1R - 428-40

GENERAL CORRESPONDENCE

YEAR(S):

2006 - 2004

ARCADIS
Infrastructure, environment, facilities

ARCADIS G&M, Inc.
1004 North Big Spring Street
Suite 300
Midland
Texas 79701
Tel 432 687 5400
Fax 432 687 5401
www.arcadis-us.com

RECEIVED
DEC - 1 2006
Environmental Bureau
Oil Conservation Division

Ed Hansen
New Mexico Oil Conservation Division
Director, Environmental Bureau
1220 So. Saint Francis Drive
Santa Fe, New Mexico 87505

Sent Certified Return Receipt # 7002 2410 0001 5812 9749

ENVIRONMENTAL

Subject:
Rice Operating Company E-15 SWD Corrective Action Plan

Date:
November 28, 2006

Contact:
Sharon E. Hall

Phone:
432 687-5400

Email:
shall@arcadis-us.com

Our ref:
MT000723

Dear Wayne:

On behalf of Rice Operating Company (ROC), ARCADIS respectfully submits this Corrective Action Plan for the SWD E-15 site.

Your consideration of and approval of this workplan is appreciated. If you have any questions or comments please call me at (432) 687-5400 or Kristin Farris Pope at (505) 393-9174 or contact us via e-mail.

Sincerely,

ARCADIS G&M, Inc.

Sharon E. Hall

Sharon E. Hall
Site Evaluation Department Manager

Copies:
Kristin Farris Pope- ROC
Chris Williams- NMOCD Hobbs
File
Report

ARCADIS

Infrastructure, environment, facilities

Imagine the result

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Environmental Bureau
Oil Conservation Division

E-15 SWD Corrective Action Workplan

Rice Operating Company
Hobbs, New Mexico

ARCADIS

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Oil Conservation Division

E-15 SWD Corrective Action Workplan
Rice Operating Company
Hobbs, New Mexico

Sharon E. Hall

Sharon E. Hall
Site Evaluation Department Manager

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DEC - 1 2006
Environmental Bureau
Oil Conservation Division

Prepared for:
Rice Operating Company

Prepared by:
ARCADIS G&M, Inc.
1004 N. Big Spring Street
Suite 300
Midland,
Texas 79701
Tel 432.687.5400
Fax 432.687.5401

Our Ref.:
MT000723.0001.00001

Date:
November 28, 2006

Tables

Figures

Appendices

1.0 SITE HISTORY AND BACKGROUND

The Hobbs SWD system is in the abandonment/restoration phase. The E-15 SWD well has been plugged and abandoned. Several tanks and a pit were historically used at the site. The tanks have been removed. The site location is shown in Figure 1 (Township 19 south, Range 38 east, north half of south half of northwest quarter of Section 15). Depth to groundwater at the site is approximately 35 feet below ground surface (bgs) based on regional data.

In a preliminary investigation in 2001, discrete geoprobe soil samples were collected at five-foot intervals to a depth of twenty feet. Field chloride analysis was performed on the samples using field-adapted Method 9253. The samples were also inspected for the presence of staining and/or odor. Sample locations and results are shown in Figure 2. The numeric value indicates the chloride concentration in milligrams per kilogram(mg/kg). A letter "V" indicates observed visual staining, and a letter "O" indicates observed odor. Sample locations and depths indicated as voids are attempted samples that resulted in no recovery.

Based on the results of the 2001 soil sampling analytical results, elevated chloride concentrations above 250 milligrams per kilogram (mg/kg) are present at the subject site, primarily located around the tanks and pit. Observed staining and odor indicated the possible presence of hydrocarbons; however, hydrocarbon concentrations were unknown.

An investigation and corrective action workplan was submitted to the New Mexico Oil Conservation Division (NMOCD) on August 30, 2004 by ARCADIS on behalf of Rice Operating Company (ROC). The workplan proposed conducting a water well inventory, drilling one soil boring and delineating and excavating soils based on model assumptions submitted in the workplan. The NMOCD requested revisions to the workplan on December 20, 2004. On behalf of ROC, ARCADIS responded to the NMOCD with a letter addendum to the workplan on January 14, 2005.

As proposed in the workplan and addendum, investigation activities were conducted at the site in August and November 2005. A soil boring was drilled on August 26, 2005, and several trenches excavated and sampled on November 14th and 15th 2005. The water well inventory will be conducted in conjunction with corrective action activities as proposed in this Corrective Action Plan (CAP).

2.0 INVESTIGATION RESULTS

One soil boring was installed at the subject site to a depth of 40 bgs in the area that exhibited the highest chloride concentration (Grid 3ND, Figure 1 of Appendix A). The boring log is included as Appendix C. Soil samples were collected at five-foot intervals, screened in the field using a photoionization detector (PID) and field tested for chlorides. Soil lithology and the presence of any observed staining or odor was recorded. The deepest boring sample, collected at total depth of the boring, was submitted to a laboratory for laboratory analysis as confirmation of the field sampling. Chloride concentrations decreased with depth prior to reaching the saturated zone. No hydrocarbons were observed or were detected with the PID or in the sample submitted for laboratory analysis. Laboratory analytical results are included in Appendix D.

Further investigation was conducted on November 14th and 15th 2005. Several trenches were excavated and sampled. Soil samples were screened in the field using a PID and field tested for chlorides. Soil lithology and the presence of any observed staining or odor was recorded. Sample locations and depth are shown on Figure 1. Field sampling analysis is shown in Table 1 and on Figure 1. No hydrocarbons were observed or were detected with the PID. Chloride impacts in soil have been delineated to a concentration of 250 mg/kg as requested by the NMOCD in an e-mail response (December 20, 2004) to the investigation workplan.

3.0 PROPOSED CORRECTIVE ACTION WORKPLAN

Vadose zone modeling for chlorides was performed using the Evapotranspiration Cover model as developed by Sandia National Labs (Alternative Landfill Cover Demonstration, Sandia National Labs). The model used the same input assumptions as the nearby Junction I-9 site and includes site specific data. The model description and input parameters are included in Appendix A.

Based on model results for the proposed cap, the maximum allowable chloride concentration in soil is above 15,000 mg/kg assuming a groundwater chloride concentration of 100 milligrams per liter. The maximum concentration of chlorides in soil at the site is 4,660 mg/kg.

ROC will install the proposed Evapotranspiration Covers in the locations shown on Figure 2. Areas currently supporting vegetation will not be disturbed. As shown in the Evapotranspiration Cover cap demonstration, the cover will be placed over the prepared, (ripped and graded) subgrade. The subgrade will establish the 5% grade allowing run-off from the capped area. A 90 centimeter layer of native soil will be placed above the prepared subgrade. Fifteen centimeters of topsoil will be placed above the native soil. The capped area will be graded to a 5% grade allowing run-off and support of vegetation.

4.0 REPORTING

A closure report that details the investigation and corrective action activities and results will be submitted to the NMOCD.

5.0 REFERENCES

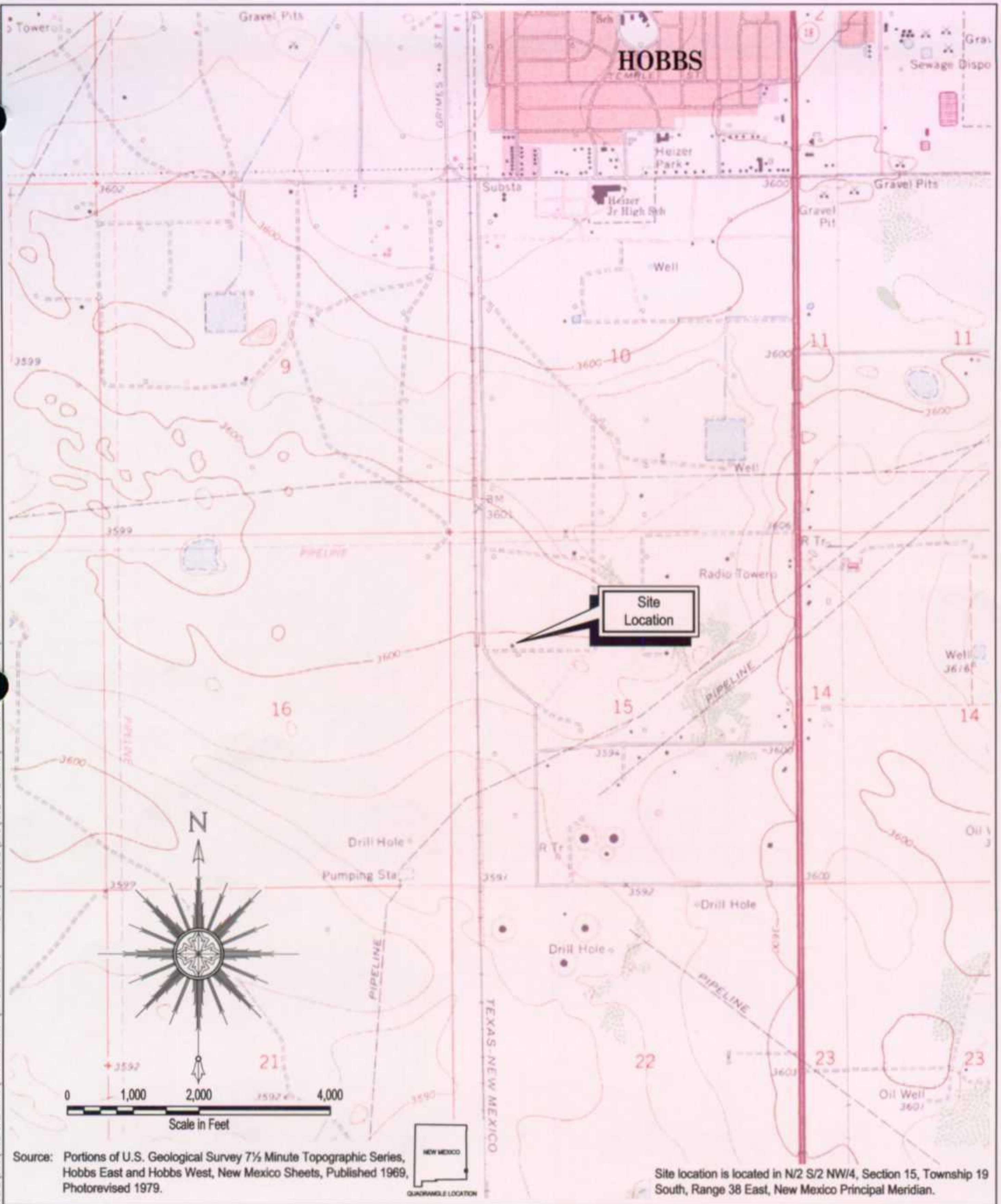
Alternative Landfill Cover Demonstration, Sandia National Labs, http:/www.sandia.gov/caps/ALCD.htm#Intro

TABLE 1
SWD E-15 Trench Sampling Results

ARCADIS

Location Name	Field Sample ID	Sample Interval (Feet)	PID (PPM)	Chlorides (PPM)
North Line	NT-1	19	0.0	1122
	NT-2	19-20	0.0	3212
	NT-3	15-16	0.0	4660
	NT-4	15	0.0	2479
	NT-5	19-20	0.0	3821
	NT-6	16	0.0	217
	NT-7	5	0.0	242
Northwest Line	NW-1	15-16	0.0	1123
	NW-2	17	0.0	537
	NW-3	8	0.0	191
		16-17	0.0	144
West Line	W-A	7	0.0	108
		14	0.0	152
	W-0	15-16	0.0	461
	W-1	17	0.0	618
	W-2	8	0.0	844
		16	0.0	590
East Line	E-1	15-16	0.0	650
	E-2	15-16	0.0	320
	E-3	7	0.0	463
		15-16	0.0	184
	E-4	7	0.0	112
Southwest Line	SW-2	17-18	0.0	501
	SW-3	8	0.0	276
		16-17	0.0	395
Center and Southeast Line	CE-1	10	0.0	249
		19-20	0.0	280
	SE-1	8	0.0	239
		17	0.0	313
	SE-2	9	0.0	184
		18	0.0	263

Notes:
Field Sample ID coordinates with Figure 2.

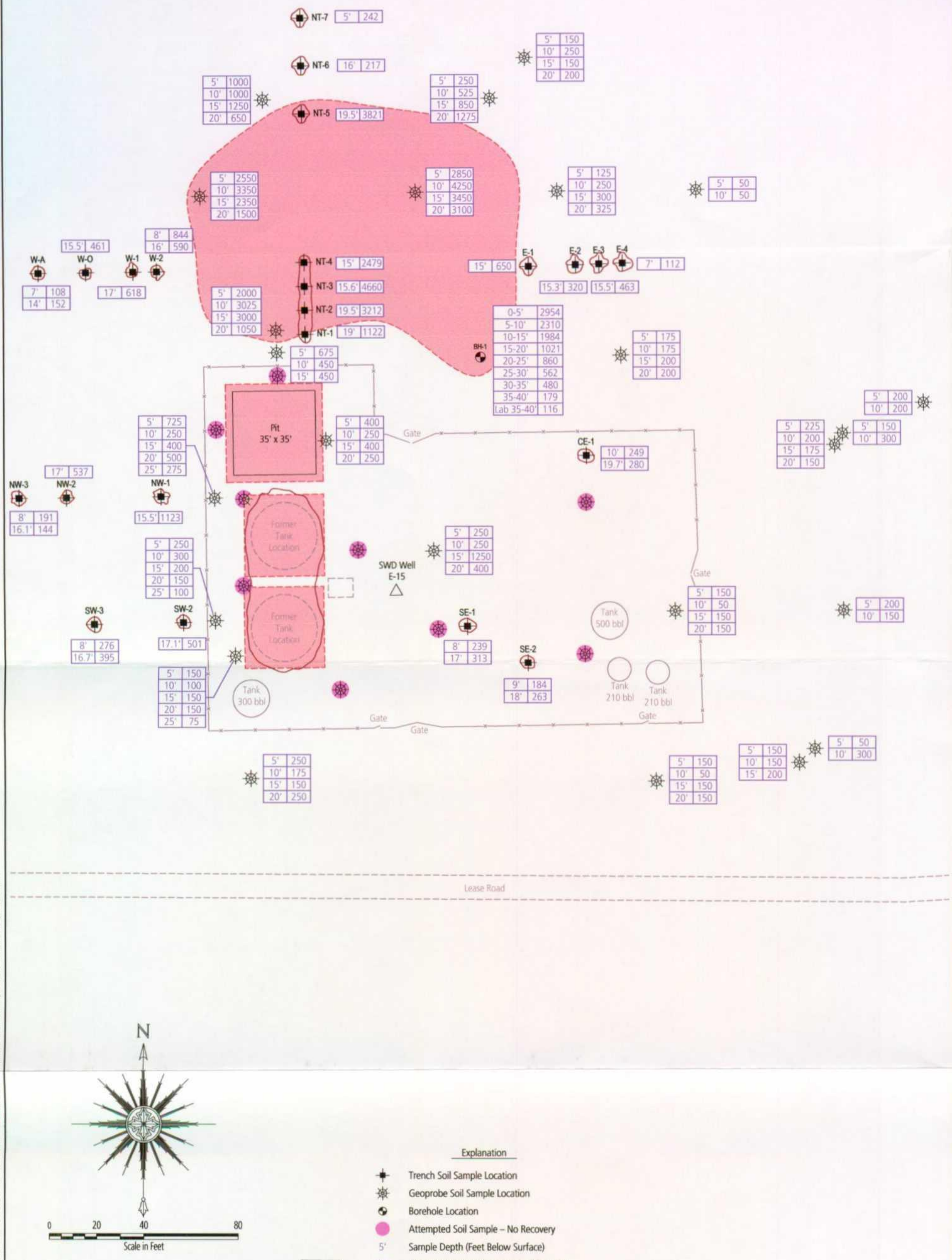


Source: Portions of U.S. Geological Survey 7½ Minute Topographic Series, Hobbs East and Hobbs West, New Mexico Sheets, Published 1969, Photorevised 1979.

Site location is located in N/2 S/2 NW/4, Section 15, Township 19 South, Range 38 East, New Mexico Principal Meridian.

Area Manager A. Schmidt	**ARCADIS**	Rice Operating Company, Inc. Hobbs SWD System -- E-15 Investigation	Project Number MT000723.0001
Project Manager S. Hall			Drawing Date 13 November 2006
Task Manager R. Lange	1004 North Big Spring Street Suite 300 Midland, TX 79701-3383 Tel: 432-687-5400 Fax: 432-687-5401 www.arcadis-us.com	Site Location Map	Figure
Technical Review S. Tischer		Lea County, New Mexico	1

31-014-00782



Source: Portions of U.S. Geological Survey 7½ Minute Topographic Series, Hobbs East and Hobbs West Quadrangle, New Mexico Sheets, Published 1969, Photorevised 1979. Site Features Derived from Client-Provided Drawing and from Arcadis Field Sketches.

11/28/06 10:47 HCLARDY R16 G:\AUTOCAD\DWG\RICE OPERATING\MT000723.0001\MT723102.DWG XREFS: G:\AUTOCAD\DWG\RICE OPERATING\MT000723.0001\GENERAL\BASEMAP.DWG;

Area Manager
A. Schmidt
Project Manager
S. Hall
Task Manager
R. Lang
Technical Review
S. Hall

ARCADIS
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Suite 300
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Rice Operating Company, Inc.
Hobbs SWD System – E-15 Investigation

Soil Sample Locations And Chloride Results

Lea County, New Mexico

Project Number
MT000723.0001
Drawing Date
03 January 2006
Figure
2

Appendix A

Evapotranspiration Cover Model

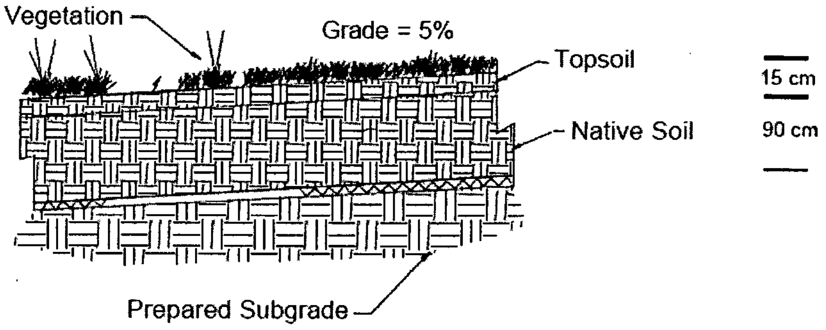
Input Parameters

Chloride Groundwater Standard	mg/L	250

Excavation

Recharge	mm/yr	0.05
	in/yr	0.0020
Infiltration Flux through landfill	ft^3/day	0.0108
Field Capacity	%	0.077
Soil Bulk Density	g/cm^3	1.855

Evapotranspiration Cover



Groundwater

Cross-sectional Area of the Aquifer	ft^2	1,500
Hydraulic Conductivity	ft/day	2
Hydraulic Gradient	ft/ft	0.00917
Groundwater Flux through Mixing Zone	ft^3/day	27.51

Background Concentration in Groundwater
mg/L
0
50
100
150
200
250

Output

Maximum Chloride Concentration Allowable in Excavation Pore Water	Maximum Chloride Concentration Allowable in Soil
mg/L	mg/kg
635,876.7	**26,394.9**
508,751.4	**21,118.0**
381,626.0	**15,841.1**
254,500.7	**10,564.2**
127,375.3	**5,287.3**
250.0	**10.4**

Consituent

Sorption Coefficient	Unitless	0

Appendix B

Soil Boring Sample Laboratory Analytical Results

ENVIRONMENTAL
LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:
Sharon Hall
ARCADIS
1004 N. Big Spring Street
Midland, TX 79701

Project: MT000723.00001
Project Number: MT000723.00001
Location: Rice Operating E-15 SWD

Lab Order Number: 5H26001

Report Date: 09/01/05

ARCADIS 1004 N. Big Spring Street Midland TX, 79701	Project: MT000723.00001 Project Number: MT000723.00001 Project Manager: Sharon Hall	Fax: (432) 687-5401 **Reported:** 09/01/05 09:44

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
BH-1 35-40'	5H26001-01	Soil	08/26/05 10:10	08/26/05 15:35

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
BH-1 35-40' (5H26001-01) Soil									
Benzene	ND	0.0250	mg/kg dry	25	EH53007	08/30/05	08/31/05	EPA 8021B	
Toluene	ND	0.0250	"	"	"	"	"	"	
Ethylbenzene	ND	0.0250	"	"	"	"	"	"	
Xylene (p/m)	ND	0.0250	"	"	"	"	"	"	
Xylene (o)	ND	0.0250	"	"	"	"	"	"	
Surrogate: a,a,a-Trifluorotoluene		*98.9 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*96.1 %*	*80-120*		"	"	"	"	

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
BH-1 35-40' (5H26001-01) Soil									
Chloride	**116**	20.0	mg/kg Wet	2	EH53008	08/30/05	08/30/05	SW 846 9253	
% Moisture	**7.7**	0.1	%	1	EH52907	08/26/05	08/29/05	% calculation	

Organics by GC - Quality Control
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EH53007 - EPA 5030C (GC)										
Blank (EH53007-BLK1)				Prepared & Analyzed: 08/30/05						
Benzene	ND	0.0250	mg/kg wet							
Toluene	ND	0.0250	"							
Ethylbenzene	ND	0.0250	"							
Xylene (p/m)	ND	0.0250	"							
Xylene (o)	ND	0.0250	"							
Surrogate: a,a,a-Trifluorotoluene	*98.4*		*ug/kg*	*100*		*98.4*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*95.9*		*"*	*100*		*95.9*	*80-120*			
LCS (EH53007-BS1)				Prepared & Analyzed: 08/30/05						
Benzene	80.8		ug/kg	100		80.8	80-120			
Toluene	82.5		"	100		82.5	80-120			
Ethylbenzene	92.5		"	100		92.5	80-120			
Xylene (p/m)	182		"	200		91.0	80-120			
Xylene (o)	91.7		"	100		91.7	80-120			
Surrogate: a,a,a-Trifluorotoluene	*105*		*"*	*100*		*105*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*106*		*"*	*100*		*106*	*80-120*			
Calibration Check (EH53007-CCV1)				Prepared: 08/30/05 Analyzed: 08/31/05						
Benzene	87.1		ug/kg	100		87.1	80-120			
Toluene	84.8		"	100		84.8	80-120			
Ethylbenzene	90.0		"	100		90.0	80-120			
Xylene (p/m)	177		"	200		88.5	80-120			
Xylene (o)	87.7		"	100		87.7	80-120			
Surrogate: a,a,a-Trifluorotoluene	*108*		*"*	*100*		*108*	*0-200*			
Surrogate: 4-Bromofluorobenzene	*112*		*"*	*100*		*112*	*0-200*			
Matrix Spike (EH53007-MS1)	**Source: 5H24009-01**			Prepared & Analyzed: 08/30/05						
Benzene	80.3		ug/kg	100	ND	80.3	80-120			
Toluene	82.1		"	100	ND	82.1	80-120			
Ethylbenzene	92.6		"	100	ND	92.6	80-120			
Xylene (p/m)	182		"	200	ND	91.0	80-120			
Xylene (o)	89.6		"	100	ND	89.6	80-120			
Surrogate: a,a,a-Trifluorotoluene	*104*		*"*	*100*		*104*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*117*		*"*	*100*		*117*	*80-120*			

Organics by GC - Quality Control

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EH53007 - EPA 5030C (GC)										
Matrix Spike Dup (EH53007-MSD1)	**Source: 5H24009-01**			Prepared: 08/30/05	Analyzed: 08/31/05					
Benzene	80.3		ug/kg	100	ND	80.3	80-120	0.00	20	
Toluene	81.5		"	100	ND	81.5	80-120	0.733	20	
Ethylbenzene	89.1		"	100	ND	89.1	80-120	3.85	20	
Xylene (p/m)	176		"	200	ND	88.0	80-120	3.35	20	
Xylene (o)	88.1		"	100	ND	88.1	80-120	1.69	20	
Surrogate: a,a,a-Trifluorotoluene	*105*		"	*100*		*105*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*109*		"	*100*		*109*	*80-120*			

General Chemistry Parameters by EPA / Standard Methods - Quality Control

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EH52907 - General Preparation (Prep)										
Blank (EH52907-BLK1)				Prepared: 08/26/05 Analyzed: 08/29/05						
% Solids	100		%							
Duplicate (EH52907-DUP1)	**Source: 5H25018-01**			Prepared: 08/26/05 Analyzed: 08/29/05						
% Solids	87.0		%		86.0			1.16	20	
Duplicate (EH52907-DUP2)	**Source: 5H24009-07**			Prepared: 08/26/05 Analyzed: 08/29/05						
% Solids	96.0		%		95.9			0.104	20	
Batch EH53008 - General Preparation (WetChem)										
Blank (EH53008-BLK1)				Prepared & Analyzed: 08/30/05						
Chloride	ND	20.0	mg/kg Wet							
Matrix Spike (EH53008-MS1)	**Source: 5H29006-01**			Prepared & Analyzed: 08/30/05						
Chloride	1960	20.0	mg/kg Wet	1000	1080	88.0	80-120			
Matrix Spike Dup (EH53008-MSD1)	**Source: 5H29006-01**			Prepared & Analyzed: 08/30/05						
Chloride	1980	20.0	mg/kg Wet	1000	1080	90.0	80-120	1.02	20	
Reference (EH53008-SRM1)				Prepared & Analyzed: 08/30/05						
Chloride	5000		mg/kg	5000		100	80-120			

Notes and Definitions

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
LCS	Laboratory Control Spike
MS	Matrix Spike
Dup	Duplicate

Report Approved By: Raland K Tuttle Date: 9/1/2005

Raland K. Tuttle, Lab Manager	Jeanne Mc Murrey, Inorg. Tech Director
Celey D. Keene, Lab Director, Org. Tech Director	LaTasha Cornish, Chemist
Peggy Allen, QA Officer	Sandra Sanchez, Lab Tech.

ARCADIS

Laboratory Task Order No./P.O. No.

CHAIN-OF-CUSTODY RECORD

Page ____ of ____

Project Number/Name MT000723.00001

Project Location Rice Operating E-15 SWD

Laboratory Environmental Lab of TExas

Project Manager Sharon Hall

Sampler(s)/Affiliation ARCADIS/RN

Sample ID/Location	Matrix	Date/XXXX Sampled	Time XXXXX	ANALYSIS / METHOD / SIZE (1) 9 oz. jar BTEX and Cl Neat						Remarks	Total
BH-1 35-40'	S	8/26/05	10:10	1						5H26001 -01	1

Sample Matrix: L = Liquid; S = Solid; A = Air

Total No. of Bottles/Containers 1

Relinquished by: Organization: ARCADIS Date 8/26/05 Time 15:35

Received by: Organization: ELOT Date 8/26/05 Time 15:35

Seal Intact? ~~Yes~~ No [✓ N/A]

Relinquished by: Organization: Date / / Time

Received by: Organization: Date / / Time

Seal Intact? Yes No N/A

Special Instructions/Remarks:

1.0°C 9oz jar w/ label no seal

Delivery Method: ☐ In Person ☐ Common Carrier ____ SPECIFY ☐ Lab Courier ☐ Other ____ SPECIFY

AG 03-12/01

Environmental Lab of Texas
Variance / Corrective Action Report – Sample Log-In

Client: ARCADIS

Date/Time: 8/26/05 15:35

Order #: 5H2600

Initials: CK

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	1.0 C
Shipping container/cooler in good condition?	[✓ Yes]	No	
Custody Seals intact on shipping container/cooler?	Yes	No	[✓ Not present]
Custody Seals intact on sample bottles?	Yes	No	[✓ Not present]
Chain of custody present?	[✓ Yes]	No	
Sample Instructions complete on Chain of Custody?	[✓ Yes]	No	
Chain of Custody signed when relinquished and received?	[✓ Yes]	No	
Chain of custody agrees with sample label(s)	[✓ Yes]	No	
Container labels legible and intact?	[✓ Yes]	No	
Sample Matrix and properties same as on chain of custody?	[✓ Yes]	No	
Samples in proper container/bottle?	[✓ Yes]	No	
Samples properly preserved?	[✓ Yes]	No	
Sample bottles intact?	[✓ Yes]	No	
Preservations documented on Chain of Custody?	[✓ Yes]	No	
Containers documented on Chain of Custody?	[✓ Yes]	No	
Sufficient sample amount for indicated test?	[✓ Yes]	No	
All samples received within sufficient hold time?	[✓ Yes]	No	
VOC samples have zero headspace?	[✓ Yes]	No	Not Applicable

Other observations:

Variance Documentation:

Contact Person: -________ Date/Time: ________ Contacted by: ________

Regarding:

Corrective Action Taken:

ARCADIS
Infrastructure, buildings, environment, communications

ARCADIS G&M, Inc.
1004 N. Big Spring Street
Suite 300
Midland Texas 79701
Tel 432.687.5400
Fax 432.687.5401
www.arcadis-us.com

ENVIRONMENTAL

SENT CERTIFIED MAIL

Wayne Price
New Mexico Energy, Minerals,
and Natural Resources Department
1220 South Saint Francis Drive
Santa Fe, New Mexico 87505

Subject: Hobbs
Letter Addendum to Rice Operating Company E-15 SWD Workplan; E-15 SWD
IR0428-40

Date:
14 January 2005

Contact:
Sharon Hall

Phone:
432 687-5400

Email:
shall@arcadis-us.com

Our ref:
MT000723.0001

Dear Mr. Price :

Rice Operating Company (ROC) and ARCADIS Geraghty and Miller (ARCADIS) are in receipt of your e-mail dated December 20, 2004 requesting that revisions to the above-referenced workplan be submitted to the New Mexico Oil Conservation Division (OCD) by January 31, 2005. On behalf of ROC, ARCADIS respectfully responds to your requests as follows:

A. OCD will not allow delineation by use of models and will require actual delineation using the following delineation criteria:

1. TPH 100 ppm

2. Chloride 250 ppm

ROC will delineate TPH to a concentration of 100 ppm and chloride to a concentration of 250 ppm in soil.

B. The site plan does not include delineation of all areas, for example the plan did not include delineation under the old tanks and in the pit area. Please explain?

The soil boring will be placed in the area that evidenced the highest concentrations of chloride (Figure 1, Grid 3ND). As demonstrated on Figure 1 of the submitted workplan, preliminary delineation (field analysis of chlorides and observation of soils for hydrocarbon odor and visible staining) has been performed and included the area formerly occupied by the tanks and the pit area. Soil impacts will be further delineated during excavation areas. As stated in item A, ROC will delineate TPH a concentration of 100 ppm and chloride to a concentration of 250 ppm in soil and will include the former tank area and the pit area.

C. The water well review does not include an actual field inspection of the area.

The water well review will include a one-half mile review of water well records and a one-half mile field inspection.

D. The plan is not clear to OCD if the single boring is going all the way to groundwater.

The boring will be completed as a monitor well if impacts are evidenced at the depth where groundwater is encountered. Impacts will be identified by field analysis for chlorides, and for hydrocarbons by PID detections, visual observation for staining and/or observance of hydrocarbon odor.

E. In order for OCD to evaluate the site a copy of the model must be supplied to OCD IT group indicating you have the rights to share the software. OCD may need instructional help in setting up and running the model at no cost to this agency. ROC should be aware this may take additional time.

A copy of the model will be provided to OCD with documentation that we are authorized to share the software. As necessary, ARCADIS will provide assistance in setting up and running the model at no cost to OCD.

If you have any questions or require additional information please call Carolyn Haynes at (505) 393-9174 or me at (432) 687-5400.

Best Regards,

Sharon E. Hall

Sharon E. Hall
Site Evaluation Department Manager

Cc: Carolyn Doran Haynes, ROC
Kristin Farris Pope, ROC

Price, Wayne

From: Price, Wayne
Sent: Monday, December 20, 2004 10:19 AM
To: Carolyn Doran Haynes (E-mail); Kristin Farris Pope (E-mail)
Cc: Sharon Hall (E-mail); Sheeley, Paul; Johnson, Larry
Subject: Rice E-15 SWD 1R0428-40

Dear Ms. Haynes:

OCD is in receipt of the Work Plan submitted by Arcadis on behalf of Rice Operating Company. ***The Plan is hereby denied for the following reasons:***

A. OCD will not allow delineation by use of models and will require actual delineation using the following delineation criteria:

1. TPH 100 ppm
2. Chloride 250 ppm

B. The site plan does not include delineation of all areas, for example the plan did not include delineation under the old tanks and in the pit area. Please explain?

C. The water well review does not include an actual field inspection of the area.

D. The plan is not clear to OCD if the single boring is going all the way to groundwater.

E. In order for OCD to evaluate the site a copy of the model must be supplied to OCD IT group indicating you have the rights to share the software. OCD may need instructional help in setting up and running the model at no cost to this agency. ROC should be aware this may take additional time.

Please re-submit by January 31, 2005.

Sincerely:

Wayne Price
New Mexico Oil Conservation Division
1220 S. Saint Francis Drive
Santa Fe, NM 87505
505-476-3487
fax: 505-476-3462
E-mail: WPRICE@state.nm.us

Price, Wayne

From: Price, Wayne
Sent: Monday, December 20, 2004 10:19 AM
To: Carolyn Doran Haynes (E-mail); Kristin Farris Pope (E-mail)
Cc: Sharon Hall (E-mail); Sheeley, Paul; Johnson, Larry
Subject: Rice E-15 SWD 1R0428-40

Dear Ms. Haynes:

OCD is in receipt of the Work Plan submitted by Arcadis on behalf of Rice Operating Company. ***The Plan is hereby denied for the following reasons:***

A. OCD will not allow delineation by use of models and will require actual delineation using the following delineation criteria:

1. TPH 100 ppm
2. Chloride 250 ppm

B. The site plan does not include delineation of all areas, for example the plan did not include delineation under the old tanks and in the pit area. Please explain?

C. The water well review does not include an actual field inspection of the area.

D. The plan is not clear to OCD if the single boring is going all the way to groundwater.

E. In order for OCD to evaluate the site a copy of the model must be supplied to OCD IT group indicating you have the rights to share the software. OCD may need instructional help in setting up and running the model at no cost to this agency. ROC should be aware this may take additional time.

Please re-submit by January 31, 2005.

Sincerely:

Wayne Price
New Mexico Oil Conservation Division
1220 S. Saint Francis Drive
Santa Fe, NM 87505
505-476-3487
fax: 505-476-3462
E-mail: WPRICE@state.nm.us

Price, Wayne

From: Kristin Farris [enviro@leaco.net]
Sent: Monday, December 13, 2004 4:08 PM
To: Price, Wayne
Cc: Shall@arcadis-us.com; Carolyn Haynes
Subject: Re: SWD E-15 Second request for information

12-13-04 North Tank (west).JPG... 12-13-04 Pit (NW).JPG 12-13-04 Site (north).JPG 12-13-04 South Tank (west).JPG...

Here are some photos of the site that were taken today. It's my understanding that S.Hall provided you with a site map. Let me know if you need any more info. Thanks.

Kristin Farris Pope

----- Original Message -----
From: "Price, Wayne" <WPrice@state.nm.us>
To: "Carolyn Doran Haynes (E-mail)" <riceswd@leaco.net>; "Kristin Farris Pope (E-mail)" <enviro@leaco.net>
Cc: "Sharon Hall (E-mail)" <shall@arcadis-us.com>
Sent: Monday, December 13, 2004 10:59 AM
Subject: SWD E-15 Second request for information

> On Nov 25, 2004 I requested photos and an area map of the site. Please
> provide by December 20, 2004.
>
> Sincerely:
>
> Wayne Price
> New Mexico Oil Conservation Division
> 1220 S. Saint Francis Drive
> Santa Fe, NM 87505
> 505-476-3487
> fax: 505-476-3462
> E-mail: WPRICE@state.nm.us
>
>

RICE Operating Company
122 West Taylor • Hobbs, New Mexico 88240
Phone: (505)393-9174 • Fax: (505) 397-1471

RECEIVED
JUN 21 2004
OIL CONSERVATION DIVISION

June 18, 2004

Mr. Gary Wink
NMOCD District 1 Office
1625 N French Drive
Hobbs, NM 88240

Re: Abandonment of SWD Facility sites Vacuum G-35 and Hobbs E-15
Lea County, NM

Dear Mr. Wink:

This letter is a response to your letter to Rice Operating Company (ROC) dated March 24, 2004, inquiring about the abandonment of wells sites at Vacuum SWD G-35, Hobbs SWD E-15 and Hobbs SWD P-16.

The abandonment of the Hobbs SWD P-16 was completed soon after the P&A of the well. This information was submitted to the District 1 Office on May 13, 2004. There was only insignificant environmental impact at this well site, all of which was remediated to the landowner's (Bill McNeill) satisfaction.

The remaining two sites are in progress for abandonment.

The Vacuum G-35 Site abandonment began July 30, 2001 with a Closure Plan (under the approved Generic Redwood Tank and Pit Closure Plan) submission to Mr. Wayne Price, NMOCD Environmental Bureau, Santa Fe. As work was progressed the site was discovered to have deep vadose zone contaminant impact. This was reported to Roger Anderson and Wayne Price, NMOCD Environmental Bureau, Santa Fe on January 18, 2002 with a follow-up letter on July 1, 2002. A monitor well was installed and has been sampled quarterly with results sent to Mr. Price on an annual basis.

ROC submitted an AFE to the Vacuum System Partners for funding for this project. The Vacuum System Operating Committee then experienced a time of disruption (about 2 years) concerning the division of interest (costs) pertaining to historical environmental remediation. ROC believes this concern has been cleared to the degree that work may progress and funding will be agreeably divided among the System Partners.

RT Hicks Consultants of Albuquerque have since been contracted to manage the environmental work of the abandonment. A RBCA Work Plan has been submitted to Mr. Price and is awaiting approval. ROC expects this project work to encompass 3 to 6 months with monitor well sampling for 2 years. This work will be done through the Environmental Bureau.

The Hobbs E-15 Site is part of the Hobbs SWD System Abandonment Project. The abandonment work at this site was delayed due to landowner dispute and lawsuit. The Property has since been purchased by Occidental Permian. Occidental Permian has granted ROC permission to continue with the abandonment and remediation work.

This site had preliminary delineation shortly after the well E-15 was P&A. The site was found to have significant vadose zone impact and considerable NORM impact of the surface and redwood tanks. The redwood tanks have been decontaminated and removed. The surface area has also been decontaminated. All of the NORM work was conducted through the NMED.

Arcadis G&M of Midland (Sharon Hall) has been contracted to manage the environmental work at this site. Extensive TPH modeling has been conducted (6 months of work) and the RBCA work plan is being developed based on this research and will be submitted to Mr. Price at the NMOCD Environmental Bureau. Salt impact appears to be less significant. Funding will be requested upon approval of the RBCA work plan.

All of this documentation is available at the ROC office and reports will be submitted to Santa Fe Environmental Bureau and District 1 Office at various stages of the work plan. Please don't hesitate to call the ROC office should you have any questions or concerns as these work plans are conducted. ROC plans to complete the surface-work at these two sites by December 31, 2004. Groundwater activities will continue for at least two years with annual submission of results to the Environmental Bureau.

Thank you for your patience and cooperation.

RICE OPERATING COMPANY

Carolyn Doran Haynes

Carolyn Doran Haynes
Engineering Manager

cc: Chris Williams
Wayne Price
JSC, KF, LBG, file


RICE Engineering & Operating, Inc.
SALT WATER DISPOSAL SYSTEM
CAUTION
DANGER
CORPORATION
SYSTEM


CAUTION
POISON GAS
MAY BE PRESENT
DANGER
RICE Engineering & Operating, Inc.

From: Price, Wayne
Sent: Monday, December 13, 2004 3:34 PM
To: 'Hall, Sharon E.'
Cc: Carolyn Doran Haynes (E-mail)
Subject: RE: SWD E-15 Second request for information

Got it! Now I need photos. This project is OCD Case # 1R0428-40. Please put this number on all correspondence, because Rice has another E-15 which is AP-27.

-----Original Message-----
From: Hall, Sharon E. [mailto:Shall@arcadis-us.com]
Sent: Monday, December 13, 2004 3:15 PM
To: Price, Wayne
Subject: RE: SWD E-15 Second request for information

On it's way. Please let me know if you do not receive it. Thank you,
Sharon

-----Original Message-----
From: Price, Wayne [mailto:WPrice@state.nm.us]
Sent: Monday, December 13, 2004 2:24 PM
To: Hall, Sharon E.
Subject: RE: SWD E-15 Second request for information

Please re-fax

-----Original Message-----
From: Hall, Sharon E. [mailto:Shall@arcadis-us.com]
Sent: Monday, December 13, 2004 12:27 PM
To: Price, Wayne; Carolyn Doran Haynes (E-mail); Kristin Farris Pope (E-mail)
Subject: RE: SWD E-15 Second request for information

Wayne- I faxed you the area map on Dec 3rd at Kristin's request. You apparently did receive it. Please confirm your fax number of 505 476-3462 and I will re-fax it. I do not have site photos. ROC was going to provide them to you. Regards, Sharon

-----Original Message-----
From: Price, Wayne [mailto:WPrice@state.nm.us]
Sent: Monday, December 13, 2004 12:00 PM
To: Carolyn Doran Haynes (E-mail); Kristin Farris Pope (E-mail)
Cc: Hall, Sharon E.
Subject: SWD E-15 Second request for information

On Nov 25, 2004 I requested photos and an area map of the site. Please provide by December 20, 2004.

Sincerely:

Wayne Price
New Mexico Oil Conservation Division
1220 S. Saint Francis Drive
Santa Fe, NM 87505
505-476-3487
fax: 505-476-3462
E-mail: WPRICE@state.nm.us

Confidentiality Notice: This e-mail,including all attachments is for the

---

Price, Wayne

From: Price, Wayne
Sent: Monday, December 13, 2004 11:00 AM
To: Carolyn Doran Haynes (E-mail); Kristin Farris Pope (E-mail)
Cc: Sharon Hall (E-mail)
Subject: SWD E-15 Second request for information

On Nov 25, 2004 I requested photos and an area map of the site. Please provide by December 20, 2004.

Sincerely:

Wayne Price
New Mexico Oil Conservation Division
1220 S. Saint Francis Drive
Santa Fe, NM 87505
505-476-3487
fax: 505-476-3462
E-mail: WPRICE@state.nm.us

Price, Wayne

From: Price, Wayne
Sent: Wednesday, November 24, 2004 10:32 AM
To: Carolyn Doran Haynes (E-mail); Kristin Farris Pope (E-mail)
Subject: Rice Projects

Dear Carolyn:

The first thing I want to do is compliment Kristin on the good job she is doing on filing, processing and maintaining records on all of your projects. Excellent work!

The next item is a question. Which ROC projects are not under the generic Jct plan or Redwood Tank closure? Are you using the Jct Box plan for redwood tank and leak sites also? I understand that EME and DB projects are all under the generic Jct plan approved on July 22, 2003 by OCD. I also understand that disclosure reports from these projects are covered on a case-by-case basis. So how is the Hobbs SWD and other ROC systems being handled? Please clarify.

Also, the conference call on Dec 1 is a discussion on a path forward procedure for the sites in the Monument area. I wasn't planning on discussing each individual site with your contractors. The call will be about OCD's understanding and procedure for addressing the groundwater issue in that area. I think having contractors on the line will cloud the issue.

Another issue is the Vacuum G-35 and F-35 projects. I sent an E-mail yesterday requiring action. I understand Randy Hicks sent E-mails concerning this project. We have a problem with his E-mails and we don't always get the attachments, and then usually we never receive the hard copy. However, It's not all his fault because we have had some E-mail problems ourselves and we have been inundated with paper work recently combined with the loss of Bill Olson. I am finding that some of the projects were in his name and may be the reason for some confusion. Please send anything associated with ROC to me and as I am making a concerted effort to process these as soon as possible.

Hobbs SWD E-15. Please send photos and area map where it is located. Was there a closure plan issued for the tanks, jct box equipment etc. and is there photos for this work? Is this part of the Hobbs abandonment project?

Sincerely:

Wayne Price
New Mexico Oil Conservation Division
1220 S. Saint Francis Drive
Santa Fe, NM 87505
505-476-3487
fax: 505-476-3462
E-mail: WPRICE@state.nm.us

Price, Wayne

From: Carolyn Doran Haynes [cdhriceswd@leaco.net]
Sent: Wednesday, November 24, 2004 2:22 PM
To: 'Price, Wayne'
Cc: 'Kristin Farris'
Subject: FW: Rice Projects

Wayne,

Please scroll down and read my responses imbedded in your email. They are in red.

-----Original Message-----
From: Rice Operating [mailto:riceswd@leaco.net]
Sent: Wednesday, November 24, 2004 11:47 AM
To: Haynes, Carolyn Doran
Subject: Fw: Rice Projects

----- Original Message -----
From: "Price, Wayne" <WPrice@state.nm.us>
To: "Carolyn Doran Haynes (E-mail)" <riceswd@leaco.net>; "Kristin Farris Pope (E-mail)" <enviro@leaco.net>
Sent: Wednesday, November 24, 2004 10:32 AM
Subject: Rice Projects

> Dear Carolyn:
>
> The first thing I want to do is compliment Kristin on the good job she is doing on filing, processing and maintaining records on all of your projects.
> Excellent work!

Thank you!

> The next item is a question. Which ROC projects are not under the generic Jct plan or Redwood Tank closure? Are you using the Jct Box plan for redwood tank and leak sites also? I understand that EME and DB projects are all under the generic Jct plan approved on July 22, 2003 by OCD. I also understand that disclosure reports from these projects are covered on a case-by-case basis. So how is the Hobbs SWD and other ROC systems being handled? Please clarify.

The Junction Box Plan is just that, a junction box plan, for all of the Systems. The reason most reports are for EME and BD is because they are the Systems with the most activity (due to barrels disposed and dollars ROC can AFE.) The Hobbs SWD project is for abandonment. The Hobbs junction boxes were evaluated also according to the junction box plan. The Hobbs E-15 site initially was to be done under the generic redwood tank and pit closure plan. The impact suspected there and the landowner (OXY) desire to keep expense minimal, however, warrants usage of a RBCA plan, so ROC called in Arcadis to develop a plan. Leak sites are not worked according to the junction box plan, and are evaluated site by site. Some of the closure conditions, however, may resemble the junction box plan closure conditions (decline of chlorides, for example). The more ROC discovers about the historical salt behavior, the more we find we can apply it to sites.

As far as which sites are not the JB plan or RWtank plan, I'll have to get back to you. Generally, if a site has come into you for a workplan approval, the site is not on one of the two plans or is out of the scope of the plan.

>
> Also, the conference call on Dec 1 is a discussion on a path forward
> procedure for the sites in the Monument area. I wasn't planning on
> discussing each individual site with your contractors. The call will be
> about OCD's understanding and procedure for addressing the groundwater
> issue in that area. I think having contractors on the line will cloud the
> issue.

The only reason I wanted the consultants on the line is because they are truly handling their projects and ROC is just coordinating. It is not a problem to exclude them.

Please understand that ROC does not have staff that has the credentials or expertise of the consultants. I'm not an environmental professional and with my ROC management responsibilities, I can't keep my hand on everything. Kristin is a degreed geologist and has been with ROC 3 years, but that doesn't approach the experience and network of the consultants.

>
>
> Another issue is the Vacuum G-35 and F-35 projects. I sent an E-mail
> yesterday requiring action. I understand Randy Hicks sent E-mails
> concerning this project. We have a problem with his E-mails and we don't
> always get the attachments, and then usually we never receive the hard
> copy.
> However, It's not all his fault because we have had some E-mail problems
> ourselves and we have been inundated with paper work recently combined
> with
> the loss of Bill Olson. I am finding that some of the projects were in
> his
> name and may be the reason for some confusion. Please send anything
> associated with ROC to me and as I am making a concerted effort to process
> these as soon as possible.

ROC will send all project info to you. I'll talk with Randy about paperwork. The G-35 and F-35 sites will be addressed with you asap. I'll consult with Randy and get him on board with what OCD is going to require. I will want to discuss the conditions with you during the conference call.

>
> Hobbs SWD E-15. Please send photos and area map where it is located. Was
> there a closure plan issued for the tanks, jct box equipment etc. and is
> there photos for this work? Is this part of the Hobbs abandonment
> project?

The E-15 site is a redwood tank and pit site. It is part of the Hobbs abandonment. The tanks and pit were NORM cleared and removed under the generic plan. The site was partially delineated under the generic plan. All work was suspended due to the I-9 McNeill site pending the lawsuit, OCD's approval of the Stage II, and the new ownership of the land (OXY). We are now set to proceed and OXY wanted a RBCA to minimize expenses, so Arcadis was called in and Sharon Hall submitted a work plan to you.

I'm on vacation right now, but will be back in the office Monday. Kristin and I will discuss these issues and will look forward to our conference call for a path forward. I have long since believed the Monument area GW will have to become a cooperative effort of all the producers in the area. I believe the information we are gathering now will map-out pockets of impact that can be addressed on a much larger scale - probably not approachable by ROC... We have a lot of work ahead, and it will take a long time to produce results. I've thought for some time now that the ROC work is just the top of the iceberg, but we're working as fast as we can. We have five consultants working on various projects and hope to secure the funding for work next year. ROC is in a precarious position these days, and I'm so glad oil is $45+/bbl. Without that, AFEs would be very difficult to gain approval.

Have a great Thanksgiving. I am on my cell phone if you need to speak for any reason. 505-631-0680. Carolyn

>
>
> Sincerely:
>
> Wayne Price
> New Mexico Oil Conservation Division
> 1220 S. Saint Francis Drive
> Santa Fe, NM 87505
> 505-476-3487
> fax: 505-476-3462
> E-mail: WPRICE@state.nm.us
>
>
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> recipient, please contact the sender and destroy all copies of this
> message. -- This email has been scanned by the MessageLabs Email Security
> System.
>

Price, Wayne

From: Hall, Sharon E. [Shall@arcadis-us.com]
Sent: Thursday, November 18, 2004 3:59 PM
To: Price, Wayne
Cc: enviro@leaco.net
Subject: ROC E-15 Legal location

Wayne, the legal location for the E-15 site is Unit E, Section 15, T19S, R38E. Let me know if you need anything else. Sharon

---

From: Price, Wayne [mailto:WPrice@state.nm.us]
Sent: Thursday, November 18, 2004 4:40 PM
To: Price, Wayne; Hall, Sharon E.; 'Carolyn Doran Haynes (E-mail)'; 'Kristin Farris Pope (E-mail)'
Cc: 'enviro@leaco.net'
Subject: RE: BD K-27-1, K-27 and M-14 Workplans

I found the disclosure reports.

> -----Original Message-----
> **From:** Price, Wayne
> **Sent:** Thursday, November 18, 2004 3:06 PM
> **To:** 'Hall, Sharon E.'; Price, Wayne; Carolyn Doran Haynes (E-mail); Kristin Farris Pope (E-mail)
> **Cc:** enviro@leaco.net
> **Subject:** RE: BD K-27-1, K-27 and M-14 Workplans
>
> Thanks Sharon. What I need now is the Disclosure reports mentioned in you e-mail.. I have went thur every Rice file and cannot find any marked July 25, 2003. When were these sent in? I need to get a copy or have Rice tell which packet they were sent in.
>
> > -----Original Message-----
> > **From:** Hall, Sharon E. [mailto:Shall@arcadis-us.com]
> > **Sent:** Wednesday, November 17, 2004 12:51 PM
> > **To:** Price, Wayne
> > **Cc:** enviro@leaco.net
> > **Subject:** BD K-27-1, K-27 and M-14 Workplans
> >
> > Wayne, here are the workplans that you were missing. Thank you, Sharon

1R042~~5~~8 - 40

ARCADIS

Infrastructure, buildings, environment, communications

ARCADIS G&M, Inc.
1004 N. Big Spring Street
Suite 300
Midland Texas 79701
Tel 432.687.5400
Fax 432.687.5401
www.arcadis-us.com

Environmental

Wayne Price
New Mexico Oil Conservation Division
1220 So. Saint Francis Drive
Santa Fe, New Mexico 87505

Sent Certified Mail

STAND-ALONES
HOBBS SWD
RED WOOD TANK

Subject:
Rice Operating Company E-15 SWD Workplan

Date:
31 August 2004

Contact:
Sharon Hall

Phone:
432 687-5400

Email:
shall@arcadis-us.com

Our ref:
MT000723.0001

Dear Mr. Price:

On behalf of Rice Operating Company, ARCADIS respectfully submits the attached proposed investigation and corrective action workplan. The site is located in Hobbs, New Mexico. If you have any questions or need further information, please call me at (432) 687-5400 or Kristin Farris Pope at (505) 393-9174.

Sincerely,

ARCADIS G&M, Inc.

Sharon E. Hall

Sharon Hall
Site Evaluation Department Manager

Copies:
Kristin Farris Pope-ROC (US Postal Service, 1st class)

Rice Operating Company
E-15 SWD Workplan

ARCADIS

Infrastructure, buildings, environment, communications

ARCADIS

Sharon E. Hall

Sharon E. Hall
Site Evaluation Department Manager

Rice Operating Company
E-15 SWD Company

Prepared for:
Rice Operating Company

Prepared by:
ARCADIS G&M, Inc.
1004 N. Big Spring Street
Suite 300
Midland,
Texas 79701
Tel 432.687.5400
Fax 432.687.5401

Our Ref.:
MT000723.0001.00001

Date:
30 August 2004

1R0425

Tables

Figures

Appendices

1.0 Site History and Background

The Hobbs SWD system is in the abandonment phase. The E-15 SWD well has been plugged and abandoned. Several tanks and a pit were historically used at the site. The locations are shown in Figure 1. The redwood tanks have been removed, and the pit is not in use. The steel tanks will be removed and cleaned.

Discrete soil samples were collected at five-foot intervals to a depth of twenty feet in 2001. Field chloride analysis was performed on the samples using field-adapted Method 9253. The samples were also inspected for the presence of staining and/or odor. Sample locations and results are shown in Figure 1. The numeric value indicates the chloride concentration in milligrams per kilogram(mg/kg). A letter "V" *indicates observed visual staining, and a letter* "O" *indicates observed odor. Sample* locations and depths indicated as voids are attempted samples that resulted in no recovery.

Based on the results of the soil sampling analytical results, elevated chloride concentrations are present at the subject site. Observed staining and odor indicate the presence of hydrocarbons; however, hydrocarbon concentrations are unknown.

2.0 Proposed Investigation and Corrective Action Workplan

A one-half mile water well inventory will be performed. The water well inventory will include a review of water well records listed on the New Mexico State Engineer Office and United States Geological Survey (USGS) websites and windmills indicated on applicable USGS topographic maps.

One soil boring will be installed at the subject site in the area that exhibited the highest chloride concentration. We propose to drill the soil boring in Grid 3ND (Figure 1). Soil samples will be collected at regular intervals no greater than five feet, screened in the field using a photo ionization detector (PID) and field tested for chlorides. Soil lithology and the presence of any observed staining or odor will be recorded. One sample, the sample collected at total depth of the boring, will be submitted to a laboratory for laboratory analysis as confirmation of the field sampling.

If impacts to soil are identified in soil samples collected from the interval at which groundwater is encountered, the soil boring will be converted to a monitoring well. The monitor well will be constructed, developed and sampled in accordance with Environmental Protection Agency and NMOCD standards. A groundwater sample will be collected and submitted for laboratory analysis for chlorides, BTEX and general chemistry.

If analytical results indicate that chloride and/or BTEX concentrations exceed New Mexico Water Quality Control Commission standards, additional monitoring wells may be installed as warranted by the results of the investigation.

Soils will be excavated from the site and the site backfilled with remediated, blended soil. Rice Operating Company proposes a delineation and action level concentration for chlorides, benzene, ethylbenzene, toluene and xylenes based on vadose zone modeling as described in the following section.

3.0 Model Assumptions and Results

3.1 Hydrocarbon Modeling

Vadose zone modeling was performed for benzene, toluene, ethylbenzene and xylenes. The computations were performed using the Vadose Zone Interactive Model (VIP) developed by Utah State University in 1987. VIP is a successor to the RITZ model created by the United States Environmental Protection Agency (USEPA). This model has been available for over 16 years, and has been tested experimentally, mathematically and in the field. Although there have been many advances in environmental literature and computer science in the past 16 years, this code endures because of its ability to handle multiple transport mechanisms and to simultaneously account for partitioning in four phases in soil pores: water, air, soil organic matter and oil (if present).

Whereas many vadose zone models were created to simulate the upward mobility of constituents from the water table to a home or basement, VIP was designed to simulate the fate and transport of petroleum hydrocarbons in a hazardous waste land treatment unit. VIP is a one-dimensional model that tracks the migration of hydrocarbon constituents from an oily zone near the surface to a chosen datum below the surface. Another attribute of VIP is that the model accounts for biodegradation, leaching and diffusive soil vapor transport. Model results are for each hydrocarbon constituent at a distance in meters above the groundwater table.

A description of the method, inputs and assumptions, results and interpretation of the results is included in Appendix A. Based on the results of the vadose zone modeling, the proposed concentrations for delineation and action level for excavation of soils at various distances above the water table are shown in Table 1.

Table 1
Maximum Allowable Soil Concentrations

Distance from Water Table (m)	Benzene mg/kg	Ethylbenzene mg/kg	Toluene mg/kg	Xylenes mg/kg
0-1	0.0307	28.7	10.2	19.2
1-2	0.48	399	149	244
2-3	0.71	570	215	353
3-4	0.98	772	295	490
4-5	1.35	1,040	405	678
5-6	1.9	1,440	570	960
6-7	2.8	2,100	840	1,420
7-8	4.5	3,350	1,360	2,270
8-9	13	5,800	3,450	5,400
9-10	43	5,800	7,050	5,400

3.2 Chloride Modeling

Chloride modeling was performed using the Hydrologic Evaluation of Landfill Performance (HELP) model. The HELP model was developed by the USEPA to assess percolation through engineered landfill covers. Inputs and calculations used the same conservative approach employed for the Junction I-9 site. A description of the method, inputs and assumptions, results and interpretation of the results is included in Appendix B. Much of the input used was based on the data used for the Junction I-9 site. Site area and estimated total groundwater flux through the site (based on the narrowest width) were the variables that were changed to reflect site-specific variables. Based on the results of the modeling, the proposed chloride concentration delineation and action level for excavation of soils is 2,087 mg/kg. Based on ambient groundwater conditions near the Junction I-9 site, the ambient chloride concentration in groundwater is likely to be approximately 100 mg/kg. To assess potential impacts, groundwater concentrations were assumed, and maximum allowable soil concentrations were computed that would not result in a degradation of water quality above the New Mexico standard of 250 milligrams per liter. The results are presented in Table 1 of Appendix B.

The proposed action level of 2,087 mg/kg is based on the installation of an upper clay liner with a permeability of no greater than 1 x 10-^{8} centimeters per second (cm/sec). Soils will be delineated to a concentration of 2,087 mg/kg. Soils with a chloride concentration in excess of 2,087 mg/kg will be excavated, blended with clean soil and returned to the excavation as fill material. Following backfilling, a 12-15 inch compacted clay layer that meets or exceeds 95% of a proctor Test ASTM-D-98 and permeability equal to or less than 1 x 10^{-8} cm/sec will be installed over the entire excavated area at a depth of 6-7 feet below ground surface.

4.0 Reporting

A report that details the investigation and corrective action activities and results will be submitted to the OCD. The report will include recommendations for further action if necessary or for closure of the site.

ARCADIS

Appendix A

Vadose Zone Modeling, Benzene, Ethylbenzene,Toluene and Xylenes

APPENDIX A
RICE OPERATING COMPANY
E-15 SWD Terminal Facility
Vadose Zone Modeling

BACKGROUND

This memorandum summarizes the vadose zone modeling conducted for the Rice Operating Company E-15 SWD Terminal facility located in Hobbs, New Mexico. Summarized in the following sections are the modeling objective, the model used, the inputs and assumptions, the outputs and the interpretation of the outputs. Model runs simulating the use of a liner are also presented here.

MODELING OBJECTIVE

The computations were performed using the Vadose zone Interactive Processes (VIP) model, developed by Utah State University in 1987. The objective of the modeling was to determine the threshold concentrations of the constituents of concern (COCs) in soil below which the concentrations of the constituents in groundwater would be within standards set by the State of New Mexico. The constituents modeled included benzene, toluene, ethylbenzene, and xylene.

In each case, the maximum soil concentration was sought for the COC in question to prevent the exceedance of the New Mexico Water Quality Control Commission groundwater standards presented in Table 1.

Table 1. Groundwater Target Concentrations

Constituent	Groundwater Standard (mg/L)
Benzene	0.01
Toluene	0.75
Ethylbenzene	0.75
Total Xylenes	0.62

METHOD

The computations were performed using the VIP model, developed by Utah State University in 1987. The numerical model was described in Grenney et al. (1987). VIP is a successor to the RITZ model created by the United States Environmental Protection Agency (USEPA). The Robert S. Kerr Environmental Research Laboratory set out to produce "RITZ Enhanced" (RITZE), but the project was completed with funding from the State of Utah and was renamed VIP. This model has been available for over 16 years, and has been tested experimentally, mathematically and in the field. Although there have been many advances in the environmental literature and computer science in the past 16 years, this code endures because of its ability to handle multiple transport mechanisms and to simultaneously account for partitioning in four phases in soil pores: water, air, soil organic matter and oil (if present).

Whereas many vadose zone models were created to simulate the upward mobility of constituents from the water table to a home or basement, VIP was designed to simulate the fate and transport of petroleum hydrocarbons in a hazardous waste land treatment unit. VIP is a one-dimensional model that tracks the migration of hydrocarbon constituents from an oily zone near the surface to a chosen datum below the surface. Another attribute of VIP is that the model accounts for biodegradation, leaching and diffusive soil vapor transport. The model does not account for the migration of nonaqueous phase liquids. Therefore, the concentration of crude oil was limited to 4% by mass, a value not expected to overcome capillary forces.

L— 40,000 ppm oil - ??

MODEL INPUTS AND ASSUMPTIONS

There are several categories of inputs necessary to run the VIP model. The model uses environmental parameters, soil properties and chemical properties, as well as numerical inputs that are more of a mathematical significance. Inputs used in each category are discussed below, except the last category. Numerical inputs are outside the scope of this study, except to say that the values used for these inputs were those recommended by Utah State University researchers, based upon experimental evidence.

Environmental Parameters

Because biodegradation has been found to be temperature-dependent (Coover and Sims, 1987), the temperature of the soil was a model input. Local temperatures are presented in Table 2. The temperatures used in the model were the average of average monthly high and low temperatures for Hobbs, New Mexico (Western Regional Climate Center, 2003). The reference data were available in degrees Fahrenheit, but the model operates in degrees Centigrade. Table 2 presents the surface temperature in both set of units. VIP also requires entries for subsurface temperature. Using the method of Fluker (1958), a set of temperatures was computed for the subsurface, at a depth of 10 feet below ground surface (bgs).

The rate at which soil pore water percolates is also a VIP model input. This value was set at 1.0 inches per year, which is equal to 6.96×10^{-3} cm/day. For the run that simulates use of a liner (benzene, 2-3 meters) a recharge rate of 6.95×10^{-5} cm/day was used.

The model domain used was 10 meters in depth. This one-dimensional domain extended from the surface to the groundwater.

Soil Properties

Three soil types were simulated: sand; caliche; and clay. For each soil type, a value was input for porosity, saturated hydraulic conductivity, density and an empirical constant related to water saturation (referred to as SMLB). These inputs can be found in Table 3. The saturated hydraulic conductivity (and the implied intrinsic permeability) of each soil type is presented in four sets of units. These values were obtained from the field. Field porosity values are also presented in Table 3. The density values were computed assuming a grain density of 2.65 g/cc. The SMLB parameter was obtained from the literature for sand and clay (Clapp and Hornberger, 1978). This parameter, often called the "Clapp and Hornberger Constant," governs an empirical equation that relates deep percolation and hydraulic conductivity to saturation. The value of SMLB for caliche was deduced from its van Genuchten parameters (Table 4). The parameters in Table 4 were determined in the laboratory using site soils.

A single value is given for saturation in Table 3 in spite of the fact that soil saturation is governed by capillary forces and varies with depth. The saturation of soil pores is nearly 100% near the water table, and it decreases with distance from the water table. One of the most important differences between the approaches of Clapp and Hornberger and of van Genuchten is that the former is based upon a single value for soil saturation and the latter is able to account for the variation in soil moisture content. The equations of Maulem and van Genuchten can be plotted to show realistic saturation-depth curves. Such curves were plotted and are attached in Appendix A-1. At sufficiently great distance from the water table (a distance that is a function of soil type), the saturation depth curves become nearly flat. At these depths, the Clapp and Hornberger model approximates reality. Because VIP uses the Clapp and Hornberger equation, it was necessary to determine single values. VIP computes its own saturation value internally, but the value used for determining diffusivity correction factors is the one in Table 3. These values were determined by visual inspection of the flat part of the saturation-depth curves.

Table 4. Soil Hydraulic Properties and van Genuchten Parameters

Depth (m)	Texture	Soil Hydraulic Properties Van Genuchten Parameters					
		2_r	2_s	$\forall$ (cm^{-1})	n	K_{sat} (cm/day)	1
0-4	Clay	0.068	0.38	0.008	1.09	4.8	0.5
4-6	Caliche	0.045	0.4	0.013	1.95	1	0.5
6-12	Sand	0.045	0.43	0.145	2.68	712.8	0.5

It should be noted that the VIP model does not allow more than one soil type in a model run. A sand lithology, the most conservative scenario was used for the model input.

Chemical Properties

The chemical properties are shown on Table 5. Chemical properties included the biodegradation rates, the partition coefficients and the air diffusivities of the COCs.

An organic constituent can reside in any one of four phases in the VIP model. It can be dissolved in the soil pore water, it can be in the soil air phase, it can partition into soil organic matter, or it can reside in a nonaqueous phase when one is present. In this model, the nonaqueous phase, the crude oil, was in the top meter or two meters of the model domain. The constants that determine the relative proportion of the constituents in each phase, the partition coefficients, are presented in Table 5. Solubility, vapor pressure and molecular weight were obtained from Thibodeaux (1996). These three parameters are not used directly in the model, but were included in Table 5 because they are used to compute the air-water partition coefficient, K_{aw}, using Henry's Law.

The oil-water partition coefficient used in the model was the published value for the octanol-water partition coefficient (K_{ow}) for the given constituent. The organic carbon-water partition coefficient (K_{oc}) was also obtained from the literature, and related to K_{ow} using the equation of Schwarzenbach and Westall (1981). The soil water partition coefficients, K_{sw}, were computed from the K_{oc} assuming a fraction organic carbon in the soil of 0.1 percent.

It was assumed that biodegradation took place in the aqueous phase, and that no degradation of the COCs took place in the oil phase or in the air in the soil pores. The biodegradation rates used in the model can be found in Table 5. The degradation rates used in the model were the geometric mean of the highest and lowest values in Howard (1991). The degradation rates were converted to units compatible with the model, units of 1/day. Howard presents degradation data in numbers of days necessary for half of the concentration to decay.

The degradation rate of oil is an important input, because the COCs partition preferentially into an oily phase. As the crude degrades, the constituents are forced to equilibrate into other phases.

No field data were available, so it was assumed that the oil decayed at a rate such that 50 percent would be degraded in 10 years, or 0.0001 day^{-1}.

Liner Simulation

The VIP model does not allow for multiple lithologies or for a low permeability zone that would simulate a liner. However, by reducing the deep percolation of groundwater by two orders of magnitude, the effect of a permeability barrier was also simulated. The deep percolation rate or "recharge" rate in the VIP model used in the model runs simulating no liner was one inch per year, or 6.95 x 10^{-3} cm/day. For the run that simulates use of a liner a recharge rate of 6.95 x 10^{-5} cm/day was used.

MODEL OUTPUT

The output of the VIP model consists of tables of concentrations of the COC in the four phases of soil listed for every depth. The four phases are soil pore water, soil pore air, any non aqueous phase, referred to as the "oil" phase, and the soil organic matter. Table 6 is summarizes each point in time requested in the input file. In addition to COC concentration in the phases, other information is presented, such as the size of each phase as a fraction of the soil pore space. VIP also summarized how much of the constituent has vented to the atmosphere, how much has been biodegraded, how much has leached beyond the bottom of the domain (in this case, how much has reached groundwater), and how much of the COC remains in the model domain.

Key results of the model runs are presented in Table 6. VIP was run repeatedly for each combination of COC, soil type, and depth. The goal of each set of runs was to determine the maximum initial soil concentration in the impacted zone that would meet two criteria:

1. The concentration of the COC in the soil pore water in the soil 10 centimeters from the water table could not exceed the groundwater target concentrations in Table 1.
2. The concentration of the COC in soil pore water in the zone impacted with crude oil could not exceed its aqueous solubility.

INTERPRETATION OF THE RESULTS

Boring logs indicate that the soil at the E-15 SWD site is not of a uniform lithology, but instead consists of sand, clay and caliche. VIP does not allow multiple soil types in a single simulation. Therefore, the sand results can be considered the most conservative. Action levels for the site, based on the sand lithology result, are shown in Table7.

A decrease in deep percolation will decrease the soil pore water content and increase the air space in the soil pores. The diffusivity of vapors in soil pore air space is a strong function of the air porosity, and a small increase in air porosity can result in a large increase in constituent mobility. Therefore, one run (benzene at a depth of 2-3 meters) was simulated in order to predict the effect of a liner. The 2-3 foot interval was selected as this is the depth immediately beneath the depth at which a liner would be installed. The installation of a liner will not result in a lesser maximum allowable concentration due to the diffusivity of vapors. Conversely, the maximum allowable concentration result for benzene at a depth of 2-3 meters is 0.818 mg/kg with a liner, 0.71 mg/kg without a liner.

Action Level Values

Table 7 presents the action levels, the maximum concentrations that (at given depths) are protective of groundwater. The data are presented as a function of the distance from the water table. The results in Table 7 are presented for ranges of depth. Appendix A-1 includes graphs of the maximum concentrations as a function of depth, assuming a 10 meter deep water table.

CONCLUSION

In conclusion, the VIP model was used to derive action levels for benzene, toluene, ethylbenzene and xylene in soil that are protective of groundwater. The Table 7 summarizes the action level soil concentrations as a function of vertical distance from the groundwater.

REFERENCES

Clapp, R.C., and M. R. Hornberger. (1978). Empirical Equations for Some Soil Hydraulic Properties. *Water Resources Research* 14:601-604.

Coover, M.P. and R. C. Sims. (1987). The Effect of Temperature an Polycyclic Aromatic Hydrocarbon Persistence in Unacclimated Agricultural Soil. *Hazardous Waste & Hazardous Materials* 4:69-82.

Fluker, B.J. 1958. Soil Temperatures. *Soil Science* 86:35-46.

Grenney, W. J., C. L. Caupp, R. C. Sims, and T. E. Short. (1987). A Mathematical Model for the Fate of Hazardous Substances in Soil: Model Description and Experimental Results. *Hazardous Waste & Hazardous Materials* 4:223-237.

Howard, P. H. 1991. *Handbook of Environmental Degradation Rates*. Lewis Publishers Inc., Chelsea, MI.

Schwarzenbach, R.P. and J. Westall. (1981). Transport of Nonpolar Organic Compounds from Surface Water to Groundwater: Laboratory Sorption Studies. *Environmental Science & Technology* 15:1360-1367.

Thibodeaux, L.J. (1996). *Environmental Chemodynamics*, Second Edition. John Wiley & Sons, Inc. New York.

Western Regional Climate Center. (2003). Hobbs, New Mexico Period of Monthly Climate Summary. wrcc@dri.edu.

Table 2. Local Temperature

	Surface				10' depth
Month	Max Temp., F	Min Temp., F	Average Temp., F	Average Temp., C	Average Temp., C
January	56.5	27.9	42.2	5.7	15.9
February	62.0	32.0	47.0	8.3	14.7
March	68.9	37.3	53.1	11.7	14.1
April	77.8	46.2	62.0	16.7	14.0
May	85.5	55.3	70.4	21.3	14.7
June	92.9	63.4	78.2	25.6	15.8
July	93.8	66.6	80.2	26.8	17.2
August	92.0	65.6	78.8	26.0	18.4
September	85.9	59.4	72.7	22.6	19.1
October	77.1	48.5	62.8	17.1	19.2
November	65.2	36.7	51.0	10.5	18.5
December	58.1	29.6	43.9	6.6	17.3
Annual	**76.3**	**47.4**	**61.8**	**16.6**	**16.6**
Max	93.8	66.6	80.2	26.8	19.2
Min	56.5	27.9	42.2	5.7	14.0
Amplitude	18.7	19.4	19.0	10.6	2.6

Table 3. Soil Properties

	Saturated Hydraulic Conductivity							Density
	cm/day	cm/sec	m2	darcies	Porosity	Saturation	SMLB	g/cc
Clay	4.8	5.56E-05	5.67E-14	0.06	0.38	6.80%	11.40	1.64
Caliche	1	1.16E-05	1.18E-14	0.01	0.40	4.50%	9.00	1.59
Sand	712.8	8.25E-03	8.42E-12	8.58	0.43	4.50%	4.05	1.51

Table 4 Moisture and S Curves

Clay **S**

h (ft)	h (cm)	θ	Sw	Sw (comp)	kr	kr (comp)	$\phi =$	0.38	Sw bar	kr ?
0.000	0.00	0.380	1.000	1	1	1	$\alpha =$	0.008	1	1
0.539	16.44	0.377	0.992	0.992033	0.77	0.030146	n =	1.09	0.991452	0.2785
0.820	25.00	0.375	0.988	0.987799	0.63	0.021226	m =	0.082569	0.986909	0.2201
1.640	50.00	0.371	0.976	0.976177	0.46	0.010411	Sm =	0.068	0.974439	0.1739
3.281	100.00	0.363	0.956	0.956498	2.80E-01	4.21E-03			0.953324	1.34E-01
6.562	200.00	0.352	0.927	0.927431	1.14E-01	1.39E-03			0.922136	6.72E-02
9.843	300.00	0.344	0.907	0.906523	7.70E-02	6.68E-04			0.899703	3.99E-02
13.12	400.00	0.338	0.890	0.890356	2.00E-02	3.86E-04			0.882356	1.86E-02
19.69	600.00	0.329	0.866	0.866255	1.00E-02	1.72E-04			0.856497	1.01E-02
24.90	759.00	0.324	0.852	0.851821	5.60E-03	1.06E-04			0.84101	6.86E-03
32.81	1000.00	0.317	0.835	0.834656	1.70E-03	5.97E-05			0.822593	4.20E-03
65.62	2000.00	0.301	0.791	0.791336	2.20E-04	1.35E-05			0.776112	1.06E-03
98.43	3000.00	0.291	0.766	0.76638	3.20E-05	5.59E-06			0.749335	4.39E-04
164.04	5000.00	0.280	0.736	0.735718	5.00E-06	1.82E-06			0.716435	1.38E-04
328.1	10000.00	0.264	0.696	0.695823	1.00E-07	3.94E-07			0.673629	2.73E-05
0	0.00		0.000	1		1			1	
0	0.00		0.000	1		1			1	

Caliche **S**

h (ft)	h (cm)	θ	Sw	Sw (comp)	kr	kr (comp)	$\phi =$	0.4	Sw bar	kr ?
0.000	0.00	0.400	1.000	1	1	1	$\alpha =$	0.013	1	1
0.539	16.44	0.391	0.978	0.977853	0.77	0.592841	n =	1.95	0.97681	0.2785
0.820	25.00	0.381	0.952	0.951971	0.63	0.442053	m =	0.487179	0.949708	0.2201
1.640	50.00	0.339	0.847	0.846818	0.46	0.179318	Sm =	0.045	0.8396	0.1739
3.281	100.00	0.255	0.637	0.637075	2.80E-01	0.032941			0.619973	1.34E-01
6.562	200.00	0.162	0.404	0.404136	1.14E-01	0.002824			0.376059	6.72E-02
9.843	300.00	0.119	0.299	0.298573	7.70E-02	0.000547			0.265521	3.99E-02
13.12	400.00	0.096	0.241	0.240645	2.00E-02	0.000163			0.204864	1.86E-02

Table 4 Moisture and S Curves

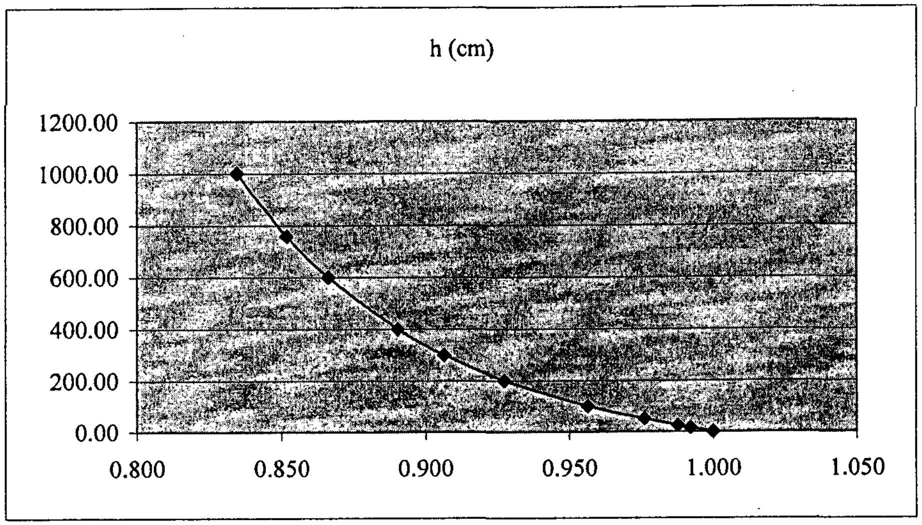
19.69	600.00	0.072	0.179	0.179491	1.00E-02	2.88E-05			0.140829	1.01E-02
24.90	759.00	0.061	0.153	0.152921	5.60E-03	1.04E-05			0.113006	6.86E-03
32.81	1000.00	0.051	0.128	0.128241	1.70E-03	3.14E-06			0.087164	4.20E-03
65.62	2000.00	0.035	0.088	0.088193	2.20E-04	1.53E-07			0.045228	1.06E-03
98.43	3000.00	0.030	0.074	0.074398	3.20E-05	2.59E-08			0.030784	4.39E-04
164.04	5000.00	0.025	0.063	0.0631	5.00E-06	2.78E-09			0.018953	1.38E-04
328.1	10000.00	0.022	0.054	0.05437	1.00E-07	1.34E-10			0.009812	2.73E-05
0	0.00		0.000	1		1			1	
0	0.00		0.000	1		1			1	

Sand S

h (ft)	h (cm)	θ	Sw	Sw (comp)	kr	kr (comp)	ϕ =	0.43	Sw bar	kr ?
0.000	0.00	0.430	1.000	1	1	1	α =	0.145	1	1
0.539	16.44	0.109	0.254	0.254347	0.77	0.001502	n =	2.68	0.219212	0.2785
0.820	25.00	0.066	0.153	0.152614	0.63	0.000126	m =	0.626866	0.112685	0.2201
1.640	50.00	0.034	0.079	0.079142	0.46	1.8E-06	Sm =	0.045	0.035751	0.1739
3.281	100.00	0.024	0.056	0.055683	2.80E-01	2.47E-08			0.011186	1.34E-01
6.562	200.00	0.021	0.048	0.048335	1.14E-01	3.37E-10			0.003493	6.72E-02
9.843	300.00	0.020	0.047	0.046688	7.70E-02	2.73E-11			0.001767	3.99E-02
13.12	400.00	0.020	0.046	0.046041	2.00E-02	4.58E-12			0.00109	1.86E-02
19.69	600.00	0.020	0.046	0.045527	1.00E-02	3.71E-13			0.000552	1.01E-02
24.90	759.00	0.020	0.045	0.045355	5.60E-03	8.64E-14			0.000372	6.86E-03
32.81	1000.00	0.019	0.045	0.045223	1.70E-03	1.56E-14			0.000234	4.20E-03
65.62	2000.00	0.019	0.045	0.04507	2.20E-04	2.13E-16			7.3E-05	1.06E-03
98.43	3000.00	0.019	0.045	0.045035	3.20E-05	1.72E-17			3.69E-05	4.39E-04
164.04	5000.00	0.019	0.045	0.045015	5.00E-06	7.25E-19			1.57E-05	1.38E-04
328.1	10000.00	0.019	0.045	0.045005	1.00E-07	9.86E-21			4.89E-06	2.73E-05
0	0.00		0.000	1		1			1	
0	0.00		0.000	1		1			1	

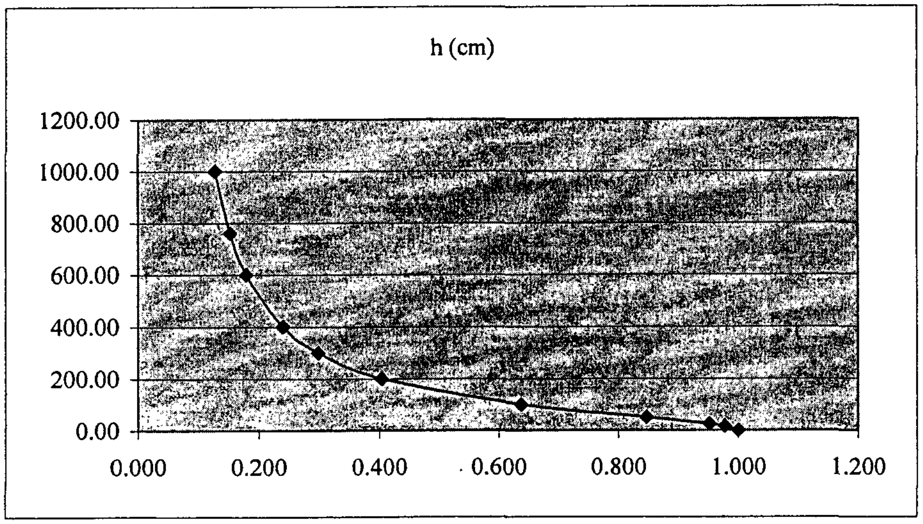
Clay

Sw	h (cm)	θ
1.000	0.00	0.380
0.992	16.44	0.377
0.988	25.00	0.375
0.976	50.00	0.371
0.956	100.00	0.363
0.927	200.00	0.352
0.907	300.00	0.344
0.890	400.00	0.338
0.866	600.00	0.329
0.852	759.00	0.324
0.835	1000.00	0.317



Caliche

Sw	h (cm)	θ
1.000	0.00	0.400
0.978	16.44	0.391
0.952	25.00	0.381
0.847	50.00	0.339
0.637	100.00	0.255
0.404	200.00	0.162
0.299	300.00	0.119
0.241	400.00	0.096
0.179	600.00	0.072
0.153	759.00	0.061
0.128	1000.00	0.051



Sw	h (cm)	θ
1.000	0.00	0.430
0.254	16.44	0.109
0.153	25.00	0.066
0.079	50.00	0.034
0.056	100.00	0.024
0.048	200.00	0.021
0.047	300.00	0.020
0.046	400.00	0.020
0.046	600.00	0.020
0.045	759.00	0.020
0.045	1000.00	0.019

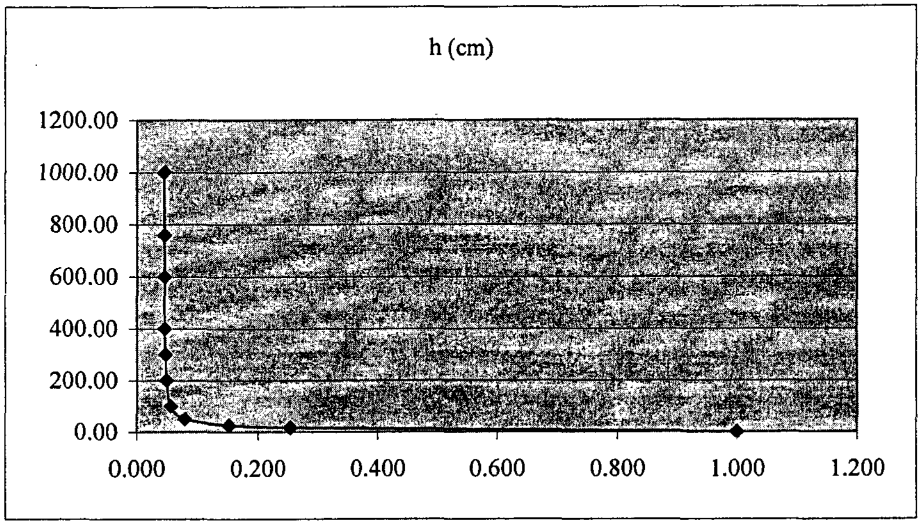


Table 5 Chemical Properties

Diffusivity in air (m^2/day)

	Sand	Caliche	Clay
Benzene	2.03E-01	1.84E-01	1.59E-01
Ethylbenzene	1.77E-01	1.61E-01	1.39E-01
Toluene	1.98E-01	1.80E-01	1.55E-01
Xylene	1.64E-01	1.49E-01	1.28E-01

Partition Coefficients

foc: 0.001

Constituent	Kow (dim)	Koc mL/g	Ksw m3/g	Kaw (dim)	MW g/mol	Solubility mg/L	Vp. atm	log Kow
Benzene	107.2	89.1	8.91E-08	0.224	78.1	1780	0.125	2.03
Ethylbenzene	1412.5	681.0	6.81E-07	0.356	106	152	0.0125	3.15
Toluene	501.2	273.0	2.73E-07	0.273	92.1	515	0.0374	2.7
Xylene	1148.2	550.0	5.50E-07	0.216	106	175	8.71E-03	3.06

Biodegradation

				Howard et al, 1991	
Constituent	Biorate day-1	days	Geo. Mean days	High days	low days
Benzene	8.15E-03	85	85.4	10	730
Ethylbenzene	5.33E-02	13	13.0	6	28
Toluene	1.73E-02	40	39.9	7	228
Xylene	9.63E-03	72	71.5	14	365

Table 6. Model Output As a Function of Depth

Run	File	Constituent	Depth (m)	Soil	Groundwater Target mg/L	Groundwater Result mg/L	Time of Max. (yr)	Soil Input Ct mg/Kg
1	MidB1S	Benzene	1	Sand	0.01	0.00987	2.0	43
2	MidB2S	Benzene	2	Sand	0.01	0.00988	2.0	13
25	MidB3S	Benzene	3	Sand	0.01	0.00989	1.6	4.5
26	MidB4S	Benzene	4	Sand	0.01	0.00999	1.6	2.8
27	MidB5S	Benzene	5	Sand	0.01	0.01000	1.6	1.9
28	MidB6S	Benzene	6	Sand	0.01	0.01000	1.6	1.35
29	MidB7S	Benzene	7	Sand	0.01	0.00998	1.6	0.98
30	MidB8S	Benzene	8	Sand	0.01	0.01000	1.6	0.71
31	MidB9S	Benzene	9	Sand	0.01	0.01000	1.6	0.48
32	MidB0S	Benzene	10	Sand	0.01	0.00998	0.0	0.0307
7	MidE1S	Ethylbenzene	1	Sand	0.75	0.149	4.5	5,800
8	MidE2S	Ethylbenzene	2	Sand	0.75	0.470	4.5	5,800
33	MidE3S	Ethylbenzene	3	Sand	0.75	0.75	4.2	3,350
34	MidE4S	Ethylbenzene	4	Sand	0.75	0.748	4.2	2,100
35	MidE5S	Ethylbenzene	5	Sand	0.75	0.746	4.2	1,440
36	MidE6S	Ethylbenzene	6	Sand	0.75	0.745	4.2	1,040
37	MidE7S	Ethylbenzene	7	Sand	0.75	0.747	4.2	772
38	MidE8S	Ethylbenzene	8	Sand	0.75	0.749	4.2	570
39	MidE9S	Ethylbenzene	9	Sand	0.75	0.749	4.2	399
40	MidE0S	Ethylbenzene	10	Sand	0.75	0.750	0.0	28.7
13	MidT1S	Toluene	1	Sand	0.75	0.484	2.5	7,050
14	MidT2S	Toluene	2	Sand	0.75	0.740	2.5	3,450
41	MidT3S	Toluene	3	Sand	0.75	0.749	2.4	1,360
42	MidT4S	Toluene	4	Sand	0.75	0.747	2.4	840
43	MidT5S	Toluene	5	Sand	0.75	0.749	2.4	570
44	MidT6S	Toluene	6	Sand	0.75	0.748	2.4	405
45	MidT7S	Toluene	7	Sand	0.75	0.747	2.4	295
46	MidT8S	Toluene	8	Sand	0.75	0.745	2.4	215
47	MidT9S	Toluene	9	Sand	0.75	0.746	2.4	149
48	MidT0S	Toluene	10	Sand	0.75	0.744	0.0	10.2
19	MidX1S	Xylene	1	Sand	0.62	0.209	4.0	5,400
20	MidX2S	Xylene	2	Sand	0.62	0.588	4.0	5,400
49	MidX3S	Xylene	3	Sand	0.62	0.618	3.7	2,270
50	MidX4S	Xylene	4	Sand	0.62	0.620	3.7	1,420
51	MidX5S	Xylene	5	Sand	0.62	0.620	3.7	960
52	MidX6S	Xylene	6	Sand	0.62	0.619	3.7	678
53	MidX7S	Xylene	7	Sand	0.62	0.619	3.7	490
54	MidX8S	Xylene	8	Sand	0.62	0.618	3.7	353
55	MidX9S	Xylene	9	Sand	0.62	0.619	3.7	244
56	MidX0S	Xylene	10	Sand	0.62	0.617	0.0	19.2

Table 7. Maximum Soil Concentrations of Key Constituents as a Function of Distance from Water Table.

Distance from Water Table (m)	Benzene mg/kg	Ethylbenzene mg/kg	Toluene mg/kg	Xylenes mg/kg
0-1	0.0307	28.7	10.2	19.2
1-2	0.48	399	149	244
2-3	0.71	570	215	353
3-4	0.98	772	295	490
4-5	1.35	1,040	405	678
5-6	1.9	1,440	570	960
6-7	2.8	2,100	840	1,420
7-8	4.5	3,350	1,360	2,270
8-9	13	5,800	3,450	5,400
9-10	43	5,800	7,050	5,400

COMPUTATIONS

Diffusivity (m2^day)

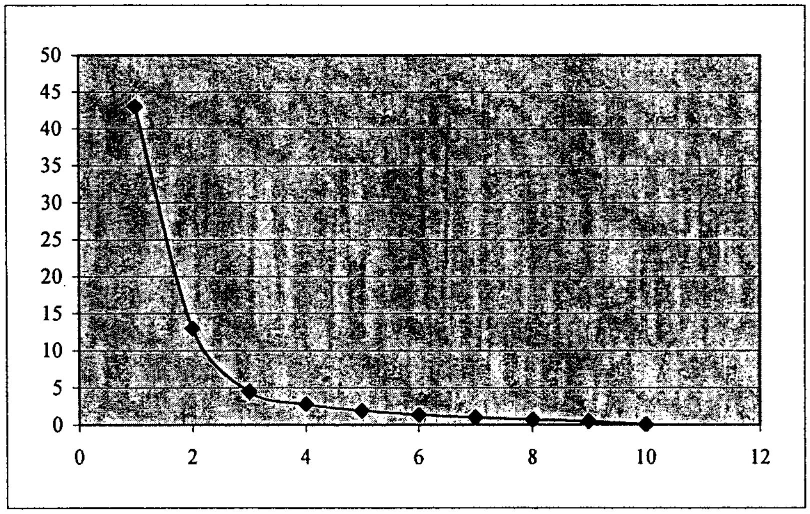
Total Porosity: 0.38
Air saturation (%): 93.2
Air-filled porosity: 0.35416

Constituent	Literature cm2/sec	Ref. Temp deg. C	Site Temp. deg. C	Computed cm2/sec	Diff. m2/day	Corrected Diff. m2/day
Benzene	0.088	25	16.6	0.084	0.728416	1.59E-01
Ethylbenze	0.077	25	16.6	0.074	0.637364	1.39E-01
Toluene	0.088	30	16.6	0.082	0.710469	1.55E-01
Xylene	0.071	25	16.6	0.068	0.587699	1.28E-01

	day-1		Fraction Remaining	Days
Oil degrad	1.00E-04	0.9999	0.6942	3650

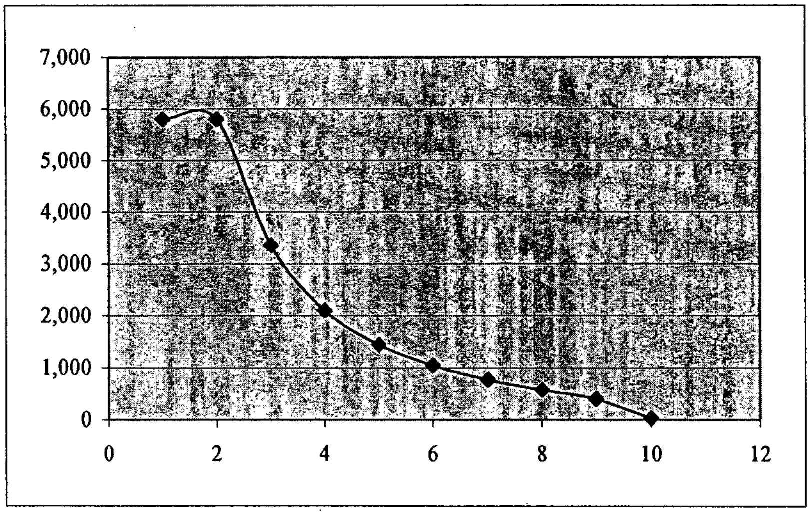
Benzene

Depth (m)	Soil Ct
1	43
2	13
3	4.5
4	2.8
5	1.9
6	1.35
7	0.98
8	0.71
9	0.48
10	0.0307



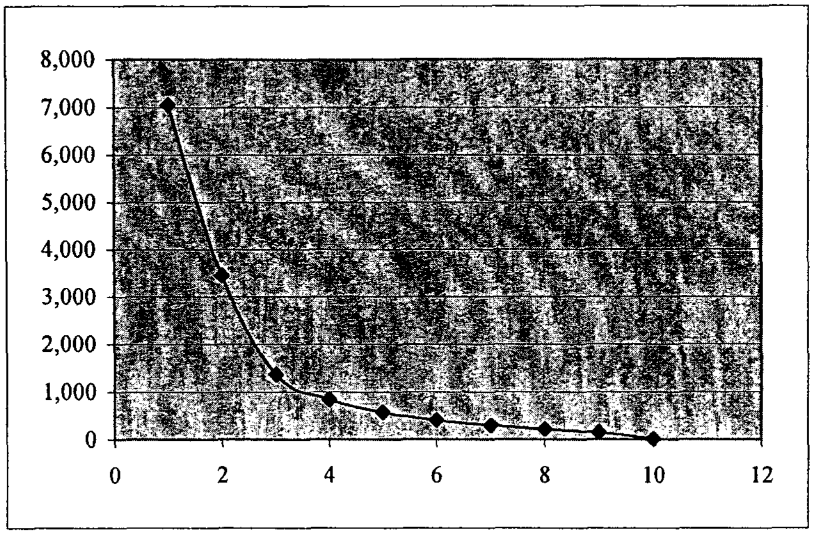
Ethylbenzene

Depth (m)	Soil Ct
1	5,800
2	5,800
3	3,350
4	2,100
5	1,440
6	1,040
7	772
8	570
9	399
10	28.7



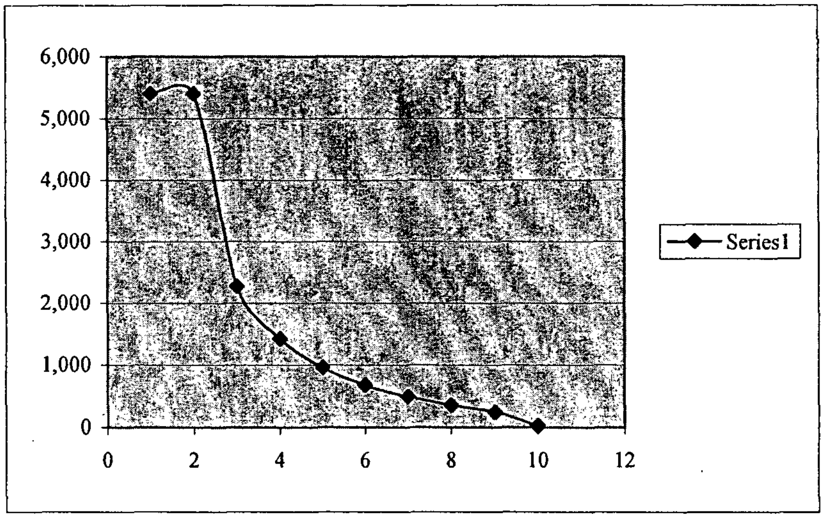
Toluene

Depth (m)	Soil Ct
1	7,050
2	3,450
3	1,360
4	840
5	570
6	405
7	295
8	215
9	149
10	10.2



Xylene

Depth (m)	Soil Ct
1	5,400
2	5,400
3	2,270
4	1,420
5	960
6	678
7	490
8	353
9	244
10	19.2



ARCADIS

Appendix B

Chloride Modeling

APPENDIX B

RICE OPERATING COMPANY
E-15 SWD Terminal Facility

Chloride Modeling

BACKGROUND

Based on analytical results, chlorides were detected at levels above background concentrations. These constituents are the focus of the remaining discussion to evaluate the potential for leaching and impacting groundwater.

Soil moisture levels will gradually increase to field capacity if there is any groundwater recharge at the site (a necessary assumption for there to exist the potential for constituents to leach). As the soil moisture increases, the total mass quantified in the soil samples will reach a new equilibrium between the dissolved and adsorbed phases. This redistribution of constituents and potential leaching in site soils was evaluated for each constituent exceeding background levels.

SOIL PARTITIONING CALCULATIONS

The total mass of a constituent in soil is distributed between two phases, one fraction in the soil moisture and the other fraction adsorbed to the solid phase. The distribution of the mass between the two phases is described by the distribution coefficient (K_d), defined as follows:

$$K_d = \frac{C_S}{C_W} \tag{1}$$

where: $C_S =$ the fraction sorbed to the soil phase (mg/g) and

$C_W =$ the fraction dissolved in pore water (mg/ml).

Equation 1 assumes a linear relationship between the processes of sorption and desorption.

The total mass in the adsorbed phase is computed by multiplying the soil concentration (C_S) by the bulk density of the soil (ρ_b; g/cm^3). The total mass in the dissolved phase in unsaturated conditions is determined by multiplying the pore water concentration (C_W) by the volumetric water content at the field capacity of the soil (θ_V, cm^3/cm^3). The total mass in the soil is calculated as the sum of each portion, as follows:

$$M_T = C_S \cdot \rho_b + C_{W.} \cdot \theta_V \tag{2}$$

where: $M_T =$ the total constituent mass per unit volume of soil (mg/cm^3).

The total mass of a constituent measured in a laboratory sample is expressed as a function of the concentration and the bulk density, using the following equation:

$$M_T = C_T \rho_b \text{ or } C_T = \frac{M_T}{\rho_b} \qquad (3)$$

The distinction between the laboratory measured soil concentration and the true soil concentration is important; the laboratory measured soil concentration represents the mass dissolved in the residual soil water as well as the portion sorbed to the soil. This distinction is also important as it permits interpretation of reported soil concentrations for refractory constituents (i.e., chloride). Representative soil and water concentrations can be computed by dividing equation (2) by ρ_b and substituting equation (1) and (3), yielding:

$$C_T = C_W \left[K_d + \frac{\theta_V}{\rho_b} \right] \qquad (4)$$

Or, in a more useful form, the pore water concentration as a function of the laboratory measured concentration:

$$C_W = \left[\frac{C_T}{K_d + \frac{\theta_V}{\rho_b}} \right] \qquad (5)$$

The soil concentration can be computed from the pore water concentration of a constituent by substituting $C_w + C_s$ for C_T in equation (5), and rearranging, and recalling that the K_d for chloride is 0:

$$C_s = \left(\frac{\theta_v}{\rho_b} + K_d - 1 \right) \qquad (6)$$

Sample calculations utilizing equations (5) and (6) are presented in part 2 of Attachment A.

PERCOLATION ESTIMATE

The ambient groundwater recharge or` percolation rate was estimated, conservatively, to be 1.0 in/yr. The true value is likely ¼ to ½ in/yr. The use of a larger value is considered to be conservative, as it will accelerate the flushing of COCs from the site soils maximizing potential groundwater impacts. A secondary percolation estimate was computed to assess the effects of capping impacted soils. This estimate was computed using the Hydrologic Evaluation of Landfill Performance (HELP) model (Schroder et al., 1995A, 1995B). The HELP model was developed by the USEPA to assess percolation through engineered landfill covers. The HELP model cover design consists of three layers: a soil or vegetative cover, a compacted clay layer, and a foundation layer of native fill. The compacted clay liner was assumed to have a permeability no greater than 1 x 10^{-8}cm/sec. The entire excavation area was assumed to have the potential to generate runoff. The final grade of the soil surface was assumed to be 4 percent, consistent with site landfill closure plan and NM LCRS. The HELP model predicted a flux rate of 0.015 in/yr through the backfill. It should be noted that this value is a conservative overestimate of the true recharge value. The HELP model was developed to ensure that engineering components were adequately designed and to evaluate the merits of engineered alternatives, and as such, consistently over predicts percolation through cover elements. Site conditions support that these are conservative estimates; significant caliche is present in undisturbed soils adjacent to the site. Therefore, it is unlikely that measurable recharge occurs at the site and that there is a low potential for constituents to be leached from site soils.

GROUNDWATER DILUTION FACTOR

The potential impact of the constituents on the groundwater system was assessed by mixing the percolation or flux through Site soils with ambient groundwater. The change in concentration in the local groundwater system directly beneath the site was determined using a mixing model:

$$C_X = \frac{Q_{GW} \cdot C_{GW} + Q_F \cdot C_W}{Q_T} \qquad (7)$$

where; $C_X =$ the mixed groundwater concentration,

$Q_{GW} =$ flux of groundwater through the mixing zone (ft^3/yr ,

$C_{GW} =$ ambient concentration in groundwater (mg/L),

$Q_F =$ water flux through the landfill area (ft^3/yr),

$Q_T =$ total groundwater flux = $Q_{GW} + Q_F$ (ft^3/yr), and

$C_W =$ constituent concentration in the pore water of the backfill soils (mg/L)

The groundwater flux through the mixing zone was computed from Darcy's Law:

$$Q_{GW} = K \cdot i \cdot A \qquad (8)$$

where: $K =$ is the hydraulic conductivity (ft/yr),

$i =$ the hydraulic gradient (ft/ft), and

$A =$ is the cross-sectional area of the aquifer within the mixing zone perpendicular to groundwater flow.

Groundwater beneath the site is approximately 30 feet (10 m) below land surface. There is no site-specific data on the hydraulic conductivity for the limestone; however, there is published hydraulic conductivity data for this geologic formation of 2.0 ft/day. The hydraulic gradient or slope of the water table is estimated to be 0.009 ft/ft, similar to conditions at the 1-9 Junction near Hobbs. The cross-sectional area of the aquifer within the mixing zone was computed to be 1500 ft^2;the narrowest width of the impacted area is approximately 150 feet and the mixing thickness was estimated to be ten feet (screen length). The flux of groundwater through this zone beneath the site is computed to be 10,041 ft^3/yr (0.14 gpm).

POTENTIAL GROUNDWATER IMPACTS FROM RESIDUAL CHLORIDE

Chloride levels in site soils are elevated above background. Similarly, the chemistry of Site groundwater has not been characterized. Based upon ambient groundwater conditions near the 1-9 Junction in Hobbs, ambient groundwater is likely between 100 and 200 mg/L. Therefore, to assess potential impacts, groundwater concentrations were assumed, and maximum allowable soil concentrations were computed that would not result in a degradation of water quality above New Mexico Regulatory limits (250 mg/L). The results are presented in Table 1. Column 1 is the estimated ambient groundwater concentration, column 2 is the maximum allowable soil concentration if the site is covered with natural soils with column 1 groundwater conditions, and column 3 is the maximum allowable soil concentration if the site is covered with a low permeable cover.

Assumptions

Site Area	24,075 sq. ft.	
Infiltration Flux	1 in/yr	
Annual Infiltration	5.496 ft3/day	
Hydraulic Gradient	0.00917 ft/ft	(based upon the Junction 9 Site)
Estimated Saturated Hydraulic Conductivity	2 ft/day	
Estimated Saturated Thickness	I0 ft	(Based upon a typical well screen length)
Estimated Total GW flux through the Site	27.51 ft3/day	(Based upon the narrowest width)

Table 1

	Concentrations			
	Uncapped		Capped	
Groundwater ppm	Pore Water ppm	Soil ppm	Pore Water ppm	Soil ppm
0.0	1,501.4	62.3	83,645.6	3,472.1
50.0	1,251.1	51.9	66,966.5	2,779.7
100.0	1,000.8	41.5	50,287.4	2,087.4
150.0	750.5	31.2	33,608.3	1,395.1
200.0	500.3	20.8	16,929.1	702.7
250.0	250.0	10.4	250.0	10.4

1. A mixing model was used to compute the maximum pore water concentration which would not cause groundwater concentration to exceed regulatory limits. Example calculations assuming ambient groundwater concentrations are 50 mg/L, regulatory limits are 250 mg/L, precipitation recharge is 1 in/yr, and groundwater flux is 5.50 ft^3/day, are summarized below:

$$C_X = \frac{Q_{GW} \cdot C_{GW} + Q_F \cdot C_W}{Q_T} \tag{7}$$

$$250 mg/L = \frac{27.5 ft^3/day \cdot 50 mg/L + 5.50 ft^3/day \cdot C_W}{33.0 ft^3/day}$$

$$C_W = 1{,}251 mg/L$$

2. The equilibrium soil concentration is computed from the pore water concentration using equation 5 from the report:

$$C_W = \frac{C_T}{K_d + \frac{\theta_v}{\rho_b}} \tag{5}$$

$$C_T = C_W + C_S$$

$$C_W = \frac{C_W + C_S}{K_d + \frac{\theta_v}{\rho_b}}$$

$$C_W \cdot K_d + C_W \cdot \frac{\theta}{\rho_b} = C_W + C_S$$

$$C_W \cdot K_d + C_W \cdot C_S = (C_W + C_S)\frac{1}{C_W}$$

$$K_d + \frac{\theta_v}{\rho_b} = \frac{C_S}{C_w}$$

Noting that the K_d for chloride is 0:

$$C_S = C_w\left(\frac{\theta_v}{\rho_b}\right)$$

$$C_S = 26{,}408 mg/L\left(\frac{0.077}{1.855}\right)$$

$$C_S = 1{,}099 mg/kg$$