ARCADIS
Infrastructure · Water · Environment · Buildings

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ENVIRONMENT

Mr. Glenn Von Gonten
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Subject:
State L-2 AP-073
Stage 2 Abatement Plan

Date:
March 27, 2012

Dear Mr. Von Gonten:

On behalf of Chesapeake Energy Corporation, ARCCADIS U.S. Inc. respectfully submits the enclosed Stage 2 Abatement plan for the State L-2 site (AP-073). A Stage 1 Abatement Plan Report was submitted on March 20, 2012. Your review and approval of this Abatement Plan will be appreciated. The landowner, Darr Angell, is anxious for us to complete soil remediation at this site.

If you have any questions please do not hesitate to contact Bradley Blevins at (575) 391-1462 or via e-mail at bblevins@chkenergy or me at (432) 687-5400, e-mail address shall@aracdis-us.com.

Contact:
Sharon Hall

Phone:
432 687-5400

Email:
shall@aracdis-us.com

Our ref:
MT001088

ARCADIS U.S., Inc.
TX Engineering License # F-533

Sincerely,

ARCADIS U.S., Inc.

Sharon E. Hall
Associate Vice President

Copies:
Bradley Blevins- Chesapeake, Hobbs

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Imagine the result

Chesapeake Energy Corporation

State L-2 AP-073

Stage 2 Abatement Plan Proposal

Hobbs, New Mexico

March 27, 2012

ARCADIS

Sharon E Hall

Sharon Hall
Associate Vice President

State L-2 AP-073

Stage 2 Abatement
Plan Proposal

Prepared for:
Chesapeake Energy
Corporation
Hobbs, New Mexico

Prepared by:
ARCADIS U.S., Inc.
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Suite 300
Midland
Texas 79701
Tel 432 687 5400
Fax 432 687 5401

Our Ref.:
MT001088.0001.00001

Date:
March 27, 2012

Figures

Appendices

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Chesapeake Energy Corporation
Hobbs, New Mexico

1. INTRODUCTION

The subject site is a former tank battery site located east of Buckeye, New Mexico. The site was purchased by Chesapeake Energy Corporation (Chesapeake) in April 2004. Chesapeake did not operate the tank battery or the associated well field and began the process of facility abandonment in 2007.

Five monitor wells and nine soil borings have been drilled at the site. Elevated chloride concentrations and limited hydrocarbon compounds were detected in soil samples collected from soil borings and monitoring wells.

2. SUMMARY OF STAGE 1 ABATEMENT ACTIVITIES

Initial site investigation activities were conducted in May of 2007 following abandonment of the tank battery. Stage 1 Abatement activities were conducted during the period of May 2007 through September 2011. Stage 1 Abatement activities included drilling and soil sampling of nine boreholes, drilling and sampling of seven monitor wells, EM 31 and EM 34 surveys, conversion of one monitoring well into a recovery well and recovery of phase-separated hydrocarbons from the recovery well.

New Mexico Oil Conservation Division (NMOCD) was notified of impacts to groundwater at the site via e-mail on May 30, 2007. NMOCD notified Chesapeake in a letter dated June 19, 2007 that a Stage 1 Abatement Plan was required for the site in accordance with Rule 19.

The Stage 1 Abatement Plan was submitted to NMOCD on August 22, 2007. The plan summarized site activities taken to date. The plan proposed the drilling and sampling of a minimum of three additional soil borings and installation and sampling of nine groundwater monitoring wells.

BBC contacted NMOCD via email on April 24, 2010 to inquire about the status of the Stage 1 Abatement Plan approval and Chesapeake's desire to conduct the proposed Stage 1 Abatement Plan activities. On May 27, 2010, NMOCD responded via email that the State was not staffed to review the Abatement Plans (APs) in a timely manner. On June 23, 2010, BBC contacted NMOCD via email to request a waiver of the Public Notice requirement and inform NMOCD that Chesapeake and the landowner were anxious to move forward with the proposed AP activities. NMOCD replied via email on June 23, 2010 stating they were still understaffed to review the AP and could not waive the Public Notice requirement. They advised BBC that Chesapeake could proceed "at

risk." On July 12, 2010 BBC informed NMOCD by registered letter that Chesapeake was planning to start the Stage 1 Assessment on or about August 23, 2010. They further informed NMOCD they would be submitting the required Public Notices, a copy of which was attached to the letter. NMOCD did not respond to the registered letter.

The public notices were published in the Hobbs News-Sun and Lovington Leader on July 22, 2010 and the Albuquerque Journal on July 24, 2010. No comments were received from the public or NMOCD during the 30-day comment period and Chesapeake proceeded with the proposed Stage 1 Abatement Plan activities on August 26, 2010. Copies of correspondence and Public Notice are included in Appendix A.

A detailed description of site activities and results can be found in the report submitted to NMOCD dated March 20, 2012 entitled State L-2 AP-073, Stage 1 Abatement Report (Site Assessment Investigation). Analytical results for soil and groundwater sampling are summarized on Figure 1.

3. STAGE 2 ABATEMENT PLAN PROPOSAL

After review of various remedial options, we propose the following Stage 2 Abatement Plan. The plan addresses soil and groundwater remediation.

3.1 Soil Remediation

The selected remedial option will be the excavation of near-surface soils and installation of clay liners. The anticipated extent and depth of excavation is based on assessment activities (laboratory analysis and visual observation) and is shown in Figure 2. Near surface soils (to a depth of 5 feet below ground surface) with chloride concentrations in excess of 1,000 milligrams per kilogram (mg/kg) and a Total Petroleum Hydrocarbons (TPH) concentration in excess of 1,000 mg/kg will be excavated and disposed. Excavated soils will be disposed at Lea Land Landfill.

Areas where chloride or TPH concentrations are expected to exceed 1,000 mg/kg at depths greater than 5 feet below ground surface soils will be excavated to a depth of 5 feet below ground surface. The area surrounding SB-1 will be excavated to a depth of 2 feet below ground surface. Subsurface chloride impacted soils are not evidenced in this area and elevated TPH concentrations at depth are not likely to inhibit growth of

vegetation. Soils will be screened in the field for chlorides using chloride field test kits and for TPH using a photoionization. Critical samples (samples used to delineate the excavations) will be submitted for laboratory analysis of chlorides and/or TPH. Following excavation, a 12-inch compacted clay layer that meets or exceeds a permeability of equal to or less than 1 x 10^{-8} centimeters per second will be installed in the excavations. The lined excavations will be backfilled with four feet of locally obtained native soil. All of the excavated areas will be re-seeded with native vegetation. Areas that are supporting vegetation will not be disturbed.

Use of the USEPA Multi-Med model demonstrates that the clay liners will mitigate the leaching of chlorides to groundwater. The model predicts that after 7000 years of infiltration through the liner the maximum concentration of chlorides in groundwater will be 150 milligrams per liter (mg/L). The Multi-Med inputs and outputs are included in Appendix A.

3.2 Groundwater Monitoring

One additional groundwater monitoring well will be installed downgradient of the site. The monitoring well will be designated MW-6.

Groundwater samples will be collected from all of the monitoring wells and analyzed for chlorides using USEPA method 9056 for each of four quarters. Groundwater samples from MW-4 will also be analyzed for benzene. Based on sample results for one year (four quarters), sampling frequency will be reviewed and may be revised.

Sampling will be discontinued when eight quarters of sample results indicate chloride and benzene concentrations are below New Mexico Water Quality Control Commission, Title 20, Chapter 6, Part 2 standards. Sample results will be submitted to the NMOCD annually on June 15.

Proposed groundwater remediation is presented in Sections 3.3.

3.3 Groundwater Remediation

Chloride concentrations in groundwater exceed New Mexico Water Quality Control Commission standards in three wells (MW-2, 580 mg/L; MW-4, 548 mg/L and MW-5, 280 mg/L). Benzene concentrations exceed New Mexico Water Quality Control Commission standards in monitoring well MW-4 at a concentration of 0.224 mg/L.

Removal of near-surface soils that are a potential source of chlorides and hydrocarbons in groundwater and lining of excavations with chloride and TPH concentrations in excess of 1,000 mg/kg will mitigate leaching of chlorides to groundwater. Considering the relatively low concentrations of chlorides in groundwater and the fact that soil removal and clay liner infiltration barrier installation will be conducted at this site, we propose monitoring the site for a period of two years before considering pumping of groundwater at this site. With the proposed source removal and mitigation and the severe drought conditions being experienced in this area, we believe it prudent to evaluate if chloride mass removal by pumping is warranted at this site.

4. PUBLIC NOTIFICATION

Written notification of submittal of the Stage 2 Abatement Plan Proposal and site activities will be sent to all surface owners of record within a one-mile radius of the site. NMOCD will be supplied with a list of parties to be notified. Publication of notice of activities will be published in a state-wide circulated newspaper, the Albuquerque Journal, and two county newspapers, the Hobbs-Daily News Sun and the Lovington Leader.

5. REMEDIATION WORK SCHEDULE

Soil remediation activities are expected to be completed in 15 working days (Monday through Friday). Groundwater remediation activities will be ongoing. An estimated completion date for groundwater remediation is not available.

6. REFERENCES

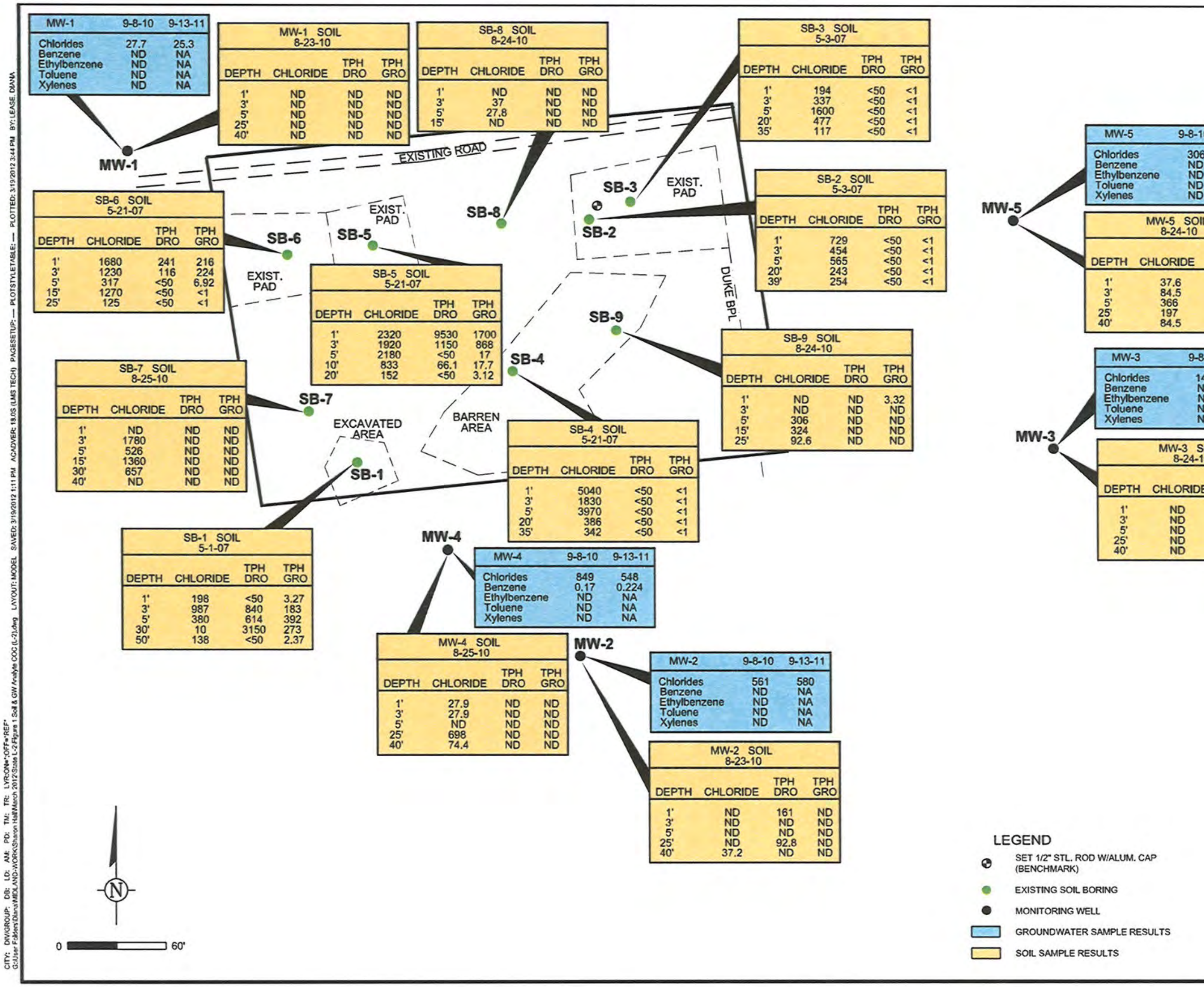
Groundwater Handbook; United States Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information; 1992

New Mexico Water Quality Control Commission, Title 20 Chapter 6, Part 2, Subpart I

State L-2 AP-073 Stage 1 Abatement Report (Site Assessment Investigation); ARCADIS; March 2012

State L-2 Salt Water Disposal Tank Battery, Stage 1 Abatement Plan (Ap-072), BBC International; August 2007

New Mexico Water Quality Control Commission, Title 20 Chapter 6, Part 2, Subpart I



MW-1	9-8-10	9-13-11
Chlorides	27.7	25.3
Benzene	ND	NA
Ethylbenzene	ND	NA
Toluene	ND	NA
Xylenes	ND	NA

MW-1 SOIL 8-23-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	ND	ND	ND
3'	ND	ND	ND
5'	ND	ND	ND
25'	ND	ND	ND
40'	ND	ND	ND

SB-8 SOIL 8-24-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	ND	ND	ND
3'	37	ND	ND
5'	27.8	ND	ND
15'	ND	ND	ND

SB-3 SOIL 5-3-07

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	194	<50	<1
3'	337	<50	<1
5'	1600	<50	<1
20'	477	<50	<1
35'	117	<50	<1

SB-2 SOIL 5-3-07

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	729	<50	<1
3'	454	<50	<1
5'	565	<50	<1
20'	243	<50	<1
39'	254	<50	<1

SB-6 SOIL 5-21-07

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	1680	241	216
3'	1230	116	224
5'	317	<50	6.92
15'	1270	<50	<1
25'	125	<50	<1

SB-5 SOIL 5-21-07

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	2320	9530	1700
3'	1920	1150	868
5'	2180	<50	17
10'	833	66.1	17.7
20'	152	<50	3.12

SB-9 SOIL 8-24-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	ND	ND	3.32
3'	ND	ND	ND
5'	306	ND	ND
15'	324	ND	ND
25'	92.6	ND	ND

SB-7 SOIL 8-25-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	ND	ND	ND
3'	1780	ND	ND
5'	526	ND	ND
15'	1360	ND	ND
30'	657	ND	ND
40'	ND	ND	ND

SB-4 SOIL 5-21-07

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	5040	<50	<1
3'	1830	<50	<1
5'	3970	<50	<1
20'	386	<50	<1
35'	342	<50	<1

SB-1 SOIL 5-1-07

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	198	<50	3.27
3'	987	840	183
5'	380	614	392
30'	10	3150	273
50'	138	<50	2.37

MW-4	9-8-10	9-13-11
Chlorides	849	548
Benzene	0.17	0.224
Ethylbenzene	ND	NA
Toluene	ND	NA
Xylenes	ND	NA

MW-4 SOIL 8-25-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	27.9	ND	ND
3'	27.9	ND	ND
5'	ND	ND	ND
25'	698	ND	ND
40'	74.4	ND	ND

MW-2	9-8-10	9-13-11
Chlorides	561	580
Benzene	ND	NA
Ethylbenzene	ND	NA
Toluene	ND	NA
Xylenes	ND	NA

MW-2 SOIL 8-23-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	ND	161	ND
3'	ND	ND	ND
5'	ND	ND	ND
25'	ND	92.8	ND
40'	37.2	ND	ND

MW-5	9-8-10	9-13-11
Chlorides	306	280
Benzene	ND	NA
Ethylbenzene	ND	NA
Toluene	ND	NA
Xylenes	ND	NA

MW-5 SOIL 8-24-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	37.6	ND	ND
3'	84.5	ND	ND
5'	366	ND	ND
25'	197	ND	ND
40'	84.5	ND	ND

MW-3	9-8-10	9-13-10
Chlorides	145	134
Benzene	ND	NA
Ethylbenzene	ND	NA
Toluene	ND	NA
Xylenes	ND	NA

MW-3 SOIL 8-24-10

DEPTH	CHLORIDE	TPH DRO	TPH GRO
1'	ND	ND	ND
3'	ND	ND	ND
5'	ND	ND	ND
25'	ND	ND	ND
40'	ND	ND	ND

LEGEND

- SET 1/2" STL. ROD W/ALUM. CAP (BENCHMARK)
- EXISTING SOIL BORING
- MONITORING WELL
- GROUNDWATER SAMPLE RESULTS
- SOIL SAMPLE RESULTS

CHESAPEAKE ENERGY CORPORATION
HOBBS, NEW MEXICO
STATE L-2 AP-073 STAGE 2 ABATEMENT PLAN

SOIL & GROUNDWATER ANALYTE CONCENTRATIONS (Milligrams Per Kilogram & Milligrams Per Liter)

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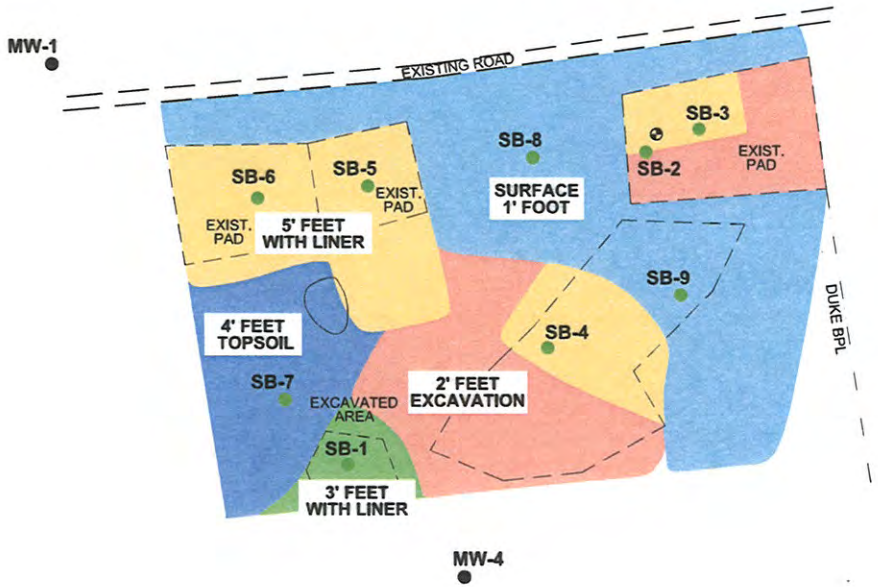
FIGURE 1



MW-5

MW-3

MW-2

LEGEND

- SET 1/2" STL. ROD W/ALUM. CAP (BENCHMARK)
- EXISTING SOIL BORING
- MONITORING WELL
- SURFACE
- 2' FEET
- 3' FEET
- 4' FEET
- 5' FEET

N

0 60'

CHESAPEAKE ENERGY CORPORATION
HOBBS, NEW MEXICO
STATE L-2 AP-073 STAGE 2 ABATEMENT PLAN

PROPOSED EXCAVATION MAP

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FIGURE 2

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Appendix A

Multi-Med Model Inputs and Outputs

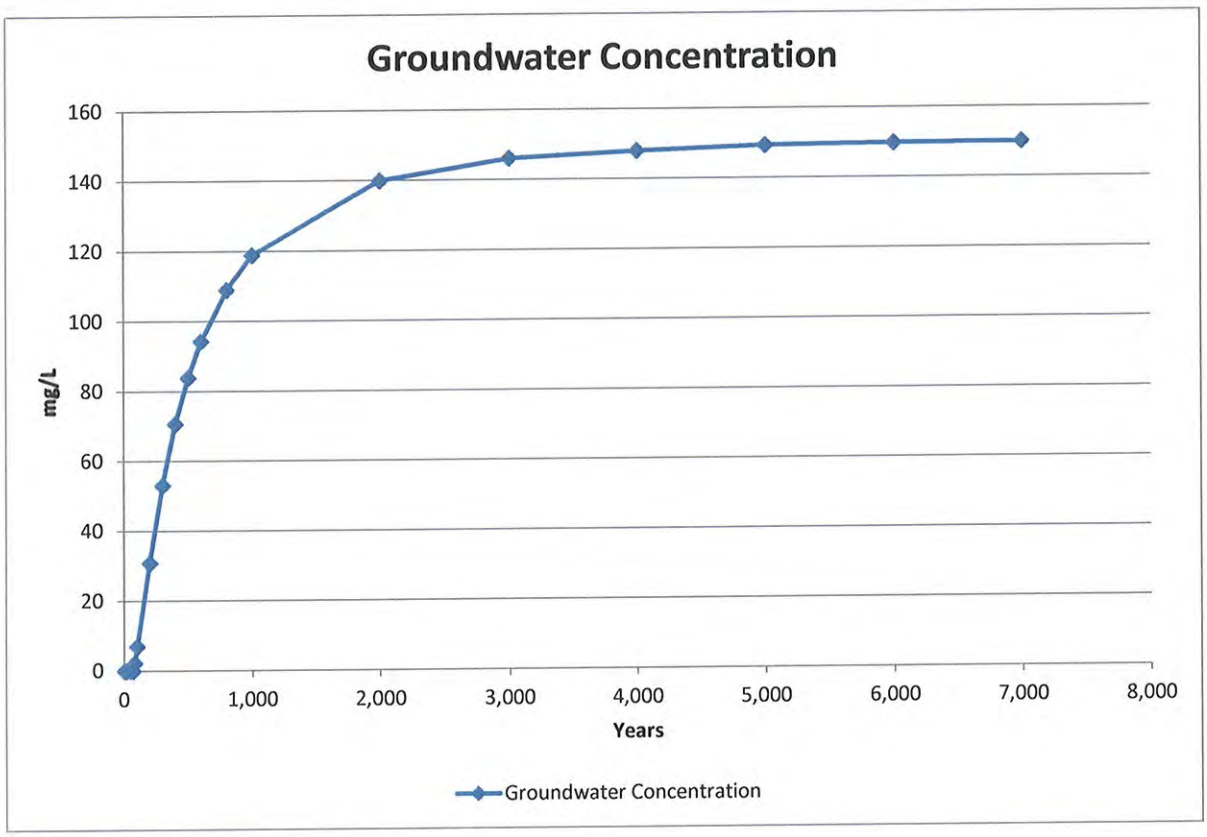
Chesapeake State L-2
Chesapeake Energy Corporation
Buckeye, Lea County, New Mexico
Multimed Model Input and Output (With Liner)

MODEL INPUT AND OUTPUT						MODEL RANGE	
INPUT PARAMETERS						Minimum	Maximum
Unsaturated Zone Flow Parameters							
Depth of Unsaturated Zone	m	46	feet	14.0	m	0.000000001	None
Hydraulic Conductivity	cm/hr	2	ft/day	2.54	cm/hr	0.00000000001	10,000
Unsaturated Zone Porosity	fraction	0.05	fraction	0.05	fraction	0.000000001	0.99
Residual Water Content	fraction	0.01	fraction	0.010	fraction	0.000000001	1
Unsaturated Zone Transport Parameters							
Thickness of Layer	m	46	feet	14.0	m	0.000000001	None
Percent of Organic Matter	%	2.6	%	2.6	%	0	100
Bulk Density	g/cm^3	1.35	g/cm^3	1.35	g/cm^3	0.01	5
Biological Decay Coefficient	1/yr	0	1/yr	0	1/yr	0	None
Aquifer Parameters							
Aquifer Porosity	fraction	0.25	fraction	0.25	fraction	0.000000001	0.99
Bulk Density	g/cm^3	1.35	g/cm^3	1.35	g/cm^3	0.01	5
Aquifer Thickness	m	15	ft	4.6	m	0.000000001	100,000
Hydraulic Conductivity	m/yr	2	ft/day	223	m/yr	0.0000001	100,000,000
Hydraulic Gradient	m/m	0.004	m/m	0.004	m/m	0.00000001	None
Organic Carbon Content	fraction	0.00315	fraction	0.00315	fraction	0.000001	1
Temperature of Aquifer	°C	14.4	°C	14.4	°C	0.00000001	None
pH		6.2		6.2		0.3	14
x-distance Radial Distance from Site to Receptor	m	1	m	1	m	1	None
Source Parameters							
Infiltration Rate from the Facility	m/yr	0.05	in/yr	0.0013	m/yr	0.0000000001	10,000,000,000
Area of Waste Disposal Unit	m^2	52,650	ft^2	4891	m^2	0.01	None
Length Scale of Facility	m	270	feet	82.3	m	0.000000001	10,000,000,000
Width Scale of Facility	m	195	feet	59.4	m	0.000000001	10,000,000,000
Recharge Rate into the Plume	m/yr	0	in/yr	0	m/yr	0	10,000,000,000
Duration of Pulse	yr	7,000	yr	7000	yr	0.000000001	None
Initial Concentration at Landfill	mg/L	5,040	mg/L	5,040	mg/L	0	None
Additional Parameters							
Method				Gaussian		Gaussian	Patch
Name of Chemical Specified				Chloride			

MODEL OUTPUT			
Final Concentration at Landfill	mg/L	150.0	mg/L

MODEL OUTPUT				
Concentration at Landfill	0.0 mg/L	Time	1	yr
	0.0 mg/L		10	yr
	0.0 mg/L		20	yr
	0.0 mg/L		50	yr
	0.0 mg/L		70	yr
	2.2 mg/L		80	yr
	6.9 mg/L		100	yr
	30.8 mg/L		200	yr
	53.0 mg/L		300	yr
	70.6 mg/L		400	yr
	83.8 mg/L		500	yr
	94.3 mg/L		600	yr
	108.9 mg/L		800	yr
	118.8 mg/L		1,000	yr
	139.9 mg/L		2,000	yr
	146.1 mg/L		3,000	yr
	148.0 mg/L		4,000	yr
	149.3 mg/L		5,000	yr
	149.8 mg/L		6,000	yr
	150.0 mg/L		7,000	yr

Chesapeake State L-2
Chesapeake Energy Corporation
Buckeye, Lea County, New Mexico



Chesapeake State L-2
Chesapeake Energy Corporation
Buckeye, Lea County, New Mexico
Multimed Model Input and Output (Without Liner)

MODEL INPUT AND OUTPUT						MODEL RANGE	
INPUT PARAMETERS						Minimum	Maximum
Unsaturated Zone Flow Parameters							
Depth of Unsaturated Zone	m	46	feet	14.0	m	0.000000001	None
Hydraulic Conductivity	cm/hr	2	ft/day	2.54	cm/hr	0.00000000001	10,000
Unsaturated Zone Porosity	fraction	0.05	fraction	0.05	fraction	0.000000001	0.99
Residual Water Content	fraction	0.01	fraction	0.010	fraction	0.000000001	1
Unsaturated Zone Transport Parameters							
Thickness of Layer	m	45	feet	13.7	m	0.000000001	None
Percent of Organic Matter	%	2.6	%	2.6	%	0	100
Bulk Density	g/cm^3	1.35	g/cm^3	1.35	g/cm^3	0.01	5
Biological Decay Coefficient	1/yr	0	1/yr	0	1/yr	0	None
Aquifer Parameters							
Aquifer Porosity	fraction	0.25	fraction	0.25	fraction	0.000000001	0.99
Bulk Density	g/cm^3	1.35	g/cm^3	1.35	g/cm^3	0.01	5
Aquifer Thickness	m	15	ft	4.6	m	0.000000001	100,000
Hydraulic Conductivity	m/yr	2	ft/day	223	m/yr	0.0000001	100,000,000
Hydraulic Gradient	m/m	0.006	m/m	0.006	m/m	0.00000001	None
Organic Carbon Content	fraction	0.00315	fraction	0.00315	fraction	0.000001	1
Temperature of Aquifer	°C	14.4	°C	14.4	°C	0.00000001	None
pH		6.2		6.2		0.3	14
x-distance Radial Distance from Site to Receptor	m	1	m	1	m	1	None
Source Parameters							
Infiltration Rate from the Facility	m/yr	1.50	in/yr	0.0381	m/yr	0.0000000001	10,000,000,000
Area of Waste Disposal Unit	m^2	52,650	ft^2	4891	m^2	0.01	None
Length Scale of Facility	m	270	feet	82.3	m	0.000000001	10,000,000,000
Width Scale of Facility	m	195	feet	59.4	m	0.000000001	10,000,000,000
Recharge Rate into the Plume	m/yr	0	in/yr	0	m/yr	0	10,000,000,000
Duration of Pulse	yr	2,000	yr	2000	yr	0.000000001	None
Initial Concentration at Landfill	mg/L	5,040	mg/L	5,040	mg/L	0	None
Additional Parameters							
Method				Gaussian		Gaussian	Patch
Name of Chemical Specified				Chloride			

MODEL OUTPUT					
Concentration at Landfill	mg/L	4,404	mg/L		1000.0 yr

MODEL OUTPUT					
Concentration at Landfill		0	mg/L	Time	1.0 yr
		0	mg/L		1.5 yr
		0	mg/L		2.0 yr
		0	mg/L		2.5 yr
		13	mg/L		3.0 yr
		522	mg/L		5.0 yr
		1,507	mg/L		10.0 yr
		2,700	mg/L		20.0 yr
		3,098	mg/L		30.0 yr
		3,229	mg/L		40.0 yr
		3,360	mg/L		50.0 yr
		4,016	mg/L		100.0 yr
		4,349	mg/L		150.0 yr
		4,380	mg/L		200.0 yr
		4,397	mg/L		250.0 yr
		4,401	mg/L		300.0 yr
		4,403	mg/L		400.0 yr
		4,404	mg/L		500.0 yr
		4,404	mg/L		800.0 yr
		4,404	mg/L		1,000.0 yr

Chesapeake State L-2
Chesapeake Energy Corporation
Buckeye, Lea County, New Mexico

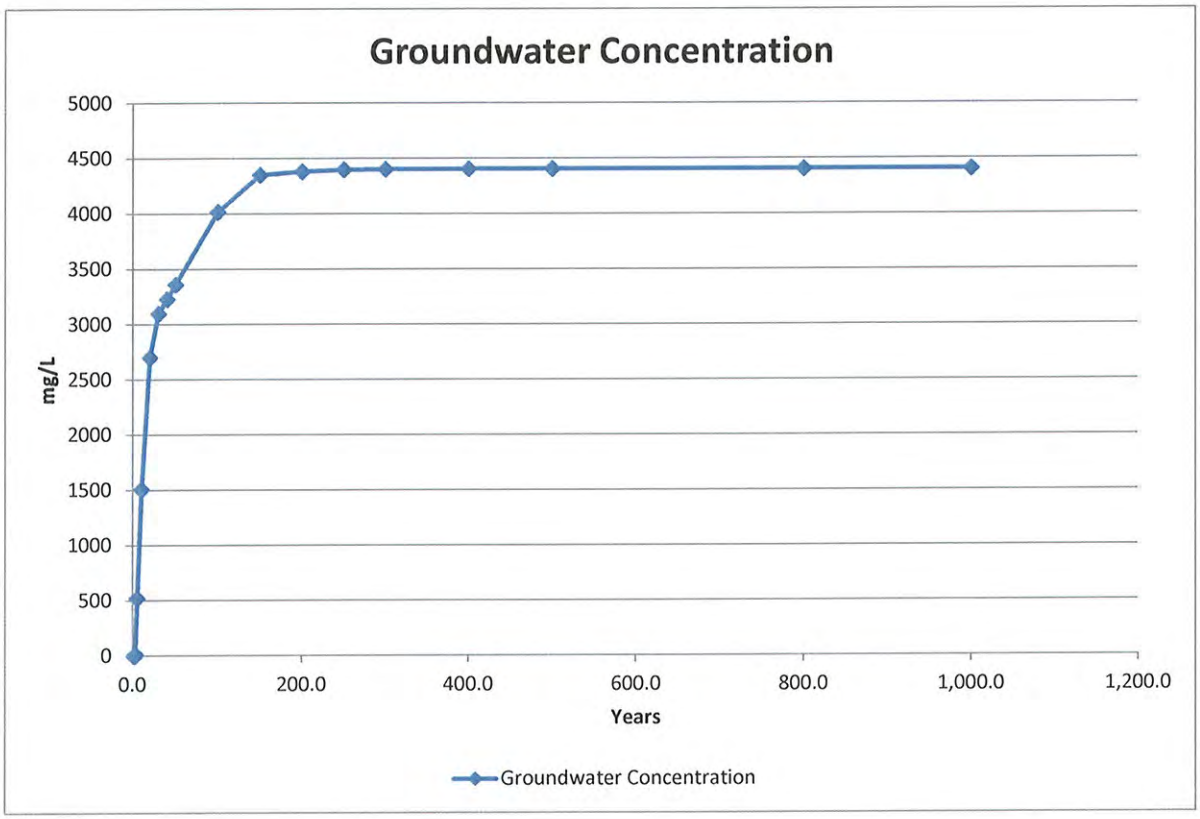


TABLE 6-2. DESCRIPTIVE STATISTICS FOR SATURATED HYDRAULIC CONDUCTIVITY (cm hr-1)

Soil Type	Hydraulic Conductivity (Ks)* x	s	CV	n
Clay**	0.2	0.42	210.3	114
Clay Loam	0.26	0.7	267.2	345
Loam	1.04	1.82	174.6	735
Loamy Sand	14.59	11.36	77.9	315
Silt	0.25	0.33	129.9	88
Silt Loam	0.45	1.23	275.1	1093
Silty Clay	0.02	0.11	453.3	126
Silty Clay Loam	0.07	0.19	288.7	592
Sand	29.7	15.6	52.4	246
Sandy Clay	0.12	0.28	234.1	46
Sandy Clay Loam	1.31	2.74	208.6	214
Sandy Loam	4.42	5.63	127	1183

* n = Sample size, = Mean, s = Standard deviation, CV = Coefficient of variation (percent)

** Agricultural soil, less than 60 percent clay

Sources: From Dean et al. (1989),
Original reference Carsel and Parrish (1988).

TABLE 6-3. TOTAL POROSITY OF VARIOUS MATERIALS

Material	No. of Analyses	Range	Arithmetic Mean
Igneous Rocks			
Weathered granite	8	0.34-0.57	0.45
Weathered gabbro	4	0.42-0.45	0.43
Basalt	94	0.03-0.35	0.17
Sedimentary Materials			
Sandstone	65	0.14-0.49	0.34
Siltstone	7	0.21-0.41	0.35
Sand (fine)	243	0.26-0.53	0.43
Sand (coarse)	26	0.31-0.46	0.39
Gravel (fine)	38	0.25-0.38	0.34
Gravel (coarse)	15	0.24-0.36	0.28
Silt	281	0.34-0.61	0.46
Clay	74	0.34-0.57	0.42
Limestone	74	0.07-0.56	0.3
Metamorphic Rocks			
Schist	18	0.04-0.49	0.38

Sources: From Mercer et al. (1982),
McWhorter and Sunada (1977),
Original reference Morris and Johnson, (1967).

Saturated water content is the maximum volumetric amount of water in the soil when all pores are filled with water. Very often it is assumed that saturated water content equals the porosity n . However, in many cases qS is smaller than n due to the fact that small amounts of air will be trapped in very small pores. Residual water content can be defined as the asymptote of the pF-curve when h gets very high negative values. Usually qR is very small - on the order of 0.001--0.02 for coarse soils but gets as high values as 0.15..0.25 for heavy clay soils. Air entry point ha is

Soil texture. Fine-textured soils can hold much more organic matter than sandy soils for two reasons. First, clay particles form electrochemical bonds that hold organic compounds. Second, decomposition occurs faster in well-aerated sandy soils. A sandy loam rarely holds more than 2% organic matter.

The recharge rate in this model is the net amount of water that percolates directly into the aquifer system outside of the land disposal facility. The recharge is assumed to have no contamination and hence dilutes the groundwater contaminant plume. The recharge rate into the plume can be calculated in a variety of ways. One possibility is to use a model, such as HELP (Hydrologic Evaluation of Landfill Performance) (Schroeder et al., 1984), without any engineering controls (leachate collection system or a liner) to simulate the water balance for natural conditions.

The infiltration rate is the net amount of leachate that percolates into the aquifer system from a land disposal facility. Because of the use of engineering controls and the presence of non-native porous materials in the landfill facility, the infiltration rate will typically be different than the recharge rate. However, it can be estimated by similar

Most soils contain 2-10 percent organic matter. *The Importance of Soil Organic Matter: Key to Drought-Resistant Soil and Sustained Food Production. http://www.fao.org*