Souder, Miller & Associates ♦ 201 S. Halagueno ♦ Carlsbad, NM 88221
(575) 689-7040

RECEIVED
By OCD District 1 at 2:09 pm, Aug 27, 2015

APPROVED Conditional
By OCD District 1 at 2:09 pm, Aug 27, 2015

1. Ensure BLM approval/concurrence.

August 14, 2015

#5B24094-BG1

NMOCD District I
1625 N. French Dr.
Hobbs, NM 88240

SUBJECT: FINAL CLOSURE REPORT FOR INCIDENT GOVERNMENT G SWD, LEA COUNTY, NEW MEXICO

Dear Kellie Jones:

Souder Miller & Associates is pleased to submit the attached Final Closure Report of the remediation of the release site located at the Government G SWD line in Lea County, New Mexico. The purpose of the Final Report is to obtain approval from the New Mexico Oil Conservation Division (NMOCD) for the closure of the release that occurred on New Mexico State Land Office property on October 12, 2006.

Souder, Miller & Associates (SMA) responded at the request of Armstrong Energy Corporation to assess and delineate the release of production fluids associated with the Government G SWD Fed well location. The release was initially reported to NMOCD by Armstrong Energy Corporation on October 12, 2006 and was a result of a flow line failure. The table below summarizes information regarding the release. Results of the assessment, delineation, and remedial activities follow in the attached closure report.

Table 1: Release information and Site Ranking

Name	Government G SWD line				
Location	Incident Number	API Number	Section, Township, Range		
	RP#1088		(Unit M)	Section 25	T 19S, R 34E NMPM
Estimated Date of Release	12-Oct-06				
Date Reported to NMOCD	12-Oct-06				
Reported by	Bruce A Stubbs, Armstrong Energy Corp				
Land Owner	Bureau Of Land Management				
Reported To	NM Oil Conservation Division (NMOCD)				
Source of Release	Flow line failure				
Released Material	Produced Water and Crude Oil				
Released Volume	70 bbls Produced Water 2 bbls Crude Oil				
Recovered Volume	15 bbls Produced Water				
Net Release	55 bbls Produced Water				
Nearest Waterway	The Pecos River is over forty miles to the west of the location.				

Depth to Groundwater	Estimated to be 110 feet
Nearest Domestic Water Source	Greater than 1,000 feet
NMOCD Ranking	0
SMA Response Dates	
Subcontractors	
Disposal Facility	
Estimated Yd^3 Contaminated Soil Excavated and Disposed	

Attached is a copy of the C-141 final located in Appendix B. For questions or comments pertaining to the release or the attached Closure Report please feel free to contact either of us.

Submitted by:

SOUDER, MILLER & ASSOCIATES

J. Austin Weyant

Austin Weyant
Project Scientist

Reviewed by:

Cynthia Gray, CHMM
Senior Scientist

FINAL CLOSURE REPORT FOR INCIDENT 1RP-1088

ARMSTRONG ENERGY CORP

GOVERNMENT "G" SWD LINE
SECTION 25, T19S R34E, NMPM
LEA COUNTY, NM

Prepared for:
Armstrong Energy Corp
P.O. Box 1973
Roswell, NM 88202

Prepared by:
Souder, Miller & Associates
201 S. Halagueno
Carlsbad, NM 88221
575-689-7040

August 14, 2015
SMA Reference
5B24094 BG1

Table of Contents

Figures:

Tables:

Appendices:

1.0 Introduction

On behalf of Armstrong Energy Corporation, SMA has prepared this report that describes the assessment, initial delineation by Armstrong Energy Corp, and subsequent mitigation of a release associated with the Government G SWD Fed release site. The site is located in Section 25, T 19S, R 34E NMPM, Lea County, New Mexico, on land owned by the Bureau Land Management. Figure 1 illustrates the vicinity and location of the site. Armstrong Energy Corporation tasked Souder Miller & Associates to resample and assess the release location.

2.0 Site Ranking and Land Jurisdiction

The release site is located approximately 40 mile east of the Pecos River, in an area owned by the State with an elevation of approximately 3,750 feet above sea level. After evaluation of the site using aerial photography and topographic maps, depth to groundwater is estimated to be less than 110 feet below ground surface (bgs).

SMA searched the New Mexico State Engineer's Office online water well database for water wells in the vicinity of the release. One well is located within a one mile radius of the site. Figure 1 depicts the site vicinity and Figure 2 shows the site itself. The physical location of this release is within the jurisdiction of NMOCD.

Based on the NMOCD Guidelines Ranking Criteria, this release location has been assigned a NMOCD ranking of 0 which requires a soil remediation standard of 10 parts per million (ppm) benzene, 50 ppm combined benzene, toluene, ethyl-benzene, and total xylenes (BTEX), and 5000 ppm total petroleum hydrocarbons (TPH). Table 1 illustrates site ranking rationale.

3.0 Assessment and Initial Results

On July 9, 2015, after receiving 811 clearance, SMA field personnel assessed the remediated release area onsite with a gas powered auger, Photo Ionization Detector (PID), and a mobile chlorides titration kit EPA method 9045D meter. The potentially affected area was found to be approximately 75 feet long and 50 feet wide. The site delineation samples were taken to depths of four feet (bsg). Bottom hole samples were found to exhibit only background levels of all contaminants of concern in all the historic spill areas. For additional information on the initial soil results and site assessment, please refer to the NMOCD approved work plan (Soil Remediation Workplan for Incident 1RP-1088. Specific sample locations for all samples are depicted on Figure 2 (Sample Location Map) along with sampling details. Field screening results are noted in Table 2 in the appendices. All samples were collected and processed according to NMOCD soil sampling procedures. Because the spilled material was limited to produced water and field screening did not indicate the presence of petroleum and prior sampling by Armstrong Energy Corp employees were negative for TPH or BTEX, the samples were sent under chain-of-custody protocols to Hall Environmental Analysis Laboratory for analysis for Total Chlorides using EPA Method 300.0.

4.0 Delineation and Ground Water Modeling Summary

Armstrong Energy Corporation (AEC) collected surface composite samples from the location on 5/29/15 as shown in Appendix A. Because of the fine mist caused by the flow-line leak and large area covered none of the surface samples collected by AEC showed elevated or plant growth limiting levels of contaminates. Chloride levels were well below 1000 ppm and all results for TPH and BTEX were below NMOCD action levels for contaminants of concern.

SMA resampled the location and collecting within three feet of the original AEC composite samples down to a depth of 4 feet (bgs). SMA conducted field EC EPA method 9045D and found slightly higher than background concentrations in the spill area, all were below the USDA recommendations for the natural vegetation see (Appendix D).

To meet the request of the NMOCD District 2 Engineer SMA used API's AMIGO online decision support tool to help assess the threat to groundwater posed by the produced water (brine) release. This screening tool was used by SMA to help evaluate AEC remedial response and the potential impacts to the environment and property. The HYDRUS-1D unsaturated flow model results from southeastern New Mexico and a simple ground water mixing model was used to estimate chloride concentrations in the vadose zone and in an underlying water table aquifer, all raw results and model inputs are in Appendix C.

5.0 Conclusions and Recommendations

NMOCD Guidelines for Remediation of Leaks, Spills, and Releases have established the following action levels for contaminants of concern with a site ranking of 0: 10 ppm (mg/kg) Benzene, 50 ppm total BTEX, and 5000 ppm TPH. The release consisted of produced water and evidence of petroleum impacts was not found during the initial assessment and delineation.

Laboratory analytical results for all final closure samples collected were below NMOCD action levels for Benzene, BTEX, and TPH as well as below laboratory detection limits for the methods used. No further remedial activities are recommended.

Soil contaminant concentrations are illustrated in Figure 2. A summary of laboratory analytical results is included in Table 3. Laboratory reports are included in Appendix C.

Photo documentation is available by request.

6.0 Closure and Limitations

The scope of our services consisted of the performance of a preliminary spill assessment, verification of release stabilization, regulatory liaison, and preparation of this Remediation Workplan. All work has been performed in accordance with generally accepted professional environmental consulting practices for oil and gas releases in the Permian Basin in New Mexico.

If there are any questions regarding this report, please contact either Austin Weyant at 575-689-7040 or Cindy Gray at 505-325-7535.

Submitted by:

SOUDER, MILLER & ASSOCIATES

J. Austin Weyant

Austin Weyant
Project Scientist

Reviewed by:

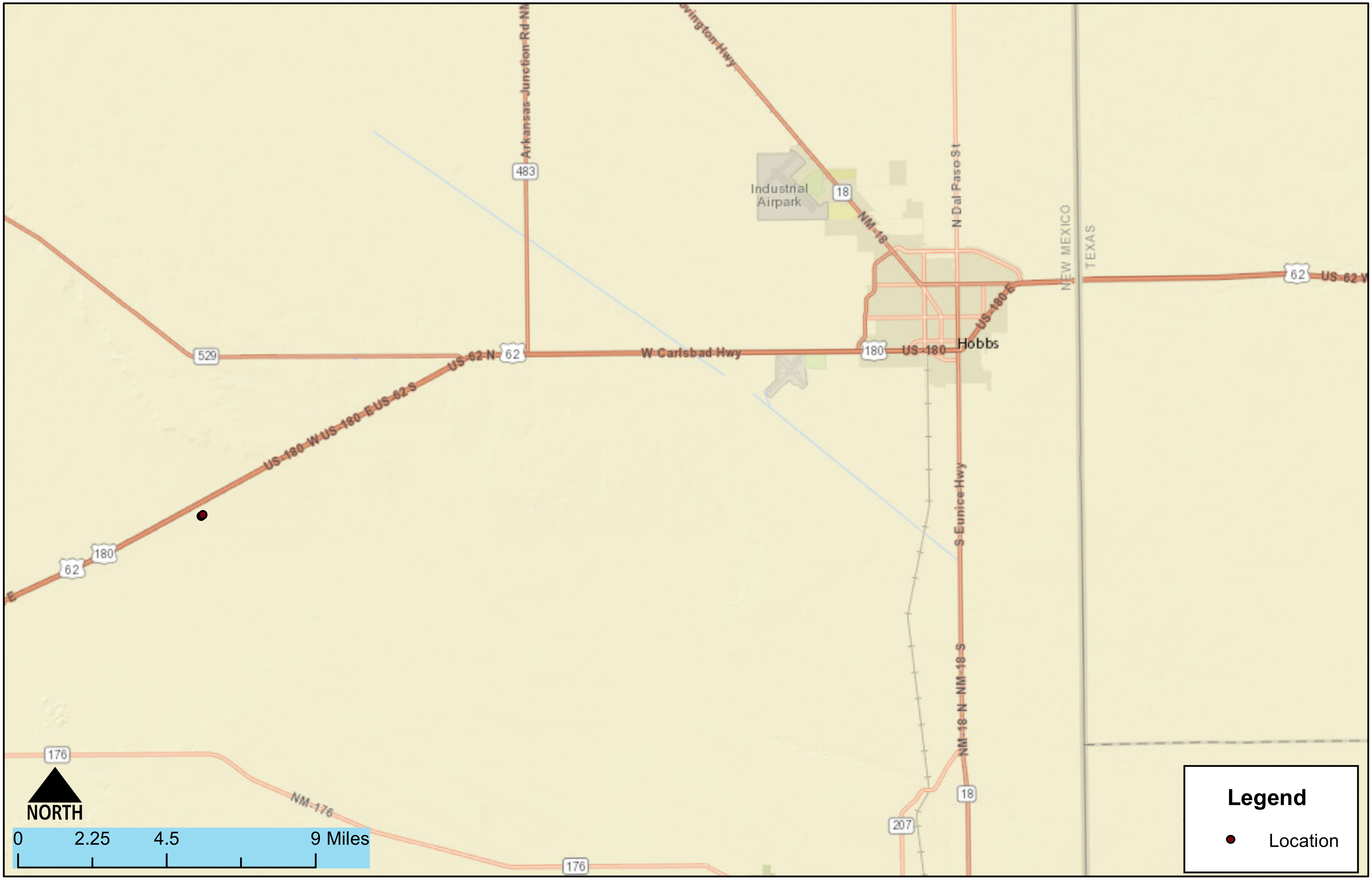
Cynthia Gray, CHMM
Senior Scientist

Figures:

Tables:

Appendices:

FIGURE 1
VICINITY MAP



Detailed Site and Sample Map
Armstrong- Superior Federal G SWD
Hobbs, New Mexico

Figure 1

Revisions

By: Date: Descr:

By: Date: Descr:

Drawn Lucas Middleton

Checked

Approved

SMA

201 South Halaguena Street
Carlsbad, New Mexico 88221
(575) 689-7040
www.soudermiller.com
Serving the Southwest & Rocky Mountains

Date Saved: 8/20/2015

Document: C:\Users\lcm\Documents\GIS DATA\MAPS\Blank- Figure 1 BG1 - Superior Federal G SWD.mxd

FIGURE 2

DETAILED SITE AND SAMPLE MAP

Detailed Site and Sample Map
Armstrong- Superior Federal G SWD
Hobbs, New Mexico

Figure 2

Revisions
By: Date: Descr:
By: Date: Descr:

Drawn Lucas Middleton
Checked
Approved

SMA

201 South Halaguena Street
Carlsbad, New Mexico 88221
(575) 689-7040
www.soudermiller.com
Serving the Southwest & Rocky Mountains

Date Saved:
8/6/2015

Document: C:\Users\lcm\Documents\GIS DATA\MAPS\Blank- Figure 2 BG1 - Superior Federal G SWD.mxd

FIGURE 3

ELECTRICAL CONDUCTIVITY CORRELATION TO EPA METHOD 300 GRAPH

Figure 4: Electrical Conductivity Correlation to EPA Method 300 Graph

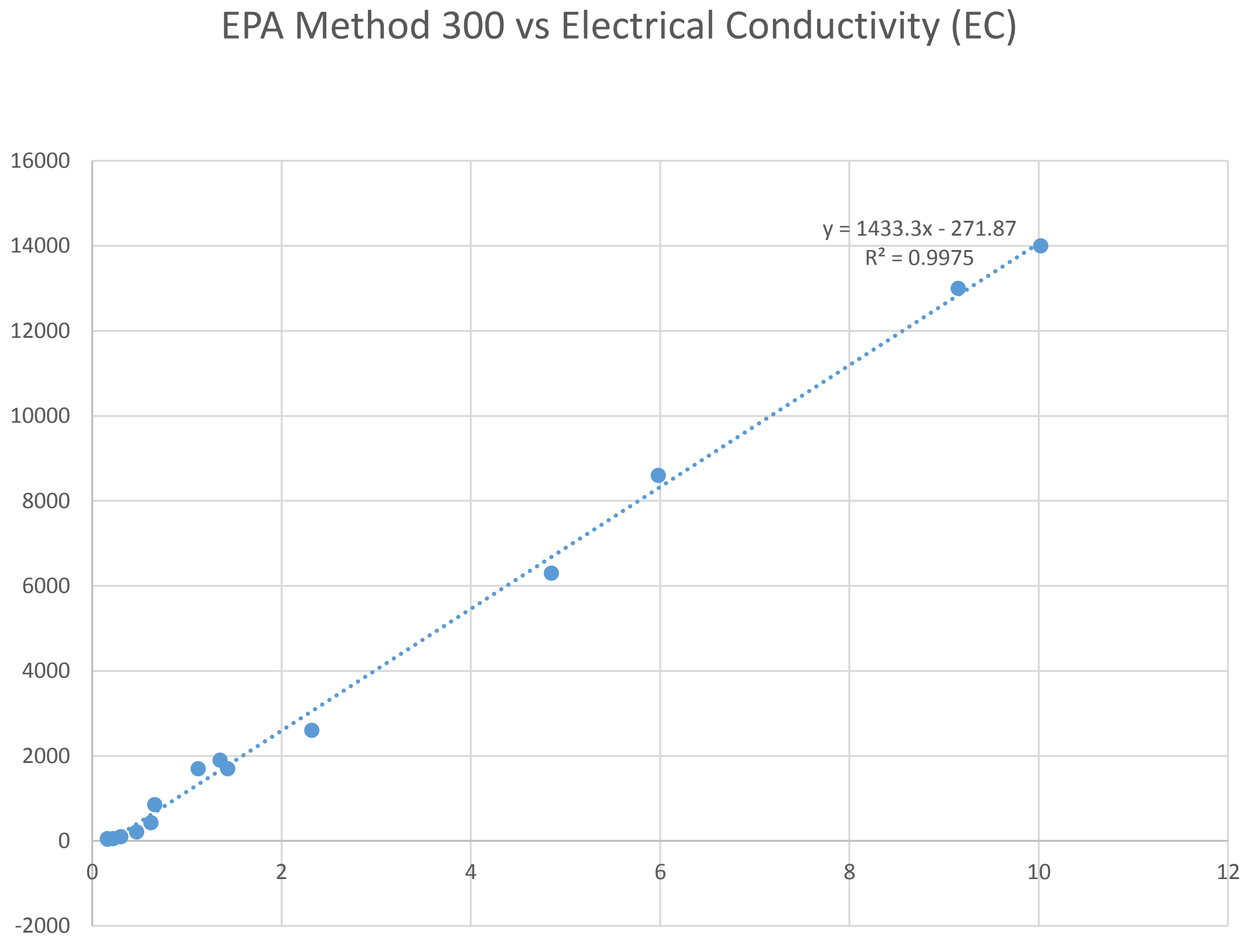


TABLE 1

RELEASE INFORMATION AND SITE RANKING

Depth to Groundwater	NMOCD Numeric Rank for this Site	Source for Ranking	Notes
< 50 BGS = 20		USGS Topo Maps; NMOSE Database	No wells located within a 1 mile of the location
50' to 99' = 10			
>100' = 0	0		
Ranking Criteria for Horizontal Distance to Nearest Surface Water	**NMOCD Numeric Rank for this Site**	**Source for Ranking**	**Notes**
< 200' = 20		USGS Topo Maps; Google Earth (An unnamed wash ~2000' to the west); PRCC Mapping Tool	
200' - 1000' = 10			
>1000' = 0	0		
Ranking Criteria for Horizontal Distance to a Water Well or Water Source	**NMOCD Numeric Rank for this Site**	**Source for Ranking**	**Notes**
<1000' from a water source? <200' from a private domestic water source? YES OR NO to BOTH. YES = 20, NO = 0		NM State Engineer Water Well Database	No wells in Sections
	0		
Total Site Ranking	**0**		
Soil Remediation Standards	**0 to 9**	**10 to 19**	**>19**
Benzene	**10 PPM**	**10 PPM**	**10 PPM**
BTEX	**50 PPM**	**50 PPM**	**50 PPM**
TPH	**5000 PPM**	**1000 PPM**	**100 PPM**

TABLE 2

SUMMARY OF FIELD SCREENING

Table 2: Summary of Field Screening Results

1RP-1088 Government G SWD Flow-line

Produced Water

FIELD SCREENING RESULTS SUMMARY

Date	Time	Field Screening Reference	Sample Depth (Feet BGS)	Chlorides Results	Lab Sample Collected Y/N
7/9/2015	12:00	ARM 4-1	2'	89	N
7/9/2015	12:00	ARM 4-2	3'	86	N
7/9/2015	12:00	ARM 5-1	2'	100	N
7/9/2015	12:00	ARM 5-2	3'	107	N
7/9/2015	12:00	ARM 6-1	2'	58	N
7/9/2015	12:00	ARM 6-2	3'	52	N
7/9/2015	12:00	BG 1	1'	48	N
7/9/2015	12:00	BG 2	1'	50	N

Enterprise Productions
Table 3: Summary of Excavation Field Screening Results

Name
Release Type
Date

FIELD SCREENING RESULTS SUMMARY

Date	Time	Field Screening Reference	Sample Depth (Feet BGS)	PID Reading	Lab Sample Collected Y/N
7/9/2015	1:00pm	ARM-4	4'	ND	Y
7/9/2015	1:00pm	ARM-5	4'	ND	Y
7/9/2015	1:00pm	ARM-6	4'	ND	Y
7/9/2015	1:00pm	BG-1	1'	ND	Y

TABLE 3

SUMMARY OF LABORATORY ANALYSES

Table 3: Summary of Laboratory Analyses

Analytical Report- 1508252/ H501358	Sample Number on Figure 2 Map	Sample Date	Depth	BTEX ppm	Benzene mg/Kg	GRO mg/Kg	DRO mg/Kg	Cl- mg/Kg
1508252-001	ARM4	7/9/2015	4'	N/A	N/A	N/A	N/A	100
1508252-002	ARM5	5/22/2015	4'	N/A	N/A	N/A	N/A	80
1508252-003	ARM6	5/22/2015	4'	N/A	N/A	N/A	N/A	46
H501358-03	G Sample #1	6/2/2015	1'	N/A	N/A	BDL	703	96
H501358-04	G Sample #2	6/2/2015	1'	N/A	N/A	BDL	113	80

APPENDIX A

LABORATORY ANALYTICAL REPORTS

HALL
ENVIRONMENTAL
ANALYSIS
LABORATORY

Hall Environmental Analysis Laboratory
4901 Hawkins NE
Albuquerque, NM 87109
TEL: 505-345-3975 FAX: 505-345-4107
Website: www.hallenvironmental.com

August 11, 2015

Austin Weyant
Souder, Miller & Associates
201 S Halagueno
Carlsbad, NM 88221
TEL: (575) 689-7040
FAX

RE: Government G OrderNo.: 1508252

Dear Austin Weyant:

Hall Environmental Analysis Laboratory received 3 sample(s) on 8/6/2015 for the analyses presented in the following report.

These were analyzed according to EPA procedures or equivalent. To access our accredited tests please go to www.hallenvironmental.com or the state specific web sites. In order to properly interpret your results it is imperative that you review this report in its entirety. See the sample checklist and/or the Chain of Custody for information regarding the sample receipt temperature and preservation. Data qualifiers or a narrative will be provided if the sample analysis or analytical quality control parameters require a flag. When necessary, data qualifers are provided on both the sample analysis report and the QC summary report, both sections should be reviewed. All samples are reported, as received, unless otherwise indicated. Lab measurement of analytes considered field parameters that require analysis within 15 minutes of sampling such as pH and residual chlorine are qualified as being analyzed outside of the recommended holding time.

Please don't hesitate to contact HEAL for any additional information or clarifications.

ADHS Cert #AZ0682 -- NMED-DWB Cert #NM9425 -- NMED-Micro Cert #NM0190

Sincerely,

Andy

Andy Freeman
Laboratory Manager
4901 Hawkins NE
Albuquerque, NM 87109

CLIENT: Souder, Miller & Associates **Lab Order:** 1508252
Project: Government G

Lab ID: 1508252-001 **Collection Date:** 7/9/2015 11:00:00 AM
Client Sample ID: ARM4 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
EPA METHOD 300.0: ANIONS							Analyst: **LGT**
Chloride	100	30	H	mg/Kg	20	8/7/2015 2:19:32 PM	20668

Lab ID: 1508252-002 **Collection Date:** 7/9/2015 11:00:00 AM
Client Sample ID: ARM5 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
EPA METHOD 300.0: ANIONS							Analyst: **LGT**
Chloride	80	30	H	mg/Kg	20	8/7/2015 2:31:57 PM	20668

Lab ID: 1508252-003 **Collection Date:** 7/9/2015 11:00:00 AM
Client Sample ID: ARM6 **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed	Batch ID
EPA METHOD 300.0: ANIONS							Analyst: **LGT**
Chloride	46	30	H	mg/Kg	20	8/7/2015 2:44:21 PM	20668

Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

Qualifiers:

*	Value exceeds Maximum Contaminant Level.	B	Analyte detected in the associated Method Blank
D	Sample Diluted Due to Matrix	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Reporting Limit	P	Sample pH Not In Range
R	RPD outside accepted recovery limits	RL	Reporting Detection Limit
S	% Recovery outside of range due to dilution or matrix		

QC SUMMARY REPORT

Hall Environmental Analysis Laboratory, Inc.

WO#: **1508252**

11-Aug-15

Client: Souder, Miller & Associates

Project: Government G

Sample ID **MB-20668**	SampType: **MBLK**			TestCode: **EPA Method 300.0: Anions**						
Client ID: **PBS**	Batch ID: **20668**			RunNo: **28069**						
Prep Date: **8/7/2015**	Analysis Date: **8/7/2015**			SeqNo: **845462**	Units: **mg/Kg**					
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	ND	1.5								

Sample ID **LCS-20668**	SampType: **LCS**			TestCode: **EPA Method 300.0: Anions**						
Client ID: **LCSS**	Batch ID: **20668**			RunNo: **28069**						
Prep Date: **8/7/2015**	Analysis Date: **8/7/2015**			SeqNo: **845463**	Units: **mg/Kg**					
Analyte	Result	PQL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	15	1.5	15.00	0	100	90	110			

Qualifiers:

*	Value exceeds Maximum Contaminant Level.	B	Analyte detected in the associated Method Blank
D	Sample Diluted Due to Matrix	E	Value above quantitation range
H	Holding times for preparation or analysis exceeded	J	Analyte detected below quantitation limits
ND	Not Detected at the Reporting Limit	P	Sample pH Not In Range
R	RPD outside accepted recovery limits	RL	Reporting Detection Limit
S	% Recovery outside of range due to dilution or matrix		

HALL
ENVIRONMENTAL
ANALYSIS
LABORATORY

Hall Environmental Analysis Laboratory
4901 Hawkins NE
Albuquerque, NM 87109
TEL: 505-345-3975 FAX: 505-345-4107
Website: www.hallenvironmental.com

Sample Log-In Check List

Client Name: SMA-CARLSBAD Work Order Number: 1508252 RcptNo: 1

Received by/date: CS 08/06/15

Logged By: **Lindsay Mangin** 8/6/2015 10:05:00 AM

Completed By: **Lindsay Mangin** 8/6/2015 3:11:42 PM

Reviewed By: mg 08/06/15

Chain of Custody

1. Custody seals intact on sample bottles? Yes ☐ No ☐ Not Present ☑
2. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
3. How was the sample delivered? UPS

Log In

4. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
5. Were all samples received at a temperature of >0° C to 6.0°C Yes ☑ No ☐ NA ☐
6. Sample(s) in proper container(s)? Yes ☑ No ☐
7. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
8. Are samples (except VOA and ONG) properly preserved? Yes ☑ No ☐
9. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
10. VOA vials have zero headspace? Yes ☐ No ☐ No VOA Vials ☑
11. Were any sample containers received broken? Yes ☐ No ☑
12. Does paperwork match bottle labels? Yes ☑ No ☐
(Note discrepancies on chain of custody)
13. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
14. Is it clear what analyses were requested? Yes ☑ No ☐
15. Were all holding times able to be met? Yes ☐ No ☑
(If no, notify customer for authorization.)

\# of preserved bottles checked for pH: ________
(<2 or >12 unless noted)
Adjusted? ________
Checked by: ________

Special Handling (if applicable)

16. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: ________ Date ________
By Whom: ________ Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding: ________
Client Instructions: ________

17. Additional remarks:

Per Austin: Run samples out of hold.

18. **Cooler Information**

Cooler No	Temp °C	Condition	Seal Intact	Seal No	Seal Date	Signed By
1	4.6	Good	Yes			

Chain-of-Custody Record

Client: Souder Miller And Associates

Mailing Address: 201 S. Halagueno
Carlsbad, NM 88220

Phone #: 575-689-5351

email or Fax#: lucas.middleton@soudermiller.com

QA/QC Package:
☐ Standard ☐ Level 4 (Full Validation)

Accreditation:
☐ NELAP ☐ Other

☐ EDD (Type)

Turn-Around Time: ☒ ~~Standard~~ ☑ Rush

Project Name: Goverment G

Project #: IRP-1088

Project Manager:

Sampler: Lcm / BN

On Ice: ☒ Yes ☐ No

Sample Temperature: 5.6 - 1.0cf = 4.6°C

HALL ENVIRONMENTAL ANALYSIS LABORATORY

www.hallenvironmental.com
4901 Hawkins NE - Albuquerque, NM 87109
Tel. 505-345-3975 Fax 505-345-4107

Analysis Request

Date	Time	Matrix	Sample Request ID	Container Type and #	Preservative Type	HEAL No. 1508252	BTEX + MTBE + TMB's (8021)	BTEX + MTBE + TPH (Gas only)	TPH Method 8015B (Gas/Diesel)	TPH (Method 418.1)	EDB (Method 504.1)	8310 (PNA or PAH)	RCRA 8 Metals	Anions (F, [✓ Cl], NO_3, NO_2, PO_4, SO_4)	8081 Pesticides / 8082 PCB's	8260B (VOA)	8270 (Semi-VOA)					Air Bubbles (Y or N)
7-9-15	1100	Soil	ARM 4	4oz		-001								✓								
7-9-15	1100	Soil	ARM 5	4oz		-002								✓								
7-9-15	1100	soil	ARM 6	4oz		-003								✓								

Date:	Time:	Relinquished by:	Received by:	Date	Time
			Celine Sun	08/06/15	1005
Date:	Time:	Relinquished by:	Received by:	Date	Time

Remarks: RW SAMPLES "HOLD" / Send MRO Separat
Cut of

If necessary, samples submitted to Hall Environmental may be subcontracted to other accredited laboratories. This serves as notice of this possibility. Any sub-contracted data will be clearly notated on the analytical report.

CARDINAL
Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

June 02, 2015

BRUCE STUBBS
ARMSTRONG ENERGY CORP
P. O. BOX 1973
ROSWELL, NM 88202

RE: SOIL SAMPLES

Enclosed are the results of analyses for samples received by the laboratory on 05/29/15 13:00.

Cardinal Laboratories is accredited through Texas NELAP under certificate number T104704398-13-5. Accreditation applies to drinking water, non-potable water and solid and chemical materials. All accredited analytes are denoted by an asterisk (*). For a complete list of accredited analytes and matrices visit the TCEQ website at www.tceq.texas.gov/field/qa/lab_accred_certif.html.

Cardinal Laboratories is accreditated through the State of Colorado Department of Public Health and Environment for:

Method EPA 552.2	Haloacetic Acids (HAA-5)
Method EPA 524.2	Total Trihalomethanes (TTHM)
Method EPA 524.4	Regulated VOCs (V1, V2, V3)

Accreditation applies to public drinking water matrices.

This report meets NELAP requirements and is made up of a cover page, analytical results, and a copy of the original chain-of-custody. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Celey D. Keene

Celey D. Keene
Lab Director/Quality Manager

Analytical Results For:

ARMSTRONG ENERGY CORP
BRUCE STUBBS
P. O. BOX 1973
ROSWELL NM, 88202
Fax To: (575) 622-2512

Received:	05/29/2015	Sampling Date:	05/29/2015
Reported:	06/02/2015	Sampling Type:	Soil
Project Name:	SOIL SAMPLES	Sampling Condition:	** (See Notes)
Project Number:	NONE GIVEN	Sample Received By:	Jodi Henson
Project Location:	NOT GIVEN		

Sample ID: SUPERIOR FED 5 #1 (H501358-01)

Chloride, SM4500Cl-B **mg/kg** **Analyzed By: CK**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**224**	16.0	06/01/2015	ND	416	104	400	3.77	

TPH 8015M **mg/kg** **Analyzed By: MS** **A-01**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<50.0	50.0	06/01/2015	ND	177	88.4	200	2.82	
DRO >C10-C28	**353**	50.0	06/01/2015	ND	192	96.0	200	5.99	

Surrogate: 1-Chlorooctane *81.1 %* *47.2-157*

Surrogate: 1-Chlorooctadecane *131 %* *52.1-176*

Sample ID: SUPERIOR FED 5 #2 (H501358-02)

Chloride, SM4500Cl-B **mg/kg** **Analyzed By: CK**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**416**	16.0	06/01/2015	ND	416	104	400	3.77	

TPH 8015M **mg/kg** **Analyzed By: MS** **A-01**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<10.0	10.0	06/01/2015	ND	177	88.4	200	2.82	
DRO >C10-C28	**57.9**	10.0	06/01/2015	ND	192	96.0	200	5.99	

Surrogate: 1-Chlorooctane *97.2 %* *47.2-157*

Surrogate: 1-Chlorooctadecane *114 %* *52.1-176*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

PHONE (575) 393-2326 ° 101 E. MARLAND ° HOBBS, NM 88240

Analytical Results For:

ARMSTRONG ENERGY CORP
BRUCE STUBBS
P. O. BOX 1973
ROSWELL NM, 88202
Fax To: (575) 622-2512

Received:	05/29/2015	Sampling Date:	05/29/2015
Reported:	06/02/2015	Sampling Type:	Soil
Project Name:	SOIL SAMPLES	Sampling Condition:	** (See Notes)
Project Number:	NONE GIVEN	Sample Received By:	Jodi Henson
Project Location:	NOT GIVEN		

Sample ID: G SAMPLE #1 (H501358-03)

Chloride, SM4500Cl-B **mg/kg** **Analyzed By: CK**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**96.0**	16.0	06/01/2015	ND	416	104	400	3.77	

TPH 8015M **mg/kg** **Analyzed By: MS** **A-01**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<50.0	50.0	06/01/2015	ND	177	88.4	200	2.82	
DRO >C10-C28	**703**	50.0	06/01/2015	ND	192	96.0	200	5.99	

Surrogate: 1-Chlorooctane	*80.7 %*	*47.2-157*
Surrogate: 1-Chlorooctadecane	*154 %*	*52.1-176*

Sample ID: G SAMPLE #2 (H501358-04)

Chloride, SM4500Cl-B **mg/kg** **Analyzed By: CK**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
Chloride	**80.0**	16.0	06/01/2015	ND	416	104	400	3.77	

TPH 8015M **mg/kg** **Analyzed By: MS** **A-01**

Analyte	Result	Reporting Limit	Analyzed	Method Blank	BS	% Recovery	True Value QC	RPD	Qualifier
GRO C6-C10	<50.0	50.0	06/01/2015	ND	177	88.4	200	2.82	
DRO >C10-C28	**113**	50.0	06/01/2015	ND	192	96.0	200	5.99	

Surrogate: 1-Chlorooctane	*97.7 %*	*47.2-157*
Surrogate: 1-Chlorooctadecane	*121 %*	*52.1-176*

Cardinal Laboratories

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

Notes and Definitions

A-01	Samples results may be biased low because samples were taken in plastic baggies instead of 4 oz glass jars.
ND	Analyte NOT DETECTED at or above the reporting limit
RPD	Relative Percent Difference
**	Samples not received at proper temperature of 6°C or below.
***	Insufficient time to reach temperature.
-	Chloride by SM4500Cl-B does not require samples be received at or below 6°C
	Samples reported on an as received basis (wet) unless otherwise noted on report

*=Accredited Analyte

Celey D. Keene

Celey D. Keene, Lab Director/Quality Manager

CARDINAL Laboratories

CHAIN-OF-CUSTODY AND ANALYSIS REQUEST

101 East Marland, Hobbs, NM 88240
(575) 393-2326 FAX (575) 393-2476

Company Name: Armstrong Energy. Corp.
Project Manager:
Address: PO Box 1973
City: Roswell **State:** **Zip:**
Phone #: **Fax #:**
Project #: **Project Owner:**
Project Name:
Project Location:
Sampler Name:

BILL TO
P.O. #:
Company:
Attn:
Address:
City:
State: **Zip:**
Phone #:
Fax #:

ANALYSIS REQUEST

FOR LAB USE ONLY Lab I.D.	Sample I.D.	(G)RAB OR (C)OMP.	# CONTAINERS	MATRIX GROUNDWATER	WASTEWATER	SOIL	OIL	SLUDGE	OTHER :	PRESERV. ACID/BASE:	ICE / COOL	OTHER :	SAMPLING DATE	TIME	Cl	TPH
H501358																
1	Superior Fed 5 #1	G	1			✓							5/29/15	12:30	✓	✓
2	#2		1			✓									✓	✓
3	G Sample #1					✓									✓	✓
4	G Sample #2					✓									✓	✓

PLEASE NOTE: Liability and Damages. Cardinal's liability and client's exclusive remedy for any claim arising whether based in contract or tort, shall be limited to the amount paid by the client for the analyses. All claims, including those for negligence and any other cause whatsoever shall be deemed waived unless made in writing and received by Cardinal within 30 days after completion of the applicable service. In no event shall Cardinal be liable for incidental or consequental damages, including without limitation, business interruptions, loss of use, or loss of profits incurred by client, its subsidiaries, affiliates or successors arising out of or related to the performance of services hereunder by Cardinal, regardless of whether such claim is based upon any of the above stated reasons or otherwise.

Relinquished By:
Date: 5/29/15
Time: 4:00
Received By:

Relinquished By: B
Date:
Time:
Received By: Jodi Henson

Delivered By: (Circle One)
Sampler - UPS - Bus - Other: 29.2°c

Sample Condition
Cool: ☐ Yes ☑ No
Intact: ☑ Yes ☐ No

CHECKED BY: (Initials) JH

Phone Result: ☐ Yes ☐ No Add'l Phone #:
Fax Result: ☐ Yes ☐ No Add'l Fax #:
REMARKS:
samples brought in plastic bags.
JH

† Cardinal cannot accept verbal changes. Please fax written changes to (575) 393-2326

#54

APPENDIX B

FORM C141 FINAL

District I
1625 N. French Dr., Hobbs, NM 88240
District II
811 S. First St., Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources

Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Form C-141
Revised August 8, 2011

Submit 1 Copy to appropriate District Office in accordance with 19.15.29 NMAC.

Release Notification and Corrective Action

OPERATOR

☐ Initial Report X Final Report

Name of Company ARMSTRONG ENERGY CORPORATION	Contact BRUCE STUBBS
Address P.O. BOX 1973, ROSWELL, NM 88202	Telephone No. 575-625-2222
Facility Name GOVERNMENT "G" SWD LINE	Facility Type FLOWLINE

Surface Owner U.S. - BLM	Mineral Owner U.S.	API No.

LOCATION OF RELEASE

Unit Letter	Section	Township	Range	Feet from the	North/South Line	Feet from the	East/West Line	County
M	25	19S	34E	1000	SOUTH	900	WEST	LEA

Latitude 32.62780N **Longitude** 103.51944W

NATURE OF RELEASE

Type of Release PRODUCED WATER AND OIL	Volume of Release 70 BW & 2 BO	Volume Recovered 15 BBLS.
Source of Release SPLIT IN FLOWLINE	Date and Hour of Occurrence 10-12-06 PM	Date and Hour of Discovery 10-12-06 8:00 AM
Was Immediate Notice Given? ☐ Yes ☐ No ☐ Not Required	If YES, To Whom?	
By Whom?	Date and Hour	
Was a Watercourse Reached? ☐ Yes X No	If YES, Volume Impacting the Watercourse.	

If a Watercourse was Impacted, Describe Fully.* N/A

Describe Cause of Problem and Remedial Action Taken.*
REPAIRED FLOWLINE. PICKED UP 15 BBLS. FLUID.THE AREA HAS BEEN TREATED WITH MICROBLAZ AND RESEEDED. ALL BUT AN AREA APPROXIMATELY 75' X 30' HAS RECOVERED.

Describe Area Affected and Cleanup Action Taken.*
THE AREA 75' X 30' WILL BE REMEDIATED AS PER THE ATTACHED PLAN.

I hereby certify that the information given above is true and complete to the best of my knowledge and understand that pursuant to NMOCD rules and regulations all operators are required to report and/or file certain release notifications and perform corrective actions for releases which may endanger public health or the environment. The acceptance of a C-141 report by the NMOCD marked as "Final Report" does not relieve the operator of liability should their operations have failed to adequately investigate and remediate contamination that pose a threat to ground water, surface water, human health or the environment. In addition, NMOCD acceptance of a C-141 report does not relieve the operator of responsibility for compliance with any other federal, state, or local laws and/or regulations.

Signature: B Stubbs	OIL CONSERVATION DIVISION	
Printed Name: BRUCE STUBBS	Approved by Environmental Specialist:	
Title: ENGINEER	Approval Date:	Expiration Date:
E-mail Address: bastubbs@armstrongenergycorp.com	Conditions of Approval:	Attached ☐
Date: 6-8-15 Phone: 575-625-2222		

* Attach Additional Sheets If Necessary

APPENDIX C:
API AMIGO SUMMARY

AMIGO

New File | Choose File No file chosen | Save | Quick Start | Manual | AMIGO

Units

○ Metric (m) ● English (inches)

Climate

Arid Hot (NM/W.Texas, Hobbs) ▼

Input for a Distant Well

Distance to Well	1000	[ft]
Source Width	3.28	[ft]
Longitudinal Dispersivity	10	[-]
Transverse Dispersivity	1	[-]

Groundwater Characterictics

Background Cl Concentration in Aquifer	cGW =	282	[mg/L]
Aquifer porosity	n =	0.3	[-]
Groundwater Table Depth	D =	10 ▼	[ft]
Aquifer Thickness	H =	50	[ft]
Slope of Water Table	i =	0.05	[-]
Hydraulic Conductivity	Ks =	3.28	[ft/d]
Groundwater Flux	Q =	8.2	[ft2/d]

Source Characteristics

Chloride Load: M = 1 [kg/m2]

Max. length of the spill in direction of GW flow: L = 90 [ft]

Plant Uptake Trigger

● 1% Input Concentration

○ 10% Input Concentration

Soil Profiles

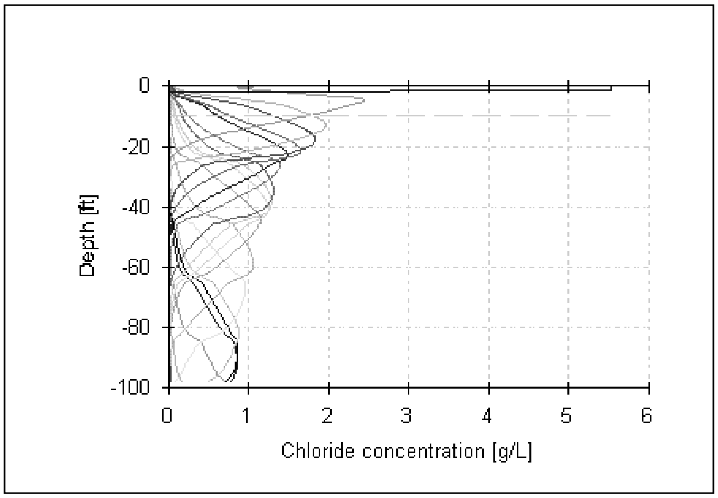
Surface Layer: Medium Sand ▼

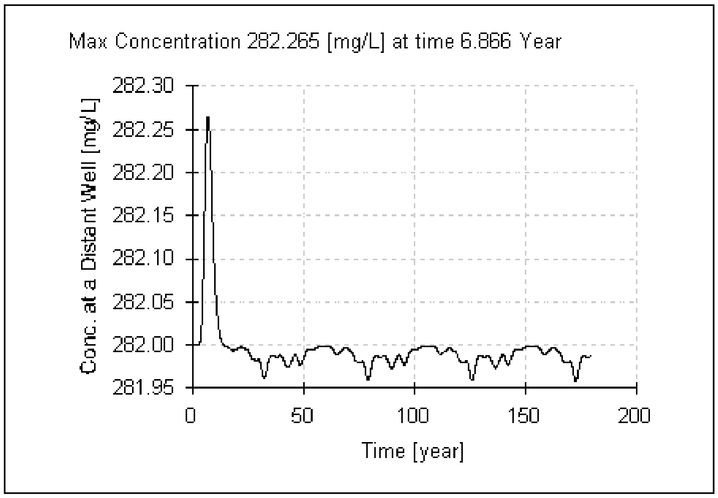
Soil Profile: P4 - Caliche (1) + Medium Sand (5) ▼

Output Charts

Quantity 1: Chloride concentration [g/L] ▼

Quantity 2: Conc. at a Distant Well [mg/L] ▼





Reduce | Display All | ☐ Legend | Export | Export All | Refresh | ☐ Auto-Refresh | Export | Export All

AMIGO

☐ New File | Choose File No file chosen | Save | Quick Start | Manual | AMIGO

Units

○ Metric (m) ● English (inches)

Climate

Arid Hot (NM/W.Texas, Hobbs) ▼

Input for a Distant Well

Distance to Well	1000	[ft]
Source Width	3.28	[ft]
Longitudinal Dispersivity	10	[-]
Transverse Dispersivity	1	[-]

Groundwater Characterictics

Background Cl Concentration in Aquifer	cGW =	282	[mg/L]
Aquifer porosity	n =	0.3	[-]
Groundwater Table Depth	D =	10 ▼	[ft]
Aquifer Thickness	H =	50	[ft]
Slope of Water Table	i =	0.05	[-]
Hydraulic Conductivity	Ks =	3.28	[ft/d]
Groundwater Flux	Q =	8.2	[ft2/d]

Source Characteristics

Chloride Load: M = 1 [kg/m2]

Max. length of the spill in direction of GW flow: L = 90 [ft]

Plant Uptake Trigger

● 1% Input Concentration

○ 10% Input Concentration

Soil Profiles

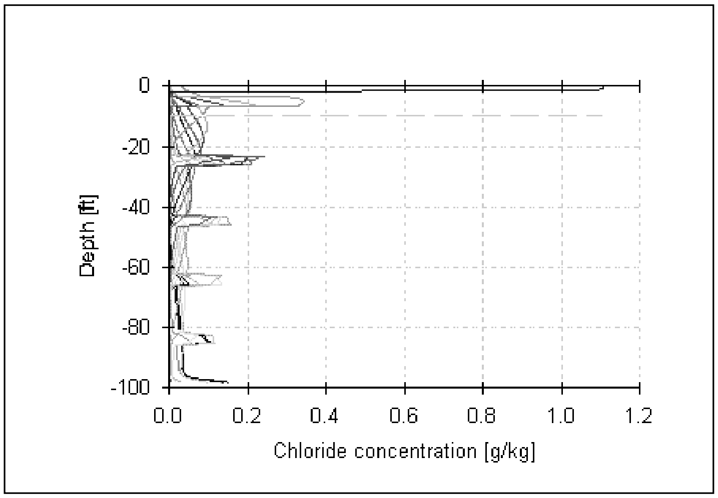
Surface Layer: Medium Sand ▼

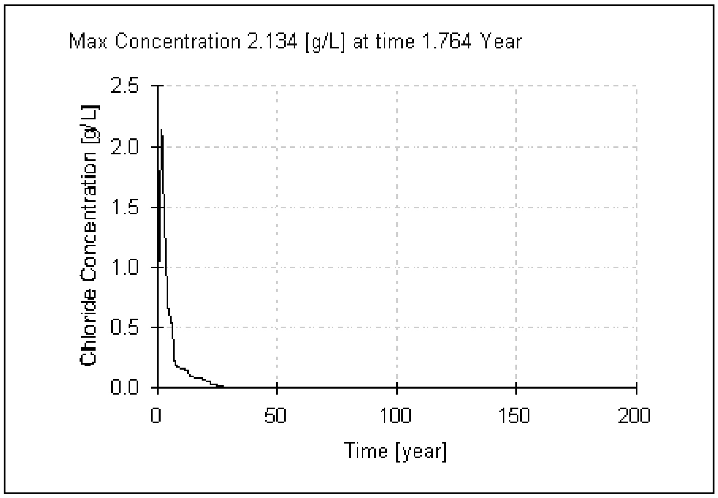
Soil Profile: P4 - Caliche (1) + Medium Sand (5) ▼

Output Charts

Quantity 1: Chloride concentration [g/kg] ▼

Quantity 2: Chloride Concentration [g/L] ▼





Reduce | Display All | ☐ Legend | Export | Export All | Refresh | ☐ Auto-Refresh | Export | Export All

United States
Department of
Agriculture

NRCS

Natural
Resources
Conservation
Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Lea County, New Mexico

Government "G" SWD Fed

August 13, 2015

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (http://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means

Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

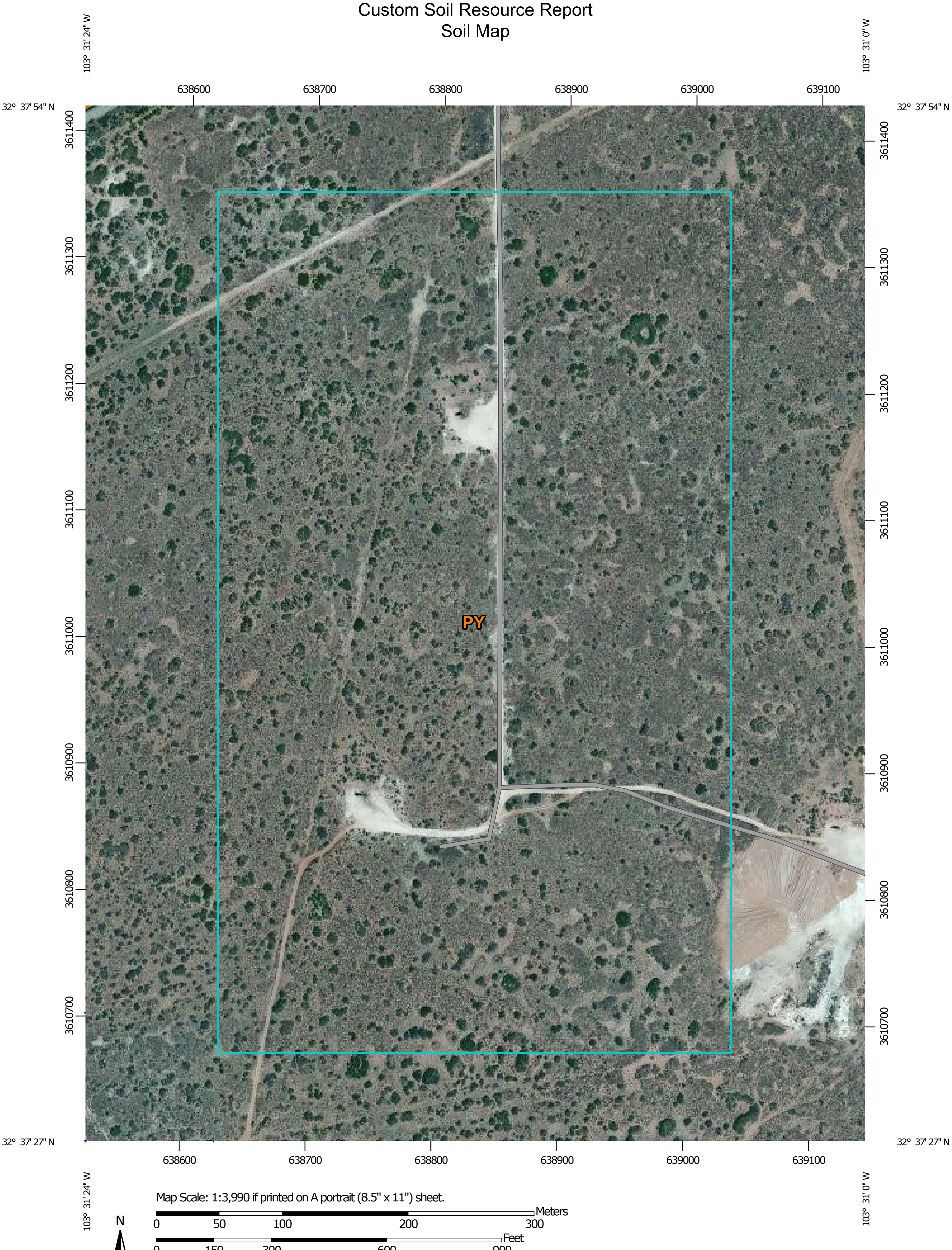
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:3,990 if printed on A portrait (8.5" x 11") sheet.

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

□ Area of Interest (AOI)

Soils

□ Soil Map Unit Polygons

〰 Soil Map Unit Lines

■ Soil Map Unit Points

Special Point Features

◉ Blowout

⊠ Borrow Pit

✳ Clay Spot

◇ Closed Depression

✕ Gravel Pit

∴ Gravelly Spot

⊗ Landfill

Λ Lava Flow

⩩ Marsh or swamp

⚒ Mine or Quarry

◎ Miscellaneous Water

◎ Perennial Water

∨ Rock Outcrop

+ Saline Spot

⁘ Sandy Spot

⊖ Severely Eroded Spot

◈ Sinkhole

≫ Slide or Slip

ø Sodic Spot

≡ Spoil Area

△ Stony Spot

∞ Very Stony Spot

Ψ Wet Spot

△ Other

⁃ Special Line Features

Water Features

∼ Streams and Canals

Transportation

┼┼┼ Rails

〰 Interstate Highways

〰 US Routes

〰 Major Roads

〰 Local Roads

Background

▨ Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lea County, New Mexico
Survey Area Data: Version 11, Sep 30, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Lea County, New Mexico (NM025)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
PY	Pyote soils and dune land	68.8	100.0%
Totals for Area of Interest		**68.8**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Lea County, New Mexico

PY—Pyote soils and dune land

Map Unit Setting

National map unit symbol: dmqr
Elevation: 3,000 to 4,400 feet
Mean annual precipitation: 10 to 16 inches
Mean annual air temperature: 58 to 64 degrees F
Frost-free period: 190 to 220 days
Farmland classification: Not prime farmland

Map Unit Composition

Pyote and similar soils: 45 percent
Dune land: 45 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Dune Land

Setting

Landform: Dunes
Landform position (two-dimensional): Backslope, shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex

Typical profile

A - 0 to 6 inches: fine sand
C - 6 to 60 inches: fine sand

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8e
Hydrologic Soil Group: A

Description of Pyote

Setting

Landform: Depressions
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Sandy eolian deposits derived from sedimentary rock

Typical profile

A - 0 to 30 inches: fine sand
Bt - 30 to 60 inches: fine sandy loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 5 percent
Gypsum, maximum in profile: 1 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 2.0
Available water storage in profile: Low (about 5.1 inches)

Interpretive groups

Land capability classification (irrigated): 6e
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: Loamy Sand (R042XC003NM)

Minor Components

Kermit

Percent of map unit: 4 percent
Ecological site: Sandhills (R042XC022NM)

Maljamar, fs

Percent of map unit: 3 percent
Ecological site: Loamy Sand (R042XC003NM)

Wink

Percent of map unit: 2 percent
Ecological site: Loamy Sand (R042XC003NM)

Playas

Percent of map unit: 1 percent
Landform: Playa floors
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

APPENDIX D

USDA SOIL EC

USDA Natural Resources Conservation Service

Indicator	Test	Function
C	F	N/D

Soil Quality Indicators

Soil Electrical Conductivity

Soil electrical conductivity (EC) measures the ability of soil water to carry electrical current. Electrical conductivity is an electrolytic process that takes place principally through water-filled pores. Cations (Ca^{2+}, Mg^{2+}, K^+, Na^+, and NH_4^+) and anions (SO_4^{2-}, Cl^-, NO_3^-, and HCO_3^-) from salts dissolved in soil water carry electrical charges and conduct the electrical current. Consequently, the concentration of ions determines the EC of soils. In agriculture, EC has been used principally as a measure of soil salinity (table 1); however, in non-saline soils, EC can be an estimate of other soil properties, such as soil moisture and soil depth. EC is expressed in deciSiemens per meter (dS/m).

Factors Affecting

Inherent - Factors influencing the electrical conductivity of soils include the amount and type of soluble salts in solution, porosity, soil texture (especially clay content and mineralogy), soil moisture, and soil temperature. High levels of precipitation can flush soluble salts out of the soil and reduce EC. Conversely, in arid soils (with low levels of precipitation), soluble salts are more likely to accumulate in soil profiles resulting in high EC. Electrical conductivity decreases sharply when the temperature of soil water is below the freezing point (EC decreases about 2.2% per degree centigrade due to increased viscosity of water and decreased mobility of ions). In general, EC increases as clay content increases. Soils with clay dominated by high cation-exchange capacity (CEC) clay minerals (e.g., smectite) have higher EC than those with clay dominated by low CEC clay minerals (e.g., kaolinite). Arid soils with high content of soluble salt and exchangeable sodium generally exhibit extremely high EC. In soils where the water table is high and saline, water will rise by capillarity and increase salt concentration and EC in the soil surface layers.

It is generally accepted that the higher the porosity (the higher the soil moisture content), the greater the ability of soil to conduct electrical currents; that is, other properties being similar, the wetter the soil the higher the EC. Soil parent materials contribute to EC variability. Granites have lower EC than marine shales and clayey lacustrine deposits have higher EC than sandy outwash or alluvial deposits. Saline (ECe ≥ 4 dS/m) and sodic (sodium absorption ratio ≥ 13) soils are characterized by high EC. Scientific literature reported a relationship between EC values measured with commercial sensors and depths to claypan, bedrock, and fragipan. Microtopographic depressions in agricultural fields typically are wetter and accumulate organic matter and nutrients and therefore have higher EC than surrounding higher lying, better drained areas.

Dynamic - Mineral soils enriched in organic matter, or with chemical fertilizers (e.g., NH_4OH) have higher CEC than non-enriched soils, because OM improves soil water holding capacity, and synthetic fertilizers augment salt content. Continuous application of municipal wastes on soil can increase soil EC in some cases. Electrical conductivity has been used to infer the relative concentration, extent, and movement of animal wastes in soils. Because of its sensitivity to soluble salts, EC is an effective measure for assessing the contamination of surface and ground water. Although EC does not provide a direct measurement of specific ions or compounds, it has been correlated with concentrations of potassium, sodium, chloride, sulfate, ammonia, and nitrate in soils. Poor water infiltration can lead to poor drainage, waterlogging, and increased EC.

Relationship to Soil Function

Soil EC does not directly affect plant growth but has been used as an indirect indicator of the amount of nutrients available for plant uptake and salinity levels. EC has been used as a surrogate measure of salt concentration, organic

Table 1. Classes of salinity and EC (1 dS/m = 1 mmhos/cm; adapted from NRCS Soil Survey Handbook)

EC (dS/m)	Salinity Class
0 < 2	Non-saline
2 < 4	Very slightly saline
4 < 8	Slightly saline
8 < 16	Moderately saline
≥ 16	Strongly saline

matter, cation-exchange capacity, soil texture, soil thickness, nutrients (e.g., nitrate), water-holding capacity, and drainage conditions. In site-specific management and high-intensity soil surveys, EC is used to partition units of management, differentiate soil types, and predict soil fertility and crop yields. For example, farmers can use EC maps to apply different management strategies (e.g., N fertilizers) to sections of a field that have different types of soil. In some management units, high EC has been associated with high levels of nitrate and other selected soil nutrients (P, K, Ca, Mg, Mn, Zn, and Cu).
Most microorganisms are sensitive to salt (high EC). Actinomycetes and fungi are less sensitive than bacteria, except for halophyte (salt-tolerant) bacteria. Microbial processes, including respiration and nitrification, decline as EC increases (table 2).

Problems with Poor Soil EC Levels

High EC can serve as an indication of salinity (EC > 4 dS/m) problems, which impede crop growth (inability to absorb water even when present) and microbial activity (tables 2 and 3). Soils with high EC resulting from a high concentration of sodium generally have poor structure and drainage, and sodium becomes toxic to plants.

Improving Soil EC

Effective irrigation practices, which wash soluble salts out of soil and beyond the rooting depth, can decrease EC. Excessive irrigation and waterlogging should be avoided since a rising water table may bring soluble salts into the root zone. In arid climates, plant residue and mulch help soils to remain wetter and thus allow seasonal precipitation and irrigation to be more effective in leaching salts from the surface. To avoid the adverse effects of high EC (salinity) in irrigation water, the leaching requirement must be calculated for each crop. Leaching requirement is the fraction of water needed to flush excessive salt below the root zone, that is, the amount of additional water required to maintain a target salinity level. Adding organic matter, such as manure and compost, increases EC by adding cations and anions and improving the water-holding capacity. In some cases, a combination of irrigation and drainage is necessary to lower salt concentration and EC. An EC water (ECw) ≤ 0.75 dS/m is considered good for irrigation water. Beyond this value, leaching or a combination of leaching and drainage will be necessary if the water is used.

Table 2. Influence of soil EC on microbial process in soils amended with NaCl or nitrate (adapted from Smith and Doran, 1996)

Microbial process	Salt added	EC Range (dS/m)	Relative Decrease (%)	Threshold EC (1:1)
Respiration	NaCl	0.7 - 2.8	17 - 47	0.7
Decomposition	NaCl + alfalfa	0.7 - 2.9	2 - 25	0.7
Nitrification	soil + alfalfa	0.7 - 2.9	10 - 37	0.7
Denitrification	NO_3-N	1 - 1.8	32 - 88	1

Measuring Soil EC

The EC pocket meter is used to take measurements in the field. The method is described in the Soil Quality Test Kit Guide. Always calibrate the EC meter before use.

The pocket meter can be augmented by a probe that is placed directly into the soil to measure subsoil EC and NO_3^- and make other estimates. NRCS soil scientists and agronomists use electromagnetic induction meters, not pocket EC meters, to map spatial variability of EC and associated soil properties at field scales. Special sensors are used for EC mapping for precision agriculture.

Time needed: 10 minutes

References:
Corwin DL and SM Lesch. 2005. Apparent soil electrical conductivity measurements in agriculture. Computers and Electronics in Agriculture 46:11-43.

Smith JL and JW Doran. 1996. Measurement and use of pH and electrical conductivity for soil quality analysis. In Methods for assessing soil quality. Soil Science Society of America Special Publication 49: 169-185.

Doolittle JA, KA Suddeth, NR Kitchen, and SJ Indorante. 1994. Estimating depths to claypans using electromagnetic induction methods.

Table 3. Salt tolerance of crops and yield decrease beyond EC threshold (adapted from Smith and Doran, 1996)

Crop species	Threshold EC 1:1 (dS/m)*	Percent yield decrease per unit EC beyond threshold EC
Alfalfa	1.1 - 1.4	7.3
Barley	4.5 - 5.7	5.0
Cotton	4.3 - 5.5	5.2
Peanut	1.4 - 1.8	29
Potato	1.0 - 1.2	12
Rice	1.7 - 2.1	12
Soybean	2.8 - 3.6	20
Tomato	1.4 - 1.8	9.9
Wheat	3.9 - 5.0	7.1

** Electrical conductivity of a 1:1 soil/water mixture relative to that of a saturated paste extract*

BLM LPC #2

Species to be planted in pounds of pure live seed* per acre:

Species	lb/acre
Plains Bristlegrass	5lbs/A
Sand Bluestem	5lbs/A
Little Bluestem	3lbs/A
Big Bluestem	6lbs/A
Plains Coreopsis	2lbs/A
Sand Dropseed	1lbs/A

*Pounds of pure live seed: Pounds of seed **x** percent purity **x** percent germination = pounds pure live seed