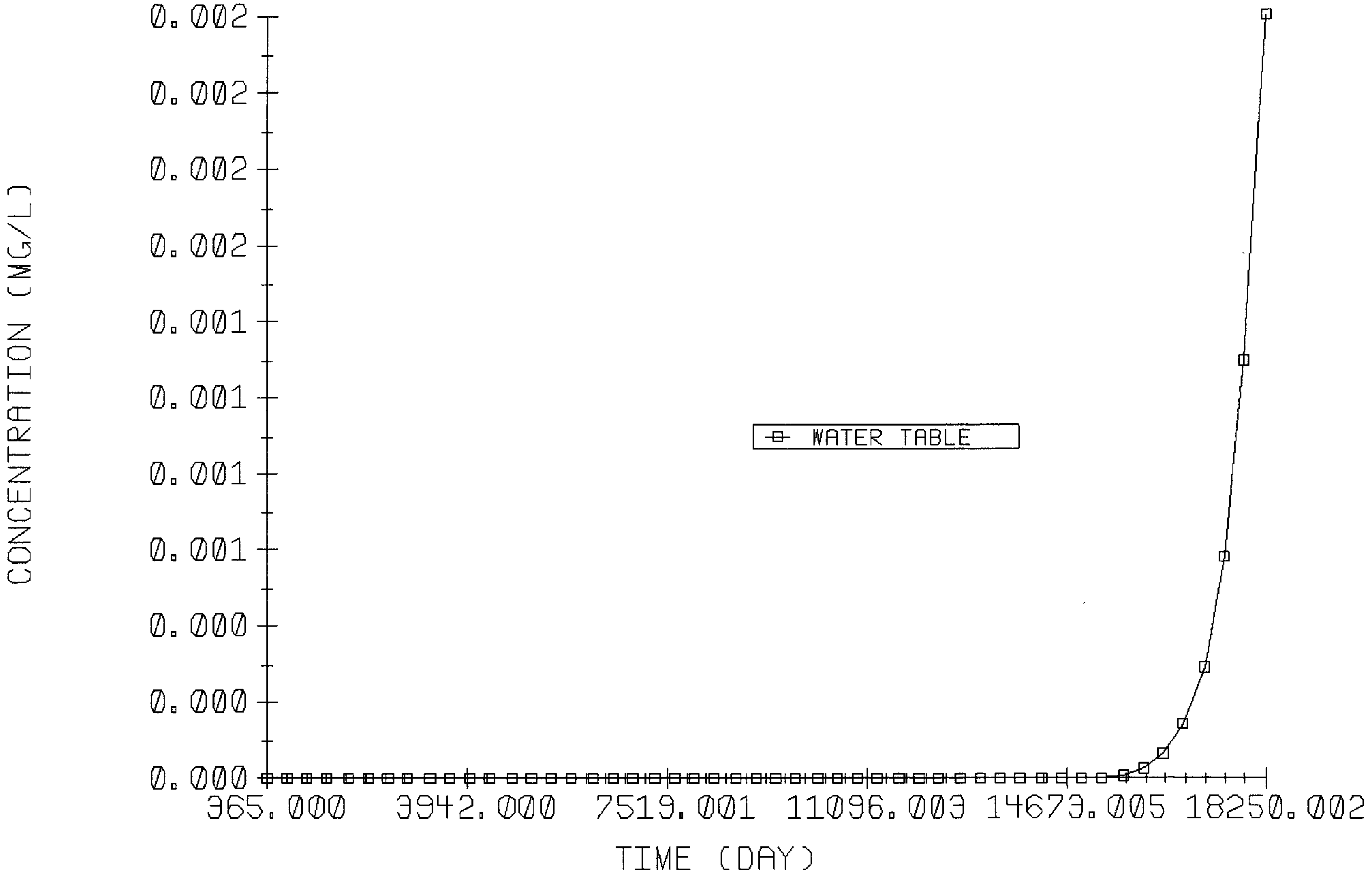
Chemical Data	
Benzene	Yes

Unsaturated Zone		
Biodecay Cooefficient	0	
Organic Carbon Fraction	0	
Soil Database	Clay	
Hydrological Database	Sedimentary	
Unsaturated Zone Thickness	1	meter
Soil Database	Clay	
van Genuchten n	1.09	(Default)
Residual Water Content	0.01001	
Unsaturated Zone Dispersivity	0	Internally

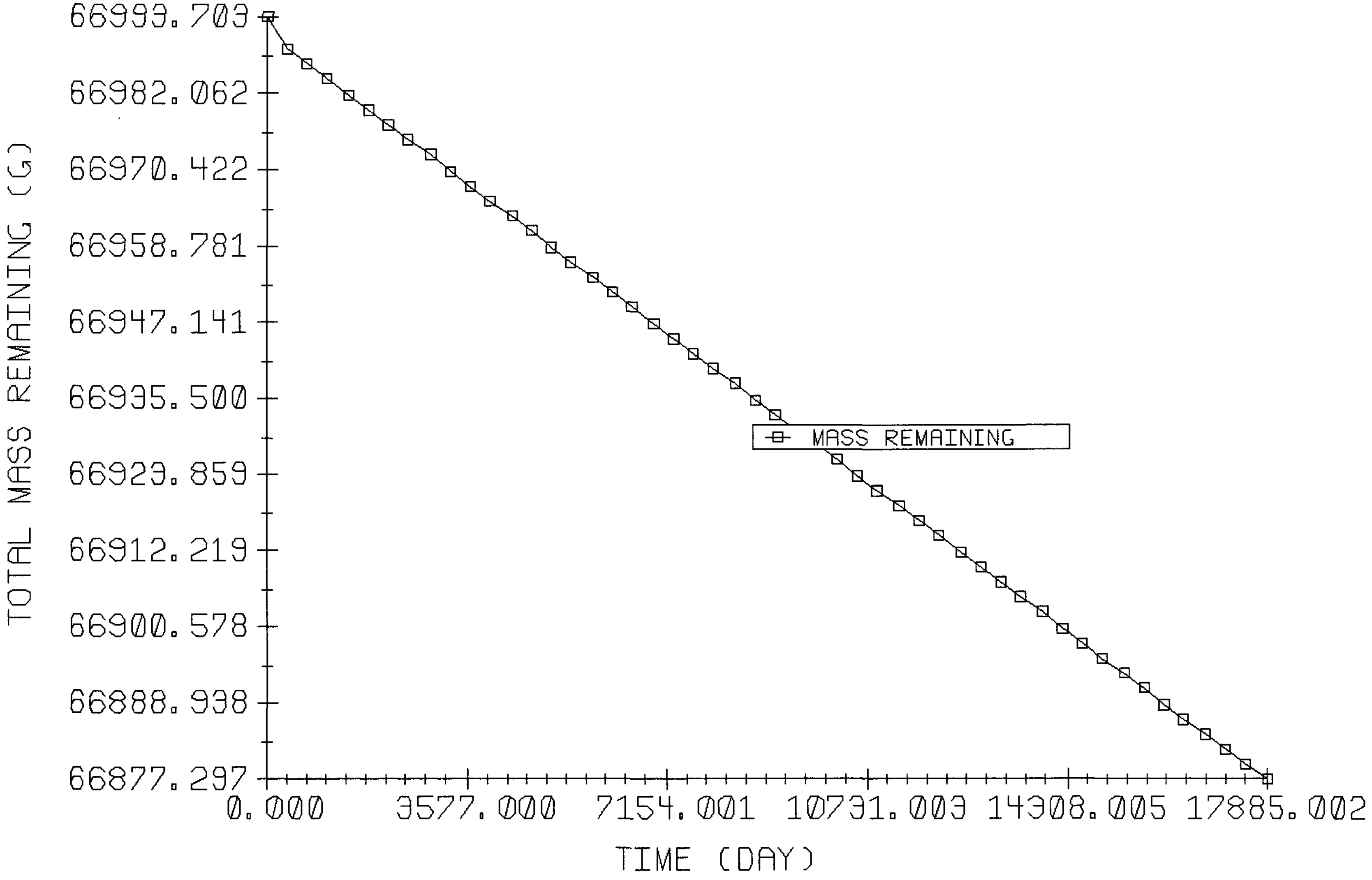
Saturated Zone		
Biodecay Cooefficient	0	
Aquifer Porosity	0.2	(Default)
Organic Carbon Fraction	0	
Longitudinal Dispersivity	0	Internally
Ratio of Long. / Trans. Dispersivities	3	
Ratio of Trans. / Vert. Dispersivities	3	
Hydrological Database	Sedimentary	
Aquifer Thickness	60	ft.
Aquifer Gradient	0.00357	
Saturated Hydraulic Conductivity	0.0986	ft / day

Net Infiltration Rate	0.00001	ft / day

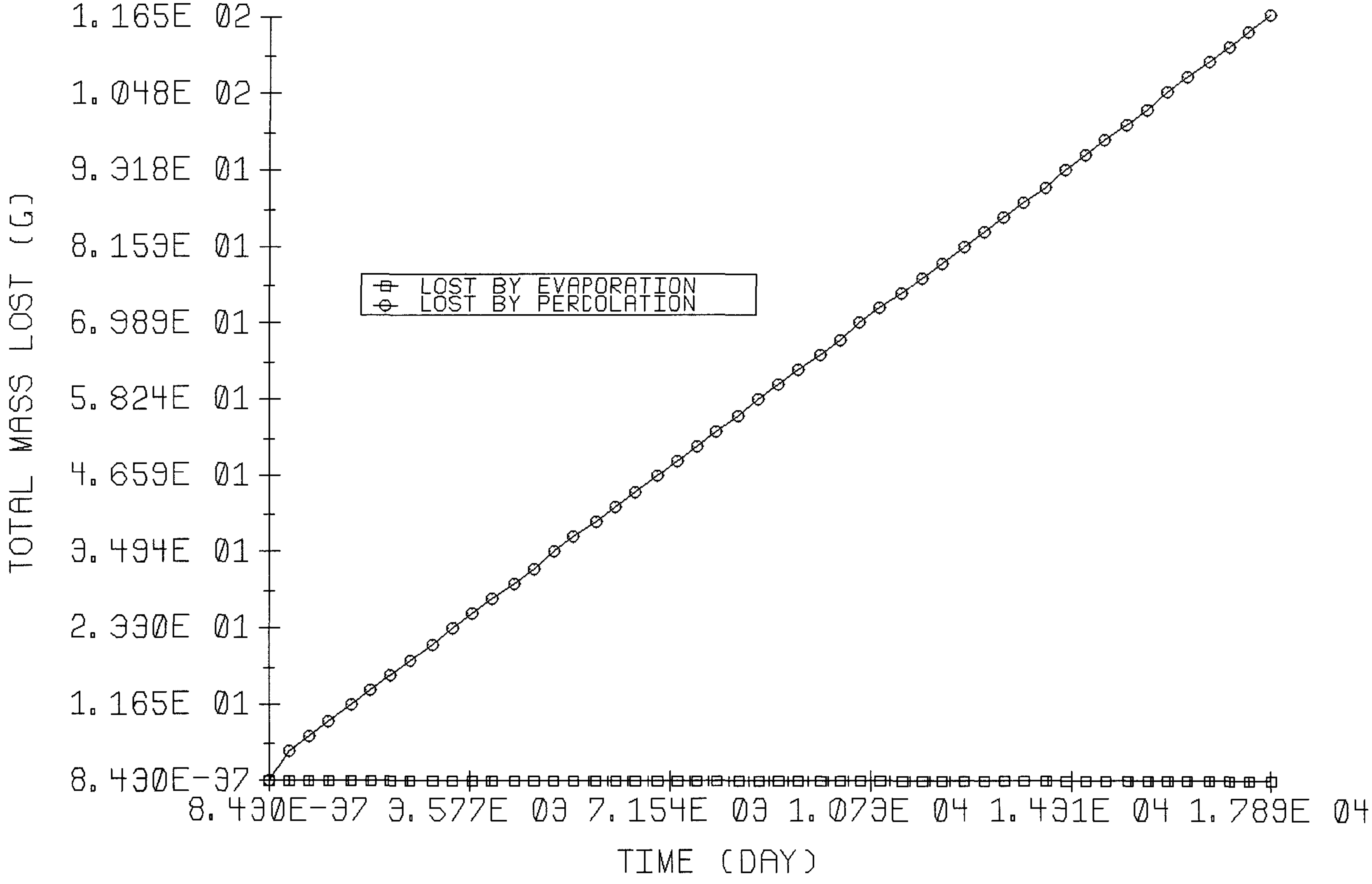
CONCENTRATION VS. TIME



MASS REMAINING VS TIME



MASS LOST VS TIME



State NBF # 1

Legal Description

State Lease - Unit "N", (Oil & Gas # 1402)
T11S-R33E-Sec.22
1,980' FNL - 1,980' FWL

Pit Description

State NBF # 1 is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 150 feet east of the separator within a raised berm approximately 2' in height. The actual pit dimensions are 50' X 60' x 3' in depth. The pit is covered in bird netting and is surrounded by a four strand barbed wire fence.

There is a minor amount of free product within the pit consisting of heavily weathered asphaltic fractions however there is no evidence of surface staining surrounding the berm. There are no signs of stressed vegetation surrounding the pit.

Pit History

State NBF # 1 was logged on December 5, 1965 and completed shortly thereafter. Burro Pipeline was permitted in October of 1967 and was connected to the wellsite prior to 1970. All emergency discharges to the pit were discontinued prior to 1970.

Distance to Surface & Ground Waters

The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 43' as determined on January 9, 1997. (See attached 7.5', hydro-geological plat maps and boring logs.)

Closure Standards

In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

Sampling Results

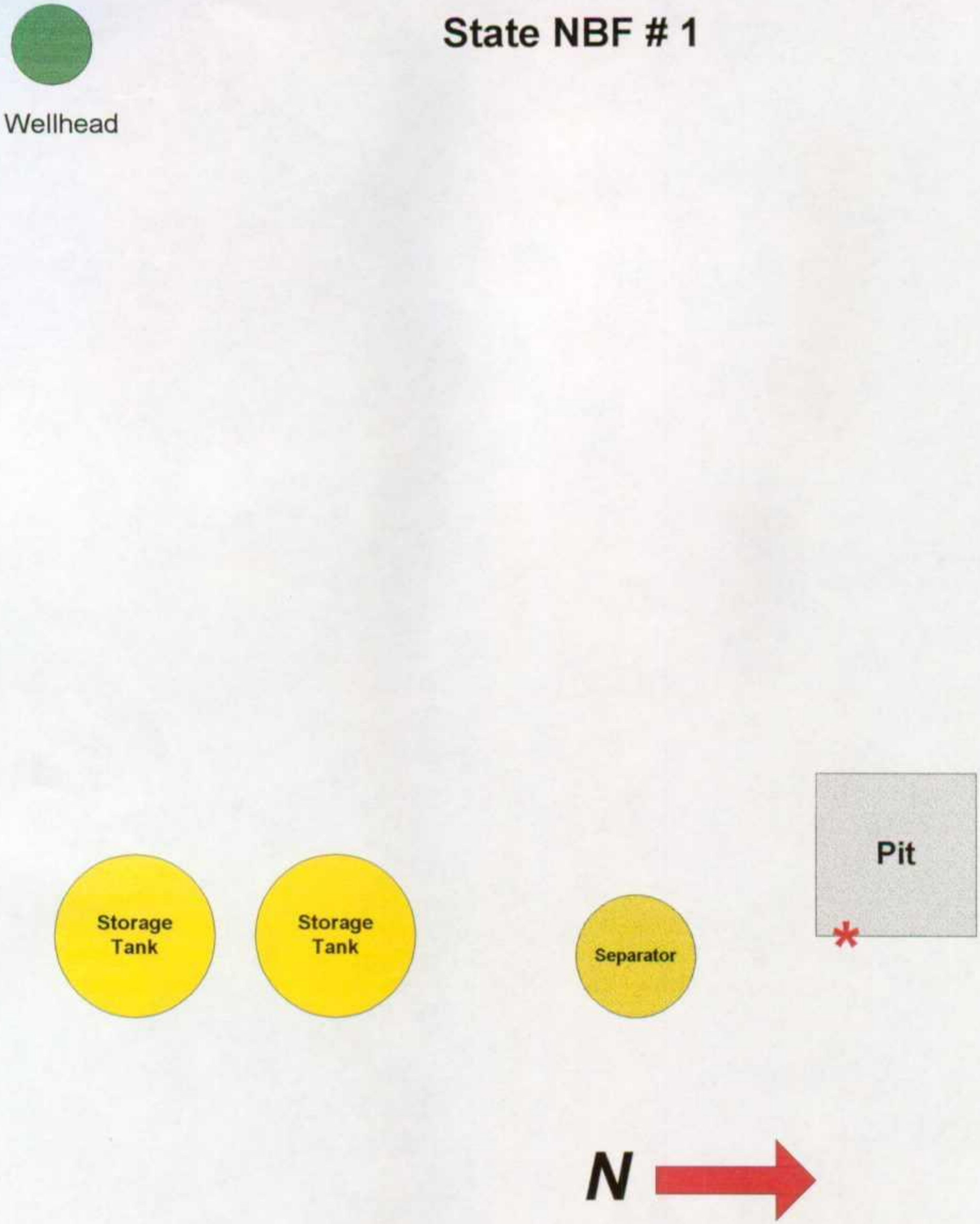
On January 10, 1997, Whole Earth supervised the coring of the pit and found hydrocarbon concentrations of less than 10,000 ppm TPH at any depth. Due to the presence of free product within the pit, the coring was performed at the southeast corner, mid-way up the berm. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

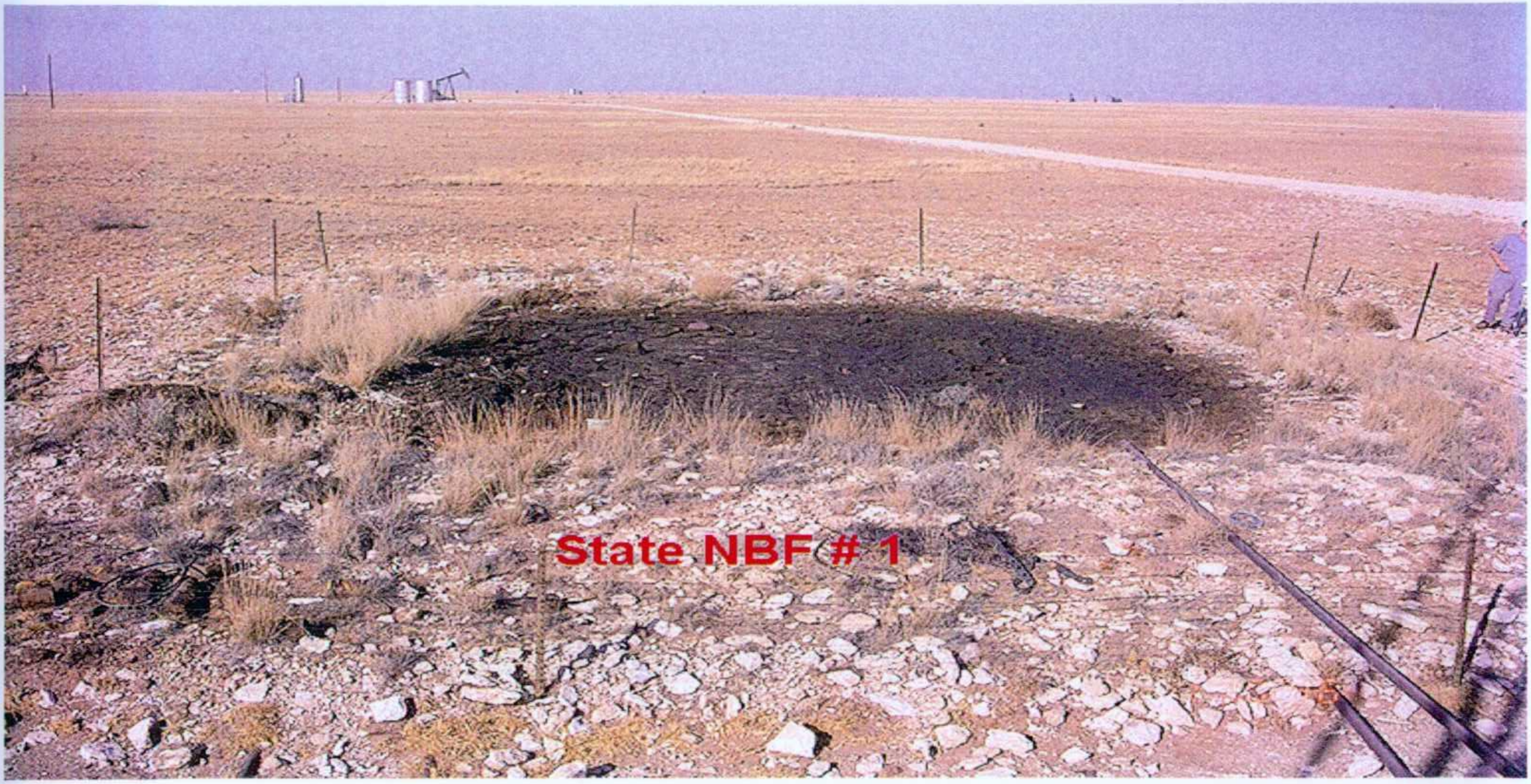
Core samples obtained from the upper vadose zone of the aquifer revealed no detectable concentrations of volatile or semi-volatile compounds. (See attached Environmental Labs of Texas analytical reports.)

Closure Protocol

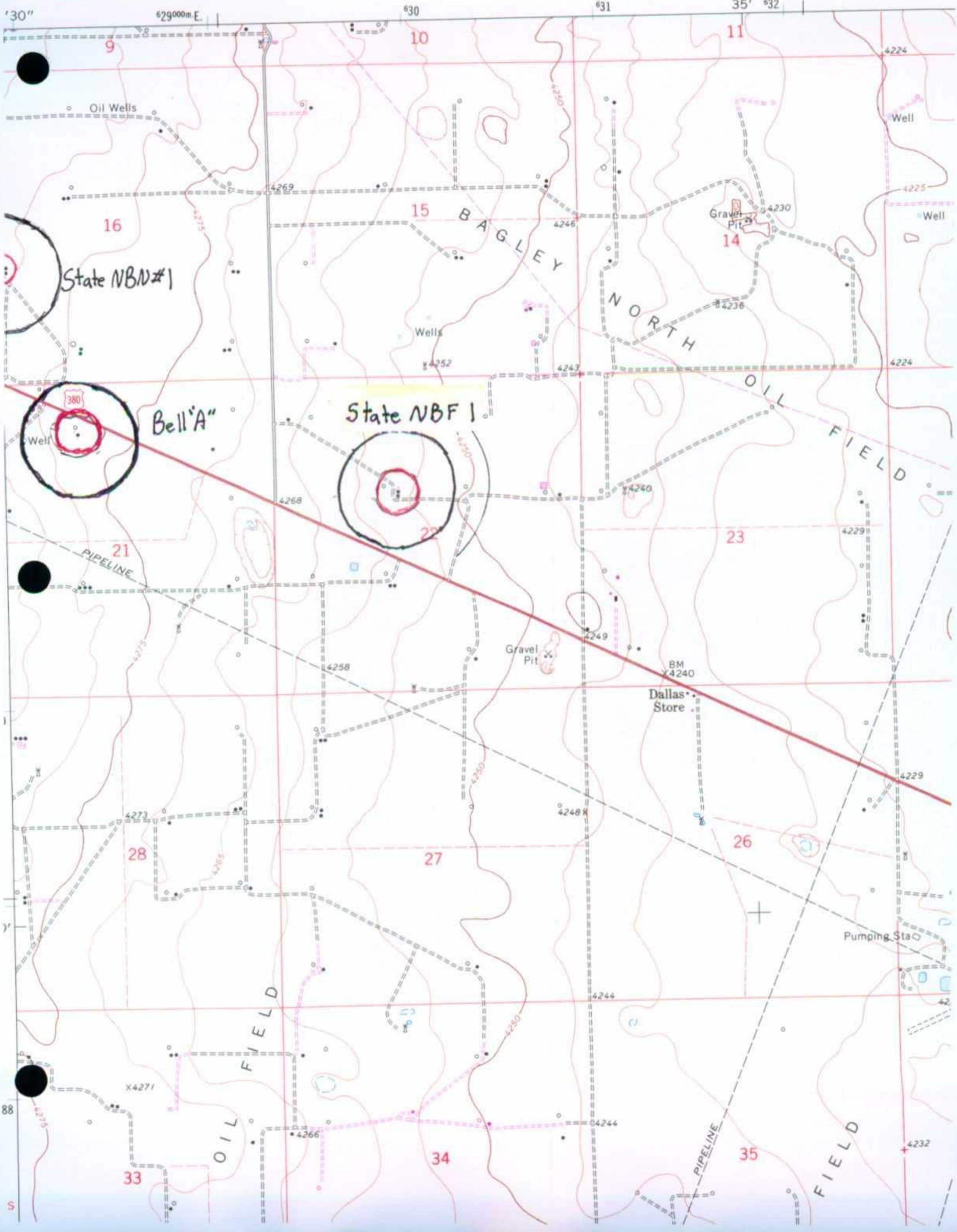
We propose to close State NBF # 1 in accordance with the attached Protocol QP-42.

State NBF # 1




State NBF # 1

UNITED STATES
EPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 2

DATE: 1-9-97

DRILL START: 1:50 PM
DRILL STOP: 3:45 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
NBF #1

TH NUMBER: 6

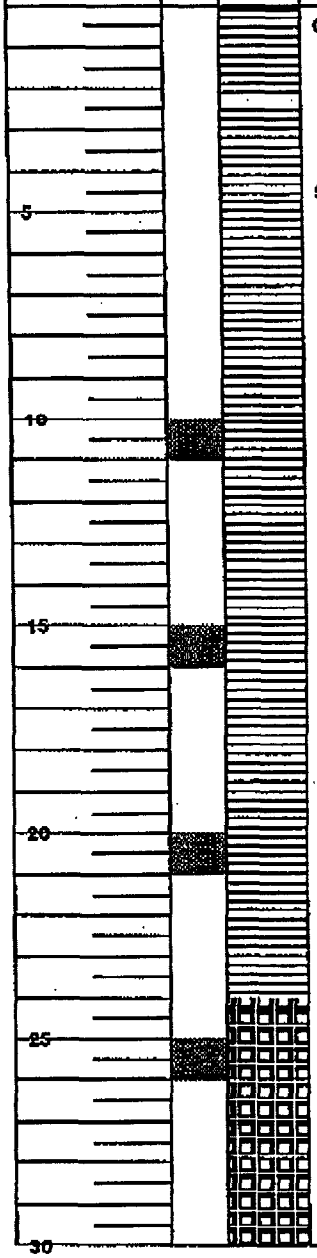
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet) | SPT | Symbol | STRATUM DESCRIPTION | Well Construction Details | PID Reading | Lab Analysis | Lab Analysis



Clay w/Caliche back fill, Brown, Firm, Dry

Silty Clay w/Caliche, Tan, Firm, Dry

Caliche w/Silty Clay, Tan, Hard, Dry

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2604 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 **OF** 2

DATE: 1-9-97

DRILL START: 1:50 PM

DRILL STOP: 3:45 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
NBF #1

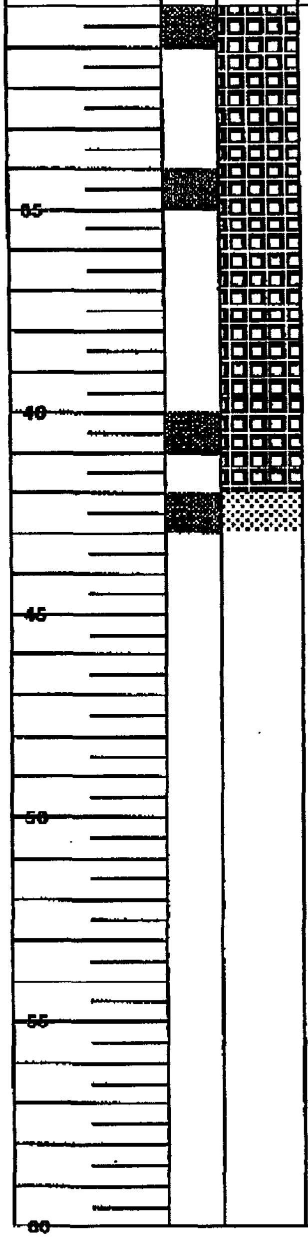
TH NUMBER: 6

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates



Depth (Feet)	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis
	Caliche w/Silty Clay, Tan, Hard, Dry (Cont'd)				
	Caliche, Gray, Hard, Dry				
	Sand, Tan, Soft, Saturated				
	TD = ±43 ft.				

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 9, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: State NBF # 1
Depth to Water: 43’

Depth	10’	15’	20’	30’	35’
Concentration	0	3,790	2,160	510	940

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________________

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Sample Type: SOIL
Project : TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: STATE NBF #1
ELT# 9908

Analysis Date: 01/19/97
Sampling Date: 01/09/97
Sample Condition: Intact/Iced

8270 COMPOUNDS	REPORTING LIMIT	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
N-Nitrosodimethylamine	0.01	ND				
2-Picoline	0.01	ND				
Methyl methanesulfonate	0.01	ND				
Ethyl methanesulfonate	0.01	ND				
Phenol	0.01	ND	91	11	84	95
Aniline	0.05	ND				
bis(2-Chloroethyl)ether	0.05	ND				
2-Chlorophenol	0.05	ND		8	74	
1,3-Dichlorobenzene	0.01	ND				
1,4-Dichlorobenzene	0.01	ND	94	10	73	93
Benzyl alchohol	0.05	ND				
1,2-Dichlorobenzene	0.01	ND				
2-Methylphenol	0.01	ND				
bis(2-Chloroisopropyl)ether	0.05	ND				
4-Methylphenol/3-Methylphenol	0.01	ND				
Acetophenone	0.05	ND				
n-Nitrosodi-n-propylamine	0.01	ND		5	79	
Hexachloroethane	0.01	ND				
Nitrobenzene	0.01	ND				
N-Nitrosopiperidine	0.05	ND				
Isophorone	0.05	ND				
2 Nitrophenol	0.05	ND	93			94
2,4-Dimethylphenol	0.05	ND				
bis(2-Chloroethoxy)methane	0.01	ND				
Benzoic acid	0.1	ND				
2,4-Dichlorophenol	0.05	ND	87			96
1,2,4-Trichlorobenzene	0.01	ND		9	79	
a,a Dimethylphenethylamine	0.1	ND				
Naphthalene	0.01	ND				
4-Chloroaniline	0.05	ND				
2,6-Dichlorophenol	0.05	ND				
Hexachlorobutadiene	0.01	ND	95			97
N-Nitroso-di-n-butylamine	0.05	ND				
4-Chloro-3-methylphenol	0.05	ND	97	12	81	93

ELT# 9906

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
2-Methylnaphthalene	0.01	ND				
1,2,4,5-Tetrachlorobenzene	0.01	ND				
Hexachlorocyclopentadiene	0.01	ND				
2,4,6-Trichlorophenol	0.05	ND	86			94
2,4,5-Trichlorophenol	0.05	ND				
2-Chloronaphthalene	0.01	ND				
1,-Chloronaphthalene	0.01	ND				
2-Nitroaniline	0.05	ND				
Dimethylphthalate	0.01	ND				
Acenaphthylene	0.01	ND				
2,6-Dinitrotoluene	0.01	ND				
3-Nitroaniline	0.05	ND				
Acenaphthene	0.01	ND	97	3	81	92
2,4-Dinitrophenol	0.05	ND				
Dibenzofuran	0.05	ND				
Pentachlorobenzene	0.01	ND				
4-Nitrophenol	0.05	ND		4	80	
1-Napthylamine	0.05	ND				
2,4-Dinitrotoluene	0.01	ND		6	79	
2-Napthylamine	0.05	ND				
2,3,4,6-Tetrachlorophenol	0.05	ND				
Fluorene	0.01	ND				
Diethylphthalate	0.01	ND				
4-Chlorophenyl-phenylether	0.01	ND				
4-Nitroaniline	0.05	ND				
4,6-Dinitro-2-methylphenol	0.01	ND				
n-Nitrosodipenlamine & Diphenylam	0.01	ND	93			90
Diphenylhydrazine	0.05	ND				
4-Bromophenyl-phenylether	0.01	ND				
Phenacetin	0.05	ND				
Hexachlorobenzene	0.01	ND				
4-Aminobiphenyl	0.05	ND				
Pentachlorophenol	0.05	ND	89	6	79	95
Pentachloronitrobenzene	0.05	ND				
Pronamide	0.01	ND				
Phenanthrene	0.01	ND				
Anthracene	0.01	ND				
Di-n-butylphthalate	0.01	ND				
Fluoranthene	0.01	ND	92			95
Benzidine	0.1	ND				
Pyrene	0.01	ND		6	88	
p-Dimethylaminoazobenzene	0.01	ND				
Butylbenzylphthalate	0.01	ND				
Benzo [a]anthracene	0.01	ND				
3,3-Dichlorobenzidine	0.01	ND				
Chrysene	0.01	ND				
bis (2-Ethylhexyl)phthalate	0.05	ND				

ELT# 9908

Page 3 of 3

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
Di-n- octlphthalate	0.01	ND	89			92
Benzo[b]fluoranthene	0.01	ND				
7,12-Dimethylbenz(a)anthracene	0.01	ND				
Benzo[k]fluoranthene	0.01	ND				
Benzo [a] pyrene	0.01	ND	96			91
3-Methylcholanthrene	0.01	ND				
Dibenzo (a,j) acridine	0.01	ND				
Indeno [1,2,3-cd] pyrene	0.01	ND				
Dibenz [a,h] anthracene	0.01	ND				
Benzo [g,h,i] perylene	0.01	ND				

METHOD: EPA SW 846-8270, 3551

SURROGATES	% RECOVERY
2-Fluorophenol SURR	81
Phenol-d6 SURR	83
Nitrobenzene-d5 SURR	86
2-Fluorobiphenyl SURR	94
2,4,6-Tribromophenol SURR	80
Terphenyl-d14 SURR	92

Michael R. Fowler
Michael R. Fowler

1-27-97
Date

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: STATE NBF #1

Analysis Date: 01/22/97
Sampling Date: 01/09/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9908	PQL	% IA	Method Blank	% EA
Chloromethane	ND	0.1	110	ND	
Vinyl chloride	ND	0.1	101	ND	
Bromomethane	ND	0.1	100	ND	
Chloroethane	ND	0.1	105	ND	
Trichlorofluoromethane	ND	0.1	102	ND	
Acetone	ND	0.1	100	ND	
1,1-Dichloroethane	ND	0.1	95	ND	69
Iodomethane	ND	1.0	92	ND	
Vinyl Acetate	ND	1.0	107	ND	
Carbon Disulfide	ND	0.1	100	ND	
Methylene Chloride	ND	0.1	110	ND	
trans-1,2-Dichloroethene	ND	0.1	98	ND	
1,1-Dichloroethane	ND	0.1	102	ND	
2-Butanone	ND	1.0	108	ND	
Chloroform	ND	0.1	106	ND	
1,1,1-Trichloroethane	ND	0.1	91	ND	
Carbon Tetrachloride	ND	0.1	94	ND	
Benzene	ND	0.1	96	ND	110
1,2 Dichloroethane	ND	0.1	97	ND	
Trichloroethene	ND	0.1	83	ND	108
1,2-Dichloropropane	ND	0.1	95	ND	
Dibromomethane	ND	0.1	115	ND	
Bromochloromethane	ND	0.1	124	ND	
2-Chloroethyl Vinyl ether	ND	1.0	123	ND	
4-Methyl 2-Pentanone	ND	1.0	120	ND	
cis 1,3 Dichloropropene	ND	0.1	105	ND	
Toluene	ND	0.1	96	ND	119
trans 1,3-Dichloropropene	ND	0.1	89	ND	
1,1,2-Trichloroethane	ND	0.1	98	ND	
Dibromochloromethane	ND	0.1	105	ND	
Tetrachloroethene	ND	0.1	107	ND	
Chlorobenzene	ND	0.1	98	ND	107

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Page 2 of 2

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: STATE NBF #1

Analysis Date: 01/22/97
Sampling Date: 01/09/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9908	PQL	% IA	Method Blank	% EA
Ethylbenzene	ND	0.1	89	ND	
m&p Xylene	ND	0.1	87	ND	
o-Xylene	ND	0.1	90	ND	
Styrene	ND	0.1	95	ND	
Bromoform	ND	0.1	113	ND	
1.1.2.2-Tetrachloroethane	ND	0.1	87	ND	
1,2,3-Trichloropropane	ND	0.1	108	ND	

SYSTEM MONITORING COMPOUNDS	% RECOVERY
Dibromofluoromethane	116
Toluene-d8	112
4-Bromofluorobenzene	86

ND=<PQL

Michael R. Fowler
Michael R. Fowler

1-27-97
Date

Modeling Data Entry
State NBF # 1

Control Data	Entry	U / M
Deterministic	Yes	
Monte Carlo	No	
Evaporation	No	
Biodecay	No	
Low Permeability Layer Below Contamination	No	

Source Data		
Waste Zone Thickness	28	ft.
Waste Zone Area	3,000	sq. ft.
Ratio of Length to Width	0.75	
Soil Thickness above Waste Zone	10	ft.
Contaminant Concentration in Soil / Waste Zone	10	ppm
Hydrocarbon Concentration in Soil / Waste Zone	10,000	ppm

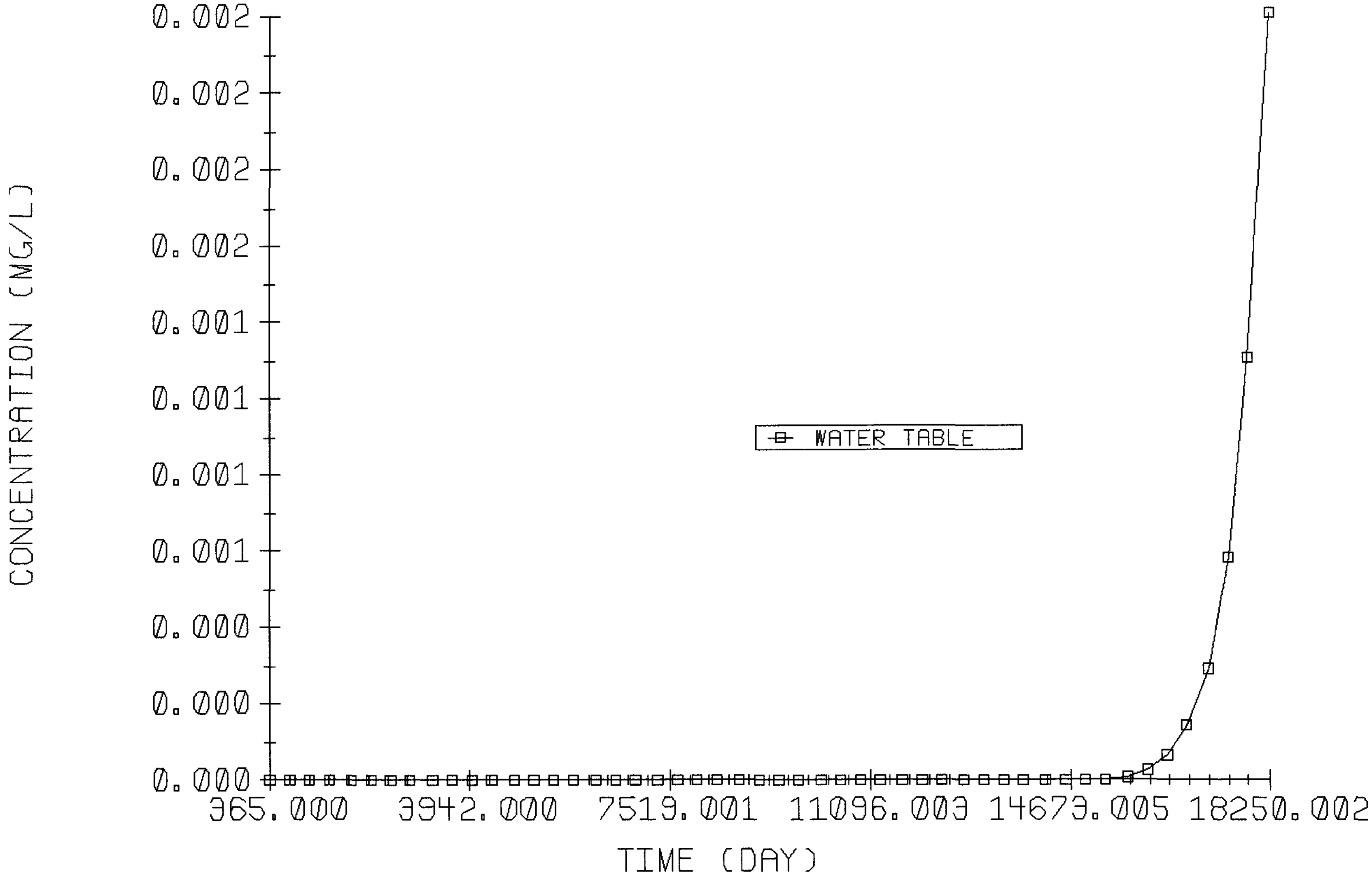
Chemical Data	
Benzene	Yes

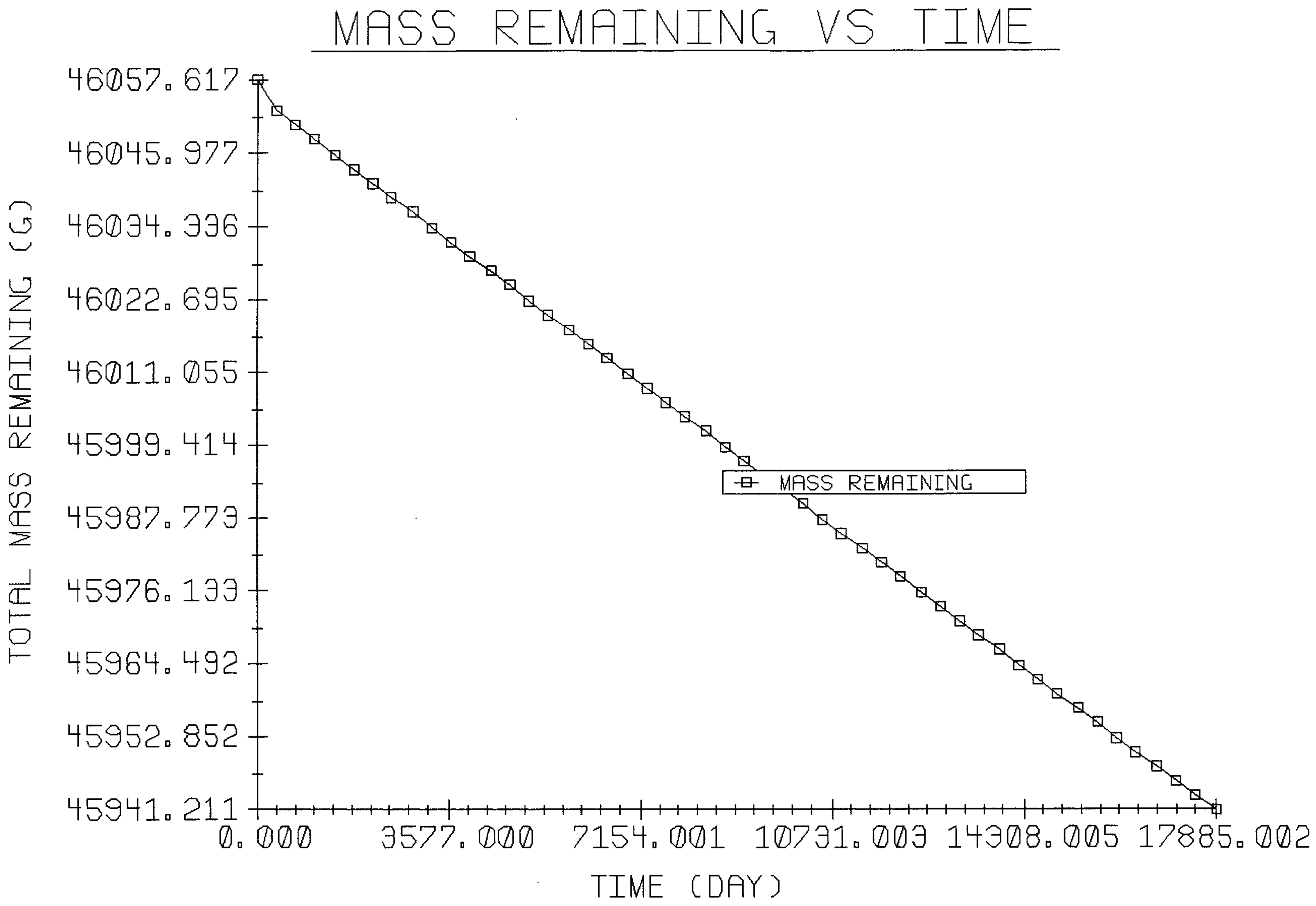
Unsaturated Zone		
Biodecay Cooefficient	0	
Organic Carbon Fraction	0	
Soil Database	Clay	
Hydrological Database	Sedimentary	
Unsaturated Zone Thickness	1	meter
Soil Database	Clay	
van Genuchten n	1.09	(Default)
Residual Water Content	0.01001	
Unsaturated Zone Dispersivity	0	Internally

Saturated Zone		
Biodecay Cooefficient	0	
Aquifer Porosity	0.2	(Default)
Organic Carbon Fraction	0	
Longitudinal Dispersivity	0	Internally
Ratio of Long. / Trans. Dispersivities	3	
Ratio of Trans. / Vert. Dispersivities	3	
Hydrological Database	Sedimentary	
Aquifer Thickness	60	ft.
Aquifer Gradient	0.00357	
Saturated Hydraulic Conductivity	0.0986	ft / day

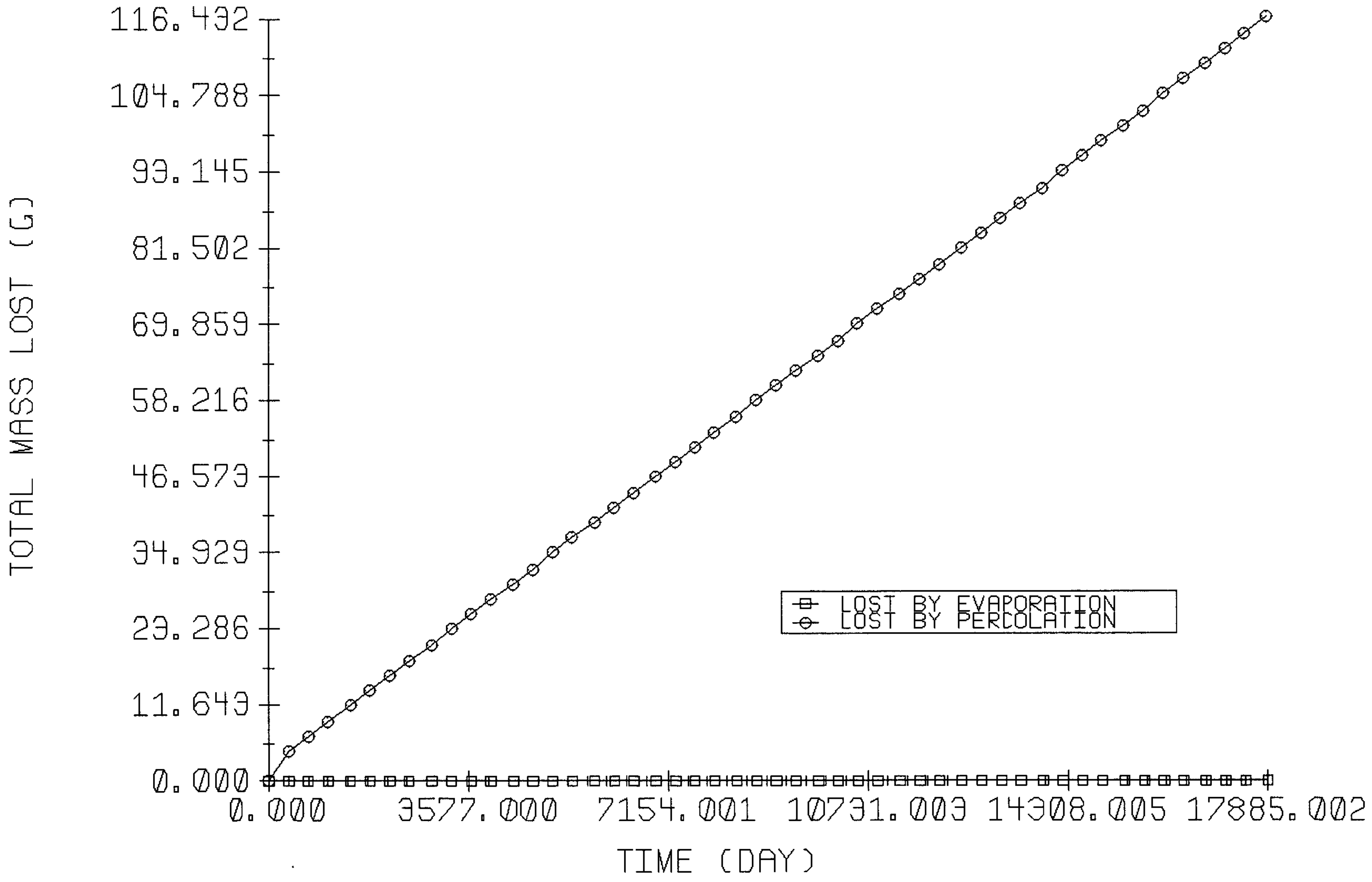
Net Infiltration Rate	0.00001	ft / day

CONCENTRATION VS. TIME




MASS REMAINING VS TIME
TOTAL MASS REMAINING (G)
46057.617
46045.977
46034.336
46022.695
46011.055
45999.414
45987.773
45976.133
45964.492
45952.852
45941.211
0.000
3577.000
7154.001
10731.003
14308.005
17885.002
TIME (DAY)
MASS REMAINING

MASS LOST VS TIME



Bell State "A"

Legal Description

Fee Lease - Unit "C"
T11S-R33E-Sec.21
720' FNL - 1,980' FWL

Pit Description

Bell State "A" is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 50 feet west of the separator in with a raised berm approximately 2' in height. The actual pit dimensions are 50' X 50' x 2' in depth. The pit is covered in bird netting and is surrounded by a four strand barbed wire fence.

There is a minor amount of free product within the pit consisting of heavily weathered asphaltic fractions however there is no evidence of surface staining surrounding the berm. There are no signs of stressed vegetation surrounding the pit.

Pit History

Bell State "A" was logged on July 14, 1966 and completed shortly thereafter. Burro Pipeline was permitted in October of 1967 and was connected to the wellsite prior to 1970. All emergency discharges to the pit were discontinued prior to 1970.

Distance to Surface & Ground Waters

The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 63' as determined on January 8, 1997. (See attached 7.5', hydro-geological plat maps and boring logs.)

Closure Standards

In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

Sampling Results

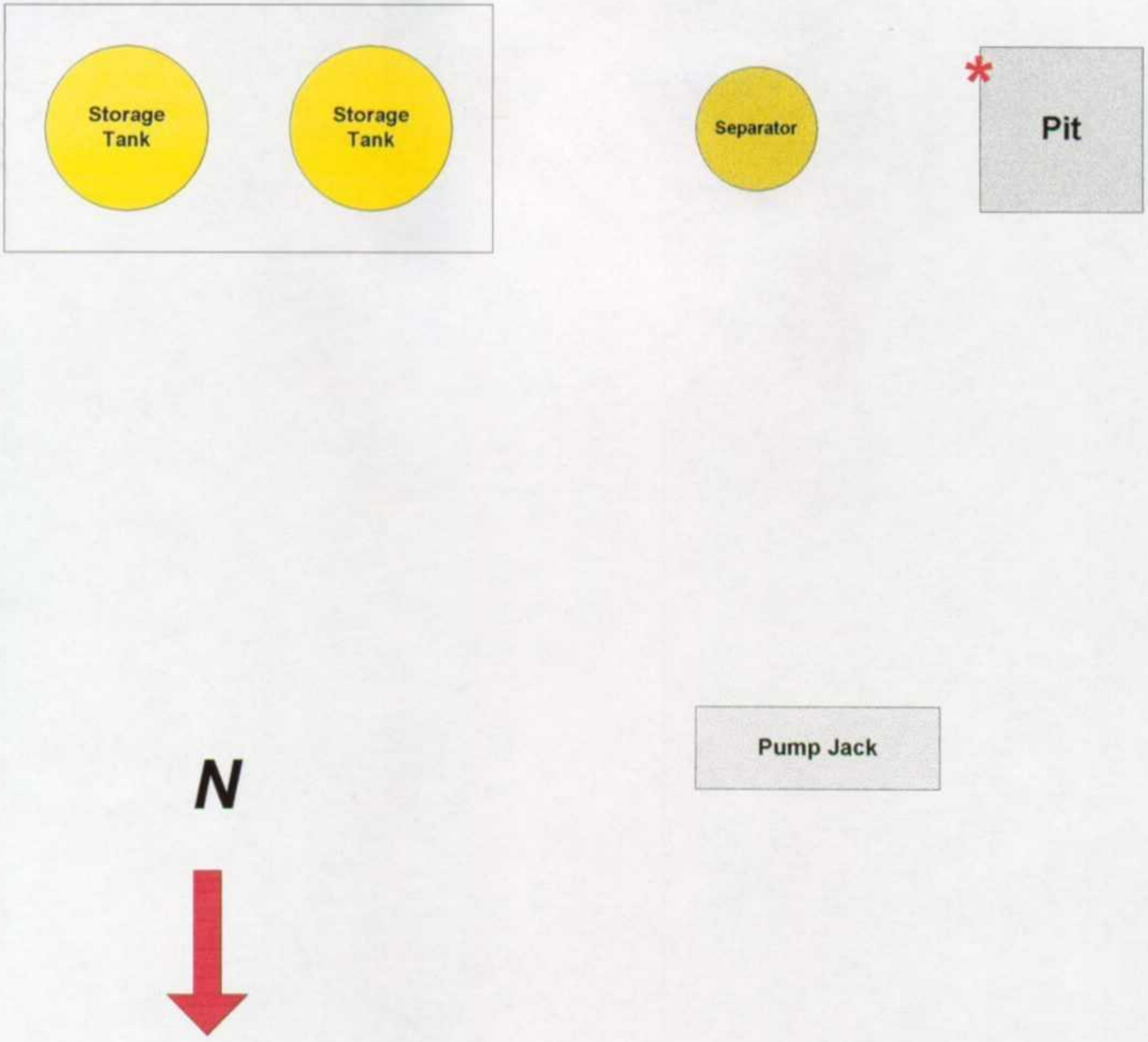
On January 8, 1997, Whole Earth supervised the coring of the pit and found hydrocarbon concentrations of less than 10,000 ppm TPH at a depth of between 10-20'. Due to the presence of free product within the pit, the coring was performed at the southeast corner, mid-way up the berm. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed). (See attached Environmental Labs of Texas analytical reports.)

Core samples obtained from the upper vadose zone of the aquifer revealed no detectable concentrations of volatile or semi-volatile compounds.

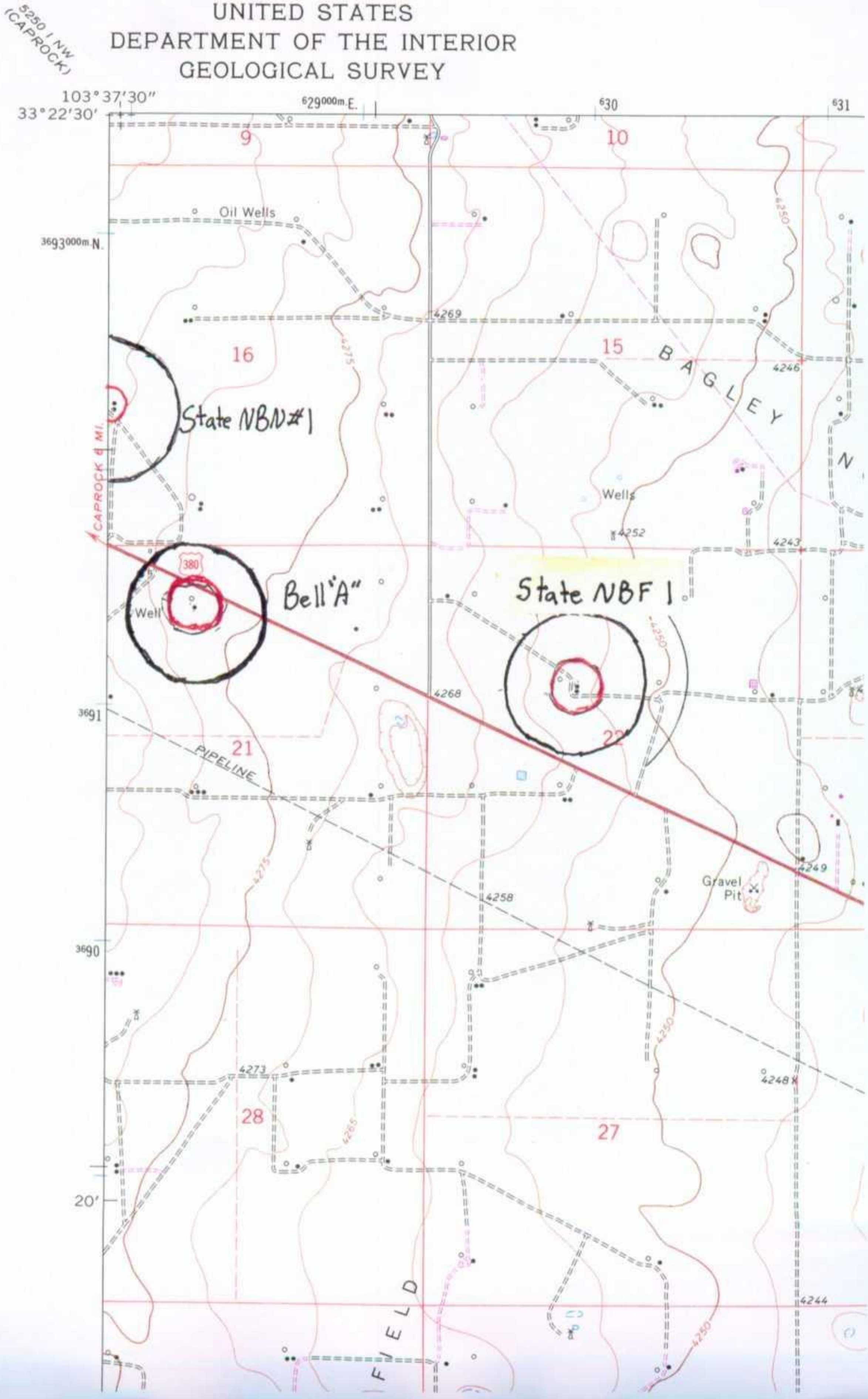
Closure Protocol

We propose to close Bell State "A" in accordance with the attached Protocol QP-42.

Bell "A"

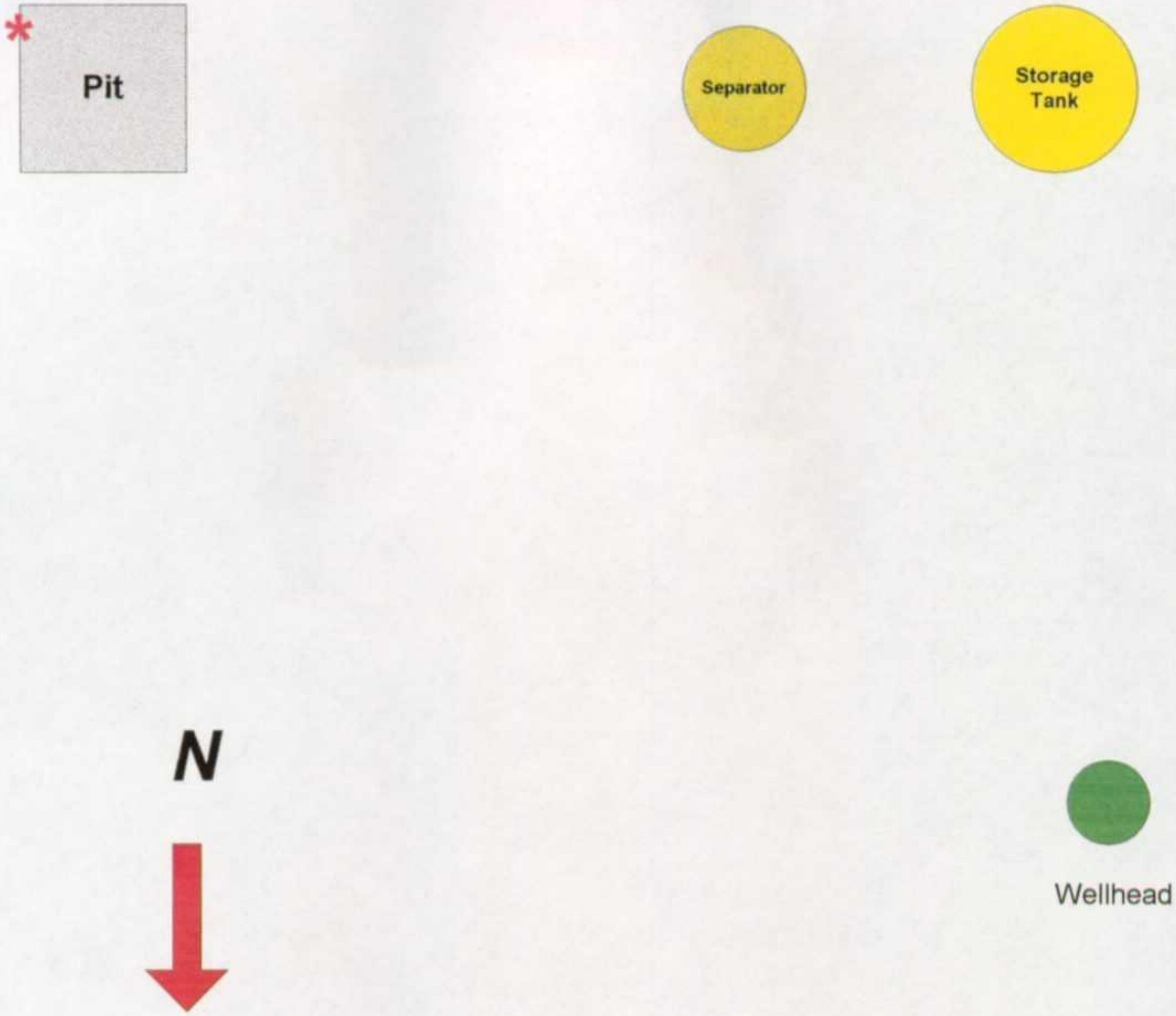


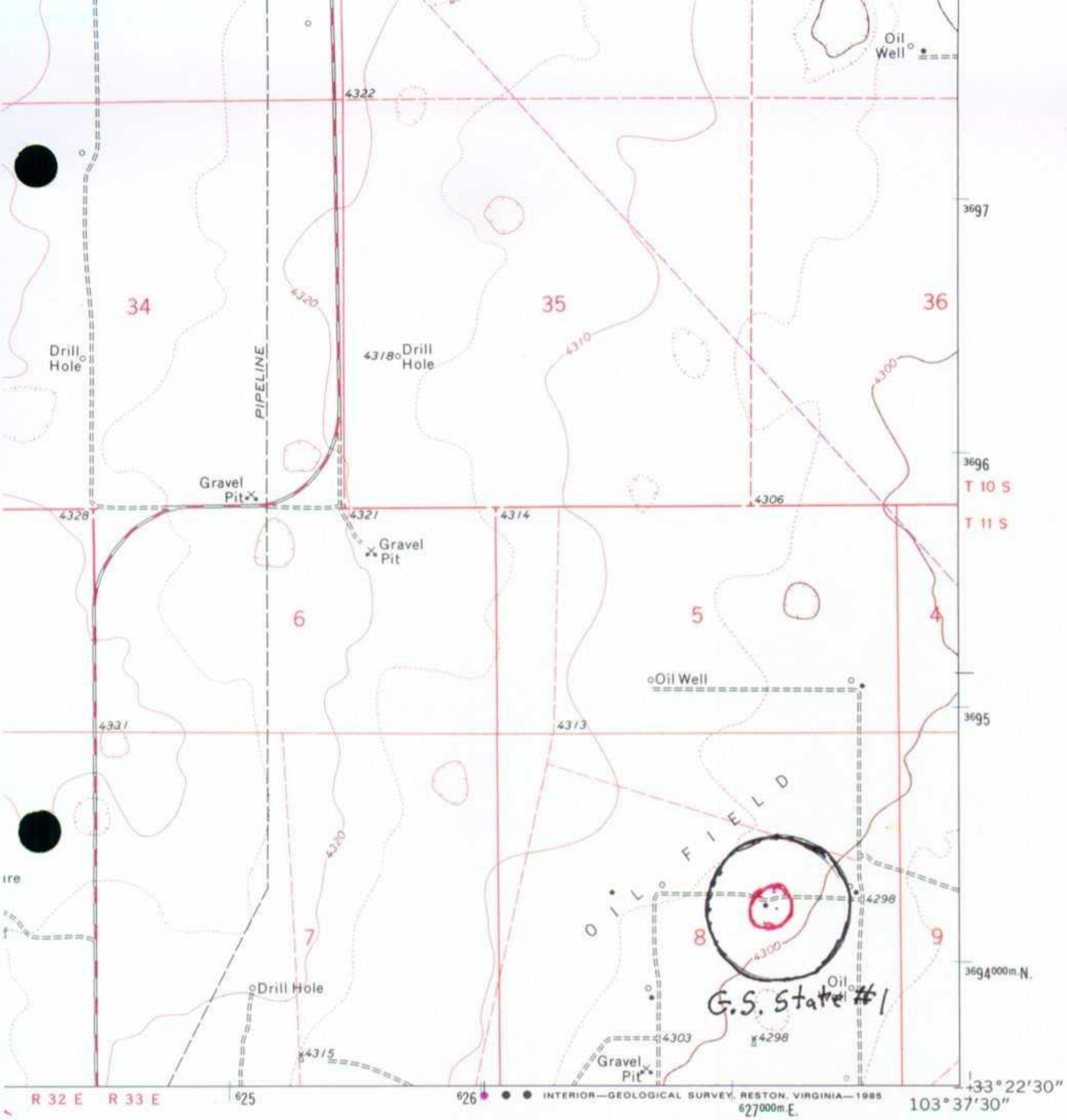
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



G.S. State # 1

GS State # 1





(DALLAS STORE)
5250 I SE

ROAD CLASSIFICATION

Primary highway, hard surface

Light-duty road, hard or improved surface

Secondary highway, hard surface

Unimproved road

Interstate Route U. S. Route State Route

QUADRANGLE LOCATION

CAPROCK, N. MEX.
33103-D6-TF-024

1973
PHOTOREVISED 1984
DMA 5250 I NW–SERIES V881

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 3

DATE: 1-6-97

DRILL START: 9:50 AM
DRILL STOP: 2:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Bell A

TH NUMBER: 3

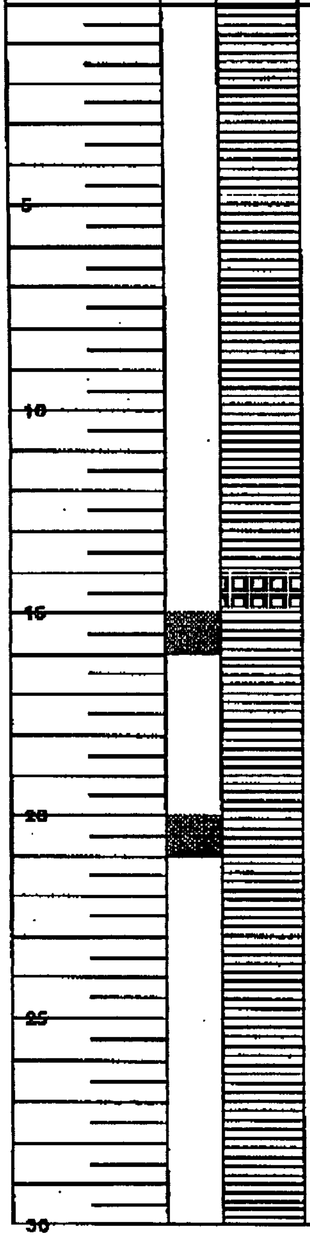
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Well Construction Details	PID Reading	Lab Analysis	Lab Analysis



STRATUM DESCRIPTION

Silty Clay W/Caliche back fill, Brown, Firm, Damp

Silty Clay w/Caliche, Tan, Firm, Damp

Caliche, Gray, Hard, Dry

Silty Clay & Caliche, Tan, Firm, Dry

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 **OF** 3

DATE: 1-8-97

DRILL START: 9:50 AM
DRILL STOP: 2:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Bell A

TH NUMBER: 3

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis	
		▤	Silty Clay & Caliche, Tan, Firm, Dry (Cont'd)					
35		▤						
		▦	Caliche, Gray, Hard, Dry					
40		▦						
		▤	Silty Clay w/Caliche, Tan, Hard, Dry					
45		▤						
50		▤						
		▤	Silty Sandy Clay, Tan, Loose, Moist					
55		▤						
60								

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 3 **OF** 3

DATE: 1-8-97

DRILL START: 9:50 AM
DRILL STOP: 2:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Bell A

TH NUMBER: 3

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis
		▤	Silty Sandy Clay, Tan, Loose, Moist (Cont'd)				
		▤	Silty Sandy Clay, Tan, Loose, Saturated				
		▤	TD = ±63 ft.				
65							
70							
75							
80							
85							
90							

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 8, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: Bell State "A"
Depth to Water: 63'

Depth	10'	20'	25'	35'	
Concentration	>10,000	5,620	6,380	4,230	

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________________

ENVIRONMENTAL LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Sample Type: SOIL
Project : TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: BELL A STATE
ELT# 9912

Analysis Date: 01/19/97
Sampling Date: 01/08/97
Sample Condition: Intact/Iced

8270 COMPOUNDS	REPORTING LIMIT	SAMPLE Concentration ppm	QC	RPD	% EA	% IA
N-Nitrosodimethylamine	0.01	ND				
2-Picoline	0.01	ND				
Methyl methanesulfonate	0.01	ND				
Ethyl methanesulfonate	0.01	ND				
Phenol	0.01	ND	91	11	84	95
Aniline	0.05	ND				
bis(2-Chloroethyl)ether	0.05	ND				
2-Chlorophenol	0.05	ND		8	74	
1,3-Dichlorobenzene	0.01	ND				
1,4 Dichlorobenzene	0.01	ND	94	10	73	93
Benzyl alchohol	0.05	ND				
1,2-Dichlorobenzene	0.01	ND				
2-Methylphenol	0.01	ND				
bis(2-Chloroisopropyl)ether	0.05	ND				
4-Methylphenol/3-Methylphenol	0.01	ND				
Acetophenone	0.05	ND				
n-Nitrosodi-n-propylamine	0.01	ND		5	79	
Hexachloroethane	0.01	ND				
Nitrobenzene	0.01	ND				
N-Nitrosopiperidine	0.05	ND				
Isophorone	0.05	ND				
2-Nitrophenol	0.05	ND	93			94
2,4-Dimethylphenol	0.05	ND				
bis(2-Chloroethoxy)methane	0.01	ND				
Benzoic acid	0.1	ND				
2,4-Dichlorophenol	0.05	ND	87			96
1,2,4-Trichlorobenzene	0.01	ND		9	79	
a,a Dimethylphenethylamine	0.1	ND				
Naphthalene	0.01	ND				
4-Chloroaniline	0.05	ND				
2,6-Dichlorophenol	0.05	ND				
Hexachlorobutadiene	0.01	ND	95			97
N-Nitroso-di-n-butylamine	0.05	ND				
4-Chloro-3-methylphenol	0.05	ND	97	12	81	93

ELT# 9912

		SAMPLE				
8270 COMPOUNDS	Reporting Limits	Concentration ppm	QC	RPD	%EA	%IA
2-Methylnaphthalene	0.01	ND				
1,2,4,5-Tetrachlorobenzene	0.01	ND				
Hexachlorocyclopentadiene	0.01	ND				
2,4,6-Trichlorophenol	0.05	ND	86			94
2,4,5-Trichlorophenol	0.05	ND				
2-Chloronaphthalene	0.01	ND				
1,-Chloronaphthalene	0.01	ND				
2-Nitroaniline	0.05	ND				
Dimethylphthalate	0.01	ND				
Acenaphthylene	0.01	ND				
2,6-Dinitrotoluene	0.01	ND				
3-Nitroaniline	0.05	ND				
Acenaphthene	0.01	ND	97	3	81	92
2,4-Dinitrophenol	0.05	ND				
Dibenzofuran	0.05	ND				
Pentachlorobenzene	0.01	ND				
4 Nitrophenol	0.05	ND		4	80	
1-Napthylamine	0.05	ND				
2,4-Dinitrotoluene	0.01	ND		6	79	
2-Napthylamine	0.05	ND				
2,3,4,6-Tetrachlorophenol	0.05	ND				
Fluorene	0.01	ND				
Diethylphthalate	0.01	ND				
4 Chlorophenyl-phenylether	0.01	ND				
4-Nitroaniline	0.05	ND				
4,6-Dinitro-2-methylphenol	0.01	ND				
n-Nitrosodipenlamine & Diphenylam	0.01	ND	93			90
Diphenylhydrazine	0.05	ND				
4-Bromophenyl-phenylether	0.01	ND				
Phenacetin	0.05	ND				
Hexachlorobenzene	0.01	ND				
4-Aminobiphenyl	0.05	ND				
Pentachlorophenol	0.05	ND	89	6	79	95
Pentachloronitrobenzene	0.05	ND				
Pronamide	0.01	ND				
Phenanthrene	0.01	ND				
Anthracene	0.01	ND				
Di-n-butylphthalate	0.01	ND				
Fluoranthene	0.01	ND	92			95
Benzidine	0.1	ND				
Pyrene	0.01	ND		6	88	
p-Dimethylaminoazobenzene	0.01	ND				
Butylbenzylphthalate	0.01	ND				
Benzo [a]anthracene	0.01	ND				
3,3-Dichlorobenzidine	0.01	ND				
Chrysene	0.01	ND				
bis (2-Ethylhexyl)phthalate	0.05	ND				

ELT# 9912

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
Di-n- octlphthalate	0.01	ND	89			92
Benzo[b]fluoranthene	0.01	ND				
7,12-Dimethylbenz(a)anthracene	0.01	ND				
Benzo[k]fluoranthene	0.01	ND				
Benzo [a] pyrene	0.01	ND	96			91
3-Methylcholanthrene	0.01	ND				
Dibenzo (a,j) acridine	0.01	ND				
Indeno [1,2,3-cd] pyrene	0.01	ND				
Dibenz [a,h] anthracene	0.01	ND				
Benzo [g,h,i] perylene	0.01	ND				

METHOD: EPA SW 846-8270, 3551

SURROGATES	% RECOVERY
2-Fluorophenol SURR	83
Phenol-d6 SURR	80
Nitrobenzene-d5 SURR	91
2-Fluorobiphenyl SURR	93
2,4,6-Tribromophenol SURR	85
Terphenyl-d14 SURR	93

Michael R. Fowler

1-27-97
Date

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: BELL STATE A

Analysis Date: 01/22/97
Sampling Date: 01/08/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9912	PQL	% IA	Method Blank	% EA
Chloromethane	ND	0.1	110	ND	
Vinyl chloride	ND	0.1	101	ND	
Bromomethane	ND	0.1	100	ND	
Chloroethane	ND	0.1	105	ND	
Trichlorofluoromethane	ND	0.1	102	ND	
Acetone	ND	1.0	100	ND	
1,1-Dichloroethane	ND	0.1	95	ND	69
Iodomethane	ND	1.0	92	ND	
Vinyl Acetate	ND	1.0	107	ND	
Carbon Disulfide	ND	0.1	100	ND	
Methylene Chloride	ND	0.1	110	ND	
trans-1,2-Dichloroethene	ND	0.1	98	ND	
1,1-Dichloroethane	ND	0.1	102	ND	
2-Butanone	ND	0.01	108	ND	
Chloroform	ND	0.1	106	ND	
1,1,1-Trichloroethane	ND	0.1	91	ND	
Carbon Tetrachloride	ND	0.1	94	ND	
Benzene	ND	0.1	96	ND	110
1,2 Dichloroethane	ND	0.1	97	ND	
Trichloroethene	ND	0.1	83	ND	108
1,2-Dichloropropane	ND	0.1	95	ND	
Dibromomethane	ND	0.1	115	ND	
Bromochloromethane	ND	0.1	124	ND	
2-Chloroethyl Vinyl ether	ND	1.0	123	ND	
4-Methyl 2-Pentanone	ND	1.0	120	ND	
cis 1,3 Dichloropropene	ND	0.1	105	ND	
Toluene	ND	0.1	96	ND	119
trans 1,3-Dichloropropene	ND	0.1	89	ND	
1,1,2-Trichloroethane	ND	0.1	98	ND	
Dibromochloromethane	ND	0.1	105	ND	
Tetrachloroethene	ND	0.1	107	ND	
Chlorobenzene	ND	0.1	98	ND	107

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Page 2 of 2

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: BELL STATE A

Analysis Date: 01/22/97
Sampling Date: 01/08/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9912	PQL	% IA	Method Blank	% EA
Ethylbenzene	ND	0.1	89	ND	
m&p Xylene	ND	0.1	87	ND	
o-Xylene	ND	0.1	90	ND	
Styrene	ND	0.1	95	ND	
Bromoform	ND	0.1	113	ND	
1,1,2,2-Tetrachloroethane	ND	0.1	87	ND	
1,2,3-Trichloropropane	ND	0.1	108	ND	

SYSTEM MONITORING COMPOUNDS	% RECOVERY
Dibromofluoromethane	111
Toluene-d8	115
4-Bromofluorobenzene	88

ND=<PQL

Michael R. Fowler
Michael R. Fowler

1-27-97
Date

Modeling Data Entry
Bell State "A"

Control Data	Entry	U / M
Deterministic	Yes	
Monte Carlo	No	
Evaporation	No	
Biodecay	No	
Low Permeability Layer Below Contamination	No	

Source Data		
Waste Zone Thickness	13	ft.
Waste Zone Area	2,500	sq. ft.
Ratio of Length to Width	1	
Soil Thickness above Waste Zone	10	ft.
Contaminant Concentration in Soil / Waste Zone	10	ppm
Hydrocarbon Concentration in Soil / Waste Zone	10,000	ppm

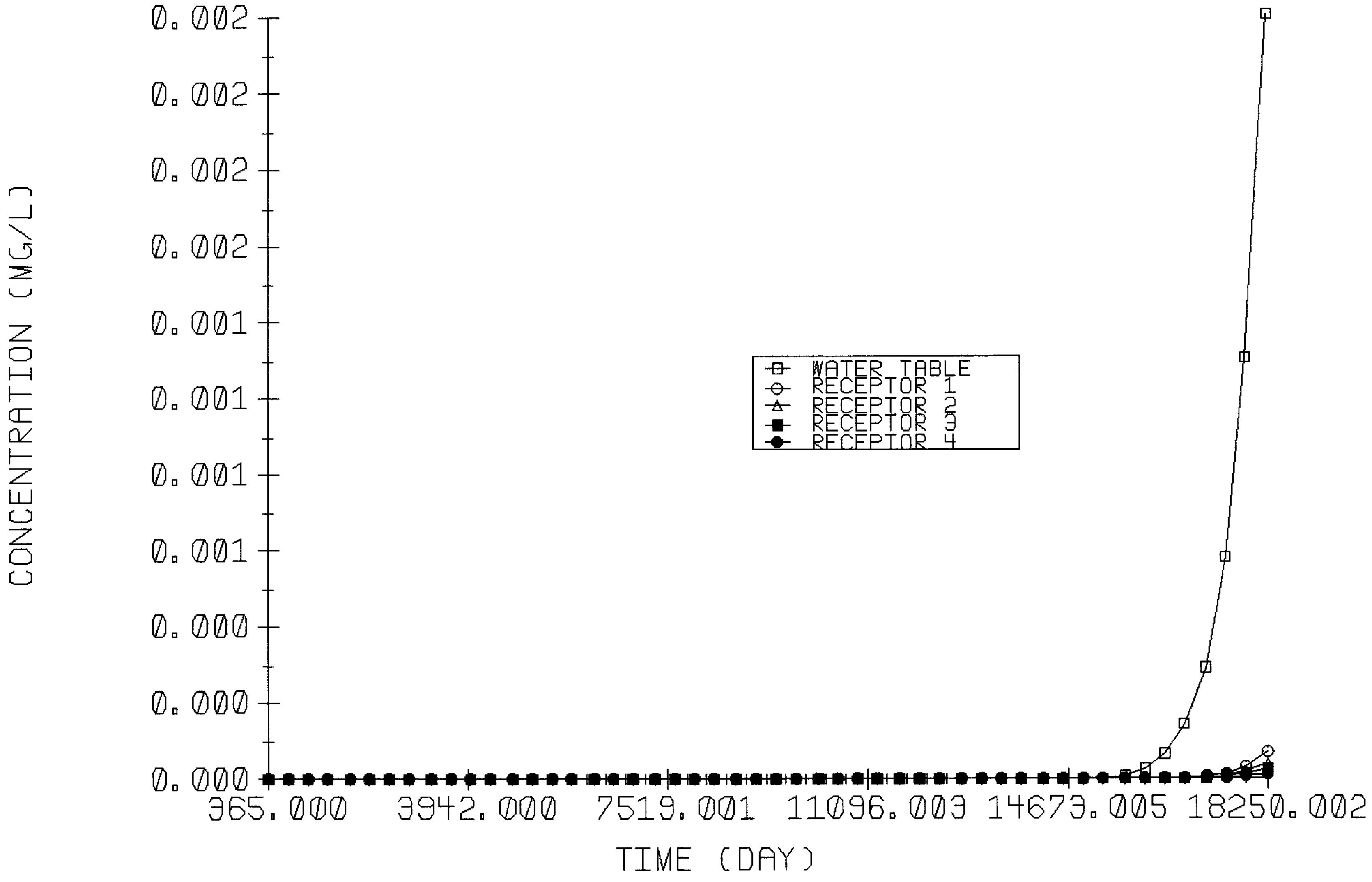
Chemical Data	
Benzene	Yes

Unsaturated Zone		
Biodecay Cooefficient	0	
Organic Carbon Fraction	0	
Soil Database	Clay	
Hydrological Database	Sedimentary	
Unsaturated Zone Thickness	1	meter
Soil Database	Clay	
van Genuchten n	1.09	(Default)
Residual Water Content	0.01001	
Unsaturated Zone Dispersivity	0	Internally

Saturated Zone		
Biodecay Cooefficient	0	
Aquifer Porosity	0.2	(Default)
Organic Carbon Fraction	0	
Longitudinal Dispersivity	0	Internally
Ratio of Long. / Trans. Dispersivities	3	
Ratio of Trans. / Vert. Dispersivities	3	
Hydrological Database	Sedimentary	
Aquifer Thickness	60	ft.
Aquifer Gradient	0.00357	
Saturated Hydraulic Conductivity	0.0986	ft / day

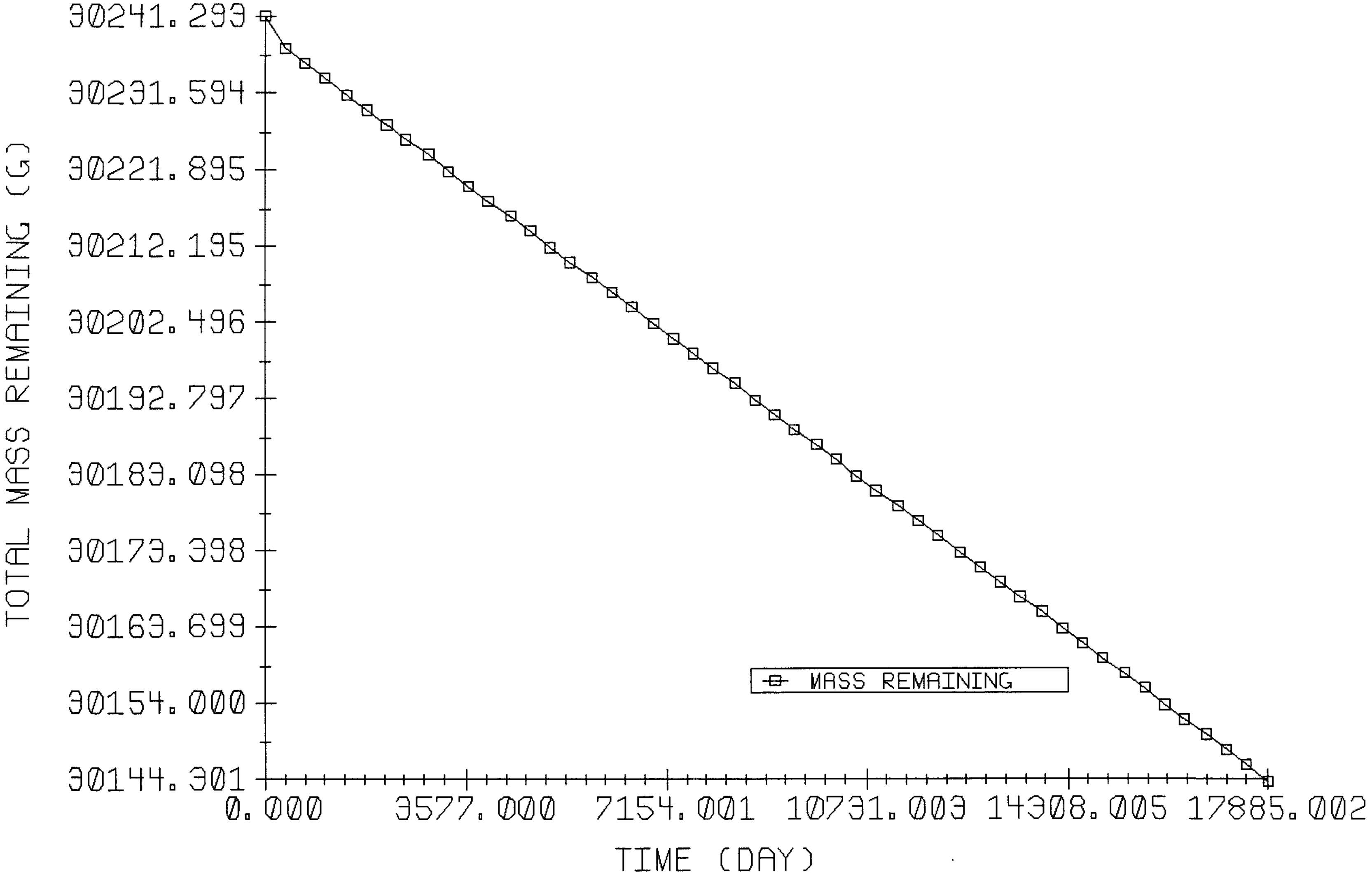
Net Infiltration Rate	0.00001	ft / day

CONCENTRATION VS. TIME

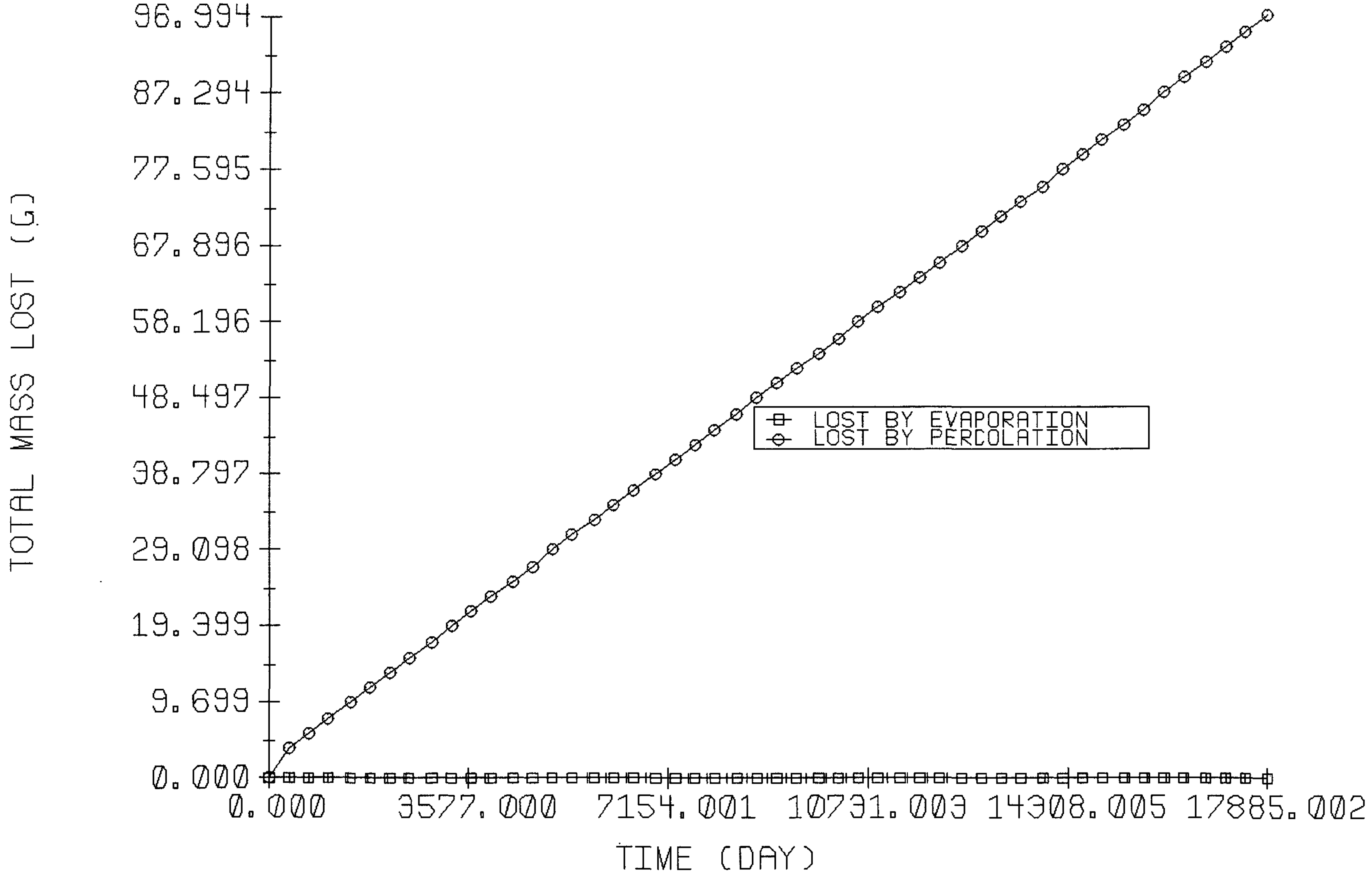


B.11

MASS REMAINING VS TIME



MASS LOST VS TIME



G.S. State # 1

Legal Description
State Lease - Unit "G"
T11S-R33E-Sec. 8
2,086' FNL - 1,874' FEL

Pit Description
G.S. State # 1 is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 150 feet west of the separator with a raised berm approximately 2' in height. The pit dimensions are approximately 60' X 50' x 3' in depth. The pit is covered in bird netting and is surrounded by a four strand barbed wire fence.

There is a minor amount of free product within the pit consisting of heavily weathered asphaltic fractions however there is no evidence of surface staining surrounding the berm. There are no signs of stressed vegetation surrounding the pit.

Pit History
G.S. State # 1 was logged on November 25, 1968 and completed shortly thereafter. Burro Pipeline was permitted in October of 1967 and was connected to the wellsite prior to 1970. All emergency discharges to the pit were discontinued prior to 1970.

Distance to Surface & Ground Waters
The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 51' as determined on January 8, 1997. (See attached 7.5', hydro-geological plat maps and boring logs.)

Closure Standards
In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of and thus must be closed to a TPH concentration of less than 100 ppm.

Sampling Results
On January 8, 1997, Whole Earth supervised the coring of the pit and found hydrocarbon concentrations of less than 10,000 ppm TPH at a depth of between 15-25'. Due to the presence of free product within the pit, the coring was performed at the southeast corner, mid-way up the berm. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

Core samples obtained from the upper vadose zone of the aquifer revealed no detectable concentrations of volatile or semi-volatile compounds. (See attached Environmental Labs of Texas analytical reports.)

Closure Protocol
We propose to close G.S. State # 1 in accordance with the attached Protocol QP-42.

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 2

DATE: 1-8-97/ 1-9-97

DRILL START: 4:00 PM
STOP: 5:30 PM
DRILL START: 7:40 AM
STOP: 8:15 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: N. of NM Hwy. 380
GS State #1

TH NUMBER: 7

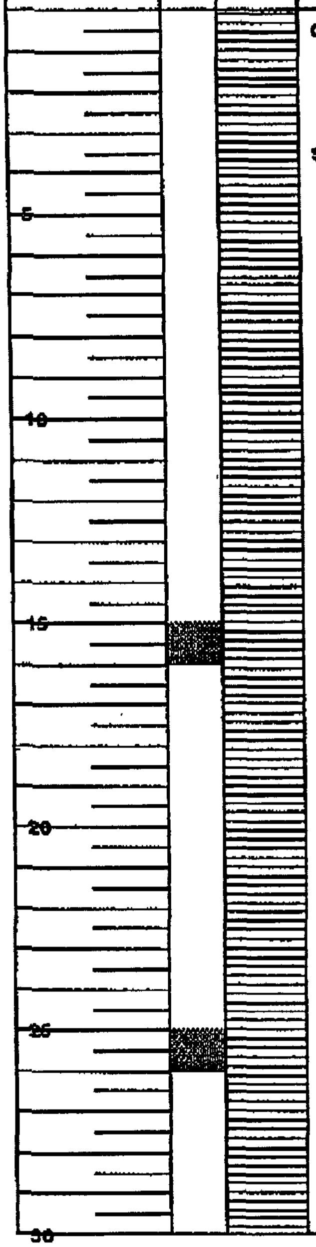
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis



Clay w/Caliche back fill, Brown, Firm, Damp

Silty Clay w/Caliche, Gray, Firm, Damp

Silty Clay w/Caliche, Tan/Gray, Firm, Damp

Silty Sandy Clay, Tan, Firm, Damp

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 **OF** 2

DATE: 1-8-97/
1-9-97

DRILL START: 4:00 PM
STOP: 5:30 PM
DRILL START: 7:40 AM
8:15 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: N. of NM Hwy. 380
GS State #1

TH NUMBER: 7

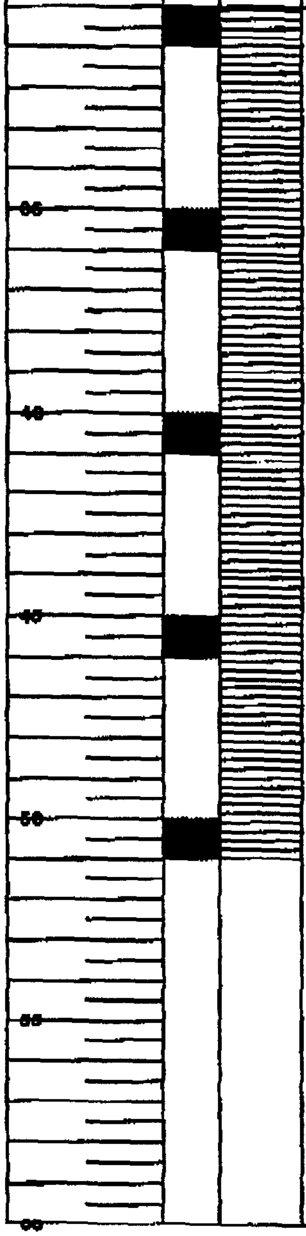
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis



Silty Sandy Clay, Tan, Firm, Damp (Cont'd)

Silty Sandy Clay, Tan, Firm, Moist

Silty Sandy Clay, Tan, Loose, Wet

TD = ±51 ft.

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 10, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: G.S. State # 1
Depth to Water: 51'

Depth	15'	25'	30'	40'	45'
Concentration	4,340	6,290	4,790	3,460	5,320

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________

ENVIRONMENTAL LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Sample Type: SOIL
Project : TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: GS STATE #1
ELT# 9907

Analysis Date: 01/19/97
Sampling Date: 01/10/97
Sample Condition: Intact/Iced

8270 COMPOUNDS	REPORTING LIMIT	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
N-Nitrosodimethylamine	0.01	ND				
2-Picoline	0.01	ND				
Methyl methanesulfonate	0.01	ND				
Ethyl methanesulfonate	0.01	ND				
Phenol	0.01	ND	91	11	84	95
Aniline	0.05	ND				
bis(2-Chloroethyl)ether	0.05	ND				
2-Chlorophenol	0.05	ND		8	74	
1,3-Dichlorobenzene	0.01	ND				
1,4-Dichlorobenzene	0.01	ND	94	10	73	93
Benzyl alchohol	0.05	ND				
1,2-Dichlorobenzene	0.01	ND				
2-Methylphenol	0.01	ND				
bis(2-Chloroisopropyl)ether	0.05	ND				
4-Methylphenol/3-Methylphenol	0.01	ND				
Acetophenone	0.05	ND				
n-Nitrosodi-n-propylamine	0.01	ND		5	79	
Hexachloroethane	0.01	ND				
Nitrobenzene	0.01	ND				
N-Nitrosopiperidine	0.05	ND				
Isophorone	0.05	ND				
2-Nitrophenol	0.05	ND	93			94
2,4-Dimethylphenol	0.05	ND				
bis(2-Chloroethoxy)methane	0.01	ND				
Benzoic acid	0.1	ND				
2,4-Dichlorophenol	0.05	ND	87			96
1,2,4-Trichlorobenzene	0.01	ND		9	79	
a,a Dimethylphenethylamine	0.1	ND				
Naphthalene	0.01	ND				
4-Chloroaniline	0.05	ND				
2,6-Dichlorophenol	0.05	ND				
Hexachlorobutadiene	0.01	ND	95			97
N-Nitroso-di-n-butylamine	0.05	ND				
4-Chloro-3-methylphenol	0.05	ND	97	12	81	93

ELT# 9907

Page 2 of 3

		SAMPLE				
8270 COMPOUNDS	Reporting Limits	Concentration ppm	QC	RPD	%EA	%IA
2-Methylnaphthalene	0.01	ND				
1,2,4,5-Tetrachlorobenzene	0.01	ND				
Hexachlorocyclopentadiene	0.01	ND				
2,4,6-Trichlorophenol	0.05	ND	86			94
2,4,5-Trichlorophenol	0.05	ND				
2-Chloronaphthalene	0.01	ND				
1,-Chloronaphthalene	0.01	ND				
2-Nitroaniline	0.05	ND				
Dimethylphthalate	0.01	ND				
Acenaphthylene	0.01	ND				
2,6-Dinitrotoluene	0.01	ND				
3-Nitroaniline	0.05	ND				
Acenaphthene	0.01	ND	97	3	81	92
2,4-Dinitrophenol	0.05	ND				
Dibenzofuran	0.05	ND				
Pentachlorobenzene	0.01	ND				
4-Nitrophenol	0.05	ND		4	80	
1-Napthylamine	0.05	ND				
2,4-Dinitrotoluene	0.01	ND		6	79	
2-Napthylamine	0.05	ND				
2,3,4,6-Tetrachlorophenol	0.05	ND				
Fluorene	0.01	ND				
Diethylphthalate	0.01	ND				
4-Chlorophenyl-phenylether	0.01	ND				
4-Nitroaniline	0.05	ND				
4,6-Dinitro-2-methylphenol	0.01	ND				
n-Nitrosodipenlamine & Diphenylam	0.01	ND	93			90
Diphenylhydrazine	0.05	ND				
4-Bromophenyl-phenylether	0.01	ND				
Phenacetin	0.05	ND				
Hexachlorobenzene	0.01	ND				
4-Aminobiphenyl	0.05	ND				
Pentachlorophenol	0.05	ND	89	6	79	95
Pentachloronitrobenzene	0.05	ND				
Pronamide	0.01	ND				
Phenanthrene	0.01	ND				
Anthracene	0.01	ND				
Di-n-butylphthalate	0.01	ND				
Fluoranthene	0.01	ND	92			95
Benzidine	0.1	ND				
Pyrene	0.01	ND		6	88	
p-Dimethylaminoazobenzene	0.01	ND				
Butylbenzylphthalate	0.01	ND				
Benzo [a]anthracene	0.01	ND				
3,3-Dichlorobenzidine	0.01	ND				
Chrysene	0.01	ND				
bis (2-Ethylhexyl)phthalate	0.05	ND				

Page 3 of 3

ELT# 9907

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
Di-n octlphthalate	0.01	ND	89			92
Benzo[b]fluoranthene	0.01	ND				
7.12-Dimethylbenz(a)anthracene	0.01	ND				
Benzo[k]fluoranthene	0.01	ND				
Benzo [a] pyrene	0.01	ND	96			91
3-Methylcholanthrene	0.01	ND				
Dibenzo (a,j) acridine	0.01	ND				
Indeno [1.2.3-cd] pyrene	0.01	ND				
Dibenz [a,h] anthracene	0.01	ND				
Benzo [g.h.i] perylene	0.01	ND				

METHOD: EPA SW 846-8270, 3551

SURROGATES	% RECOVERY
2-Fluorophenol SURR	84
Phenol-d6 SURR	81
Nitrobenzene-d5 SURR	89
2-Fluorobiphenyl SURR	91
2,4,6-Tribromophenol SURR	82
Terphenyl-d14 SURR	93

Michael R. Fowler

1-27-97
Date

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: GS STATE #1

Analysis Date: 01/22/97
Sampling Date: 01/10/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9907	PQL	% IA	Method Blank	% EA
Chloromethane	ND	0.1	110	ND	
Vinyl chloride	ND	0.1	101	ND	
Bromomethane	ND	0.1	100	ND	
Chloroethane	ND	0.1	105	ND	
Trichlorofluoromethane	ND	0.1	102	ND	
Acetone	ND	1.0	100	ND	
1,1-Dichloroethane	ND	0.1	95	ND	69
Iodomethane	ND	1.0	92	ND	
Vinyl Acetate	ND	1.0	107	ND	
Carbon Disulfide	ND	0.1	100	ND	
Methylene Chloride	ND	0.1	110	ND	
trans-1,2-Dichloroethene	ND	0.1	98	ND	
1,1-Dichloroethane	ND	0.1	102	ND	
2-Butanone	3.286	1.0	108	ND	
Chloroform	ND	0.1	106	ND	
1,1,1-Trichloroethane	ND	0.1	91	ND	
Carbon Tetrachloride	ND	0.1	94	ND	
Benzene	ND	0.1	96	ND	110
1,2 Dichloroethane	ND	0.1	97	ND	
Trichloroethene	ND	0.1	83	ND	108
1,2-Dichloropropane	ND	0.1	95	ND	
Dibromomethane	ND	0.1	115	ND	
Bromochloromethane	ND	0.1	124	ND	
2-Chloroethyl Vinyl ether	ND	1.0	123	ND	
4-Methyl 2-Pentanone	ND	1.0	120	ND	
cis 1,3 Dichloropropene	ND	0.1	105	ND	
Toluene	ND	0.1	96	ND	119
trans 1,3 Dichloropropene	ND	0.1	89	ND	
1,1,2-Trichloroethane	ND	0.1	98	ND	
Dibromochloromethane	ND	0.1	105	ND	
Tetrachloroethene	ND	0.1	107	ND	
Chlorobenzene	ND	0.1	98	ND	107

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: GS STATE #1

Analysis Date: 01/22/97
Sampling Date: 01/10/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240. (ppm) Compounds	ELT# 9907	PQL	% IA	Method Blank	% EA
Ethylbenzene	ND	0.1	89	ND	
m&p Xylene	ND	0.1	87	ND	
o-Xylene	ND	0.1	90	ND	
Styrene	ND	0.1	95	ND	
Bromoform	ND	0.1	113	ND	
1,1,2,2-Tetrachloroethane	ND	0.1	87	ND	
1,2,3-Trichloropropane	ND	0.1	108	ND	

SYSTEM MONITORING COMPOUNDS	% RECOVERY
Dibromofluoromethane	84
Toluene-d8	104
4-Bromofluorobenzene	84

ND=<PQL

Michael R. Fowler

Michael R. Fowler

1-27-97
Date

Modeling Data Entry
G.S. State # 1

Control Data	Entry	U / M
Deterministic	Yes	
Monte Carlo	No	
Evaporation	No	
Biodecay	No	
Low Permeability Layer Below Contamination	No	

Source Data		
Waste Zone Thickness	30	ft.
Waste Zone Area	3,000	sq. ft.
Ratio of Length to Width	0.75	
Soil Thickness above Waste Zone	10	ft.
Contaminant Concentration in Soil / Waste Zone	10	ppm
Hydrocarbon Concentration in Soil / Waste Zone	10,000	ppm

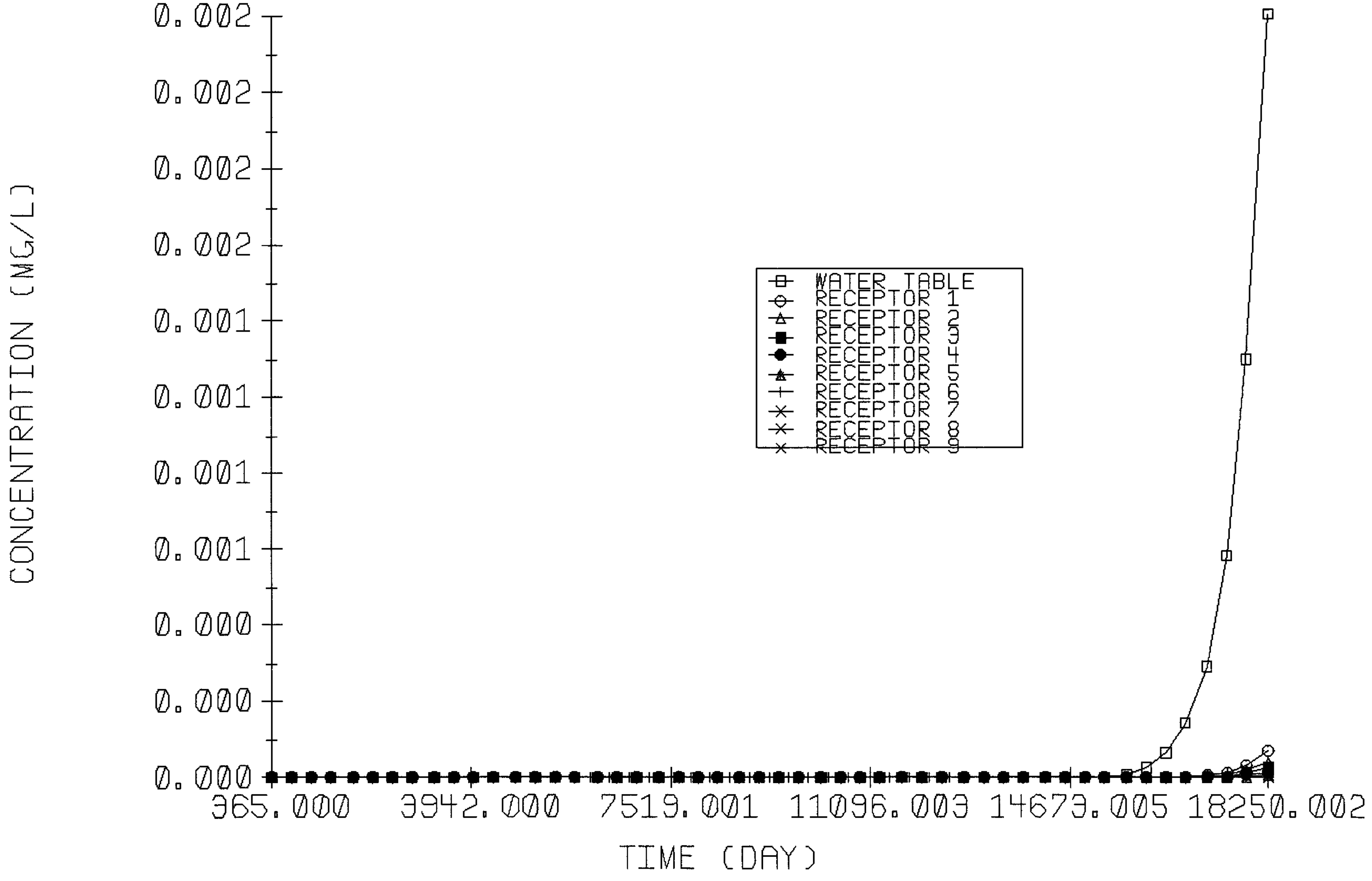
Chemical Data	
Benzene	Yes

Unsaturated Zone		
Biodecay Cooefficient	0	
Organic Carbon Fraction	0	
Soil Database	Clay	
Hydrological Database	Sedimentary	
Unsaturated Zone Thickness	1	meter
Soil Database	Clay	
van Genuchten n	1.09	(Default)
Residual Water Content	0.01001	
Unsaturated Zone Dispersivity	0	Internally

Saturated Zone		
Biodecay Cooefficient	0	
Aquifer Porosity	0.2	(Default)
Organic Carbon Fraction	0	
Longitudinal Dispersivity	0	Internally
Ratio of Long. / Trans. Dispersivities	3	
Ratio of Trans. / Vert. Dispersivities	3	
Hydrological Database	Sedimentary	
Aquifer Thickness	60	ft.
Aquifer Gradient	0.00357	
Saturated Hydraulic Conductivity	0.0986	ft / day

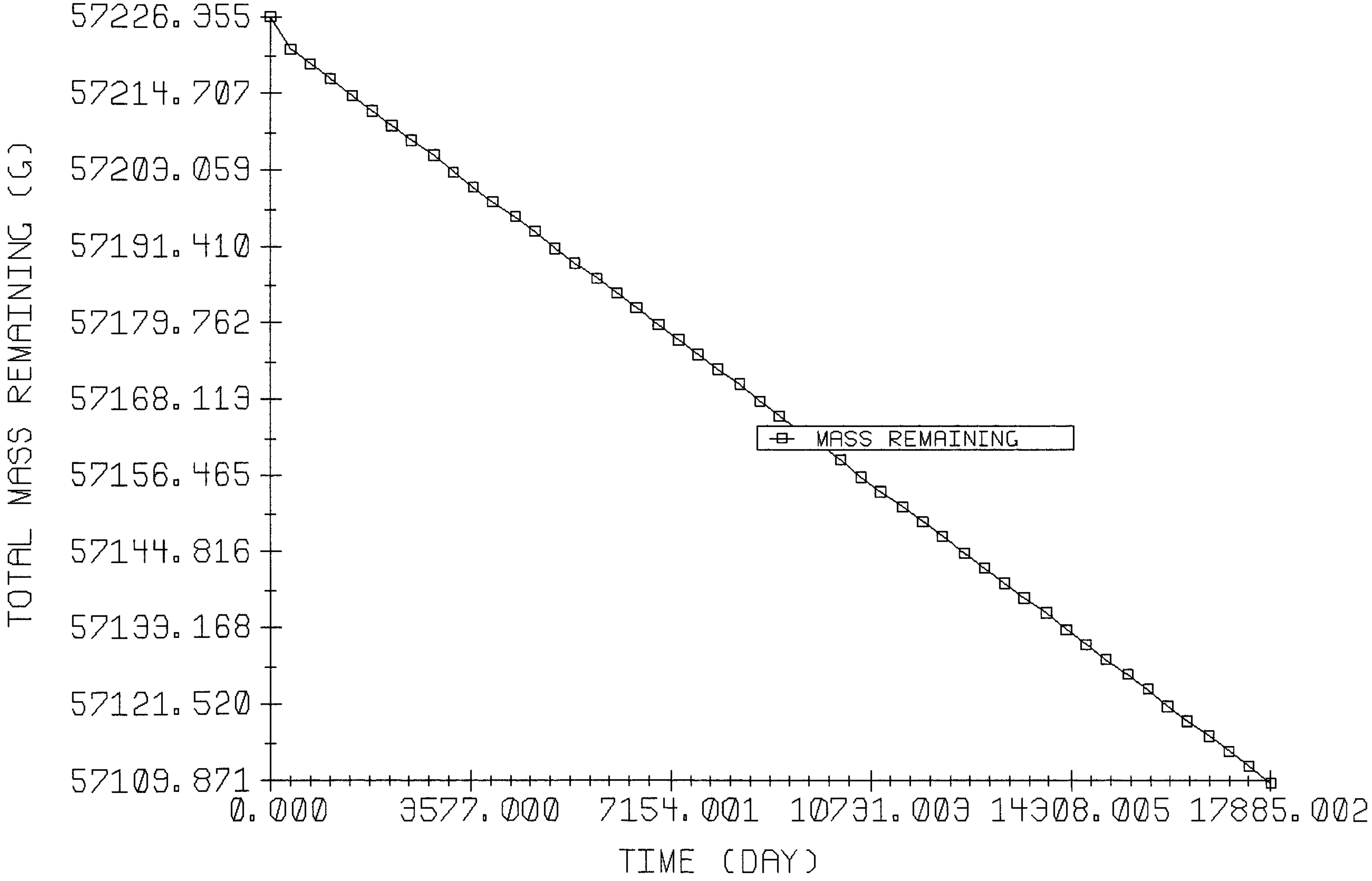
Net Infiltration Rate	0.00001	ft / day

CONCENTRATION VS. TIME

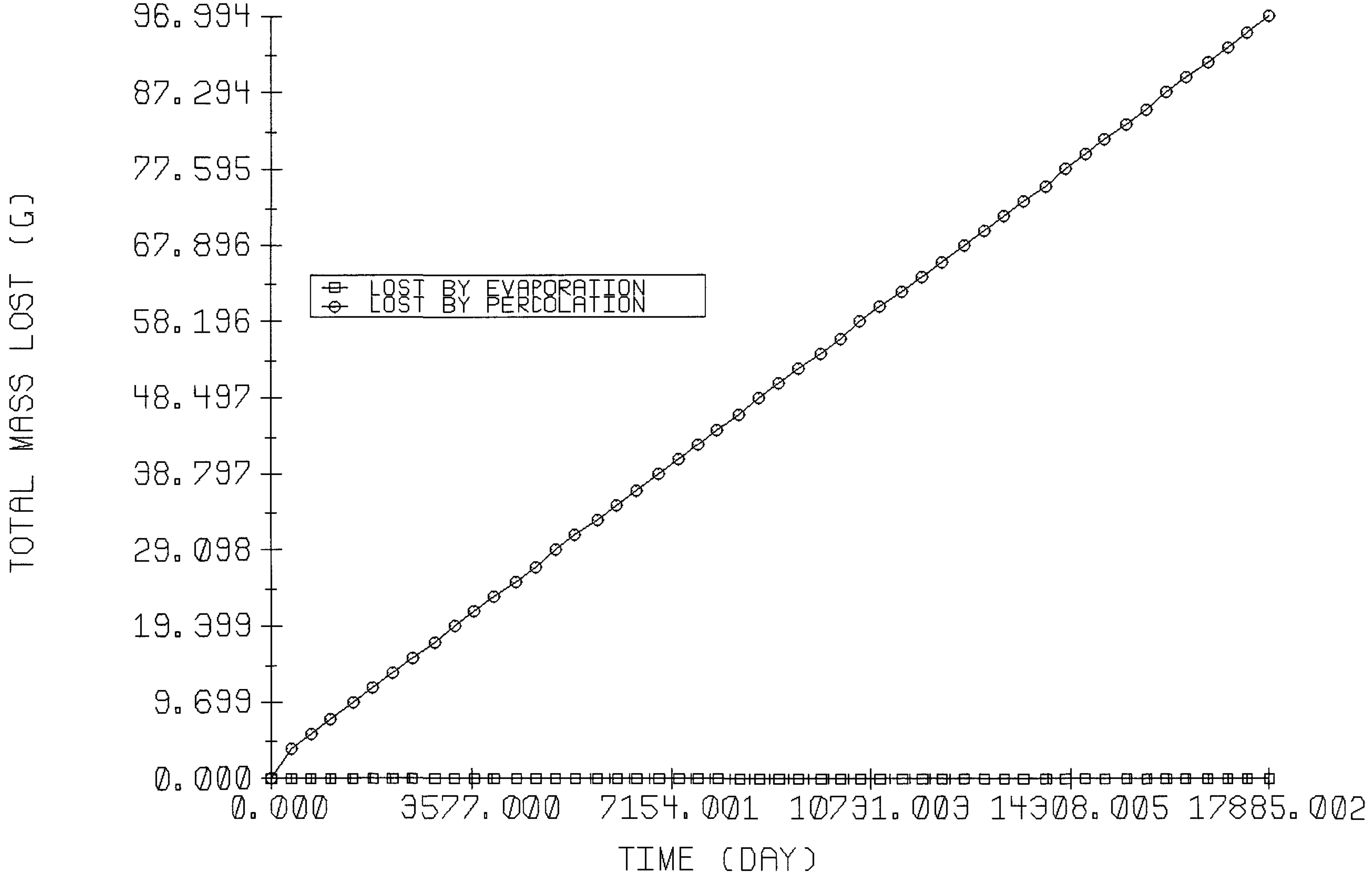


GS State

MASS REMAINING VS TIME



MASS LOST VS TIME



Mable COM # 1

Legal Description

State Lease K3905 - (Oil & Gas #5846)
T11S-R33E-Sec.29
660' FNL - 660' FWL

Pit Description

Mable COM # 1 is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 120 feet north of the separator. There is no record of the original pit dimension

The pit was closed at some point in the past by folding the berm walls into the open excavation. There is no record of any contracted remediation activities having occurred at the pit site. The old pit site was recently selected for remediation on the basis of heavy end, asphaltic contamination having seeped to the surface. There are no signs of stressed vegetation surrounding the pit.

Pit History

Mable COM # 1was logged on May 18, 1968 and completed shortly thereafter. Burro Pipeline was permitted in October of 1967 and was connected to the wellsite prior to 1970. All emergency discharges to the pit were discontinued prior to 1970.

On December 16th, Whole Earth excavated to a depth of approximately 20' and found hydrocarbon concentrations in excess of closure standards. Further excavation was impeded by the mechanical limits of the excavation equipment.

Distance to Surface & Ground Waters

The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 68' as determined on January 6, 1997. (See attached 7.5', hydro-geological plat maps and boring logs.)

Closure Standards

In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

Sampling Results

On January 6, 1997, Whole Earth supervised the coring of the pit and found hydrocarbon concentrations in excess of closure standards for the entire distance to the upper vadose zone. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

Core samples obtained from the upper vadose zone of the aquifer revealed free product atop the water table. (See attached Environmental Labs of Texas analytical reports.)

Closure Protocol

We propose to close Mable COM # 1 in accordance with the attached Protocol QP-43.

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 3	**DATE:** 1-6-97	**DRILL START:** 9:45 AM **DRILL STOP:** 12:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Madle Com

TH NUMBER: 2

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis	
		▤	Silty Clay & Caliche, Brown, Firm, Dry					
		▤	Silty Clay w/Caliche, Black, Firm, Dry					
5		▤						
10		▤						
		▤	Silty Clay w/Caliche, Gray, Firm, Damp					
15		▤						
		▤	Silty Clay w/Caliche, Light Gray, Firm, Damp					
20		▤						
	▨	▤	Silty Clay w/Caliche, Dark Tan, Firm, Damp					
25		▤						
		▤	Silty Sandy Clay, Tan, Firm, Damp					
30								

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 **OF** 3	**DATE:** 1-6-97	**DRILL START:** 9:45 AM **DRILL STOP:** 12:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Midle Com

TH NUMBER: 2	**AUGER TYPE:** HOLLOW STEM	**CASING ELEVATION:** N/A
	DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.	**LOGGED BY:** Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis	
		▤	Silty Clay w/ Caliche, Dark Tan, Firm, Damp (Cont'd)					
35	▨	▤	Silty Sandy Clay, Tan, Firm, Damp					
40		▤						
45		▤						
50		▤						
55		▤						
60								

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 3 **OF** 3

DATE: 1-6-97

DRILL START: 9:45 AM
DRILL STOP: 12:30 PM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Midle Com

TH NUMBER: 2

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Dales

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lab Analysis	Lab Analysis	
		▤	Silty Sandy Clay, Tan, Firm, Damp (Cont'd)					
	■	░	Silty Sand, Tan, Soft, Saturated					
65		░						
			TD = ±68 ft.					
70								
75								
80								
85								
90								

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Sample Type: SOIL
Project : TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: MABLE COM
ELT# 9913

Analysis Date: 01/19/97
Sampling Date: 01/06/97
Sample Condition: Intact/Iced

8270 COMPOUNDS	REPORTING LIMIT	SAMPLE Concentration ppm	QC	RPD	% EA	% IA
N-Nitrosodimethylamine	0.01	ND				
2-Picoline	0.01	ND				
Methyl methanesulfonate	0.01	ND				
Ethyl methanesulfonate	0.01	ND				
Phenol	0.01	ND	91	11	84	95
Aniline	0.05	ND				
bis(2-Chloroethyl)ether	0.05	ND				
2-Chlorophenol	0.05	ND		8	74	
1,3-Dichlorobenzene	0.01	ND				
1,4-Dichlorobenzene	0.01	ND	94	10	73	93
Benzyl alchohol	0.05	ND				
1,2-Dichlorobenzene	0.01	ND				
2-Methylphenol	0.01	ND				
bis(2-Chloroisopropyl)ether	0.05	ND				
4-Methylphenol/3-Methylphenol	0.01	ND				
Acetophenone	0.05	ND				
n-Nitrosodi-n-propylamine	0.01	ND		5	79	
Hexachloroethane	0.01	ND				
Nitrobenzene	0.01	ND				
N-Nitrosopiperidine	0.05	ND				
Isophorone	0.05	ND				
2-Nitrophenol	0.05	ND	93			94
2,4-Dimethylphenol	0.05	ND				
bis(2-Chloroethoxy)methane	0.01	ND				
Benzoic acid	0.1	ND				
2,4-Dichlorophenol	0.05	ND	87			96
1,2,4-Trichlorobenzene	0.01	ND		9	79	
a,a Dimethylphenethylamine	0.1	ND				
Naphthalene	0.01	ND				
4-Chloroaniline	0.05	ND				
2,6-Dichlorophenol	0.05	ND				
Hexachlorobutadiene	0.01	ND	95			97
N-Nitroso-di-n-butylamine	0.05	ND				
4-Chloro-3-methylphenol	0.05	ND	97	12	81	93

ELT# 9913

		SAMPLE				
8270 COMPOUNDS	Reporting Limits	Concentration ppm	QC	RPD	%EA	%IA
2-Methylnaphthalene	0.01	ND				
1,2,4,5-Tetrachlorobenzene	0.01	ND				
Hexachlorocyclopentadiene	0.01	ND				
2,4,6 Trichlorophenol	0.05	ND	86			94
2,4,5-Trichlorophenol	0.05	ND				
2-Chloronaphthalene	0.01	ND				
1,-Chloronaphthalene	0.01	ND				
2-Nitroaniline	0.05	ND				
Dimethylphthalate	0.01	ND				
Acenaphthylene	0.01	ND				
2,6-Dinitrotoluene	0.01	ND				
3-Nitroaniline	0.05	ND				
Acenaphthene	0.01	ND	97	3	81	92
2,4-Dinitrophenol	0.05	ND				
Dibenzofuran	0.05	ND				
Pentachlorobenzene	0.01	ND				
4-Nitrophenol	0.05	ND		4	80	
1-Napthylamine	0.05	ND				
2,4-Dinitrotoluene	0.01	ND		6	79	
2-Napthylamine	0.05	ND				
2,3,4,6-Tetrachlorophenol	0.05	ND				
Fluorene	0.01	ND				
Diethylphthalate	0.01	ND				
4-Chlorophenyl-phenylether	0.01	ND				
4-Nitroaniline	0.06	ND				
4,6-Dinitro-2-methylphenol	0.01	ND				
n-Nitrosodipenlamine & Diphenylarr	0.01	ND	93			90
Diphenylhydrazine	0.05	ND				
4-Bromophenyl-phenylether	0.01	ND				
Phenacetin	0.05	ND				
Hexachlorobenzene	0.01	ND				
4-Aminobiphenyl	0.05	ND				
Pentachlorophenol	0.05	ND	89	6	79	95
Pentachloronitrobenzene	0.05	ND				
Pronamide	0.01	ND				
Phenanthrene	0.01	ND				
Anthracene	0.01	ND				
Di-n-butylphthalate	0.01	ND				
Fluoranthene	0.01	ND	92			95
Benzidine	0.1	ND				
Pyrene	0.01	ND		6	88	
p-Dimethylaminoazobenzene	0.01	ND				
Butylbenzylphthalate	0.01	ND				
Benzo [a]anthracene	0.01	ND				
3,3-Dichlorobenzidine	0.01	ND				
Chrysene	0.01	ND				
bis (2-Ethylhexyl)phthalate	0.05	ND				

ELT# 9913

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
Di-*n*- octlphthalate	0.01	ND	89			92
Benzo[b]fluoranthene	0.01	ND				
7,12-Dimethylbenz(a)anthracene	0.01	ND				
Benzo[k]fluoranthene	0.01	ND				
Benzo [a] pyrene	0.01	ND	96			91
3-Methylcholanthrene	0.01	ND				
Dibenzo (a,j) acridine	0.01	ND				
Indeno [1,2,3-cd] pyrene	0.01	ND				
Dibenz [a,h] anthracene	0.01	ND				
Benzo [g,h,i] perylene	0.01	ND				

METHOD: EPA SW 846-8270, 3551

SURROGATES	% RECOVERY
2-Fluorophenol SURR	86
Phenol-d6 SURR	83
Nitrobenzene-d5 SURR	96
2-Fluorobiphenyl SURR	95
2,4,6-Tribromophenol SURR	81
Terphenyl-d14 SURR	93

Michael R. Fowler

1-27-97
Date

ENVIRONMENTAL LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97	Analysis Date: 01/22/97
Reporting Date: 01/23/97	Sampling Date: 01/06/97
Project Name: TATUM PIT SAMPLING	Sample Type: SOIL
Project Location: WEST OF TATUM, NM	Sample Condition: C&I
Field Code: MABLE COM	

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9913	PQL	% IA	Method Blank	% EA
Chloromethane	ND	0.1	110	ND	
Vinyl chloride	ND	0.1	101	ND	
Bromomethane	ND	0.1	100	ND	
Chloroethane	ND	0.1	105	ND	
Trichlorofluoromethane	ND	0.1	102	ND	
Acetone	ND	1.0	100	ND	
1,1-Dichloroethane	ND	0.1	95	ND	69
Iodomethane	ND	1.0	92	ND	
Vinyl Acetate	ND	1.0	107	ND	
Carbon Disulfide	ND	0.1	100	ND	
Methylene Chloride	ND	0.1	110	ND	
trans-1,2-Dichloroethene	ND	0.1	98	ND	
1,1-Dichloroethane	ND	0.1	102	ND	
2-Butanone	ND	1.0	108	ND	
Chloroform	ND	0.1	106	ND	
1,1,1-Trichloroethane	ND	0.1	91	ND	
Carbon Tetrachloride	ND	0.1	94	ND	
Benzene	ND	0.1	96	ND	110
1,2 Dichloroethane	ND	0.1	97	ND	
Trichloroethene	ND	0.1	83	ND	108
1,2-Dichloropropane	ND	0.1	95	ND	
Dibromomethane	ND	0.1	115	ND	
Bromochloromethane	ND	0.1	124	ND	
2-Chloroethyl Vinyl ether	ND	1.0	123	ND	
4-Methyl 2-Pentanone	ND	1.0	120	ND	
cis 1,3 Dichloropropene	ND	0.1	105	ND	
Toluene	2.383 [illegible]	0.1	96	ND	119
trans 1,3-Dichloropropene	ND	0.1	89	ND	
1,1,2-Trichloroethane	ND	0.1	98	ND	
Dibromochloromethane	ND	0.1	105	ND	
Tetrachloroethene	ND	0.1	107	ND	
Chlorobenzene	ND	0.1	98	ND	107

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: MABLE COM

Analysis Date: 01/22/97
Sampling Date: 01/06/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9913	PQL	% IA	Method Blank	% EA
Ethylbenzene	4.059	0.1	89	ND	
m&p Xylene	21.053	0.1	87	ND	
o-Xylene	10.193	0.1	90	ND	
Styrene	ND	0.1	95	ND	
Bromoform	ND	0.1	113	ND	
1,1,2,2-Tetrachloroethane	ND	0.1	87	ND	
1,2,3-Trichloropropane	ND	0.1	108	ND	

SYSTEM MONITORING COMPOUNDS	% RECOVERY
Dibromofluoromethane	101
Toluene-d8	105
4-Bromofluorobenzene	105

ND=<PQL

Michael R. Fowler
Michael R. Fowler

1-27-97
Date

Iva COM # 1

Legal Description
Fee Lease - Unit "H"
T11S-R33E-Sec. 20
2,130' FNL - 660' FEL

Pit Description
Iva COM #1 is described as an unlined emergency upset pit that was used in conjunction with on-site separation and storage. The pit lies approximately 150 feet north of the separator. The original pit dimensions were approximately 40' X 50' X 3' deep.

There are no signs of stressed vegetation surrounding the pit.

Pit History
Iva COM #1 was logged on March 26, 1968 and completed shortly thereafter. Burro Pipeline was permitted in October of 1967 and was connected to the wellsite prior to 1970. All emergency discharges to the pit were discontinued prior to 1970.

On December 16th, Whole Earth excavated to a depth of approximately 20' and found hydrocarbon concentrations in excess of closure standards. Further excavation was impeded by the mechanical limits of the excavation equipment.

Distance to Surface & Ground Waters
The attached plat map demonstrates that the pit is more than 1,000 ft. from a surface water body or private domestic water source. The vertical distance to ground water is 53' as determined on January 8, 1997. (See attached 7.5', hydro-geological plat maps and boring logs.)

Closure Standards
In accordance with the Oil Conservation Division *Unlined Surface Impoundment Closure Guidelines* (Feb. '93) the pit has a total ranking score of >19 and thus must be closed to a TPH concentration of less than 100 ppm.

Sampling Results

On January 8, 1997, Whole Earth supervised the coring of the pit and found hydrocarbon concentrations in excess of closure standards for the entire distance to the upper vadose zone. (See attached field sampling report and plat map.) The field tests were conducted using EPA Method 418.1 (modified) in accordance with Whole Earth Quality Procedures QP-6 and QP-25 (enclosed).

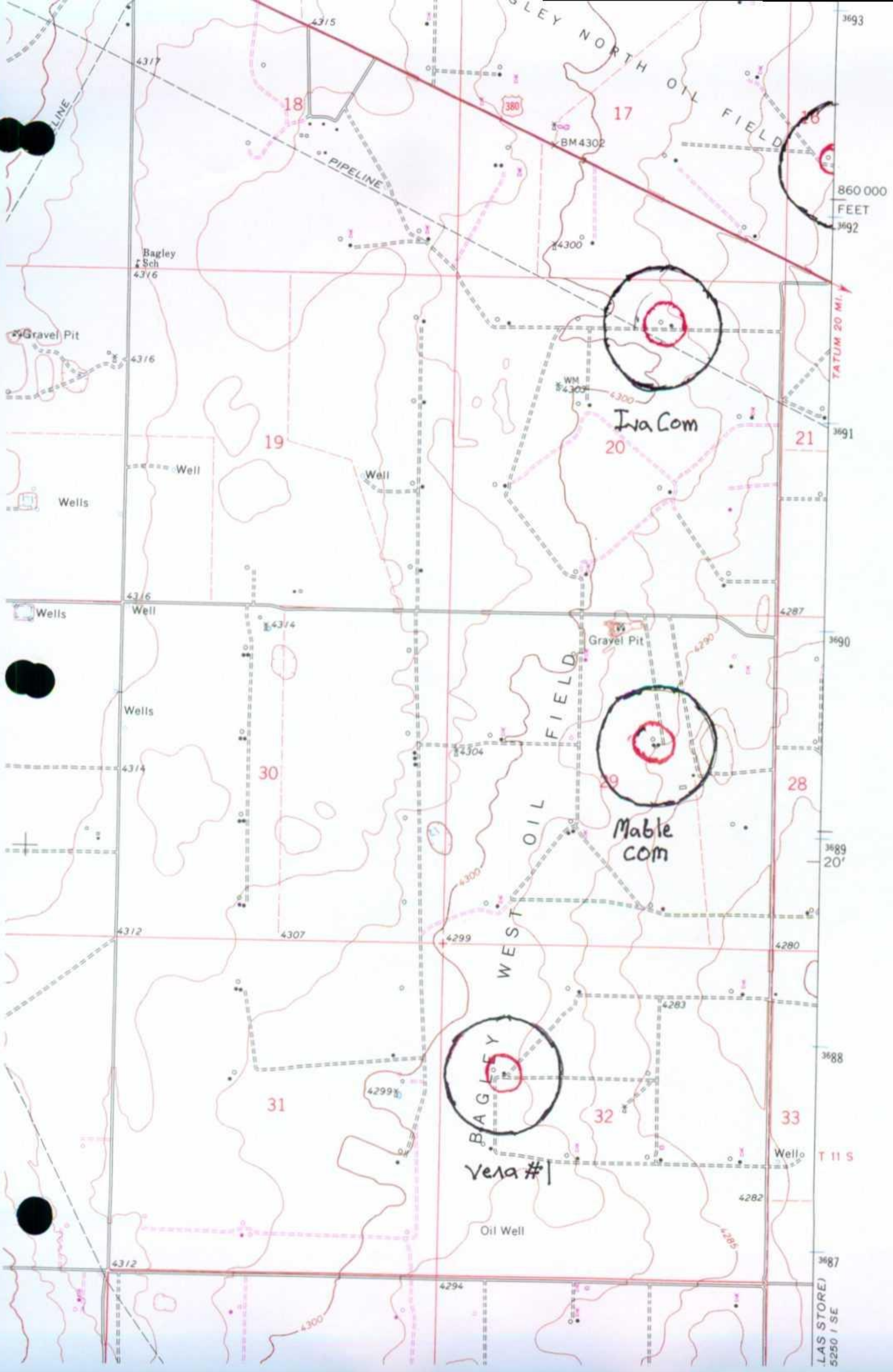
Core samples obtained from the upper vadose zone of the aquifer revealed free product atop the water table. (See attached Environmental Labs of Texas analytical reports.)

Closure Protocol

We propose to close IvaCOM # 1 in accordance with the attached Protocol QP-43.

Mable # 1

Mable COM



BAGLEY NORTH OIL FIELD
4315
4317
18
17
16
380
BM 4302
PIPELINE
LINE
860 000 FEET
3693
3692
4300
Bagley Sch
4316
Gravel Pit
4316
WM 4303
4300
Iva Com
19
20
21
3691
TATUM 20 MI.
Well
Well
Wells
Wells
4316
Well
4314
4287
Gravel Pit
4290
3690
BAGLEY WEST OIL FIELD
Wells
4304
4314
30
29
28
Mable Com
3689
20′
4300
4312
4307
4299
4280
4283
3688
4299
31
32
33
Vera #1
Well
T 11 S
4282
Oil Well
4285
3687
4312
4294
4300
LAS STORE)
5250 I SE

Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 6, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: Mable COM # 1
Depth to Water: 68'

Depth	**10'**	**20'**	**30'**	**35'**	**50'**
Concentration	**>10,000**	**>10,000**	**>10,000**	**>10,000**	**>10,000**

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

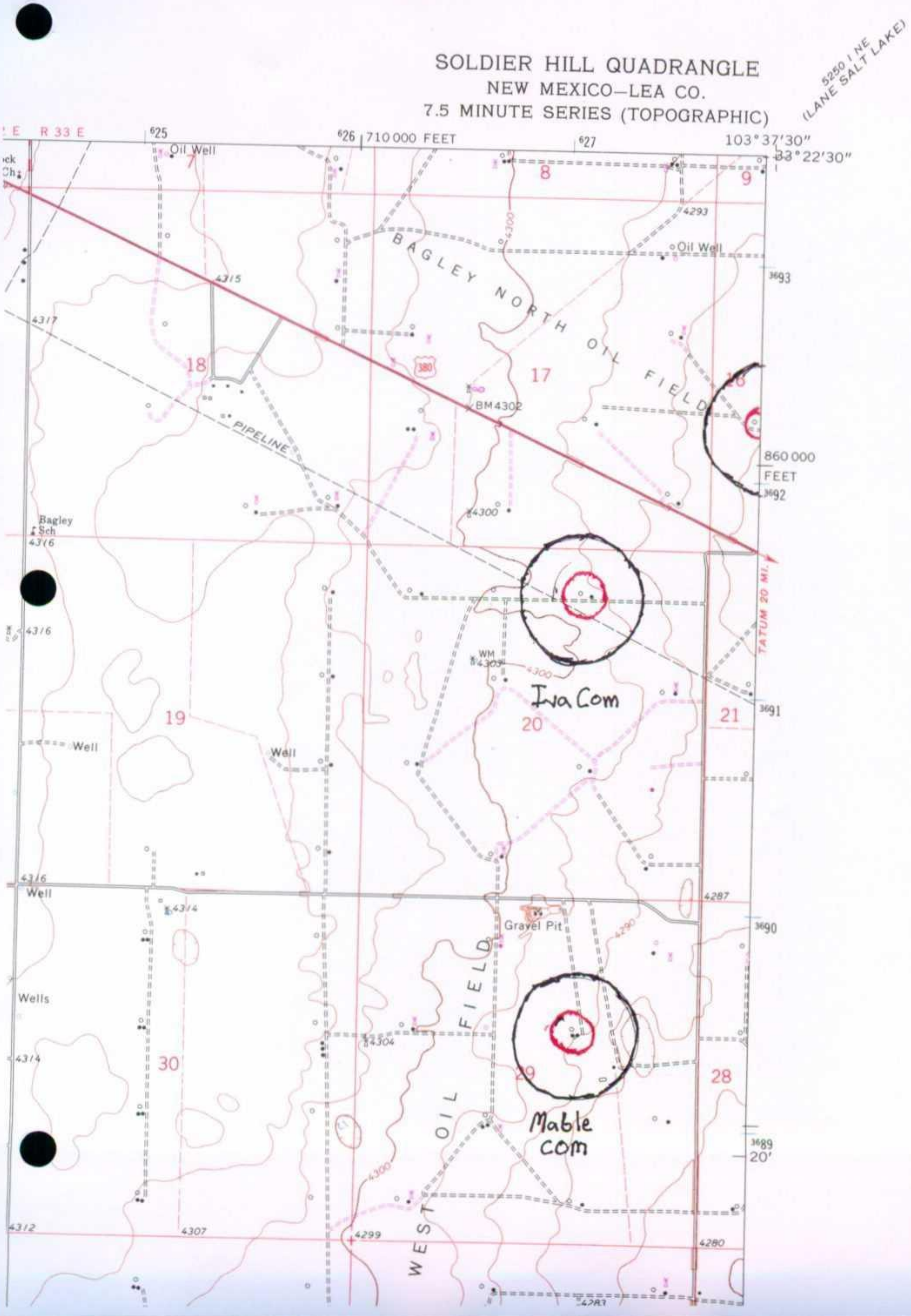
Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ______________________________

Iva COM

SOLDIER HILL QUADRANGLE
NEW MEXICO—LEA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Whole Earth Environmental
Field Form (TPH)

Client Name: Tipperary Corporation
Project Name: Tatum Production Pit Investigation
Date: January 6, 1997
Analyzer SN: 01152
Technician: M. Griffin
Pit Name: Iva COM # 1
Depth to Water: 53'

Depth	10'	20'	30'	35'	50'
Concentration	>10,000	>10,000	>10,000	>10,000	>10,000

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Depth					
Concentration					

Note: All TPH Concentrations in parts per million (ppm)

Signature of Technician: ____________________

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2004 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 1 **OF** 2

DATE: 1-7-97/ 1-8-97

DRILL START: 4:45 PM

DRILL STOP: 8:40 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Iva Com 181

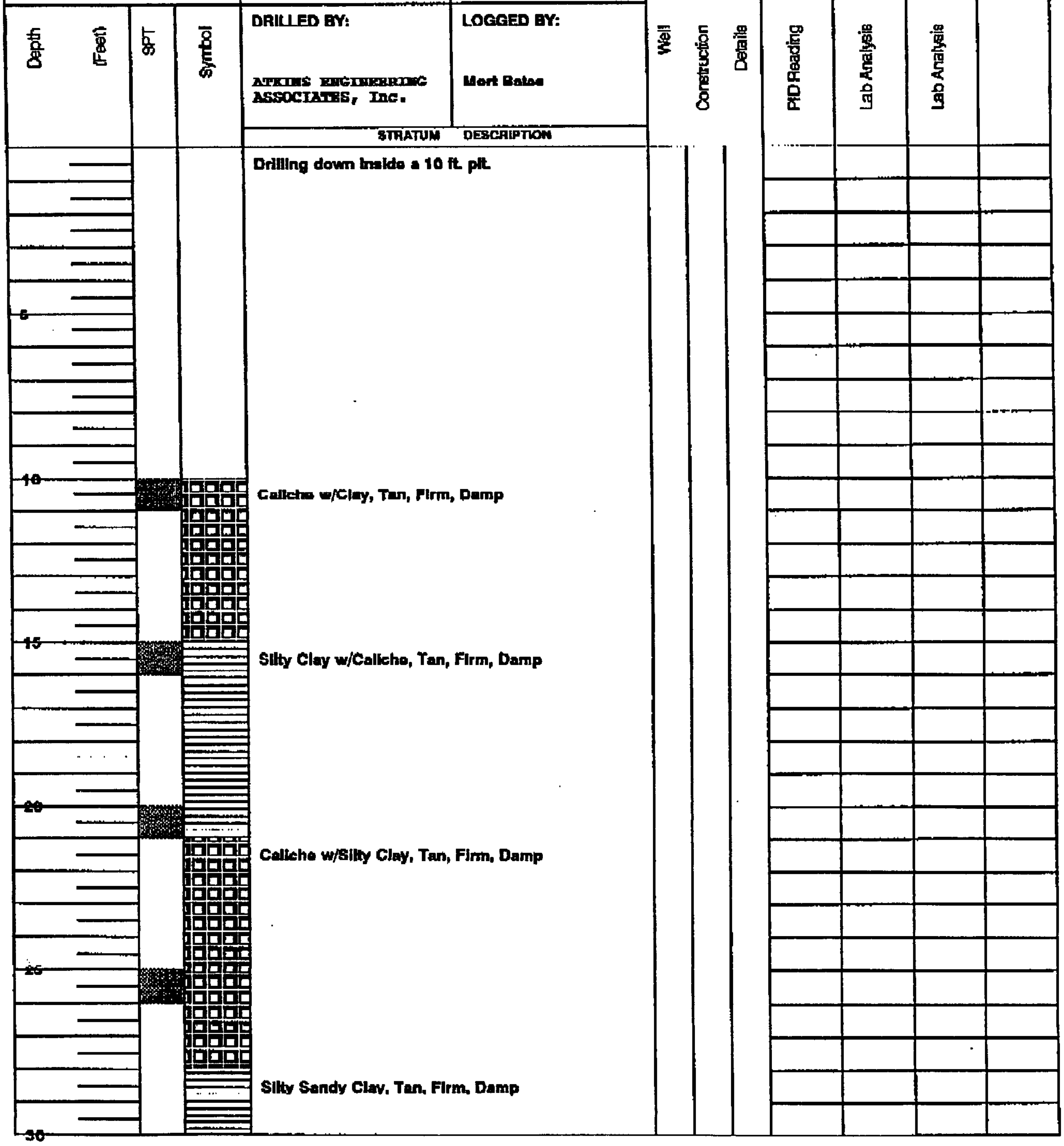
TH NUMBER: 1-A

AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mert Bates



Drilling down inside a 10 ft. pit.

Caliche w/Clay, Tan, Firm, Damp

Silty Clay w/Caliche, Tan, Firm, Damp

Caliche w/Silty Clay, Tan, Firm, Damp

Silty Sandy Clay, Tan, Firm, Damp

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2904 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

PAGE 2 **OF** 2

DATE: 1-7-97/ 1-8-97

DRILL START: 4:45 PM
DRILL STOP: 8:40 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Iva Com 181

TH NUMBER: 1-A

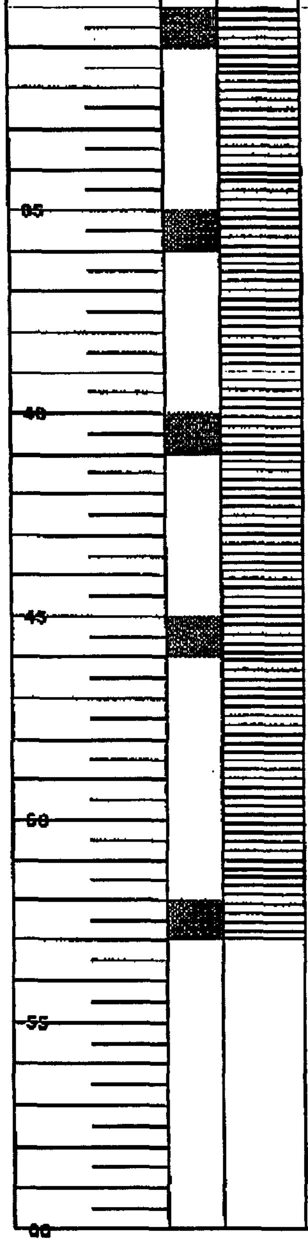
AUGER TYPE: HOLLOW STEM

CASING ELEVATION: N/A

DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.

LOGGED BY: Mort Bates

Depth (Feet) | SPT | Symbol | STRATUM DESCRIPTION | Well Construction Details | PID Reading | Lab Analysis | Lab Analysis



Silty Sandy Clay, Tan, Firm, Damp (Cont'd)

Silty Sandy Clay, Tan, Loose, Saturated

TD = ±53 ft.

BORING LOG

ATKINS ENGINEERING ASSOCIATES, INC

2004 West Second Street, Roswell, New Mexico 88202-3156

PROJECT NAME: Tipperary Corp. - Whole Earth Environmental, Inc.
Mike Griffin
Job #96464.00

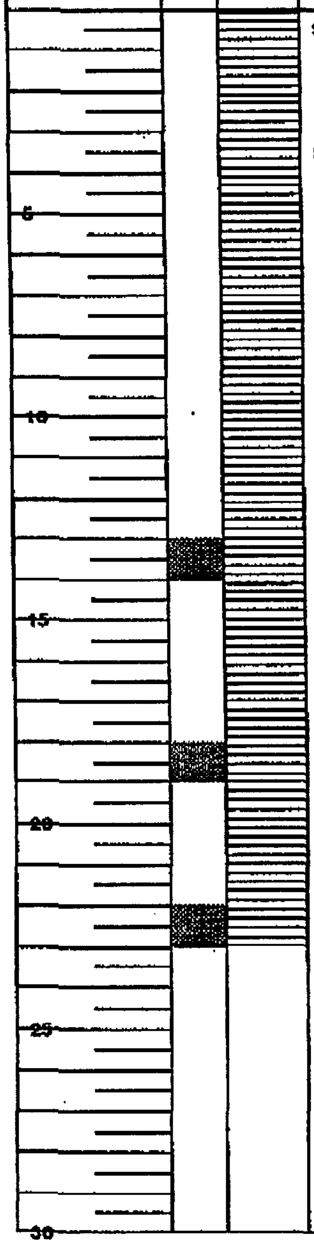
PAGE 1 **OF** 1	**DATE:** 1-6-97	**DRILL START:** 8:30 AM	**DRILL STOP:** 9:30 AM

SITE LOCATION: Caprock, New Mexico

BORING LOCATION: S. of NM Hwy. 380
Iva Com 151

TH NUMBER: 1	**AUGER TYPE:** HOLLOW STEM	**CASING ELEVATION:** N/A
	DRILLED BY: ATKINS ENGINEERING ASSOCIATES, Inc.	**LOGGED BY:** Mort Bates

Depth (Feet)	SPT	Symbol	STRATUM DESCRIPTION	Well Construction Details	PID Reading	Lat Analysis	Lab Analysis	



Silty Clay w/Caliche, Brown, Firm, Dry

Silty Clay w/Caliche, Reddish-Tan, Firm, Dry

Silty Clay, Tan, Firm, Dry

Silty Clay, Tan, Loose, Dry

TD = ±23 ft.

ENVIRONMENTAL LAB OF TEXAS, INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800 854-4358

Receiving Date: 01/10/97
Sample Type: SOIL
Project : TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: IVA COM
ELT# 9909

Analysis Date: 01/17/97
Sampling Date: 01/09/97
Sample Condition: Intact/Iced

8270 COMPOUNDS	REPORTING LIMIT	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
N-Nitrosodimethylamine	0.01	ND				
2-Picoline	0.01	ND				
Methyl methanesulfonate	0.01	ND				
Ethyl methanesulfonate	0.01	ND				
Phenol	0.01	ND	89	9	82	93
Aniline	0.05	ND				
bis(2-Chloroethyl)ether	0.05	ND				
2-Chlorophenol	0.05	ND		11	63	
1,3-Dichlorobenzene	0.01	ND				
1,4-Dichlorobenzene	0.01	ND	87	8	67	91
Benzyl alchohol	0.05	ND				
1,2-Dichlorobenzene	0.01	ND				
2-Methylphenol	0.01	ND				
bis(2-Chloroisopropyl)ether	0.05	ND				
4-Methylphenol/3-Methylphenol	0.01	ND				
Acetophenone	0.05	ND				
n-Nitrosodi-n-propylamine	0.01	ND		4	73	
Hexachloroethane	0.01	ND				
Nitrobenzene	0.01	ND				
N-Nitrosopiperidine	0.05	ND				
Isophorone	0.05	ND				
2-Nitrophenol	0.05	ND	89			93
2,4-Dimethylphenol	0.05	ND				
bis(2-Chloroethoxy)methane	0.01	ND				
Benzoic acid	0.1	ND				
2,4-Dichlorophenol	0.05	ND	80			91
1,2,4-Trichlorobenzene	0.01	ND		7	77	
a,a Dimethylphenethylamine	0.1	ND				
Naphthalene	0.01	ND				
4-Chloroaniline	0.05	ND				
2,6-Dichlorophenol	0.05	ND				
Hexachlorobutadiene	0.01	ND	93			89
N-Nitroso-di-n-butylamine	0.05	ND				
4-Chloro-3-methylphenol	0.05	ND	79	5	78	91

ELT# 9909

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
2-Methylnaphthalene	0.01	ND				
1,2,4,5-Tetrachlorobenzene	0.01	ND				
Hexachlorocyclopentadiene	0.01	ND				
2,4,6-Trichlorophenol	0.05	ND	83			92
2,4,5-Trichlorophenol	0.05	ND				
2-Chloronaphthalene	0.01	ND				
1,-Chloronaphthalene	0.01	ND				
2-Nitroaniline	0.05	ND				
Dimethylphthalate	0.01	ND				
Acenaphthylene	0.01	ND				
2,6-Dinitrotoluene	0.01	ND				
3-Nitroaniline	0.05	ND				
Acenaphthene	0.01	ND	92	3	79	94
2,4-Dinitrophenol	0.05	ND				
Dibenzofuran	0.05	ND				
Pentachlorobenzene	0.01	ND				
4-Nitrophenol	0.05	ND		8	74	
1-Napthylamine	0.05	ND				
2,4-Dinitrotoluene	0.01	ND		9	73	
2-Napthylamine	0.05	ND				
2,3,4,6-Tetrachlorophenol	0.05	ND				
Fluorene	0.01	ND				
Diethylphthalate	0.01	ND				
4-Chlorophenyl-phenylether	0.01	ND				
4-Nitroaniline	0.05	ND				
4,6-Dinitro-2-methylphenol	0.01	ND				
n-Nitrosodipenlamine & Diphenylam	0.01	ND	91			93
Diphenylhydrazine	0.05	ND				
4-Bromophenyl-phenylether	0.01	ND				
Phenacetin	0.05	ND				
Hexachlorobenzene	0.01	ND				
4-Aminobiphenyl	0.05	ND				
Pentachlorophenol	0.05	ND	84	7	78	91
Pentachloronitrobenzene	0.05	ND				
Pronamide	0.01	ND				
Phenanthrene	0.01	ND				
Anthracene	0.01	ND				
Di-n-butylphthalate	0.01	ND				
Fluoranthene	0.01	ND	90			94
Benzidine	0.1	ND				
Pyrene	0.01	ND		5	89	
p-Dimethylaminoazobenzene	0.01	ND				
Butylbenzylphthalate	0.01	ND				
Benzo [a]anthracene	0.01	ND				
3,3-Dichlorobenzidine	0.01	ND				
Chrysene	0.01	ND				
bis (2-Ethylhexyl)phthalate	0.05	ND				

ELT# 9909

8270 COMPOUNDS	Reporting Limits	SAMPLE Concentration ppm	QC	RPD	%EA	%IA
Di-n- octiphthalate	0.01	ND	97			98
Benzo[b]fluoranthene	0.01	ND				
7.12-Dimethylbenz(a)anthracene	0.01	ND				
Benzo[k]fluoranthene	0.01	ND				
Benzo [a] pyrene	0.01	ND	93			96
3-Methylcholanthrene	0.01	ND				
Dibenzo (a,j) acridine	0.01	ND				
Indeno [1,2,3-cd] pyrene	0.01	ND				
Dibenz [a,h] anthracene	0.01	ND				
Benzo [g.h.i] perylene	0.01	ND				

METHOD: EPA SW 846-8270. 3551

SURROGATES	% RECOVERY
2-Fluorophenol SURR	88
Phenol-d6 SURR	84
Nitrobenzene-d5 SURR	89
2-Fluorobiphenyl SURR	93
2,4,6-Tribromophenol SURR	82
Terphenyl-d14 SURR	91

Michael R. Fowler

Michael R. Fowler

1-27-97

Date

ENVIRONMENTAL
LAB OF , INC.

"Don't Treat Your Soil Like Dirt!"

Bottom hole sample

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: IVA COM

Analysis Date: 01/22/97
Sampling Date: 01/09/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846 8240. (ppm) Compounds	ELT# 9909	PQL	% IA	Method Blank	% EA
Chloromethane	ND	0.1	110	ND	
Vinyl chloride	ND	0.1	101	ND	
Bromomethane	ND	0.1	100	ND	
Chloroethane	ND	0.1	105	ND	
Trichlorofluoromethane	ND	0.1	102	ND	
Acetone	ND	1.0	100	ND	
1,1-Dichloroethane	ND	0.1	95	ND	69
Iodomethane	ND	1.0	92	ND	
Vinyl Acetate	ND	1.0	107	ND	
Carbon Disulfide	ND	0.1	100	ND	
Methylene Chloride	ND	0.1	110	ND	
trans-1,2-Dichloroethene	ND	0.1	98	ND	
1,1-Dichloroethane	ND	0.1	102	ND	
2-Butanone	ND	1.0	108	ND	
Chloroform	ND	0.1	106	ND	
1,1,1-Trichloroethane	ND	0.1	91	ND	
Carbon Tetrachloride	ND	0.1	94	ND	
Benzene	ND	0.1	96	ND	110
1,2 Dichloroethane	ND	0.1	97	ND	
Trichloroethene	ND	0.1	83	ND	108
1,2-Dichloropropane	ND	0.1	95	ND	
Dibromomethane	ND	0.1	115	ND	
Bromochloromethane	ND	0.1	124	ND	
2-Chloroethyl Vinyl ether	ND	1.0	123	ND	
4-Methyl 2-Pentanone	ND	1.0	120	ND	
cis 1,3 Dichloropropene	ND	0.1	105	ND	
Toluene	6.613	0.1	96	ND	119
trans 1,3-Dichloropropene	ND	0.1	89	ND	
1,1,2-Trichloroethane	ND	0.1	98	ND	
Dibromochloromethane	ND	0.1	105	ND	
Tetrachloroethene	ND	0.1	107	ND	
Chlorobenzene	ND	0.1	98	ND	107

WHOLE EARTH ENVIRONMENTAL
ATTN: MR. MIKE GRIFFIN
19606 SAN GABRIEL
HOUSTON, TEXAS 77084
FAX: 800-854-4358

Page 2 of 2

Receiving Date: 01/10/97
Reporting Date: 01/23/97
Project Name: TATUM PIT SAMPLING
Project Location: WEST OF TATUM, NM
Field Code: IVA COM

Analysis Date: 01/22/97
Sampling Date: 01/09/97
Sample Type: SOIL
Sample Condition: C&I

Volatiles EPA SW 846-8240, (ppm) Compounds	ELT# 9909		PQL	% IA	Method Blank	% EA
Ethylbenzene	5.146	.75	0.1	89	ND	
m&p Xylene	42.45		0.1	87	ND	
o-Xylene	22.14	.60	0.1	90	ND	
Styrene	ND		0.1	95	ND	
Bromoform	ND		0.1	113	ND	
1,1,2,2-Tetrachloroethane	ND		0.1	87	ND	
1,2,3-Trichloropropane	ND		0.1	108	ND	

SYSTEM MONITORING COMPOUNDS	% RECOVERY
Dibromofluoromethane	103
Toluene-d8	109
4-Bromofluorobenzene	113

ND=<PQL

Michael R. Fowler
Michael R. Fowler

1-27-97
Date

Pit Remediation Protocol
Tipperary Corporation
Tatum Pit Closure Project
Pits Requiring Modeling

1.0 Purpose

This protocol is provide a detailed outline of the steps to be employed in the remediation and final closure of the Tipperary pits requiring risk assessment modeling.

2.0 Scope

This protocol is site specific for the following Tipperary pits:

- Vera # 1
- State NBN # 1
- State NBF # 1
- Bell State "A"
- G.S. State # 1

3.0 Preliminary

Prior to any field operations, Whole Earth Environmental shall conduct the following activities:

3.1 Client Review

3.1.1 Whole Earth shall meet with cognizant personnel within Tipperary to review this protocol and make any requested modifications or alterations prior to submittal to the State of New Mexico Oil Conservation Division.

3.1.2 Changes to this protocol will be documented and submitted for final review by Tipperary Corporation prior to submittal to the Oil Conservation Division.

3.2 Oil Conservation Division Review

3.2.1 Upon client approval, this protocol and associated modeling results will be submitted to the New Mexico Oil Conservation Division for review and comment. Recommended changes will be reviewed by the client prior to implementation.

3.2.2 Any recommended changes effecting costs will require a revised quotation to be issued to the client for approval prior to the commencement of any on-site remediation activity.

4.0 Safety

4.1 Prior to work on the site, Whole Earth shall obtain the location and phone numbers of the nearest emergency medical treatment facility. We will review all safety related issues with the appropriate Tipperary personnel, sub-contractors and exchange phone numbers.

4.2 A tailgate safety meeting shall be held and documented each day. All sub-contractors must attend and sign the daily log-in sheet.

4.3 Anyone allowed on to location must be wearing sleeved shirts, steel toed boots, and long pants. Each vehicle must be equipped with two way communication capabilities.

4.4 Prior to any excavation, the area shall be surveyed with a line finder. If lines are discovered within the area to be excavated they shall be marked with pin flags on either side of the line at maximum five foot intervals.

5.0 Fluid Removal

Prior to any excavation, the pit fluids shall be removed by vacuum truck and transported to the Gandy / Marley, Inc. Landfarm. A shipping manifest and O.C.D. Form C-117-A shall be prepared for each load and included within the final closure report.

6.0 Excavation & Remediation

6.1 The site shall be excavated to a minimum depth of 10’. All excavated material will be deposited immediately adjacent to the pit site.

6.2 The bottom of the pit and all four side walls will be tested for TPH and BTEX concentrations using WEQP-06 and WEQP-19. Excavation will continue until such concentrations are <10,000 ppm TPH, <10 ppm benzene and <50 ppm total BTEX.

6.3 Upon reaching the required depth and side wall dimensions, the bottom of the pit will be made as smooth as possible with excavation equipment. Sand will be deposited in the bottom of the pit in a minimum thickness of 6”.

6.4 A polyethylene liner of a minimum thickness of 40 mils will be spread atop the sand to the pit edge and an additional 6" of sand deposited above it.

6.5 The excavated materials will be mixed and blended with additional topsoils obtained from the area immediately adjacent to the pit until the hydrocarbon concentrations fall below the maximum limits as described in Paragraph 6.2 of this protocol. The remediated materials will then be replaced into the excavated area, compacted and the surface contoured to provide for positive drainage.

6.6 The top two feet of the excavation shall be covered in remediated materials having a maximum TPH concentration of <100 ppm and benzene concentrations of <2 ppm.

7.0 Documentation & Reporting

7.1 At the conclusion of the pit remediation project, Whole Earth will prepare a closure report to include the following information:

- A plat map of the location showing the exact location of the pit, the dimensions prior to excavation and the actual excavated dimensions.
- Photographs of the pit prior to excavation, at the point of maximum excavation and after final closure
- Field Sampling Report to include the side wall and pit bottom TPH and BTEX concentrations after excavation.
- Field Sampling Report to include TPH and BTEX concentrations of all remediated materials deposited into the pit deposited into the pit.
- Daily calibration records of each testing instrument
- Shipping manifests and OCD Form C-117-A
- Risk assessment model and supporting documentation
- M.S.D.S. and permeability certification of liner materials

Pit Remediation Protocol
Tipperary Corporation
Tatum Pit Closure Project
Pits Requiring Removal of Free Phase Product From the Water Table

1.0 Purpose

This protocol is provide a detailed outline of the steps to be employed in the remediation and final closure of the Tipperary pits requiring removal of free product from the water table.

2.0 Scope

This protocol is site specific for the following Tipperary pits:

- Iva COM # 1
- Mable COM # 1

3.0 Preliminary

Prior to any field operations, Whole Earth Environmental shall conduct the following activities:

3.1 Client Review

3.1.1 Whole Earth shall meet with cognizant personnel within Tipperary to review this protocol and make any requested modifications or alterations prior to submittal to the State of New Mexico Oil Conservation Division.

3.1.2 Changes to this protocol will be documented and submitted for final review by Tipperary Corporation prior to submittal to the Oil Conservation Division.

3.2 Oil Conservation Division Review

3.2.1 Upon client approval, this protocol and associated modeling results will be submitted to the New Mexico Oil Conservation Division for review and comment. Recommended changes will be reviewed by the client prior to implementation.

3.2.2 Any recommended changes effecting costs will require a revised quotation to be issued to the client for approval prior to the commencement of any on-site remediation activity.

4.0 Safety

4.1 Prior to work on the site, Whole Earth shall obtain the location and phone numbers of the nearest emergency medical treatment facility. We will review all safety related issues with the appropriate Tipperary personnel, sub-contractors and exchange phone numbers.

4.2 A tailgate safety meeting shall be held and documented each day. All sub-contractors must attend and sign the daily log-in sheet.

4.3 Anyone allowed on to location must be wearing sleeved shirts, steel toed boots, and long pants. Each vehicle must be equipped with two way communication capabilities.

4.4 Prior to any excavation, the area shall be surveyed with a line finder. If lines are discovered within the area to be excavated they shall be marked with pin flags on either side of the line at maximum five foot intervals.

5.0 Excavation & Remediation

5.1 The site shall be excavated to a minimum depth of 10'. All excavated material will be deposited immediately adjacent to the pit site.

5.2 The bottom of the pit and all four side walls will be tested for TPH and BTEX concentrations using WEQP-06 and WEQP-19. Excavation will continue until such concentrations are <10,000 ppm TPH, <10 ppm benzene and <50 ppm total BTEX.

5.3 The excavated materials will be mixed and blended with additional topsoils obtained from the area immediately adjacent to the pit until the hydrocarbon concentrations fall below the maximum limits as described in Paragraph 5.2 of this protocol. The remediated materials will then be replaced into the excavated area, compacted and the surface contoured to provide for positive drainage.

5.4 The top two feet of the excavation shall be covered in remediated materials having a maximum TPH concentration of <100 ppm and benzene concentrations of <2 ppm.

6.0 Draw-down & Monitoring Wells

6.1 At the completion of the surface remediation portion of the project, Whole Earth will supervise the installation of one draw-down and one monitoring well at the pit site. The draw-down well will be drilled in the approximate center of the pit and extend a minimum distance of 5' into the water table to accommodate seasonal fluctuations. The well shall be driven by a windmill and the collected fluids sent to the existing well site separation and storage equipment.

6.2 The monitoring well will be offset a maximum distance of 50' to the southwest of the draw-down well and will be used to evaluate the efficacy of the pumping efforts. The well will be installed and monitored on an annual basis in accordance with the *Unlined Surface Impoundment Closure Guidelines* III. C.

7.0 Documentation & Reporting

7.1 At the conclusion of the pit remediation project, Whole Earth will prepare a closure report to include the following information:

- A plat map of the location showing the exact location of the pit, the dimensions prior to excavation and the actual excavated dimensions.
- Photographs of the pit prior to excavation, at the point of maximum excavation and after final closure
- Field Sampling Report to include the side wall and pit bottom TPH and BTEX concentrations after excavation.
- Field Sampling Report to include TPH and BTEX concentrations of all remediated materials deposited into the pit deposited into the pit.
- Daily calibration records of each testing instrument
- Design and construction details of the draw-down and monitoring wells.

QP-03

WHOLE EARTH ENVIRONMENTAL
QUALITY PROCEDURE

Procedure for the Recycling of Freon 113

Completed By: Approved By: Effective Date: / /

1.0 Purpose

This procedure is written to define the methods to be employed in the collection and recycling spent Freon.

2.0 Scope

This procedure is to be used with all Freon compounds employed by the company.

3.0 Procedure

3.1 All Freon used in the field shall be collected after each dispencement into a recycling container. The container shall be constructed of tinted Pyrex glass and shall be insulated to maintain a constant temperature, and shall be sealed by means of a teflon cap.

3.2 All materials containing any but trace amounts of Freon shall be collected. This includes the soil samples.

3.3 Once the recycling container is full, it shall be turned in to the Field Superintendent and the employee shall be issued a new recycling container.

3.4 All recycle materials will me maintained in a well ventilated storage area until approximately five gallons have accumulated.

3.5 Once an accumulation of recyclable materials has been collected, the Field Superintendent shall recycle the materials in the Freon recycler. The distilled fluids will be inspected for purity using the "MEGA" TPH analyzer and if found to be at a concentration level of less than two parts per million the batch will be released to inventory.

3.6 A split sample of the material shall be sent to a an approved laboratory for confirmation of concentration. If the laboratory confirmation of purity is less than two parts per million concentration, the Field Superintendent will release the material for field use.

QP-06

WHOLE EARTH ENVIRONMENTAL
QUALITY PROCEDURE

Procedure for Conducting Field TPH Analysis

Completed By: Approved By: Effective Date: / /

1.0 Purpose

To define the procedure to be used in conducting total percentage hydrocarbon testing in accordance with EPA Method 418.1 (modified) using the "MEGA" TPH Analyzer.

2.0 Scope

This procedure is to be used for field testing and on site remediation information.

3.0 Procedure

3.1 The G.A.C. "MEGA" TPH analyzer is an instrument that measures concentrations of aliphatic hydrocarbons by means of infra-red spectrometry. It is manufactured to our specifications and can accurately measure concentrations from two parts per million through 100,000 parts per million. The unit is factory calibrated however minor calibration adjustments may be made in the field. Quality Procedure 25 defines the field calibration methods to be employed.

3.2 Prior to taking the machine into the field, insert a 500 ppm and 5,000 ppm calibration standard into the sample port of the machine. Zero out the Range dial until the instrument records the exact standard reading.

3.3 Once in the field, insert a large and small cuvette filled with clean Freon 113 into the sample port of the machine. Use the range dial to zero in the reading. If the machine does not zero, do not attempt to adjust the span dial. Immediately implement Quality Procedure 25 .

3.4 Place a 100 g. weight standard on the field scale to insure accuracy. Zero out the scale as necessary.

3.5 Tare a clean 100 ml. sample vial with the Teflon cap removed. Add 10 g. (+/- .01 g), of sample soil into the vial taking care to remove rocks or vegetable matter from the sample to be tested. If the sample is wet, add up to 5 g. silica gel or anhydrous sodium sulfate to the sample after weighing.

3.6 Dispense 10 ml. Freon 113 into the sample vial.

3.7 Cap the vial and shake for five minutes.

3.8 Carefully decant the liquid contents of the vial into a filter/desiccant cartridge and affix the cartridge cap. Recap the sample vial and set aside.

3.9 Insert the metal tip of the pressure syringe into the cap opening and slowly pressurize. **WARNING: APPLY ONLY ENOUGH PRESSURE ON THE SYRINGE TO EFFECT FLOW THROUGH THE FILTERS. TOO MUCH PRESSURE MAY CAUSE THE CAP TO SEPARATE FROM THE BODY OF THE CARTRIDGE.** Once flow is established through the cartridge direct the flow into the 5 cm. cuvette until the cuvette is full. Reverse the pressure on the syringe and remove the syringe tip from the cartridge cap. Set the cartridge aside in a vertical position.

3.10 The cuvette has two clear and two frosted sides. Hold the cuvette by the frosted sides and carefully insert into the sample port of the machine. Read the right hand digital read-out of the instrument. If the reading is less than 1,000 ppm. the results shall be recorded in the field Soil Analysis Report. If the result is higher than 1,000 ppm, continue with the dilution procedure.

4.0 Dilution Procedure

4.1 When initial readings are greater than 1,000 ppm using the 5 cm. cuvette, pour the contents of the 5 cm. cuvette into a 1 cm. cuvette. Insert the 1. Cm cuvette into the metal holder and insert into the test port of the instrument.

4.2 Read the left hand digital read-out of the machine. If the results are less than 10,000 ppm, record the results into the field Soil Analysis Report. If greater than 10,000 ppm, continue the dilution process. **Concentrations**

>10,000 ppm are to be used for field screen purposes only.

4.3 Pour the contents of the small cuvette into a graduated glass pipette. Add 10 ml. pure Freon 113 into the pipette. Shake the contents and pour into the 1 cm. cuvette. Repeat step 4.2. adding two zeros to the end of the displayed number. If the reported result is greater than 100,000 ppm. the accuracy of further readings through additional dilutions is extremely questionable. Do not use for reporting purposes.

4.4 Pour all sample Freon into the recycling container.

QP-19

WHOLE EARTH ENVIRONMENTAL
QUALITY PROCEDURE

Sampling and Testing Protocol
BTEX Speciation in Soil

Completed By: Approved By: Effective Date: / /

1.0 Purpose

This procedure is to be used to determine the concentrations of Benzene, Toluene, Ethyl-Benzene and Xylene (BTEX) in soils.

2.0 Scope

This procedure is to be used as the standard field measurement for soil BTEX concentrations. It is not to be used as a substitute for full spectrographic speciation of organic compounds.

3.0 Procedure

3.1 Sample Collection and Preparation

3.1.1 Collect at least 500 g. of soil from the sample collection point. Take care to insure that the sample is representative of the general background to include visible concentrations of hydrocarbons and soil types. If necessary, prepare a composite sample of soils obtained at several points in the sample area. Take care to insure that no loose vegetation, rocks or liquids are included in the sample(s).

3.1.2 The soil sample(s) shall be immediately inserted into a one quart or larger polyethylene freezer bag and sealed. When sealed, the bag should contain a nearly equal space between the soil sample and trapped air.

3.1.3 The sealed samples shall be allowed to set for a minimum of five minutes at a minimum temperature of 70°F.

3.1.4 The sealed sample bag should be massaged to break up any clods, and to provide the soil sample with as much exposed surface area as practically possible.

3.2 Sampling Procedure

3.2.1 The instrument to be used in conducting VOC concentration testing shall be a Photovac Ion-chromatograph with BTEX Module. Prior to use the instrument shall be zeroed out in accordance with QP-55.

3.2.2 Carefully open one end of the collection bag and insert the probe tip into the bag taking care that the probe tip not touch the soil sample or the side walls of the bag. If VOC analysis was conducted on the sample prior to BTEX analysis, care should be taken to insure that a sufficient air volume exists in the bag to provide accurate results. **If the available air space within the bag is insufficient to run a full analysis, the sample shall be discarded.**

3.2.3 Set the instrument to retain the highest result reading value. Record the reading onto the Field Analytical Report Form and additionally enter the location code into the instrument data logger.

4.0 After testing, the soil samples shall be returned to the sampling location, and the bags collected for off-site disposal. **IN NO CASE SHALL THE SAME BAG BE USED TWICE. EACH SAMPLE CONTAINER MUST BE DISCARDED AFTER EACH USE.**

QP-19

WHOLE EARTH ENVIRONMENTAL
QUALITY PROCEDURE

Sampling and Testing Protocol
BTEX Speciation in Soil

Completed By: Approved By: Effective Date: / /

1.0 Purpose

This procedure is to be used to determine the concentrations of Benzene, Toluene, Ethyl-Benzene and Xylene (BTEX) in soils.

2.0 Scope

This procedure is to be used as the standard field measurement for soil BTEX concentrations. It is not to be used as a substitute for full spectrographic speciation of organic compounds.

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3.1 Sample Collection and Preparation

3.1.1 Collect at least 500 g. of soil from the sample collection point. Take care to insure that the sample is representative of the general background to include visible concentrations of hydrocarbons and soil types. If necessary, prepare a composite sample of soils obtained at several points in the sample area. Take care to insure that no loose vegetation, rocks or liquids are included in the sample(s).

3.1.2 The soil sample(s) shall be immediately inserted into a one quart or larger polyethylene freezer bag and sealed. When sealed, the bag should contain a nearly equal space between the soil sample and trapped air.

3.1.3 The sealed samples shall be allowed to set for a minimum of five minutes at a minimum temperature of 70^{0}F.

3.1.4 The sealed sample bag should be massaged to break up any clods, and to provide the soil sample with as much exposed surface area as practically possible.

3.2 Sampling Procedure

3.2.1 The instrument to be used in conducting VOC concentration testing shall be a Photovac Ion-chromatograph with BTEX Module. Prior to use the instrument shall be zeroed out in accordance with QP-55.

3.2.2 Carefully open one end of the collection bag and insert the probe tip into the bag taking care that the probe tip not touch the soil sample or the side walls of the bag. If VOC analysis was conducted on the sample prior to BTEX analysis, care should be taken to insure that a sufficient air volume exists in the bag to provide accurate results. **If the available air space within the bag is insufficient to run a full analysis, the sample shall be discarded.**

3.2.3 Set the instrument to retain the highest result reading value. Record the reading onto the Field Analytical Report Form and additionally enter the location code into the instrument data logger.

4.0 After testing, the soil samples shall be returned to the sampling location, and the bags collected for off-site disposal. **IN NO CASE SHALL THE SAME BAG BE USED TWICE. EACH SAMPLE CONTAINER MUST BE DISCARDED AFTER EACH USE.**

QP-25

WHOLE EARTH ENVIRONMENTAL
QUALITY PROCEDURE

Procedure for Instrument Calibration and Quality Assurance Analysis for General Analysis "MEGA" TPH Analyzer

Completed By: Approved By: Effective Date: / /

1.0 Purpose

This procedure outlines the methods to be employed in calibrating the GAC MEGA TPH analyzer and for determining and reporting of accuracy curves.

2.0 Scope

This procedure shall be followed each day that the instrument is used.

3.0 Procedure

3.1 Turn the instrument on and allow to warm up with no cuvette in the receptacle. The instrument will take between five and ten minutes to come to equilibrium as can be determined by the concentration display readings moving a maximum of 5 ppm on the low scale. If the instrument continues to display erratic readings greater than 5 ppm, remove the cover and check both the mirrors and chopper to insure cleanliness.

3.2 All TPH standards shall be purchased form Environmental Resources Corporation and as a condition of their manufacture subject to independent certification by third party laboratories. Each standard is received with a calibration certificate.

3.3 Insert the low range (100 ppm) calibration standard into the receiving port and note the result on the right hand digital display. If the displayed reading is less than 98 ppm or greater than 102 ppm, remove the circuit board cover panel and zero out the instrument in accordance with QP-26.

(Note: Except in New Mexico, set the span to read 105% of actual standard).

3.4 Repeat the process with the mid range (500 ppm) calibration standard. If the displayed reading is less than 490 ppm or greater than 510 ppm zero out the span as described in QP-26.

3.5 Repeat the process again with the 1,000 and 5,000 ppm calibration standards.

3.6 Pour clean Freon 113 into a filter cartridge and extract into 10 ml cuvette. Insert the cuvette into the receiving port and zero out the instrument reading using the far right adjustment knob on the instrument. Repeat using the 1 ml cuvette and the left hand zero dial.

4.0 Determining & Reporting Instrument Accuracy

4.1 After making the fine adjustment with the zero dials reinsert each calibration standard into the instrument and note the concentration values. ***If any concentration value exceeds 2% of the standard set point, repeat all steps in section 3.0 of this Procedure.*** Note the actual concentration values displayed by the instrument after each calibration standard.

4.2 The four calibration standards shall be used in reporting span deviation as follows:

Standards Range			
100 ppm	**500 ppm**	**1,000 ppm**	**5,000 ppm**
0-250 ppm	251-750 ppm	751-2,500 ppm	2,501-10,000 ppm

4.3 Divide the actual instrument reading value of each calibration sample by the concentration shown on the standard (e.g.. 501 ppm instrument reading / 500 ppm standard = 1.002%). These readings shall be reported for each test performed.

5.0 Recalibration

5.1 If any sample exceeds the concentration of 1,000 ppm on the 10 ml cuvette or 10,000 ppm on the 1 ml cuvette, the cuvette must be thoroughly rinsed with clean Freon and the instrument re-zeroed in accordance with 3.6 of this procedure.

QP-55

WHOLE EARTH ENVIRONMENTAL
QUALITY PROCEDURE

Procedure for Instrument Calibration and Quality Assurance Analysis for Photovac Gas Chromatograph

Completed By: Approved By: Effective Date: / /

1.0 Purpose

This procedure outlines the methods to be employed in calibrating the Photovac analyzer in the BTEX mode and for determining and reporting of accuracy curves.

2.0 Scope

This procedure shall be followed each day that the instrument is used.

3.0 Procedure

Start-up

3.1 Turn the instrument on and press the Battery button. A battery status report will appear on the screen. If the charge level is less than 8.0, either charge the battery or insert a fresh battery pack.

3.2 Open carrier gas valve on right side of instrument. The instrument is now tuning the lamp. If any "boot" problems occur during warm-up, the "chck" symbol will appear on the screen. Pressing TUTOR will prompt the instrument to provide details. The instrument will not progress beyond the start-up mode until all prompts are cleared.

3.3 The next screen display will be "purj" and will last approximately ten minutes. The instrument is purging the column.

Calibrate

3.4 Connect the regulator to cylinder of calibration gas. Connect calibration adapter and tee assembly to both the regulator and instrument. **DO NOT FORCE ANY CONNECTION!**

3.5 Inspect the open end of the tee vent to insure unobstructed flow.

3.6 Enter CAL on the key pad. The instrument will query "benzene?". Following the prompts and using the key pad, set the concentrations to those defined on the calibration gas bottle. Follow the same procedure for toluene, ethyl-benzene and xylene. After each compound, the instrument will read that the next analysis will be a calibration.

3.7 Press ENTER on key pad. The instrument will calibrate itself for the concentrations specified.

Confirmation Sample

3.8 After each calibration, run the calibration gas through the instrument once again. The display readings should be **exactly** those of the concentrations displayed on the calibration gas bottle. **If they are not, the instrument needs factory calibration; do not use.**

4.0 Recalibration

4.1 The instrument is designed with software that prompts you to recalibrate each day, each thirty minutes of use, and after running a sample with high concentrations of one or more of the detected compounds.

5.0 Reporting Instrument Accuracy

5.1 The instrument accuracy as certified by the factory is 15% within one decade of instrument set point. Lower detection limits are 0.1 ppm for benzene and 1.0 ppm for toluene, ethylbenzene and xylene.

5.2 These standards and detection limits must be shown on all reports in which the instrument is used.

VADSAT Modeling

The VADSAT modeling program was selected for this project as the most appropriate tool for simulating hydrocarbon migration. The software was developed by the American Petroleum Institute to be a universally accepted method for modeling the migration of the most common oilfield pollutants onto the vadose zones of groundwater sources.

Though the model has the capability of simulating evaporative and bio-decay reductions to the plume source, the enclosed simulations do not reflect any such losses. The calculated concentrations are based solely on what may be expected to occur through convection and dispersion at the noted depths and concentrations when an impermeable liner is placed above a contaminant plume having a TPH concentration of <10,000 ppm TPH and <10 ppm benzene.

Included within this section is an excerpt of the model showing the mathematical assumptions upon which it is based. The site specific data is included with each individual pit modeled.

3. Description of VADSAT

The VADSAT model consists of three modules: 1) a source model which considers the release of chemicals from a contaminated soil zone, 2) an unsaturated or vadose zone model which considers transport of chemicals vertically through the unsaturated zone to the water table, and 3) a saturated zone model which simulates three dimensional transport of dissolved chemicals in the groundwater. These three submodels are linked and executed once for deterministic simulations or repeatedly for Monte Carlo simulations. A description of the three submodels and of the Monte Carlo analysis will be given in this chapter.

3.1 Source Submodel

Waste constituents are assumed to occur within a specified interval which may start at or below the ground surface and extend to some depth above or below the water table. The areal extent of the contaminated soil zone, which is subsequently referred to as the "waste zone", is described as a rectangular region in plan view. The waste zone may be engineered (e.g. landspreading or burial) or it may represent a region of residual organic liquid saturation following a spill or leak. Two types of chemical species are considered: (1) inorganic salts and (2) organic species in an oily waste or any nonaqueous liquid phase (denser or lighter than water). Since salts and oily waste will behave differently, a different source submodel is used for each. The two locations of the waste zones considered are: 1) source above the water table, and 2) source below the water table.

3.1.1 Source Above the Water Table

Source for salts

The assumption used in modeling inorganic species (salts) is that the concentration of the species that passes through the waste zone is constant and equal to an equilibrium solubility-controlled value. Under this assumption, the waste zone acts as a constant strength source of contamination for a period of time, t_o [T], after which the concentration of leachate is zero. The duration of the source is given by

$$t_o = \frac{M_t}{q_u C_S^o} \tag{3.1}$$

where M_t is the total mass of the species in the waste zone per unit area [M L^{-2}], q_u is the net recharge rate [L T^{-1}] and C_S^o is the dissolved concentration of the species [ML^{-3}]. The total species mass per area in the water zone is given by

$$M_t = \rho_b L_w F_s \tag{3.2a}$$

where ρ_b is the waste zone dry bulk density [M L^{-3}], L_w is the thickness of the waste zone [L], and F_s is the mass of salts in the waste zone per mass of total solids [M M^{-1}]. Soil bulk density is computed from soil porosity by

$$\rho_b = \rho_s(1 - \phi) \tag{3.2b}$$

where ρ_s is the particle density, which is assumed to be 2.65 g cm^{-3} and ϕ is the waste zone porosity, assumed to be the same as that of the unsaturated zone porosity, ϕ_u. Assuming all of the salts are dissolved, the mass fraction of salts is related to the dissolved concentration by

$$F_s = \frac{\phi C_s^o}{\rho_b} \tag{3.3}$$

Data requirements for the inorganic source model are C_s^o, M_t, L_w, ϕ_u and q_u.

Nonaqueous liquid

Depletion of organic species, such as benzene or other potential contaminants in a nonaqueous liquid (e.g., crude oil, residual hydrocarbon, oily waste, solvent, etc.) over time is assumed to occur due to combined effects of water percolating through the waste zone and to evaporation of volatile components from the soil surface. A molar balance for compound i may be written as

$$\frac{dm_i}{dt} = -\frac{J_i^w}{W_i} - \frac{J_i^v}{W_i} \tag{3.4}$$

where m_i is the number of moles of i per unit area in the hydrocarbon [moles L^{-2}], W_i is the molecular weight of i [M $moles^{-1}$], J_i^w is the rate of mass depletion per area due to percolating water [ML^{-2} T^{-1}], J_i^v is the rate of mass depletion per area due to volatilization

[M L^{-2} T^{-1}] and t is time. The aqueous loss is assumed to be purely convective and is given by

$$J_i^w = q_u C_i^w \tag{3.5}$$

where q_u is the net recharge rate [L T^{-1}] and C_i^w is the aqueous concentration of i [M L^{-3}], which is related to the composition of the hydrocarbon by

$$C_i^w = x_i S_i \tag{3.6}$$

where S_i is the aqueous solubility of pure component i [M L^{-3}], and x_i is the mole fraction of i in the hydrocarbon [moles moles^{-1}]. The mole fraction may be written as

$$x_i = \frac{m_i W_H}{\rho_b L_w F_H} \tag{3.7}$$

where m_i is the moles of species i per area [moles L^{-2}], m_H is the total moles of hydrocarbon per unit area [moles L^{-2}], W_H is average molecular weight of hydrocarbon [M mole^{-1}], ρ_b is the bulk density of the waste zone [M L^{-3}], L_w is the thickness of the waste zone [L], and F_H is the mass of hydrocarbon per mass of solids in the waste zone [M M^{-1}].

The diffusive vapor loss rate at the soil surface is computed assuming a linear concentration drop from the waste zone to the soil surface as

$$J_i^v = D_i^v \frac{C_i^v}{L_d} \tag{3.8}$$

where D_i^v is the gas phase diffusion coefficient for i in the porous medium [L^2 T^{-1}], C_i^v is the vapor concentration in the waste zone [M L^{-3}], and L_d is the diffusion path length [L], which is taken as $L_c + L_w/2$, where L_c is the waste cover thickness. For land-spread waste, $L_c = 0$. The effective diffusion coefficient is estimated from the free gas diffusion coefficient, D_i^{vo}, using the Millington-Quirk (1961) model as

$$D_i^v = (\phi - \theta)^{10/3} \phi^{-2} D_i^{vo} \tag{3.9}$$

where ϕ and θ are the porosity and volumetric water content of the cover, respectively, which are assumed to be the same as in the underlying soil. In the case of lined pits, a fine grained liner is assumed to restrict contaminant loss from the waste zone which is liquid saturated. The gas phase concentration in the waste zone is related to the aqueous concentration via Henry's law as

$$C_i^v = H_i C_i^w \tag{3.10}$$

where H_i is the dimensionless Henry's constant for species i. Combining (3.4) - (3.10) yields

$$\frac{dm_i}{dt} = -\beta_i m_i \tag{3.11}$$

where β_i is a waste zone depletion coefficient given by

$$\beta_i = \frac{q_u W_H S_i}{\rho_b L_w F_H W_i} + \frac{D_i^v H_i W_H S_i}{\rho_b L_d L_w F_H W_i} \tag{3.12}$$

The first term in (3.12) represents aqueous losses from the waste zone and the second term describes vapor losses. Assuming that F_H does not change significantly with time, i.e. that the waste consists primarily of low solubility components, (3.11) may be solved analytically to obtain

$$m_i = m_i^o \, exp(-\beta_i t) \tag{3.13}$$

where m_i^o is the initial moles of i per area. Output information on the time for source depletion is computed based on the operational definition of source depletion at the time when $m_i / m_i^o = 0.01$, hence $t_o = 4.6/\beta_i$. The aqueous concentration will likewise decrease exponentially with time according to

$$C_i = C_i^w \, exp(-\beta_i t) \tag{3.14}$$

where C_i^w is the initial aqueous concentration of species i given by

$$C_i^w = \frac{f_i^o W_H \rho_i S_i}{W_i \rho_H} \tag{3.15}$$

where f_i^o is the initial volume fraction of component i in the hydrocarbon, ρ_i is the density of component i, and ρ_H is the average density of hydrocarbon.

Data requirements for the organic source submodel are S_i, H_i, W_i, ρ_i, D_i^{vo}, f_i^o, W_H, ρ_H, F_H, L_w, L_c, ρ_b, ϕ and θ. The compound solubility, Si, density, ρ_i, molecular weight, Wi, Henry's constant, Hi, free air diffusion coefficient, D_i^{vo}, and the initial volume fraction in the waste, f_i^o, are compound specific input parameters. Soil bulk density, ρ_b, Soil water content in the cover above the waste zone (if present) is assumed to be the same as that in underlying soil, the estimation of which is described later.

3.1.2 Source Below the Water Table

For the analysis in this section, the waste zone is assumed to be located below the water table. The mass loading rate to groundwater is computed for the inorganic and organic waste types directly, and transport in the unsaturated zone is not considered.

Source for salts

As discussed in section 3.1.1, the waste zone is assumed to act as a constant strength source of contamination for a period of time, t_o [T], after which the concentration of leachate is zero. Assuming horizontal groundwater flow through the waste zone, the duration of the source is given by

$$t_o = \frac{M_T}{q_s L_w B C_S^o} \tag{3.16}$$

where M_T is the total mass of the species in the waste zone [M], q_s is the Darcy velocity in the x direction [L T^{-1}] and B is the width of the waste zone [L] perpendicular to the groundwater flow. The total species mass is given by

$$M_T = \rho_b L_w B A F_s \tag{3.17}$$

where ρ_b is the waste zone dry bulk density [M L^{-3}], L_w is the thickness of the waste zone [L], A is the length of the waste zone [L], and M_T is the total species mass in the waste zone [M]. The mass loading rate [MT^{-1}] into the groundwater is

$$M_o = q_s B L_w C_S^o \ . \tag{3.18}$$

Nonaqueous liquid

Assuming horizontal flow through the waste zone, a mass balance equation for the total mass of a species in a hydrocarbon phase of the waste zone can be written as

$$\frac{dM_T}{dt} = -q_s B L_w C_T \tag{3.19a}$$

$$\frac{dM_T}{dt} = -q_s M_T / A\theta \tag{3.19b}$$

$$\frac{dM_T}{dt} = -\beta M_T \tag{3.19c}$$

where C_T is the aqueous phase concentration of a soluble species [ML^{-3}] in the waste zone at time t, and β is a depletion coefficient for the waste zone below the water table given by

$$\beta = q_s / A\theta \tag{3.20}$$

The aqueous phase concentration will decrease exponentially with time according to

$$C_T = C_i^w \; exp(-\beta t) \tag{3.21}$$

where C_i^w is given by (3.15). The mass loading rate [MT^{-1}] into the groundwater at time t is

$$M_o = q_s B L_w C_T. \tag{3.22}$$

3.2 Unsaturated Zone Transport Submodel

Transport in the unsaturated zone is modeled from the bottom of the waste zone to the water table assuming negligible horizontal spreading. Linear adsorption and first order decay reactions are considered for reactive chemicals. The governing equation for one dimensional transport in the unsaturated zone may be written

$$R_{ui}\frac{\partial C_i}{\partial t} = D_u\frac{\partial^2 C_i}{\partial x^2} - V_u\frac{\partial C_i}{\partial x} - \mu_{u_i} C_i \tag{3.23}$$

where C_i is the concentration of component i in the aqueous phase [ML^{-3}], D_u is the dispersion coefficient in the unsaturated zone [L^{2}T^{-1}], V_u is the pore water velocity in the unsaturated zone [LT^{-1}], μ_{u_i} is a first-order decay coefficient for component i in the unsaturated zone [T^{-1}], x is distance [L], t is time [T] and R_{ui} is the retardation factor (explained later).

3.2.1 Solution for Inorganic Transport

Salts are modeled as nonadsorbing conservative solutes with =1 and = 0. The relevant initial and boundary conditions for (3.23) to obtain f

$$\frac{\partial C_i}{\partial x}(\infty, t) = 0 \tag{3.27c}$$

The solution is given by *van Genuchten and Alves* (1982) as

$$C_i(x, t) = C_i^o \, exp(-\beta_i t) B(x, t) \tag{3.28a}$$

where

$$B(x, t) = \frac{1}{2} exp\left[\frac{(V_u - w)x}{2D_u}\right]\left(erfc\left[\frac{R_{u_i}x - wt}{2\left[D_u R_{u_i} t\right]^{1/2}}\right]\right)$$

$$+ \frac{1}{2} exp\left[\frac{(V_u + w)x}{2D_u}\right] erfc\left[\frac{R_{u_i}x + wt}{2\left[D_u R_{u_i} t\right]^{1/2}}\right] \tag{3.28b}$$

and

$$w = V_u\left[1 + \frac{4D_u R_{u_i}}{V_u^2}[\mu_{u_i} - \beta_i]\right]^{1/2} \tag{3.28c}$$

The chemical flux at the water table is computed from the flux concentration, water flux and source area in the same manner as in the salt model.

3.2.3 Unsaturated Zone Pore Water Velocity

The actual flow behavior in the vadose zone can be quite complicated when one considers the effects of spatial heterogeneity and transient boundary conditions. However, in the present analysis, we are concerned with simulating the average conditions over long term periods. In light of this objective, it was decided to simplify the flow calculations, utilizing a unit hydraulic gradient approximation. This approach has been proven to work reasonably well even in moderately heterogeneous soils under steady flow conditions (*Yeh*, 1989). The major simplification obtained from this assumption is that the pressure head in the soil profile is constant, as is the moisture content. Darcy's equation for the unit gradient case may be written as

$$q_u = k_r K_{su} \tag{3.29}$$

where K_{su} is the saturated hydraulic conductivity of the unsaturated zone [L T^{-1}], k_r is the relative permeability [L^0], and q_u is the net recharge rate [L T^{-1}]. The relative permeability will depend on the volumetric water content, θ, in a manner described by the *Brooks-Corey* (1964) model as

$$k_r = \left[\frac{\theta - \theta_r}{\phi_u - \theta_r}\right]^{\gamma} \qquad (3.30)$$

where ϕ_u is the porosity in the unsaturated zone, θ_r is an "irreducible" water content and γ is a pore size distribution parameter. Owing to the availability of a large database on statistical distributions of van Genuchten model parameters (*Carsel and Parrish*, 1988), we relate the Brooks-Corey exponent to the van Genuchten parameter n following *Lenhard et al.* (1989) as

$$\gamma = 3 + \frac{2}{(n-1)(1-0.5^{n/(n-1)})} \qquad (3.31)$$

Using (3.29 and 3.30), we calculate the water content, which is used in turn to estimate the pore water velocity, V_u, as

$$V_u = \frac{q_u}{\theta} \qquad (3.32)$$

If $q_u > K_{su}$ for a given set of parameters, the flux q_u is set equal to K_{su} assuming the excess flow will be diverted to runoff, and ϕ is equal to the unsaturated zone porosity, ϕ_u. If a soil layer of low permeability occurs above the waste zone, the analysis proceeds as above, except that the maximum water flux is set equal to the saturated hydraulic conductivity of the low permeability zone, $K_{sw}[LT^{-1}]$, rather than that of the soil.

3.2.4 Adsorption and Decay of Organics

The retardation factor for organic species is computed from

$$R_{u_i} = 1 + \frac{\rho_b f_{oc} k_{oc_i}}{\theta} \qquad (3.33)$$

where f_{oc} is the ratio of soil organic carbon to total dry soil mass [M M^{-1}] and k_{oc} is the organic carbon normalized partition coefficient [L^3 M^{-1}]. The model requires f_{oc} and k_{oc_i} to be input.

Considering decay of organic species that may occur in the dissolved or absorbed state, the decay coefficient may be defined by

$$\mu_{u_i} = \mu_{uw}\theta + F\mu_{uw}\rho_b f_{oc} k_{oc_i} \qquad (3.34)$$

where μ_{uw} is the decay coefficient for aqueous phase species and F is a factor that relates aqueous phase decay to adsorbed phase decay. VADSAT restricts the user to either specify $F = 0$ (no solid phase decay) or $F = 1$ (solid and dissolved phase decay coefficients are equal).

The decay of organic species is a complex process that may often be satisfactorily approximated as an apparent first-order reaction. Field observations of transport from which apparent first order decay coefficients may be inferred are not available in great numbers. *Chiang et al.* (1989) modeled the transport and attenuation of BTX in an aquifer in Michigan. Based on a mass balance analysis of field data over time, an apparent first order decay coefficient for benzene of approximately 0.01 day^{-1} was calculated. Data from a controlled field experiment by *Barker et al.* (1987) indicates a rate constant for benzene of about 0.008 day^{-1}. The California Office of Underground Storage Tanks recommends using 0.002 day^{-1} as a conservative value for benzene decay.

3.2.5 Dispersion in the Unsaturated Zone

The dispersion coefficient in the unsaturated zone is regarded as a linear function of the pore water velocity, V_u, as

$$D_u = \alpha_L V_u \tag{3.35}$$

where α_L is the unsaturated zone dispersivity $[L]$. The latter may be treated as a function of the distance from the source to the water table. Based on data from *Gelhar et al.* (1985) on field measurements of dispersion in the unsaturated zone, the following bilinear model was obtained to describe the scale-dependent dispersivity

$$ln\alpha_L = -4.933 + 3.811 ln\, x \qquad x \le 2m \tag{3.36a}$$

$$ln\alpha_L = -2.727 + 0.584 ln\, x \qquad x > 2m \tag{3.36b}$$

where x is the distance from the source to the observation location (i.e., the water table). Variability in $ln\alpha_L$ is approximately normally distributed with a standard deviation of 1.18 for $x \le 2m$ and of 0.34 for $x > 2m$.

3.3 Saturated Zone Transport Submodel

3.3.1 Horizontal Plane Source Transport Model

Leaching of chemicals from the unsaturated zone will result in an areally distributed horizontal plane source at the water table. Treating the source as a point source or as a partially penetrating vertical plane source, as employed in certain models, will yield a less accurate representation of the chemical distribution, particularly at locations near the source. Furthermore, due to limited vertical mixing near a chemical source, consideration must generally be given to groundwater transport in three dimensions. An analytical three-dimensional, horizontal plane source solute transport model (HPS) developed by *Galya* (1987) is used to simulate transient saturated zone transport. The model considers three-dimensional convective-dispersive transport with linear adsorption and first-order decay in a one-dimensional planar regional groundwater flow field. For a uniform velocity field, chemical transport in an aquifer with uniform hydrogeologic properties can be described by

$$R_{s_i}\frac{\partial C_i}{\partial t} = D_x\frac{\partial^2 C_i}{\partial x^2} + D_y\frac{\partial^2 C_i}{\partial y^2} + D_z\frac{\partial^2 C_i}{\partial z^2}$$

$$-\frac{q_s \partial C_i}{\phi_s \partial x} - \mu_{s_i} C_i + \frac{Q_i(x, y, z)}{\phi_s} \qquad (3.37)$$

where C_i is the aqueous concentration of species i in the aquifer; q_s is the Darcy velocity in the saturated zone in the down-gradient (x) direction; t is time; D_x, D_y and D_z are dispersion coefficients in the x, y and z directions, respectively; R_{s_i} is the retardation factor for species i in the saturated zone; ϕ_s is the saturated zone porosity, μ_{s_i} is a first-order decay coefficient for mass loss in the saturated zone; and Q_i is a source term for contaminant $[MT^{-1}L^{-3}]$ which is nonzero over a finite rectangular area at the water table and zero elsewhere. Initial and boundary conditions are stipulated by

$$C_i = 0 \qquad for \qquad t = 0 \qquad (3.38a)$$

$$C_i = 0 \qquad for \qquad x, y = \pm\infty \qquad (3.38b)$$

$$D_z\frac{\partial C_i}{\partial z} = 0 \qquad for \qquad z = 0 \qquad (3.38c)$$

$$D_z\frac{\partial C_i}{\partial z} = 0 \qquad for \qquad z = H \qquad (3.38d)$$

where H is the aquifer thickness and $z = 0$ represents the water table. The solution of (3.37) is obtained by the superposition of Green's function for x, y and z directions. The primitive form of the solution is given by

$$C_i = \frac{1}{\phi_s R_{s_i}} X_o(x, t) Y_o(y, t) Z_o(z, t) T_i(t) \qquad (3.39)$$

where X_o, Y_o and Z_o are the Green's function solutions to the convection-dispersion equation in x, y and z directions, and T_i is a first-order decay function. Time convolution yields a solution for the concentration of the chemical at any point in space and time due to an arbitrary time-dependent mass loading rate $M_i(t)$ as

$$C_i(x, y, z, t) = \frac{1}{\phi_s R_{s_i}} \int_0^t M_i(\tau) X_o(x, t-\tau) Y_o(y, t-\tau)$$

$$Z_o(z, t-\tau) T_i(t-\tau) d\tau \qquad (3.40)$$

where τ is a dummy variable for integration and $M_i(t)$ is given from the unsaturated zone model. The derivation of Green's functions for the x, y and z directions is described by *Galya* (1987).

3.3.2 Saturated Zone Model Parameters

Dispersion coefficients in the saturated zone are described by expressions of the form

$$D_x = \alpha_x q_s / \phi_s \qquad (3.41a)$$

$$D_y = \alpha_y q_s / \phi_s \qquad (3.41b)$$

$$D_z = \alpha_z q_s / \phi_s \qquad (3.41c)$$

where α_x, α_y and α_z are dispersivities in the x, y and z directions. Dispersivities in the saturated zone may be estimated from the database of *Gelhar et al.* (1985). The longitudinal dispersivity, α_x, is observed to be a function of distance from the source which may be described by the empirical expression

$$ln\alpha_x = -3.795 + 1.774\, ln\ x - 0.093 (ln\ x)^2 \qquad (3.42)$$

where x is the distance from the source in the direction of the flow field. Variability in $ln\alpha_x$ is assumed to be normally distributed with a standard deviation of 1.58 as determined from the results of *Gelhar et al.* (1985). Transverse dispersivities, α_y and α_z, are described by

$$\alpha_y = \frac{\alpha_x}{\tau_1} \qquad (3.43a)$$

$$\alpha_z = \frac{\alpha_y}{\tau_2} \qquad (3.43b)$$

where τ_1 and τ_2 are taken as lognormally distributed random variables. Field data indicate the dispersion ratio τ_1 has a mean of 3 with a standard deviation of 1, while τ_2 has a mean value of 87 with a standard deviation of 31 (*API*, 1987).

To ensure that the saturated zone concentration below the source does not exceed the concentration leaving the unsaturated zone, the vertical dispersivity is subjected to the following constraint for an unsaturated zone source

$$\alpha_z \geq \frac{q_u^2 L}{q_s^2} \tag{3.44a}$$

and for a source below the water table, the constraint is

$$\alpha_z \geq \frac{L_w^2}{L} \tag{3.44b}$$

where L_w is the waste zone thickness below the water table, q_u is the unsaturated zone Darcy velocity, q_s is the saturated zone Darcy velocity, and L is the length of the source parallel to the flow direction. A message is printed in the output file when the vertical dispersivity is adjusted by (3.44).

Additional aquifer properties required by the model are aquifer thickness, H, aquifer porosity, ϕ_s, aquifer organic carbon content, f_{oc_s}, and aquifer Darcy velocity in the direction of the regional gradient, q_s. Component-specific properties for organic species transport are the organic carbon normalized partition coefficient, k_{oc_i}, and the first order decay coefficient in the saturated zone. The retardation factor is computed from (3.33) in the same manner as for the unsaturated zone, except that the water content in the saturated zone is replaced by the saturated zone porosity.

To convert from mass fluxes per area from the unsaturated zone model to total mass fluxes and to define the source distribution in space, the user must specify the source area, A, and the ratio of source length in the direction of flow to the width, $S_R = L/W$. Distributions of A and S_R are regarded as log-normal.

3.3.3 Evaluation of Maximum Concentration at Receptor

In order to provide a conservative assessment of the effects of contaminant leaching on groundwater, it is of interest to determine the peak concentration at receptor locations in the saturated zone. If the time elapsed from placement of waste in the unsaturated zone to the time of peak concentration at the receptor is t_{max}, then it is necessary to compute the receptor concentration at this time only. However, since the source is transient in nature, even though the saturated zone solution may only be needed for t_{max}, the concentration exiting the unsaturated zone must be known as a function of time from $t = 0$ to t_{max} to define the temporal source function for the saturated zone model. For the purpose of estimating the duration of the unsaturated zone analysis, a conservative (i.e., high) first estimate of t_{max} is taken as the mean travel time through the unsaturated and saturated zones times a factor to account for tailing due to dispersion. For the case of salts, which are not adsorbed, we define this estimate by

$$t_1 = \frac{4L_s\phi_s}{q_s} + \frac{4L_u\phi_u}{q_u} \tag{3.45a}$$

where L_u and L_s are travel distances in unsaturated and saturated zones, respectively, and other terms are as previously defined. For the case of oily wastes, a similar procedure is used, except that retardation is considered so that

$$t_1 = \frac{4L_s\phi_s R_{s_i}}{q_s} + \frac{4L_u\phi_u R_{u_i}}{q_u} \tag{3.45b}$$

The duration of the unsaturated zone analyses may be reduced in some instances. If the source is depleted by time $t_2 < t_{max}$, then the unsaturated zone solution need only be computed for the interval $t = 0$ to t_2. For the case of salt transport, which has a pulse-type input function at the source, the duration of nonzero effluent concentrations from the unsaturated zone may be estimated as the duration of the pulse plus the travel time through the unsaturated zone times a factor to account for dispersion. The computational procedure for salts is

$$t_2 = t_o + \frac{4L_u\phi_u}{q_u} \tag{3.46a}$$

where t_o is the duration of the pulse at the source defined by (3.1). For organic chemical transport, a similar procedure is employed, but with the duration of the exponentially decaying source taken as the time when the source mass has decreased by a factor e^{-6}. The expression for an oily waste source is

$$t_2 = \frac{6}{\beta_i} + \frac{4L_u\phi_u R_{u_i}}{q_u} \tag{3.46b}$$

where β_i is the source decay parameter for species *i* given by (3.12). The final time for the unsaturated zone analyses is taken to be t_u = *minimum* (t_1, t_2) where t_1 and t_2 are computed from the appropriate expressions for salts or oily waste.

Concentrations leaving the unsaturated zone are computed over the time period t_u in 300 equal intervals. Concentrations obtained from the model at times $t = (t_u/300, 2\,t_u/300, .. t_u)$ are stored in an array and subsequently scanned by a search algorithm to determine the time, t_u , at which the concentration at the water table reaches a maximum. The effluent concentration is taken to be zero for $t > t_u$

An improved estimate is next made of the time, t_{Rmax}, at which the maximum concentration occurs at a receptor in the saturated zone as

$$t_{Rmax} = t_u + t_s \tag{3.47}$$

where t_s is the time for the peak concentration to propagate from the point of entry into the groundwater to the receptor. An estimate of t_s is made by computing the time required to propagate a *dirac* pulse in the direction of flow. The solution to the one dimensional convection-dispersion equation for a dirac pulse is

$$C_i(x, t) = \frac{x^2}{V_R t(4\pi D_R t)^{1/2}} exp \frac{-(x - V_R t)^2}{4 D_R t} \tag{3.48a}$$

where $D_R = D_x / R_{si}$ and $V_R = q_s / \phi_s R_{si}$. For a given set of x, D_R and V_R values, the time corresponding to the maximum for the dirac solution may be obtained by setting $\partial C_i / (\partial t) = 0$, which yields

$$exp\left(\frac{-(x - V_R t)^2}{4 D_R t}\right)\left(\frac{-3 V_R^2\, x^2 t^2 + (2 V_R x^3 - 6 D_R x^2) t + x^4}{8 D_R V_R t^3 (\pi D_R t)^{1/2}}\right) = 0 \tag{3.48b}$$

For (3.48b) to hold, it is sufficient that

$$-3 V_R^2 x^2 t^2 + (2 V_R x^3 - 6 D_R x^2) t + x^4 = 0 \ , \tag{3.49}$$

which is a quadratic polynomial in *t* for given x, D_R and V_R.The positive root of this polynomial yields an estimate of t_s. This value is employed in (3.47) to obtain an approximation of the actual time, t_{max}, at which the receptor concentration reaches a maximum.

Due to the gradual release characteristics of organic contaminants from oily wastes, the peaks are generally rather broad and receptor concentrations computed at the estimated time t_{Rmax} generally yield accurate values for the peak receptor concentration. For the case of salt migration, the peak is usually narrower, so the concentration computed at t_{Rmax} may underestimate the actual peak. Therefore, in the latter case, the peak concentration is refined using a search algorithm starting from the value at t_{Rmax}. The golden ratio algorithm (*Forsythe et al.*, 1977) is employed to find the peak receptor concentration by progressively bisectioning the initial time interval, (i.e., by calculating and comparing the concentrations corresponding to times at the beginning and at the end of each time interval until the last two consecutive concentrations differ by a specified tolerance). Upon satisfying the convergence criteria, t_{max} as taken at the midpoint of the final time interval.

The highest 70-year exposure level at a receptor location is computed as the average concentration over a period from 35 years before to 35 years after the peak concentration. Using a three-point trapezoid rule integration, the 70-year exposure concentration, C_{70}, is computed as

$$C_{70} = \frac{1}{4}C(t_{max} - 35) + \frac{1}{2}C(t_{max}) + \frac{1}{4}C(t_{max} + 35) \qquad (3.50)$$

where $C(t)$ denotes the computed receptor concentration at time t in years.

Verification of the correctness and accuracy of the computer model VADSAT, which implements the coupled source zone, vadose zone and saturated zone submodels was performed by comparing results with other analytical solutions for special cases and by performing sensitivity analyses.

3.4 Monte Carlo Method

The screening model described in the preceding sections contains a number of parameters which are subject to variability from location to location due to heterogeneous waste, soil and aquifer characteristics and variations in climate. As a result of the uncertain nature of model input parameters, predictions are also uncertain and may be characterized by a probability distribution. The most general manner of determining the nature of prediction uncertainty, given the distribution of input parameters, is to use Monte Carlo simulation methods.

The Monte Carlo method involves execution of the model for many realizations of parameter sets from their statistical distributions to obtain the distribution of possible model outcomes. The method requires a knowledge of the probability distribution functions of the random input parameters. Monte Carlo methods are well documented and have been applied extensively to groundwater contamination problems. Applications of the Monte Carlo method have been discussed by *Wagner and Gorelick* (1987), *Smith and Freeze* (1979), and *Warren and Price* (1961) among others.

A Monte Carlo analysis of the screening model described in the preceding chapter was implemented in VADSAT. A random number generation algorithm described by *Press et al.* (1986) was used to generate realizations of random input parameters according to their specified probability distribution functions. Distributions of all input parameters are assumed to be independent. Histograms and statistical moments (mean and variance) of the model output (e.g, maximum concentration at a receptor location) are computed from the results. Input parameters in VADSAT which are regarded as random variables are listed in Tables 4.5 and 4.6 along with their distribution types for transport of salts or hydrocarbon species. Depending on the nature of the parameter, the distribution type is assumed to be log-normal or uniform. Regardless of the distribution type, all distributions are specified in terms of the mean and standard deviation of the original variable. Note that several parameters that are often characterized by normal distributions are regarded here as log-normal. In practice, normal distributions with a low variance are closely approximated by a log-normal distribution when the appropriate variance transformation described below is used. The log-normal distribution has the advantage that it handles cases with high variance more accurately than the normal distribution.

For variables characterized by a range from X_{min} to X_{max} (e.g., 95 percent lower and upper confidence limits), the mean and standard deviation may be estimated by

$$m = \frac{X_{max} + X_{min}}{2} \tag{3.51a}$$

$$\sigma = \frac{X_{max} - X_{min}}{\sqrt{12}} \tag{3.51b}$$

which may be employed to compute the required input parameters for VADSAT from the known range. Equation (3.51) is exact for uniformly distributed variables.

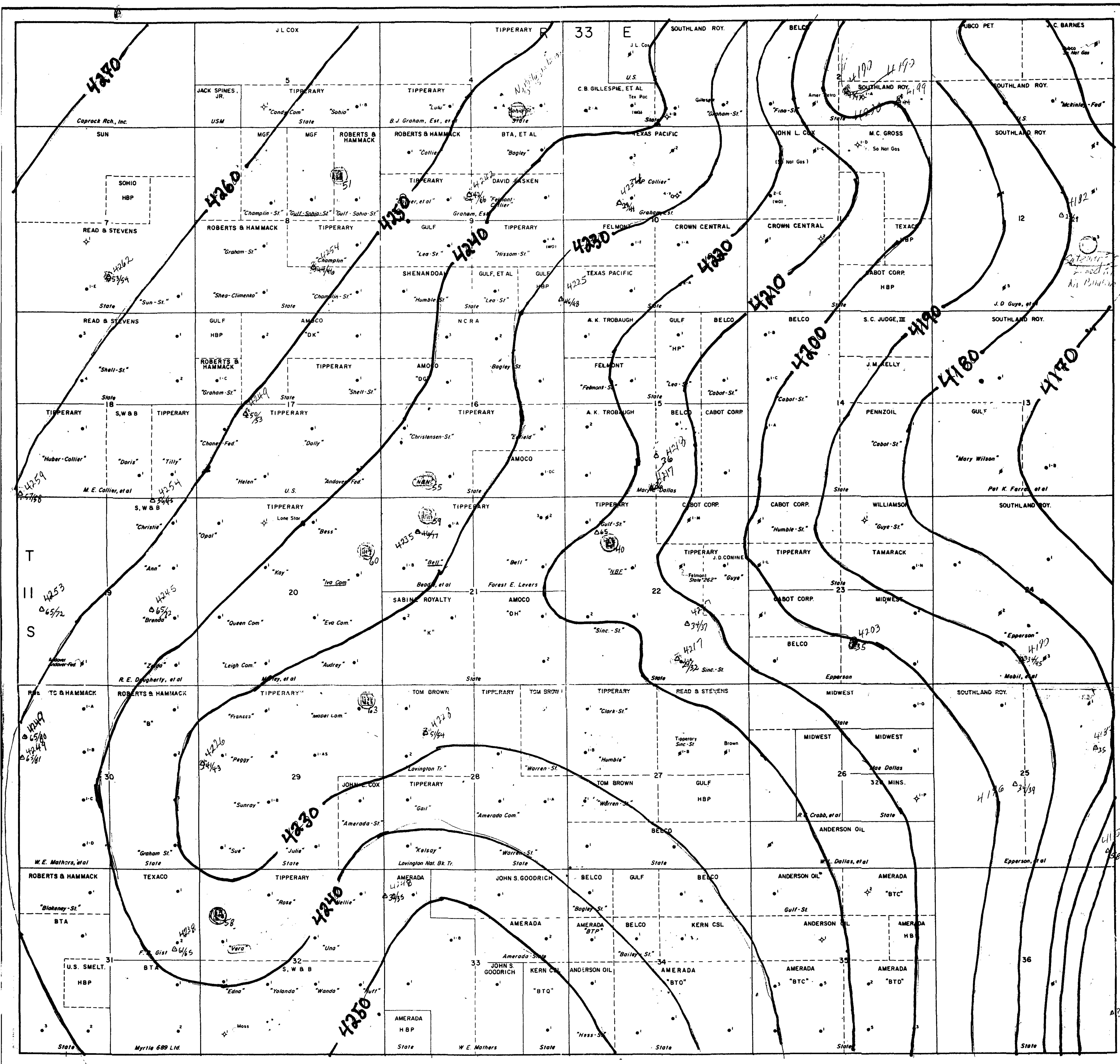
For log-normally distributed variables, the following conversion formulas are used internally by the program to determine the mean and variance of log-transformed variables as

$$m_{ln} = ln(m) - \frac{\sigma_{ln}^2}{2} \tag{3.52a}$$

$$\sigma_{ln}^2 = ln\frac{\sigma^2}{m^2} + 1 \tag{3.52b}$$

where m_{ln} and σ_{ln}^2 are the mean and variance of the log-transformed variable and m and σ^2 are the mean and variance of the original random variable. The user directly inputes m and σ, whereas m_{ln} and σ_{ln}^2 are used internally by the program to generate the random variables for the transformed normal distribution $N(m_{ln}, \sigma_{ln}^2)$. Log-normal distributions are truncated at $\pm 3\sigma$ or $\pm 3\sigma_{ln}$.

Verification of the Monte Carlo analysis implemented in VADSAT was performed by comparing statistical distributions of model output with independently computed distributions based on a first-order error analysis.



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