1R - 415

REPORTS

DATE:

2006

April 2006

Surface Restoration & Closure Report

ABO 1-G Release Site
Near Lovington, New Mexico

1RP-415

R.T. HICKS CONSULTANTS, LTD.

901 RIO GRANDE BLVD. NW, SUITE F-142, ALBUQUERQUE, NM 87104

R. T. HICKS CONSULTANTS, LTD.
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

April 27, 2006

Wayne Price
NMOCD Environmental Bureau Chief
1220 South St. Francis Drive
Santa Fe, New Mexico 87505
Via E-mail and Federal Express

RE: Final Closure Report
Abo 1G Pipeline Release NMOCD Case #1R0415
Section 1, 17S, 36E, Unit G

Dear Wayne:

The attachment describes the implementation of the NMOCD-approved remedy: excavation and exportation of a portion of the upper vadose zone and the placement of a monolithic evapotranspiration (ET) infiltration barrier. The Table of Contents provides a description of the material in each section of this report. Only two sections of the attachment include new information to NMOCD. Tab 1, Executive Summary summarizes the implementation of the NMOCD-approved remedy. Tab 7 provides information on ET infiltration barriers that suggests that these barriers are very effective and as a result, moisture collection from lysimeters placed below the barrier may be difficult.

It is our understanding that NMOCD prefers to delay plugging and abandonment of the existing monitor well until two years of annual sampling confirms the performance of the ET cover. ROC is agreeable to this condition.

Please expect a report in early 2007 that presents the results of the lysimeter and monitor well sampling. If you have any questions regarding this submission, please contact me at our Albuquerque office. We trust this submission meets with your approval and written confirmation of your satisfaction would be appreciated.

Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T. Hicks

Randall Hicks
Principal

Copy: Rice Operating Company

April, 2006

Lovington Abo

Surface Restoration and Closure Report

RICE OPERATING COMPANY
HOBBS, NEW MEXICO

Prepared for:

Rice Operating Company
122 W. Taylor
Hobbs, NM 88240

R.T. HICKS CONSULTANTS, LTD.

901 RIO GRANDE, SUITE F-142, ALBUQUERQUE, NM, 87104

TABLE OF CONTENTS

EXECUTIVE SUMMARY

LOCATION

The Abo 1G Discharge Site is located about 6 miles southeast of the center of Lovington, New Mexico. Plate 1 is a 1:24,000 topographic map showing the location of the site relative to Route 18, the Hobbs-Lovington Highway. Plate 2 is a 1:6,000 image (2004) of the site location and nearby features such as the Navajo Lovington Refinery and the Lovington-Hobbs highway.

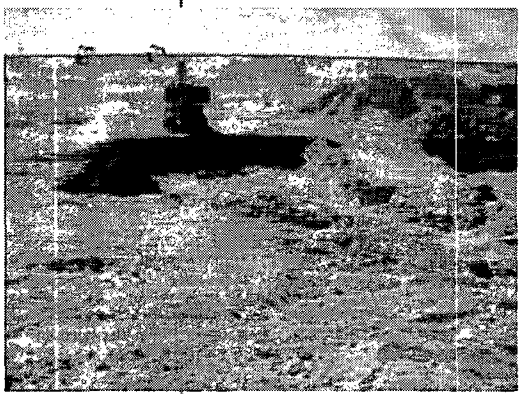


Figure 1. Adding Clay to Grid 63. View is to the South.

SPILL SITE REMEDIATION

NMOCD approved the Corrective Action Plan in November, 2005 and Rice began excavation of the site in January 2006. Initially, excavation proceeded in grids where the July 2005 field program (see Plate 3 and Table 1) revealed chloride above 1000 mg/kg. In general, excavation proceeded to a depth of 1-foot below ground surface (bgs) then ROC collected a five point composite sample from the bottom of the grid and field tested for chloride concentration and volatile organic compounds (VOC). If the result of the field chloride measurement was above 1000 mg/kg, excavation was continued vertically another foot. Additional grids with composite surface chloride concentrations above 1000 mg/kg were excavated following the same protocols as above. The Standard Operating Procedures (SOP) in Tab 6 of the attachment provides details on sample collection

Excavation within a grid ceased when either the composite floor sample yielded a chloride concentration below 1000 mg/kg or at a maximum depth of 5 feet bgs. In either of these cases, final samples were submitted to a laboratory for confirmatory analysis (see Table 2). Excavation was also halted in a grid if a final sample was only marginally above 1000 mg/kg and concentration the profile showed a declining chloride concentration with depth from previously excavated material.

As shown in Plate 4, 14 grid sections were excavated in a northern area and 15 grid sections were excavated in a southern area.

Excavated material was initially placed in stockpiles (Plate 4). Some of this material (Piles 3, 4, and 6) was blended with imported material to create the backfill material that would support vegetation. Imported material was composed of either a fine grained caliche byproduct material or a clean, top sand removed to expose caliche for quarrying. Suppliers were Wallach Concrete Co. and RWI. These materials were blended with the stockpiled material on the site to create the backfill material. Additional material was added and blended to a pile until a composite sample featured a chloride concentration below 250 mg/kg.

As a result of chloride concentrations obtained during the installation of Lysimeter 1, an additional area including parts of grids 2,6,7,10,12, and 18 was excavated to 5 feet bgs and capped with 1 foot of clay (Plate 4).

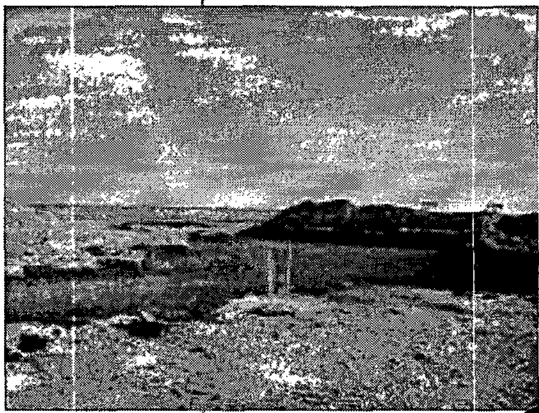


Figure 2. Clay Installed in the Southern Grids. View is to the Southeast.

As stated above, all backfill material featured chloride concentrations below 250 mg/kg. Those grids for which final bottom samples tested above 1000 mg/kg received a one-foot thick clay cap (uncompacted) extended to a 31 by 31 foot square (Plate 4). The clay was moistened as installed and a final top cover of the blow sand was placed over the clay. Grids with 1) final samples below 1000 mg/kg or with 2) a declining chloride concentration and a marginally higher than 1000 mg/kg concentration were finished with the backfill material (Plate 4). The site was graded with a crown to promote runoff from large precipitation events.

Imported materials consisted of:

- 1716 yards caliche base material from Wallach Concrete Co.
- 1092 yards of top sand from Wallach Concrete Co.
- 1392 yards caliche mixed with topsoil from RWI's caliche pit.
- 480 yards of red bed clay from Wallach Concrete Co.

Exported Materials consisted of:

- 2952 yards to Sundance Services Inc. in Eunice, N.M.
- 612 yards of material was spread on the ROC yard with NMOCD approval.

Lysimeter Installation

In order to provide a demonstration of the effectiveness of the ET infiltration barrier, Hicks Consultants installed a pan lysimeter and tensiometer access tubes in each of the excavated areas to allow sampling of vadose zone moisture. The lysimeters were placed 4 and 8 feet below the floor of the particular excavated grid section. The casings for tensiometers were installed to depths corresponding to both one-foot above and one-foot below each lysimeter. Should it be not possible to collect soil moisture samples, tensiometer (matric potential) measurements will provide an explanation as to if there exists a difficulty with the lysimeter. See Appendix A for a detailed description of the installation.

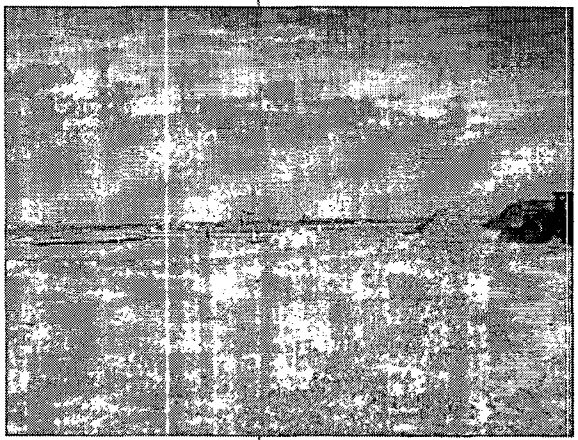


Figure 3. View is to the east of the northern excavated area as backfilling is being completed. Lysimeter 1 and MW-1 are in the center of the middle distance.

TABLES

Table 1: Abo Apache LA leak site Surface Samples

Samples Pulled: 7/21/05
Samples Titrated: 7/22/05
All highlighted squares sent to lab
ALL Squares are 25ft x 25ft

Square Number	Chloride	Square Number	Chloride
1	3653	39	3409
2	375	40	11067
3	93	41	316
4	826	42	44
5	13458	43	112
6	7860	44	1128
7	83	45	2143
8	348	46	127
9	7502	47	89
10	4855	48	74
11	9646	49	288
12	581	50	179
13	1216	51	246
14	12110	52	2351
15		53	634
16	948	54	284
17	407	55	6339
18	2715	56	2863
19	247	57	429
20	121	58	5192
21	77	59	7588
22	5686	60	10041
23	466	61	8222
24	708	62	3594
25	2240	63	1190
26	6806	64	515
27	11411	65	109
28	5347	66	137
29	1468	67	139
30	7732	68	104
31	7879	69	136
32	2279	70	222
33	8568	71	160
34	109	72	117
35	6749	73	63
36	7774	74	129
37	2399		
38	2327		

Table 2: ABO Apache LA Leak Site Remediation
Field CL- Titration Results

Lab Results in Bold

Grid#	Comments	1' bgs Cl-	2' bgs Cl-	3' bgs Cl-	4' bgs Cl-	5' bgs Cl-	
1	excavated to 1' bgs	247/ **214**					tph-192
2	Top 1' soil used to blend w/ soil from grid #1,5,6,11	no test					
3	Top 1' soil used to blend w/ soil from grid #1,5,6,11	no test					
4	Top 1' soil used to blend w/ soil from grid #1,5,6,11	no test					
5		576/ **867**					
6	excavated to 1' bgs	297/ 594					
7	Top 1' soil used to blend w/ soil from grid #1,5,6,11	no test					
8	Top 1' soil used to blend w/ soil from grid #1,5,6,11	no test					
9		835/ **2010**	579/ **1040**				Leave alone per Carolyn 1-25-06
10		840/ **1240**	1050				Leave alone per Carolyn 1-25-06
11		403					
12	not excavated	no test					
13		659/ **604**					no clay
14		451/ **706**					no clay
15	not excavated	no test					
16	not excavated	no test					
17	not excavated	no test					
18		193/ **334**					
19	not excavated	no test					
20	not excavated	no test					

Grid#	Comments	1' bgs Cl-	2' bgs Cl-	3' bgs Cl-	4' bgs Cl-	5' bgs Cl-	
21	not excavated	no test					
22		574/ **948**					no clay
23	not excavated	no test					
24	not excavated	no test					
25		1494	929	1087	818/ **1170**		Leave alone per Carolyn 1-25-06
26		489	794/ **754**				
27		405/ **756**					no clay
28		503/ 908					no clay
29		1250	1004	680/ **1480**	927	722/ **933**	no clay
30		2476	1529	904/ **1410**	815	701/ **730**	no clay
31		2690	1532	742/ **1060**	1080	1098/ **1380**	Install clay liner extend 3' over grid
32		1216/ **1960**	621/ **1020**				Leave alone per Carolyn 1-25-06
33		533/ **1020**	537/ **809**				no clay
34	not excavated	no test					
35		2801	579/ **1140**				Leave alone per Carolyn 1-25-06
36		2624				2120	Install clay liner extend 3' over grid
37	Initial excavation to 5' bgs					341/ **594**	no clay
38	Initial excavation to 5' bgs					1562/1 **330**	Install clay liner extend 3' over grid
39	Initial excavation to 5' bgs					739/ **1360**	Install clay liner extend 3' over grid
40		200 /1214	1070	1043	1043	1025	Install clay liner extend 3' over grid
41	not excavated						
42	not excavated						
43	not excavated						

Table 2: ABO Apache LA Leak Site Remediation; Field CL- Trtration Results

Grid#	Comments	1' bgs Cl-	2' bgs Cl-	3' bgs Cl-	4' bgs Cl-	5' bgs Cl-	
44	1'bgs edge of vegetation	253/ **290**					no clay
45	1'bgs edge of vegetation	227/ **267**					no clay
46	not excavated	no test					
47	not excavated	no test					
48	not excavated	no test					
49	not excavated	no test					
50	not excavated	no test					
51	not excavated	no test					
52		538/ **625**					no clay
53		218/ **734**					no clay
54		923/ **1960**	845	660/ **962**			no clay
55		1819	928	1048/ **1220**		1071/ **1470**	Install clay liner extend 3' over grid
56		309/ **2750**	1188	893	1675	1041/ **1640**	Install clay liner extend 3' over grid
57	Initial excavation to 5' bgs					906/ **1560**	Install clay liner extend 3' over grid
58	Initial excavation to 5' bgs					1273/ **1720**	Install clay liner extend 3' over grid
59	Initial excavation to 5' bgs					749/ **1100**	Install clay liner extend 3' over grid
60		2588	1010	852/ **1130**	921	1074/ **1360**	Install clay liner extend 3' over grid
61		2120	1154	927/ **1320**	876	1171/ **1380**	Install clay liner extend 3' over grid
62		197/ **785**					no clay
63		442/ **1260**			913	990/ **1170**	Install clay liner extend 3' over grid
64	not excavated	no test					
65	not excavated						
66	not excavated						
67	not excavated						
68	not excavated						

Table 2: ABO Apache LA Leak Site Remediation; Field CL- Trtration Results

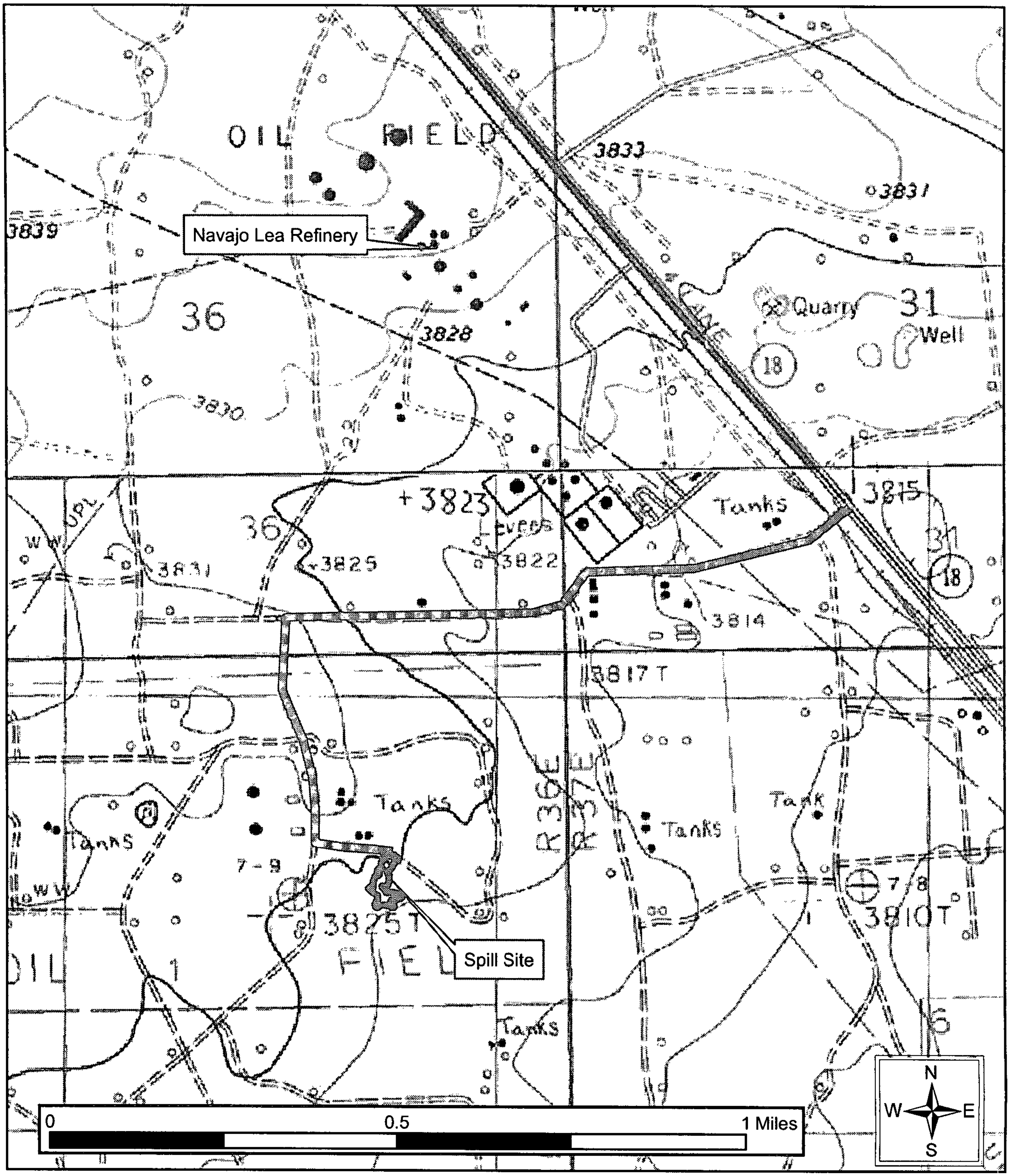
Grid#	Comments	1' bgs Cl-	2' bgs Cl-	3' bgs Cl-	4' bgs Cl-	5' bgs Cl-	
69	not excavated						
70	not excavated						
71	not excavated						
72	not excavated						
73	not excavated						
74	Initial excavation to 5' bgs to edge of vegetation					263/ 424	no clay
75	Initial excavation to 5' bgs to edge of vegetation					322/ 712	no clay
76	N. wall excavated to confirm cl- from #37						

Pile #3 Lab cl-250
Pile #4 Lab cl- 261

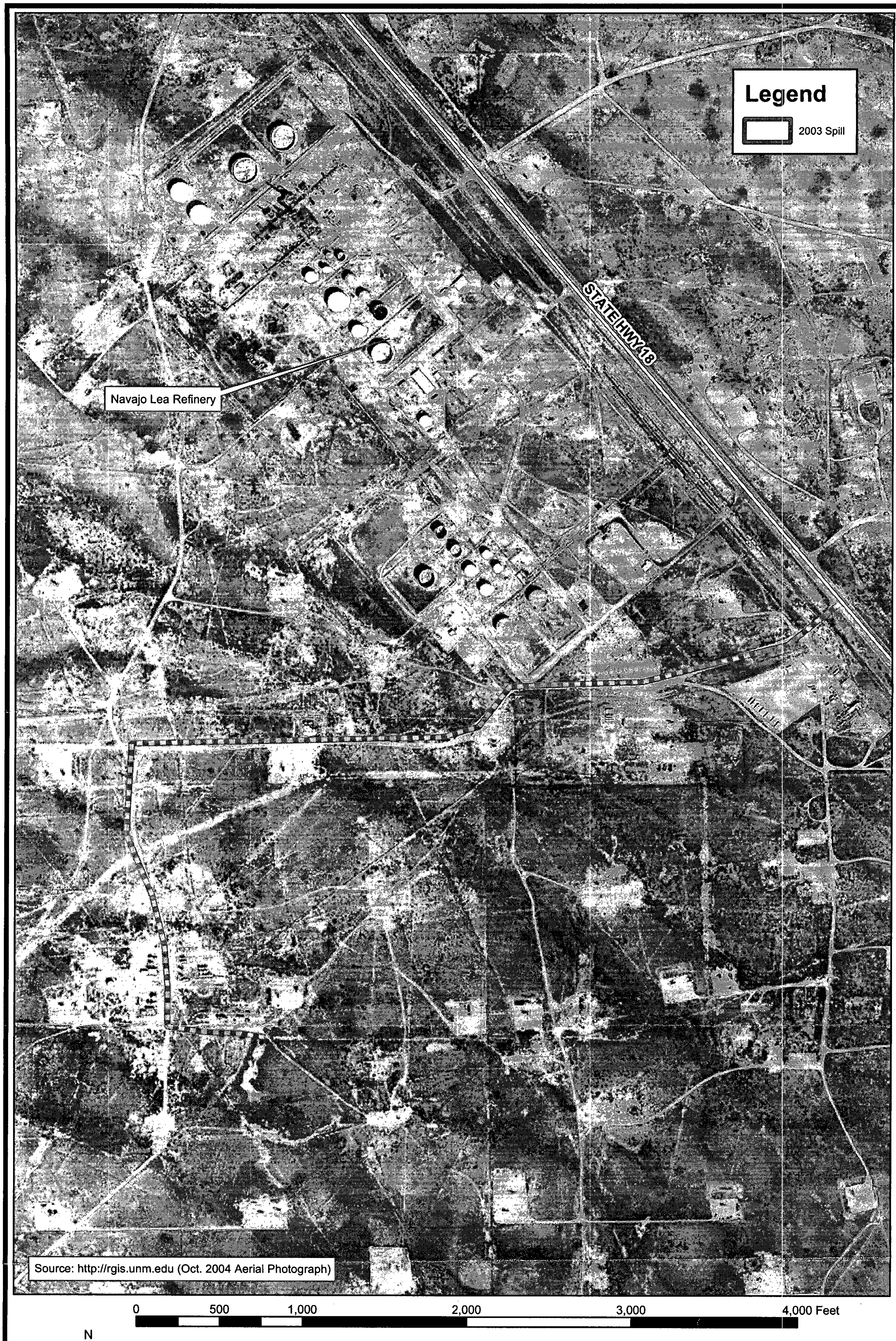
Table 2: ABO Apache LA Leak Site Remediation; Field CL- Trtration Results

PLATES

Directions: From Lovington, NM, proceed on Highway 18 for approximatly 5.3 miles. Head southwest on an unnamed dirt road (0.5 miles southeast of the Navajo Lea Refinery. Proceed on the dirt road for approximately 0.8 miles. Head south on an unamed dirt road for approximately 0.3 miles. Head east on an unnamed dirt road immediatley south of a tank battery. Proceed east for approximately 550 feet. The spill site is on the south side of the road.



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Site Location Map (USGS Lovington SE 7.5' Quad)	Plate 1
	ABO 1G Realease Site, OCD Case #1R0415	August 2005



R.T. Hicks Consultants, Ltd
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

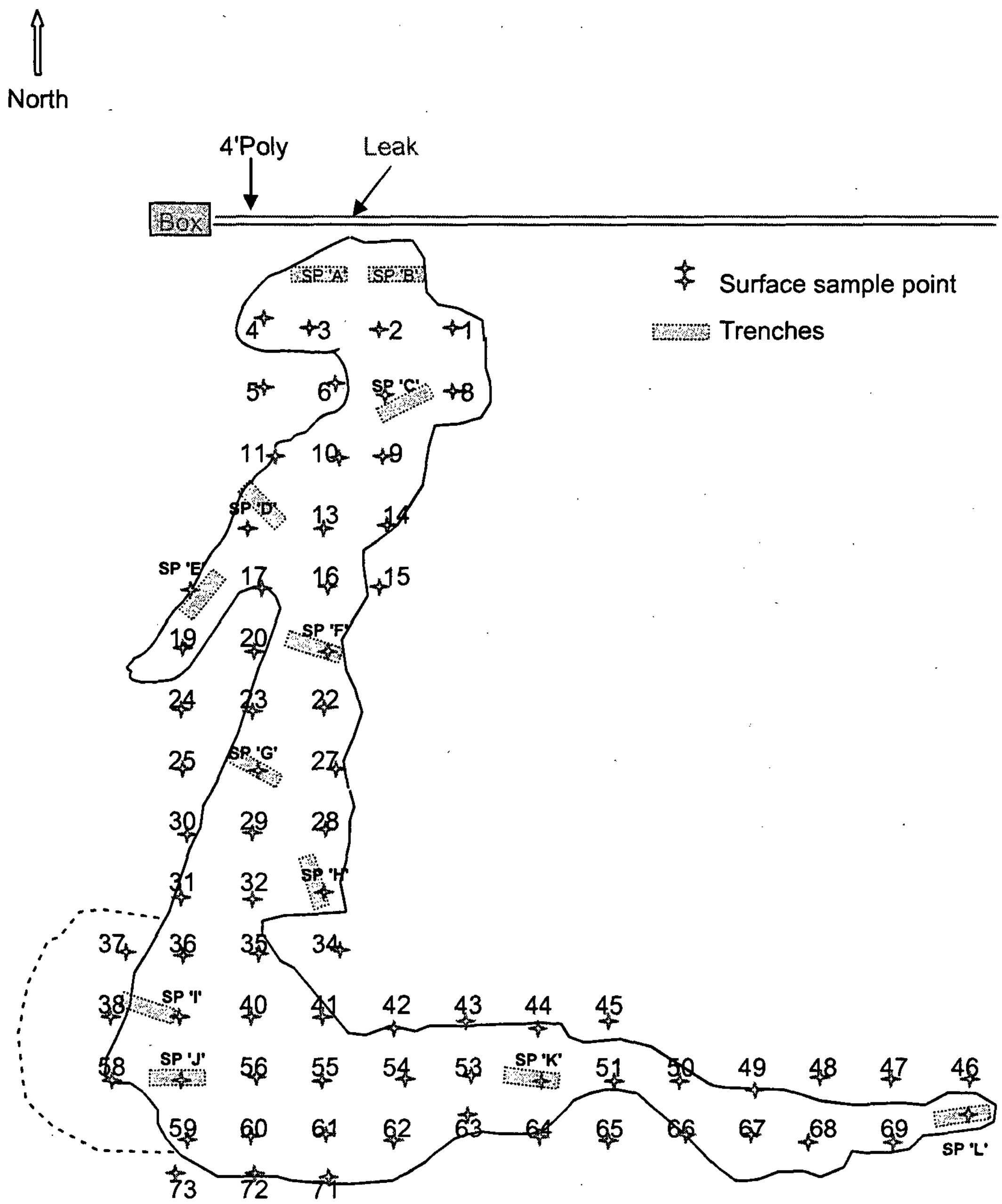
Location of Realese and Sourrounds

ABO 1G Realease Site, OCD Case #1R0415

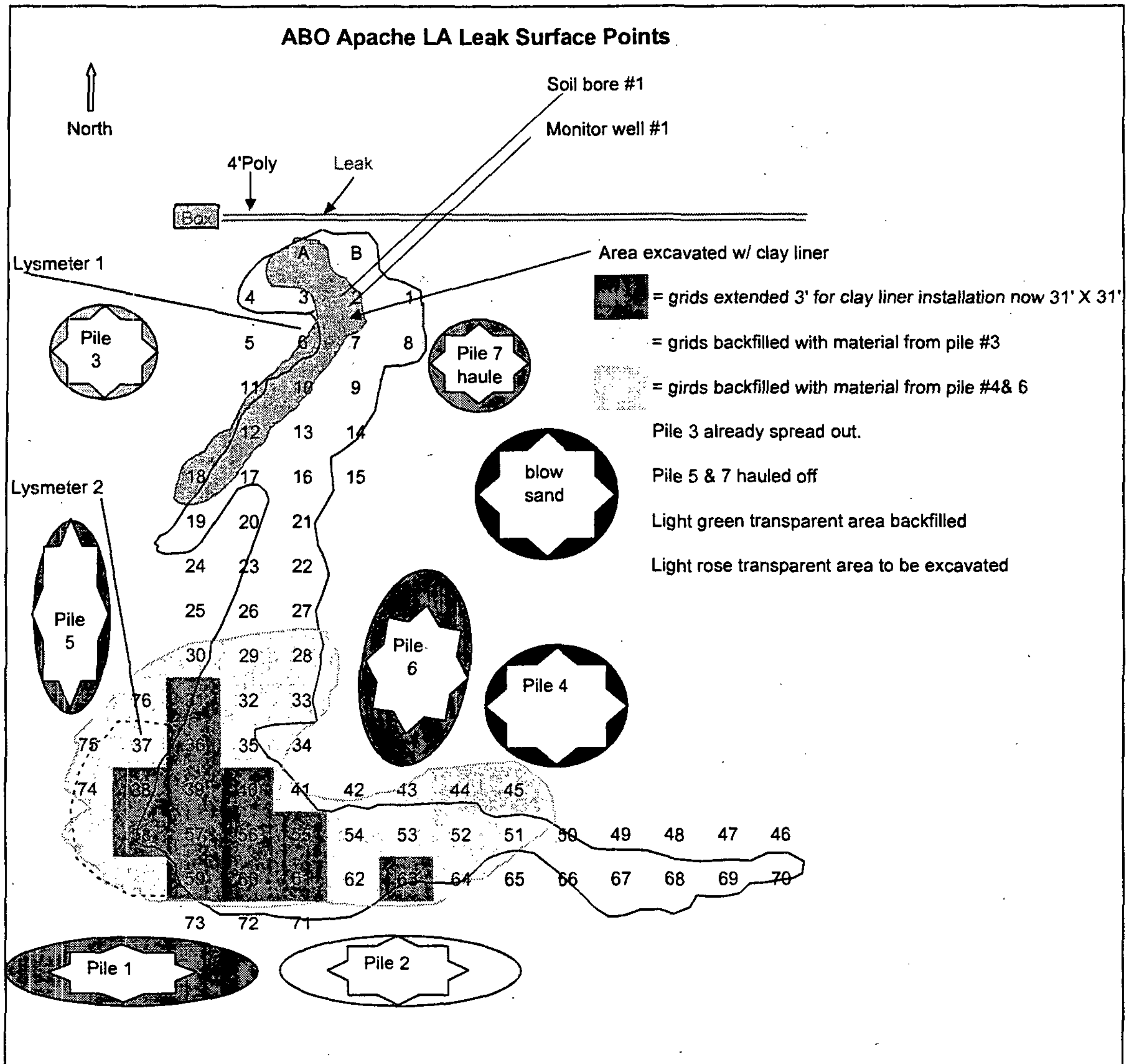
Plate 2

August 2005

ABO Apache LA Leak



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 505-266-5004	**Abo 1-G Site**	**Plate 3**
	Abo 1-G Site Grid Map	**April 2006**



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 505-266-5004	**Abo 1-G Site**	**Plate 4**
	Soil Remediation Schematic	**April 2006**

APPENDIX A

Appendix A

Lysimeter and Tensiometer Casing Installation at the Abo 1-G Site

Two pan lysimeters were installed by R.T. Hicks Consultants at the site on January 19 and 20, 2006. Lysimeters 1 and 2 were installed in grid numbers 6 and 38 respectively. Grid 6 is within the northern excavated area and grid 38 is within the southern excavated area. With each lysimeter, two casings were installed such that the bottoms of the casings access the vadose zone at depths above and below the lysimeters. These allow installation of a removable tensiometer to measure soil matric potential and hence, soil moisture content. Should retrieval of a sample of vadose zone water be not possible, these moisture contents will explain whether there is a problem with the lysimeter or that there is simply too little moisture to sample.

Grid 6 is approximately 50 feet south of the release origin and 30 feet west of MW-1. Lysimeter 1 was installed in trench dug 8 feet below the excavated ground surface, one foot below the former ground surface.

Grid 38 is approximately 35 feet southwest of SB-3 and was excavated to a depth of 5 feet below ground surface (bgs). Lysimeter 2 was installed in a trench dug 4 feet below the excavated ground surface or 9 feet bgs.

Both lysimeters were installed in vertically oriented 3 inch PVC casing with a sealed cap on the bottom. Six inches above the bottom of the cap is a horizontal extension composed of 2.5 feet of 3 inch diameter PVC casing slotted on its upper diameter exposing half of the casing to vadose zone flow. This lateral extension collects the vadose zone flux and delivers it to the six inch sump. The lysimeters are installed vertically in the six inch sumps.

The sumps and the horizontal extensions were filled with a blended mixture by volume of 30% silica flour and 70% clean fill sifted through a number 30 screen. The fill was field tested to contain 137 mg/kg chloride by ROC personnel.

The trench floors were horizontally excavated to allow the horizontal extension to be positioned laterally underneath the unexcavated vadose zone. After placement of the casing, the space between the casing and the unexcavated trench wall was packed first with the mixture of the silica flour and the screened fill and finally with the screened fill.

An additional 6 inch deep excavation was made in the trench floor to allow placement of the deep 2 inch PVC casing. The bottom of the casing and excavation was packed with the mix of silica flour and screened fill. The shallow casing was placed with its bottom a foot above the lsimeter pan by excavating a slot in the trench wall. The bottom of this casing was also packed with the silica flour and screened fill.

After covering the bottoms of all casings with the clean fill to a depth of one foot, the trenches were backfilled level to the previously excavated surface with the material originally excavated from the trench. A six inch thick bentonite cap was installed around each site's three vertical casings at this elevation with an additional bentonite cap placed around the casings upon backfill of the respective grids to the new ground level.

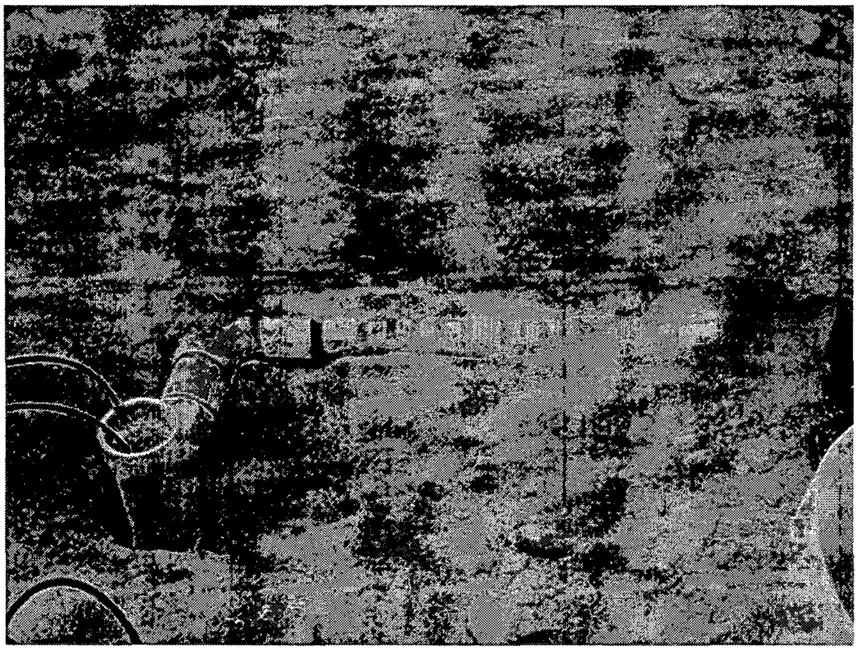


Figure 1: Lysimeter 2 with fill material during installation. Slotted collection pan is in trench dug under intact vadose zone material.

Figure 2 : Detail of Lysimeter 2 showing collection tubes to vertically mounted collection vessel in the capped sump.

Figure 3: Bentonite being placed around Lysimeter 1 casing and associated Tensiometer casings. MW-1 is visible to the upper right of Lysimeter 1 casings.

Randall Hicks

From: Kristin Farris Pope [kpriceswd@valornet.com]
Sent: Monday, March 27, 2006 3:47 PM
To: Wayne Price
Cc: Carolyn Haynes; Randall Hicks
Subject: Abo 1G Release Site Water Analysis

Per condition 5 of NMOCD's recent (Nov. 4) conditional approval letter to Rice Operating Company regarding the Abo 1G Release Site (Case #1R0415),

"The on-site monitor well shall be maintained for two years, sampled and analyzed quarterly for chlorides. If chlorides exceed the WQCC groundwater standards then ROC shall report pursuant to Rule 116. The results of the sample shall be submitted to the OCD and the city of Lovington every quarter."

please find the attachment of the most recent lab analysis from the monitoring well at the subject site. Should you have any questions, please feel free to contact me.

Kristin Farris Pope
Project Scientist
RICE Operating Company
Hobbs, New Mexico
(505) 393-9174

Randall Hicks

From: Randall Hicks [r@rthicksconsult.com]
Sent: Thursday, January 05, 2006 12:03 PM
To: 'Price, Wayne, EMNRD'
Cc: 'Kristin Farris Pope'; 'David Hamilton'
Subject: Lovington Abo

Wayne

ROC is digging the hole and stockpiling the caliche in anticipation of NMOCD approval of the reuse-recycle program.

Can you provide Rice with a date as to when you may be able to approve/question or disapprove this plan?

The Pitch:

This plan is fully consistent with the NMOCD chloride mass loading restrictions on landfarms (which I believe is 1000 ppm chloride on a 5 acre landfarm that is two feet thick). Our simulation essentially verifies what your VADSAT model predicts. A loading of 1300 ppm chloride on a 6 inch lift on a 15-foot wide road that runs perpendicular to ground water flow will not cause a measurable impact on ground water quality. The chloride mass load of our proposal is less than your simulation, the distance perpendicular to groundwater flow is less than your simulation and all other model inputs should be essentially the same.

We honestly believe that our proposal is

1. Consistent with good science
2. Consistent with NMOCD policy
3. Compliant with all NMOCD Rules
4. Much better for the environment as a whole when compared with a dig-haul-dispose alternative

Please call me with any questions.

Randy Hicks
505-266-5004
cell: 505-238-9515

Randall Hicks

From: Carolyn Doran Haynes [cdhriceswd@valornet.com]

Sent: Thursday, January 05, 2006 3:33 PM

To: 'Price, Wayne, EMNRD'

Cc: 'Sanchez, Daniel J., EMNRD'; 'Randall Hicks'; TKostrubala@slo.state.nm.us

Subject: Road Repair Material - ABO project

Wayne,

I have discussed the usage for road repair of <1000ppm chloride, <100ppm TPH caliche with Leon Anderson, SLO, Hobbs office. He was quite enthusiastic about it, saying that he's wanted this for a long time and he certainly supports the proposal, but was also cautious and wanted confirmation from the Santa Fe office. I contacted Thaddeus Kostrubala, environmental engineer, of the Santa Fe SLO office and will forward to him the proposal we sent to you at NMOCD. He will review and discuss with others in his office before rendering opinion.

Would you please copy the SLO on NMOCD's reply: TKostrubala@slo.state.nm.us

Rice Operating Company (ROC) wants to assure the NMOCD that the caliche material from the ABO IG Excavation Project meeting this criteria: <1000ppm Chloride and <100ppm TPH, would NOT be used on the land owned by the City of Lovington, nor will it be used within 1 mile of their perimeter.

At this time, the road repair material will be used in the Oil Center vicinity on NM State Land – Sections 1-36, T21S, R36E where groundwater is 100+ feet BGS or not available; where there are no surface bodies of water or domestic water wells within 1000 feet of the road repair site; and only where there is agreement with the surface landowner to do so.

ROC is also willing to monitor the chloride infiltration to confirm the modeling results by periodically investigating the soils beneath and near the road repair for the migration of chlorides. The effort afforded to expanding the environmental benefit of our oilfield remediation projects is effort well placed.

Thank you for your consideration of this matter.

PS: Have you had any thoughts about the February 1 meeting location? We should be installing the lysimeters and tensiometers at the ABO site around this time...any interest in seeing that? We could combine the two events.

Carolyn Doran Haynes
Engineering Manager
RICE *Operating Company*
505-393-9174
505-397-1471 (fax)

Randall Hicks

From: Kristin Farris Pope [kpriceswd@valornet.com]

Sent: Thursday, December 29, 2005 11:26 AM

To: Paul Sheeley; Larry Johnson; Wayne Price; Roger Anderson; Sanchez, Daniel J., EMNRD; Pat Wise

Cc: Carolyn Haynes; Roy Rascon; Katie Lee; Randall Hicks; rariceswd@valornet.com

Subject: Abo 1G work

I would like to notify you that Rice Operating Company will begin delineation and excavation activities at the Abo 1G Release Site per the NMOCD-approved work plan submitted by R.T. Hicks Consultants on **Tuesday, January 3, 2006**. The site is located in Unit 'G', Sec. 1, T17S, R36E. A Maintenance Activity Permit (#12270501) has been obtained from the City of Lovington for these actions. Please contact ROC should you have any questions.

Kristin Farris Pope
Project Scientist
RICE Operating Company
Hobbs, NM 88240
(505) 393-9174

Randall Hicks

From: Carolyn Doran Haynes [cdhriceswd@valornet.com]
Sent: Monday, November 21, 2005 3:13 PM
To: 'Randall Hicks'
Subject: FW: Rice ABO 1G Release site 1R0415

Just in case you didn't get the copy from Wayne

Carolyn Doran Haynes
Engineering Manager
RICE *Operating Company*
505-393-9174
505-397-1471 (fax)

From: Price, Wayne, EMNRD [mailto:wayne.price@state.nm.us]
Sent: Thursday, November 17, 2005 12:10 PM
To: Carolyn Doran Haynes; Sanchez, Daniel J., EMNRD
Cc: Kristin Farris Pope; Randall Hicks; hsncpbm@leaco.net
Subject: RE: Rice ABO 1G Release site 1R0415

Dear Ms. Haynes:

Point #1: OCD's intent is for ROC to remove as much chloride mass to some practical extent. If there are areas where the contamination is only three (3) feet deep then you would only be required to remove that portion.

Point#3. OCD will require clean back-fill at this site due to the sensitive nature i.e. close proximity to a public well supply.

If you have any further questions please do not hesitate to call or write.

From: Carolyn Doran Haynes [mailto:cdhriceswd@valornet.com]
Sent: Friday, November 11, 2005 12:18 PM
To: Price, Wayne, EMNRD; Sanchez, Daniel J., EMNRD
Cc: 'Kristin Farris Pope'; 'Randall Hicks'
Subject: RE: Rice ABO 1G Release site 1R0415

Wayne and Daniel,

There are 2 points of your conditions for the ABO 1G Release Site that Rice and System Partners would like clarification.

Point # 1: Remove a minimum of five (5) feet of soil in all impacted areas and dispose of at an approved OCD site.

For Example: Remove IMPACTED soils or a minimum of 5 feet – if impacted soils are only 3' deep or less (as many of the perimeter areas are) just remove the 3 feet. If impact is greater than 5 feet, remove 5 feet.

Also, for disposal of removed soils, dispose of soils greater than 1000 ppm Chlorides (or a concentration that OCD can support) and stage lesser-impacted soils for on-site blending.

Point # 3: Backfill over the barrier area with a minimum of three (3) feet of clean soil that will support vegetation.

It is ROC's experience that soils <1000 ppm Chloride can successfully support native vegetation. The API (and Dr. Lloyd E. Deuel and Texas A&M) actually supports a concentration of 800 ppm Chloride. A web site for reference would be: http://agnews.tamu.edu/drought/DRGHTPAK/SALITAB9.HTM Look for the Texas A&M University document titled "Chloride Tolerance of Agricultural Crops."

Could OCD clarify an acceptable concentration? ROC would like to retain as much of the native soil as possible to blend with fresh, foreign soil that will be hauled-in. Generally, with the consideration for 12" of compacted clay (95% of proctor test with permeability of $<1 \times 10^{-7}$ cm/sec?) we will haul in an amount equal to the hauled-out amount. We will compact all soils and slightly mound the area to compensate for settling over time.

Please respond so ROC can distribute the AFE for this work. We will meet the January closure request if we get this out asap.

Thank you.

Carolyn Doran Haynes
Engineering Manager
RICE *Operating Company*
505-393-9174
505-397-1471 (fax)

From: Price, Wayne, EMNRD [mailto:wayne.price@state.nm.us]
Sent: Friday, November 04, 2005 3:44 PM
To: cdhriceswd@valornet.com
Cc: Sheeley, Paul, EMNRD; hsncpbm@leaco.net; seay04@leaco.net
Subject: Rice ABO 1G Release site 1R0415

Dear Ms. Haynes:

Please find enclosed the work plan approval for the Lovington ABO 1G release site. Please notify the City of Lovington and the OCD Hobbs office before starting.

Wayne Price-Senior Environmental Engr.
Oil Conservation Division
1220 S. Saint Francis
Santa Fe, NM 87505
E-mail wayne.price@state.nm.us
Tele: 505-476-3487
Fax: 505-4763462

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November 04, 2005

Carolyn Doran Haynes
Rice Operating Company
122 West Taylor
Hobbs, New Mexico 88240

Re: ABO 1G Release Site OCD Case ***#1R0415***
Unit Letter G, Sec. 1, T17S, R36E
Lea County, NM

Dear Ms. Haynes:

The New Mexico Oil Conservation Division (NMOCD) is in receipt of Rice Operating Company's (ROC) second "Amended Corrective Action Plan" dated August 2005 submitted by R.T. Hicks Consultants, Ltd. OCD hereby approves of the plan with the following conditions:

1. Remove a minimum of five (5) feet of soil in all impacted areas and dispose of at an approved OCD site.

2. Install a clay barrier over any area where the chlorides remaining in the vadose exceeds 1000 mg/kg. The barrier design shall be pursuant to Item 5.d. of the plan and shall extend at a minimum of three (3) feet horizontally over impacted areas.

3. Backfill over the barrier area with a minimum of three (3) feet of clean soil that will support vegetation.

4. Re-vegetate, and fence per item 5.f. of the plan. The area should be initially watered to enhance plant growth.

5. The on-site monitor well shall be maintained for two years, sampled and analyzed quarterly for chlorides. If chlorides exceed the WQCC groundwater standards then ROC shall report pursuant to Rule 116. The results of the sample shall be submitted to the OCD and the city of Lovington every quarter.

6. ***<u>Submit a closure plan for OCD approval by Jan 31, 2006.</u>*** Please include photos of the project, sample results to-date, and written summary of the project. A copy of the plan shall be submitted to the City of Lovington.

Sincerely;

Daniel Sanchez- Compliance and Enforcement Manager

cc: OCD Hobbs Office
City of Lovington, NM

Randall Hicks

From: katie Lee [katie@rthicksconsult.com]
Sent: Friday, September 02, 2005 3:09 PM
To: wayne.price@state.nm.us; daniel.sanchez@state.nm.us; roger.anderson@state.nm.us
Cc: Randall Hicks (Randall Hicks); Kristen at Rice
Subject: RE: Lovington Abo 1G CAP

Gentlemen,

We wanted to make sure that you all were aware that the Amended Lovington Abo 1 G Corrective Action Plan (NMOCD Case #1R0415) is available on our ftp site at: ftp://hicks:k6bbuufe@ftp.swcp.com/Abo1G_CAP/

If you have trouble accessing the document, please let me know. A hard copy of the report is on its way to the Santa Fe office and the Hobbs office.

Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
505-266-5004

-----Original Message-----
From: katie Lee [mailto:katie@rthicksconsult.com]
Sent: Wednesday, August 31, 2005 5:34 PM
To: 'wayne.price@state.nm.us'
Cc: Randall Hicks (Randall Hicks); Kristen at Rice (kpriceswd@valornet.com)
Subject: Lovington Abo 1G CAP

Hello Mr. Price,

The Amended Lovington Abo 1G Corrective Action Plan (NMOCD Case #1R0415) is available on our ftp site at: ftp://hicks:k6bbuufe@ftp.swcp.com/Abo1G_CAP/ . Our transmittal letter is attached.

Two appendices will follow via snail mail due to their prohibitive size. If you have any trouble opening this document, please let me know.

Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Randall Hicks

From: katie Lee [katie@rthicksconsult.com]
Sent: Wednesday, August 31, 2005 5:34 PM
To: wayne.price@state.nm.us
Cc: Randall Hicks (Randall Hicks); Kristen at Rice
Subject: Lovington Abo 1G CAP

Hello Mr. Price,

The Amended Lovington Abo 1G Corrective Action Plan (NMOCD Case #1R0415) is available on our ftp site at: ftp://hicks:k6bbuufe@ftp.swcp.com/Abo1G_CAP/ . Our transmittal letter is attached.

Two appendices will follow via snail mail due to their prohibitive size. If you have any trouble opening this document, please let me know.

Best regards,

Katie Lee
Staff Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Office Phone: 505-266-5004
Fax: 505-266-0745

Randall Hicks

From: Randall Hicks [R@rthicksconsult.com]
Sent: Friday, August 12, 2005 5:05 PM
To: 'wayne.price@state.nm.us'
Cc: 'kpriceswd@valornet.com'; 'David Hamilton'
Subject: Lovington Abo

Wayne

The characterization program was more extensive than we originally thought and we were able to set up the model with the new data by today.

We believe this progress report demonstrates the good faith of ROC by moving forward with creating a scientifically-sound remedy for the release site. Such a remedy begins with data – which we now have for the newly "discovered" 1992 release.

Have a good weekend.

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Kristin Farris Pope [kpriceswd@valornet.com]
Sent: Monday, July 18, 2005 11:37 PM
To: Roger Anderson; Wayne Price; Daniel Sanchez; Paul Sheeley; Larry Johnson
Cc: pwise@lovington-nm.org; Randall Hicks; Carolyn Haynes
Subject: Work Notification--Abo Apache G1 leak site

ROC notifies OCD of the following delineation activities to be performed at the **Abo Apache 1G leak site** (unit 'G', Sec. 1, T17S, R36E):

July 20-22, 2005 Site grid and chloride survey using hand tools
July 25-27, 2005 Delineation using a trackhoe <= 20 ft BGS

NMOCD case number for this site is 1R0415. Should you have any questions regarding these activities, do not hesitate to contact me.

Kristin Farris Pope
Project Scientist
RICE Operating Company
Hobbs, NM 88240
(505) 393-9174

Randall Hicks

From: Carolyn Doran Haynes [cdhriceswd@valornet.com]
Sent: Monday, July 18, 2005 5:13 PM
To: wayne.price@state.nm.us; daniel.sanchez@state.nm.us; roger.anderson@state.nm.us
Cc: 'Kristin Farris Pope'; 'Randall Hicks'
Subject: ABO 1G site

Wayne Price, Roger Anderson and Daniel Sanchez:

Thank you for your time and attention for Friday's meeting.

Wayne, I called you earlier in the day and left a message for you to call at your convenience concerning the ABO 1G Release Site. I have also not been able to connect with the major System Partners, leaving messages both on the land and cell lines.

If the following activities meet with your approval, this will be the immediate path forward to perform additional delineation at the site for the historical leak and surface:

July 15: The One Call was made so excavation for delineation can begin by the 20th
July 20-22: The site will be marked for grid-lines and the surface sampled for an overall surface chloride snapshot
July 25-29: A track hoe will be available to start excavation trenching to 20' BGS - top to bottom, side to side of the site
July 25-29: Field chloride analysis will be conducted on samples at 2' intervals, or as applicable
Aug 1-3: With this additional site information, chloride loads will be recalculated
Aug 3-10: Simulations of HYDRUS 1D modeling using various excavation and moisture barrier scenarios
Aug 10-12: Wrap-up information, conclusions, path forward
Aug 12: Report Results and propose site remediation plan to NMOCD

As always, for all significant activities at the site, Rice will be giving advance notice to the NMOCD and City of Lovington.

If this meets with your approval, Rice will proceed with notifying the City of Lovington.

Carolyn Doran Haynes
Engineering Manager
RICE *Operating Company*
505-393-9174
505-397-1471 (fax)

Randall Hicks

From: Randall Hicks [R@rthicksconsult.com]
Sent: Monday, May 09, 2005 11:53 AM
To: 'Price, Wayne'
Cc: 'Sheeley, Paul'; 'Kristin Farris Pope'
Subject: FW: Lovington Abo

Wayne

Thanks for the information. I hope to meet with Paul Sheeley in Lovington on another matter and perhaps we can simply combine the trips. I am on the phone to Paul after I finish this.

With respect to surface soil samples, I understand that ROC did not collect surface samples for two reasons:

1. Soon after the release, one could easily see that the surface soil was coated with salt. Therefore, surface samples would not provide more information than the photograph on the cover of the June 2004 report – the chloride concentration on the surface would be very high. The samples from NMOCD confirm what the photograph shows.
2. More importantly from my perspective is the fact that the surface soils in the area range in thickness from zero to, perhaps, six inches. You can see the rocks of caliche in the photograph and when I walked the site much of the ground surface was predominantly **fractured** caliche. I think that we all felt that the main mass of chloride would be below the fractured caliche, not in the thin layer of overlying soil.

Therefore, we had no surface samples to report to NMOCD. We did have an analysis of the produced water, the area of the spill and a relatively good guess as to the volume released. This data regarding the nature of the spill also gave us sufficient confidence to proceed without detailed characterization of the thin surface soil. We thought that even with high concentrations of chloride in the surface soil, the thin layer of soil would not hold a large mass. We concentrated our efforts at characterization of the material beneath the fractured caliche. ROC did take some surface soil samples, but these were taken after several rainfall events.

I fear that after the precipitation of 2004-05 that surface soil samples will provide little additional benefit over the deep soil samples obtained from the monitoring well boring.

ROC and Hicks Consultants fully understand the importance of protecting the ground water resources of New Mexico and we understand that the proximity of the water supply wells makes this situation worthy of careful consideration by all parties. We are applying the best science to the problem to develop the best solution. We appreciate your help and counsel.

Randy

Randall Hicks

From: Price, Wayne [WPrice@state.nm.us]
Sent: Friday, May 06, 2005 2:42 PM
To: 'Randall Hicks'; Price, Wayne; Martin, Ed
Cc: 'Kristin Farris Pope'; Sheeley, Paul; Patrick B. McMahon (E-mail); Martin, Ed; Mike Griffin (E-mail)
Subject: RE: Lovington Abo

Hi Randy, the city of Lovington has supplied OCD with soil surface samples that show high chlorides (11,000-22,000 mg/kg). Unless I missed something we did not see levels listed that high in your reports. So, I have requested the District office to go out and collect samples early next week. If you want to split call Paul Sheeley (OCD). Once I get our sample results then our technical staff will determine a path forward hopefully that be satisfactory to all parties and will protect the environment. OCD considers this a high profile case since it is located in close proximity to the Lovington City fresh water well field. OCD is concerned about the amount of time that has passed with no remedial action. OCD will make a decision very soon.

Starting Last week OCD Environmental Bureau was instructed by our Bureau Chief that no files may leave the office but can be copied in our office for $.25 per copy.

I quickly reviewed the data base and did not find any Devon Projects near Buckeye. I do have two Devon projects 1R0432 and 1R0433 which included some analysis using the Hydrus 1D. These projects were both amended by the contractor and basically turned out to be very large excavation projects which are still in progress. Both may have groundwater contamination and reports are due in July 05. If they do have groundwater contamination then most likely they will be subject to Rule 19.

-----Original Message-----
From: Randall Hicks [mailto:R@rthicksconsult.com]
Sent: Friday, May 06, 2005 1:23 PM
To: 'Price, Wayne'; emartin@state.nm.us
Cc: 'Kristin Farris Pope'
Subject: Lovington Abo

Wayne

Here is what I understand you need for your evaluation of the Lovington Abo 1G spill site:

1. An photo or digital image of the original spill
2. Results of any surface soil analyses
3. A spill report – which I believe Kristin faxed to you.

If there is anything else we can do, let us know.

As discussed earlier today, I would like a copy of the NMOCD file for the site that Jan Hendrickx told me that he performed some modeling. Jan suggested that it was a Devon site near Buckeye – a CD Dickerson site or something like that?

By this email I am alerting **Kinko** of Santa Fe to call Wayne Price at 476-3487 to schedule a time for the file pick-up. In your absence, I am asking KINKOs to call Ed Martin at NMOCD to retrieve the file.

Thanks

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

-----Original Message-----
From: Price, Wayne [mailto:WPrice@state.nm.us]
Sent: Friday, May 06, 2005 2:42 PM
To: 'Randall Hicks'; Price, Wayne; Martin, Ed
Cc: 'Kristin Farris Pope'; Sheeley, Paul; Patrick B. McMahon (E-mail); Martin, Ed; Mike Griffin (E-mail)
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Sent: Friday, May 06, 2005 1:23 PM
To: 'Price, Wayne'; emartin@state.nm.us
Cc: 'Kristin Farris Pope'
Subject: Lovington Abo

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By this email I am alerting **Kinko** of Santa Fe to call Wayne Price at 476-3487 to schedule a time for the file pick-up. In your absence, I am asking

KINKOs to call Ed Martin at NMOCD to retrieve the file.

Thanks

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Kristin Farris [enviro@leaco.net]
Sent: Friday, February 25, 2005 7:53 AM
To: Price, Wayne
Cc: Carolyn Haynes; Larry Johnson; Paul Sheeley; Randall Hicks; Rozanne Johnson
Subject: Re: NMOCD Case #1R0415

Basin Environmental Technologies of Lovington will re-sample the monitoring well at the Abo Apache 1A leak site on Tuesday, March 1, 2005 at approximately 1:00 pm. NMOCD-Hobbs will split samples.

Please let me know if this schedule is agreeable to everyone. Thanks.

Kristin Farris Pope

----- Original Message -----
From: Price, Wayne
To: 'katie@rthicksconsult.com' ; Price, Wayne ; Carolyn Doran Haynes (E-mail)
Cc: Kristen at Rice ; Randall Hicks ; Sheeley, Paul ; Johnson, Larry
Sent: Monday, February 21, 2005 11:01 AM
Subject: RE: NMOCD Case #1R0415

After reviewing the lab QA/QC check-in sheet, it appears the sample bottle was not labeled. Please make arrangements to resample this monitoring well. Provide OCD the results no later than March 21, 2005. In addition, please contact the OCD Hobbs office and make arrangements for them to witness and/or split samples.

-----Original Message-----
From: katie Lee [mailto:katie@rthicksconsult.com]
Sent: Tuesday, December 21, 2004 12:43 PM
To: Wayne Price
Cc: Kristen at Rice; Randall Hicks
Subject: RE: NMOCD Case #1R0415

Dear Mr. Price,

My apologies for the mistake in the NMOCD case number for Lovington Abo. It was marked as #1R0414, when in fact it should have read #1R0415. Attached, the report with the transmittal letter corrected. A hard copy of this report (with the incorrect number) has already been mailed to you. I can fax you the corrected first page, or send it via the post, as seems best to you.

Best regards,

Katie Lee
Associate Scientist

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Phone: 505-266-5004
Fax: 505-266-0745

-----Original Message-----
From: katie Lee [mailto:katie@rthicksconsult.com]
Sent: Monday, December 20, 2004 3:32 PM
To: Wayne Price
Cc: Kristen at Rice; Randall Hicks
Subject: NMOCD Case #1R0414

Dear Mr. Price:

Attached, please find a transmittal letter and supporting documents for the Rice Operating Company Abo 1G Leak Site, NMOCD Case # 1R0414. If you have any trouble with these documents, questions, comments, etc, please let us know. A paper copy follows via snail mail. Happy holidays!

Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Phone: 505-266-5004
Fax: 505-266-0745

Randall Hicks

From: Price, Wayne [WPrice@state.nm.us]
Sent: Monday, February 21, 2005 11:01 AM
To: 'katie@rthicksconsult.com'; Price, Wayne; Carolyn Doran Haynes (E-mail)
Cc: Kristen at Rice; Randall Hicks; Sheeley, Paul; Johnson, Larry
Subject: RE: NMOCD Case #1R0415

After reviewing the lab QA/QC check-in sheet, it appears the sample bottle was not labeled. Please make arrangements to resample this monitoring well. Provide OCD the results no later than March 21, 2005. In addition, please contact the OCD Hobbs office and make arrangements for them to witness and/or split samples.

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Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Phone: 505-266-5004
Fax: 505-266-0745

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From: katie Lee [mailto:katie@rthicksconsult.com]
Sent: Monday, December 20, 2004 3:32 PM
To: Wayne Price
Cc: Kristen at Rice; Randall Hicks
Subject: NMOCD Case #1R0414

Dear Mr. Price:

Attached, please find a transmittal letter and supporting documents for the Rice Operating Company Abo 1G Leak Site, NMOCD Case # 1R0414. If you have any trouble with these documents, questions, comments, etc, please let us know. A paper copy follows via snail mail. Happy holidays!

Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Phone: 505-266-5004
Fax: 505-266-0745

Randall Hicks

From: Carolyn Doran Haynes [cdhriceswd@leaco.net]
Sent: Tuesday, December 14, 2004 3:37 PM
To: 'Price, Wayne'
Cc: R@rthicksconsult.com; 'Kristin Farris'
Subject: FW: Lovington ABO leak site 1R0414

Dear Mr. Price:

You requested further information by today on this work site (as described below in your email).

The plot plan and boring log will be sent via RT Hicks Consultants before the end of the week (December 17). The monitor well has been developed and was sampled November 24th. The samples were sent to Environmental Labs of Texas and ROC is awaiting results. Results will be submitted as soon as received.

Thank you,

Carolyn Haynes

-----Original Message-----
From: Rice Operating [mailto:riceswd@leaco.net]
Sent: Tuesday, December 07, 2004 1:26 PM
To: Haynes, Carolyn Doran
Subject: Fw: Lovington ABO leak site 1R0414

----- 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: "Pat Wise (E-mail)" <pwise@lovington-nm.org>; "Patrick B. McMahon (E-mail)" <hsncpbm@leaco.net>
Sent: Tuesday, December 07, 2004 10:13 AM
Subject: Lovington ABO leak site 1R0414

> Please provide a plot plan showing the location of the new monitor
> well, please send boring log and all analytical results by December
> 14, 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
>
>
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> message. -- This email has been scanned by the MessageLabs Email Security

Randall Hicks

From: Pat Wise [pwise@lovington-nm.org]
Sent: Thursday, November 04, 2004 2:56 PM
To: Randall Hicks
Subject: Re: Lovington Abo

Mr. Hicks:

I was aware of the intent to install the monitoring well, and will waive the permit approval if you will forward me a copy of the OCD's approval of the installation. Thanks for your cooperation.

Pat Wise, Manager
City of Lovington

----- Original Message -----
From: Randall Hicks
To: 'Pat Wise (E-mail)'
Cc: 'Kristin Farris Pope' ; david@rthicksconsult.com ; 'Sheeley, Paul' ; 'Johnson, Larry' ; 'Price, Wayne' ; 'Patrick B. McMahon (E-mail)'
Sent: Thursday, November 04, 2004 1:02 PM
Subject: RE: Lovington Abo

Mr. Wise

About 5 minutes ago, I was informed that we should have obtained a permit for tomorrow's monitor well installation activity at the Abo-1G site (see attached map). I immediately called your office and spoke with Charles who told me the purpose of the permit process is to make sure the City remains informed about what is going on near your wells.

May I assume that our notification sent to you on 11/1/04 and copies of previous correspondence with the NMOCD will serve as a permit application for this first time? And I promise that for any future activity of R.T. Hicks Consultants on City property we will fill out the appropriate permits.

Thanks for understanding about this lapse on my part. If you have any questions regarding our work at this site, please contact me.

Randy Hicks
505-266-5004

-----Original Message-----
From: Price, Wayne [mailto:WPrice@state.nm.us]
Sent: Thursday, November 04, 2004 11:42 AM
To: 'Randall Hicks'; Price, Wayne; Pat Wise (E-mail); Patrick B. McMahon (E-mail)
Cc: Kristin Farris Pope; david@rthicksconsult.com; Sheeley, Paul; Johnson, Larry
Subject: RE: Lovington Abo

OCD approves of the installation of the monitor well and sampling of the soil and water. OCD will require that the sample of the soil in the boring be conducted every 5 feet to groundwater.

At this time OCD does not approve of the remediation work. OCD will evaluate the monitor well results and soil boring results before we approve the remediation plan. We will also wait on comments from the City of Lovington.

-----Original Message-----
From: Randall Hicks [mailto:R@rthicksconsult.com]
Sent: Thursday, October 28, 2004 9:05 AM
To: 'Price, Wayne'
Cc: Kristin Farris Pope; david@rthicksconsult.com
Subject: Lovington Abo
Wayne

Here is our plan for drilling at the Lovington Abo spill

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Price, Wayne [WPrice@state.nm.us]

Sent: Thursday, November 04, 2004 11:42 AM

To: 'Randall Hicks'; Price, Wayne; Pat Wise (E-mail); Patrick B. McMahon (E-mail)

Cc: Kristin Farris Pope; david@rthicksconsult.com; Sheeley, Paul; Johnson, Larry

Subject: RE: Lovington Abo

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To: 'Price, Wayne'
Cc: Kristin Farris Pope; david@rthicksconsult.com
Subject: Lovington Abo

Wayne

Here is our plan for drilling at the Lovington Abo spill

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Randall Hicks [R@rthicksconsult.com]
Sent: Thursday, November 04, 2004 3:11 PM
To: 'Pat Wise (E-mail)'
Subject: FW: Lovington Abo

Here it is

-----Original Message-----
From: Price, Wayne [mailto:WPrice@state.nm.us]
Sent: Thursday, November 04, 2004 11:42 AM
To: 'Randall Hicks'; Price, Wayne; Pat Wise (E-mail); Patrick B. McMahon (E-mail)
Cc: Kristin Farris Pope; david@rthicksconsult.com; Sheeley, Paul; Johnson, Larry
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Wayne

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Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

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Sent: Thursday, November 04, 2004 1:02 PM
To: 'Pat Wise (E-mail)'
Cc: 'Kristin Farris Pope'; 'david@rthicksconsult.com'; 'Sheeley, Paul'; 'Johnson, Larry'; 'Price, Wayne'; 'Patrick B. McMahon (E-mail)'
Subject: RE: Lovington Abo

Mr. Wise

About 5 minutes ago, I was informed that we should have obtained a permit for tomorrow's monitor well installation activity at the Abo-1G site (see attached map). I immediately called your office and spoke with Charles who told me the purpose of the permit process is to make sure the City remains informed about what is going on near your wells.

May I assume that our notification sent to you on 11/1/04 and copies of previous correspondence with the NMOCD will serve as a permit application for this first time? And I promise that for any future activity of R.T. Hicks Consultants on City property we will fill out the appropriate permits.

Thanks for understanding about this lapse on my part. If you have any questions regarding our work at this site, please contact me.

Randy Hicks
505-266-5004

-----Original Message-----
From: Price, Wayne [mailto:WPrice@state.nm.us]
Sent: Thursday, November 04, 2004 11:42 AM
To: 'Randall Hicks'; Price, Wayne; Pat Wise (E-mail); Patrick B. McMahon (E-mail)
Cc: Kristin Farris Pope; david@rthicksconsult.com; Sheeley, Paul; Johnson, Larry
Subject: RE: Lovington Abo

OCD approves of the installation of the monitor well and sampling of the soil and water. OCD will require that the sample of the soil in the boring be conducted every 5 feet to groundwater.

At this time OCD does not approve of the remediation work. OCD will evaluate the monitor well results and soil boring results before we approve the remediation plan. We will also wait on comments from the City of Lovington.

> -----Original Message-----
> **From:** Randall Hicks [mailto:R@rthicksconsult.com]
> **Sent:** Thursday, October 28, 2004 9:05 AM
> **To:** 'Price, Wayne'
> **Cc:** Kristin Farris Pope; david@rthicksconsult.com

Subject: Lovington Abo
Wayne

Here is our plan for drilling at the Lovington Abo spill

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Randall Hicks [R@rthicksconsult.com]
Sent: Thursday, October 28, 2004 9:05 AM
To: 'Price, Wayne'
Cc: Kristin Farris Pope; 'david@rthicksconsult.com'
Subject: Lovington Abo

Wayne

Here is our plan for drilling at the Lovington Abo spill

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Price, Wayne [WPrice@state.nm.us]
Sent: Friday, October 01, 2004 11:42 AM
To: Carolyn Doran Haynes (E-mail); Randall Hicks (E-mail); Pat McCasland (E-mail)
Cc: Johnson, Larry; Sheeley, Paul; Olson, William
Subject: FW: Rice ABO IG release site

Dear Ms Haynes, Mr. Randy Hicks, and Mr. Pat Wise:

OCD is in receipt of the revised work plan (attached below) Dated August 31, 2004. The revised plan contains actions that will remove as much of the sterile topsoil as possible, import sufficient topsoil, re-vegetate, add water if necessary and monitor.

OCD supports source removal particular in this case because of the proximity to the City of Lovington fresh water well field. By removing the bulk of the contaminated soil, which still lies near the surface, OCD feels the future impairment of groundwater will be minimal if any. To make sure OCD is protecting the water supply of the City of Lovington we will also require a monitor well to be located in the spill area. If this method fails to protect fresh water then OCD would require additional actions.

I am asking for comments and concurrence so we may proceed ASAP.

-----Original Message-----
From: Randall Hicks [mailto:R@rthicksconsult.com]
Sent: Friday, October 01, 2004 10:25 AM
To: 'Price, Wayne'
Cc: 'Carolyn Doran Haynes'
Subject:

Wayne

Indeed, this was to be delivered to you on the 30th, when we finished it. I fear that if you do not have a record of it in your email, it slipped through the cracks in my office. I will see if we have a record of it being sent from another machine.

I apologise.

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Carolyn Doran Haynes [cdhriceswd@leaco.net]

Sent: Thursday, August 12, 2004 10:25 AM

To: 'Price, Wayne'

Cc: 'Randall Hicks'; enviro@leaco.net

Subject: ABO 1G Release Site OCD Case #1R0415

Dear Mr. Price:

Rice Operating Company (ROC) is in receipt of your request to submit a new work plan for the above referenced site. ROC respectfully pleads for an extension of the August 13 deadline to August 31, in order to adequately develop a work plan that addresses the OCD concerns. ROC has discussed this timeline issue with RT Hicks Consultants and they concur that a revised plan can be submitted before August 31.

ROC appreciates any consideration the OCD will afford to extend this deadline.

Thank you,

Carolyn Doran Haynes
Engineering Manager
RICE Operating Company
PH: 505-393-9174
FX: 505-397-1471

Randall Hicks

From: Price, Wayne [WPrice@state.nm.us]
Sent: Friday, August 06, 2004 3:47 PM
To: Carolyn Doran Haynes (E-mail)
Cc: Pat Wise (E-mail); Randall Hicks (E-mail); Sheeley, Paul; Johnson, Larry
Subject: Rice Operating Co.-Abo 1G Release site OCD Case # 1R0415

Dear Ms. Haynes:

OCD is in receipt of the corrective action plan dated June 07, 2004 submitted by RT Hicks. Please note due to the close proximity to the City of Lovington's fresh water well field OCD feels compelled to deny the plan as submitted. Please re-submit with a plan to remove the salt contaminated soil within some practical limit. Please submit by August 13, 2004. The longer "no action" is performed the deeper the salt will migrate into the vadose zone and a higher potential of groundwater contamination exists. We will not accept a model that allows groundwater contamination and dilution in this area. The model may be used after excavation to demonstrate no further threat exist.

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

Randall Hicks

From: Randall Hicks [R@rthicksconsult.com]
Sent: Friday, June 11, 2004 2:10 PM
To: 'Price, Wayne'
Cc: 'Carolyn Doran Haynes'; 'Kristin Farris'; 'david@rthicksconsult.com'
Subject: Abo 1G Release Corrective Action Plan

Wayne

Please expect the work plan for Vacuum G-35 in a few hours.

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: Randall Hicks [R@rthicksconsult.com]
Sent: Friday, April 02, 2004 3:51 PM
To: 'Price, Wayne'
Cc: 'enviro@leaco.net'; 'david hamilton'
Subject: Lovington Abo Leak

Wayne

We sent this workplan to you on January 22 and you responded to our workplan with:

Please send all of the backup information. Map, plats, analysis, etc. Also I am not sure how I can approve a process without seeing the modeling results which take into account the soil flushing etc. I will probably require a monitor well in this case due to its proximity to the Lovington well field and there are also many down gradient wells.

We then wrote back on January 29 with:

Wayne

We fully agree with your assessment that you cannot approve a remedy based upon what we sent you. Our recent submission was NOT a work plan to implement a remedy. It was a work plan to:

1. *Collect data for HYDRUS simulations (Item 1 of work plan)*
2. *Run Hydrus of various scenarios (Item 1)*
3. *Evaluate the soil and ground water data in concert with the HYDRUS results (Item 2), then to*
4. *Submit a Corrective Action Plan that includes a proposed remedy with our technical justification (Item 2)*

We anticipate that you will review the proposed remedy submitted under item 2 of our work plan, comment, and after NMOCD approval of the remedy, ROC will implement the approved remedy.

Our submission provides the framework for our path forward toward a remedy. It is not the proposed remedy. We hypothesize that soil flushing will prove to be the best remedy for the site – but we cannot support this hypothesis until we do the work. We hope to complete this project ASAP and your comments/approval of our work plan is greatly appreciated. We have already begun data collection and plan to run HYDRUS for the site late next week.

Sorry about the confusion.

Unless you see some deficiencies in our approach outlined in the workplan, we plan to perform the data analysis; HYDRUS modeling and write a report that is similar in scope to our Zachary Hinton remedy report. Then you will be able to respond to a report rather than a workplan. Sound good?

Incidentally, do you have any comments or questions on the Zachary Hinton Report of January 29, 2004?

Thanks for your help and have a good weekend.

Randy Hicks
505-266-5004 - office
505-238-9515 - cell

Randall Hicks

From: katie Lee [katie@rthicksconsult.com]
Sent: Tuesday, December 21, 2004 12:43 PM
To: Wayne Price
Cc: Kristen at Rice; Randall Hicks
Subject: RE: NMOCD Case #1R0415

Dear Mr. Price,

My apologies for the mistake in the NMOCD case number for Lovington Abo. It was marked as #1R0414, when in fact it should have read #1R0415. Attached, the report with the transmittal letter corrected. A hard copy of this report (with the incorrect number) has already been mailed to you. I can fax you the corrected first page, or send it via the post, as seems best to you.

Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Phone: 505-266-5004
Fax: 505-266-0745

-----Original Message-----
From: katie Lee [mailto:katie@rthicksconsult.com]
Sent: Monday, December 20, 2004 3:32 PM
To: Wayne Price
Cc: Kristen at Rice; Randall Hicks
Subject: NMOCD Case #1R0414

Dear Mr. Price:

Attached, please find a transmittal letter and supporting documents for the Rice Operating Company Abo 1G Leak Site, NMOCD Case # 1R0414. If you have any trouble with these documents, questions, comments, etc, please let us know. A paper copy follows via snail mail. Happy holidays!

Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Randall Hicks

From: katie Lee [katie@rthicksconsult.com]
Sent: Monday, December 20, 2004 3:32 PM
To: Wayne Price
Cc: Kristen at Rice; Randall Hicks
Subject: NMOCD Case #1R0414

Dear Mr. Price:

Attached, please find a transmittal letter and supporting documents for the Rice Operating Company Abo 1G Leak Site, NMOCD Case # 1R0414. If you have any trouble with these documents, questions, comments, etc, please let us know. A paper copy follows via snail mail. Happy holidays!

Best regards,

Katie Lee
Associate Scientist
R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW F-142
Albuquerque, NM 87104

Phone: 505-266-5004
Fax: 505-266-0745

Randall Hicks

From: Katie Lee [katie@rthicksconsult.com]
Sent: Thursday, January 22, 2004 11:09 AM
To: Wayne Price
Cc: Kristen at Rice; Carolyn Haynes; Randall Hicks
Subject: Lovington Abo

Mr. Price:

Attached please find our submission of a Lovington Abo work plan. If you have any questions or any trouble with this document, please don't hesitate to contact me.

Best regards,

Katie
R.T. Hicks Consultants, Ltd.
505.266.5004

R. T. Hicks Consultants, Ltd.

901 Rio Grande Blvd. NW Suite F-142 Albuquerque, NM 87109 505.266.5004 Fax: 505.266.0745

January 22, 2004

Mr. Wayne Price
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Abo 1G Leak Site: Section 1, 17S 36E Unit G

Dear Mr. Price:

Rice Operating Company retained Hicks Consultants to address potential environmental concerns at the above referenced site. This submission proposes a scope of work that we believe will best mitigate any threat to human health and the environment and lead to closure of the regulatory file for this site.

Background

The Abo 1G Discharge Site is located about 6 miles southeast of the center of Lovington, New Mexico. Plate 1 shows the location of the site relative to Route 18, the Hobbs-Lovington Highway. The pipeline failure released produced water with little or no hydrocarbons.

Rice Operating Company (ROC) prepared a Release Notification report that summarizes activities to date. Plate 2 shows the geometry of the release and the locations of soil borings used to characterize the release. Soil boring SB2 is uphill from the spill site and we consider this a "background" location. The soil borings within the area of the release (#1 and #3) show a decline in chloride concentrations from more than 1000 ppm chloride to background levels (about 280 ppm) at 45 feet and 15 feet below land surface respectively. Because the water table lies about 80 feet below land surface, this observed decrease of chloride concentrations suggests that the release from did not create saturated conditions between ground surface and ground water.

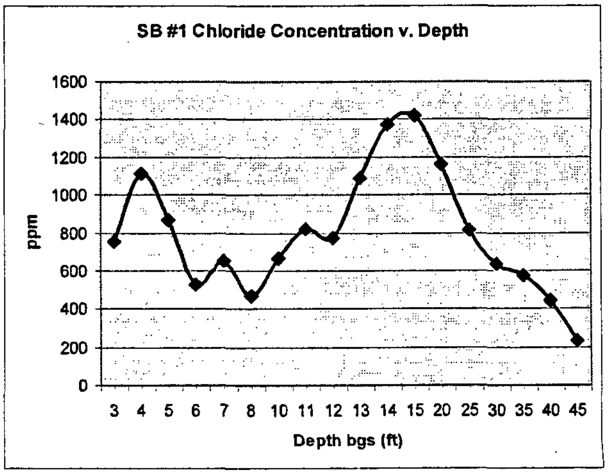


Figure 1 plots the chloride

concentration v. depth for Soil Boring #1. This diagram for Soil Boring #1 shows that the recent release is the second of two releases at or near this site. This data and that from Soil Boring #3 demonstrate that the center of mass from the recent release is at a depth of 4-5 feet below land surface. From 13-20 feet below land surface in Soil Boring #1, a second center of mass exists. As stated earlier, chloride concentrations decline to background levels from 40-45 feet in this boring. ROC confirmed that an earlier release of about 10 barrels did occur in the past near Soil Boring #1.

We conclude that these soil boring data show no evidence of potential ground water impairment. The chloride from the releases remains within the vadose zone. Based upon our experience with other sites, we hypothesize that the chloride will remain in the vadose zone for decades, centuries, or indefinitely. Previous research on the migration and fate of chloride conducted by API suggest that any vertical migration of chloride is so slow that ground water quality cannot be materially impacted by releases of this magnitude. Therefore, we have restricted our proposed activities to reclamation of the surface to its original productive capacity and performing simulation modeling to determine if the residual chloride mass in the vadose zone poses no threat to ground water quality.

1. Evaluate Chloride Flux from the Vadose Zone to Ground Water

We propose to employ HYDRUS1D and a simple ground water mixing model to evaluate the potential of residual chloride mass in the vadose zone to materially impair ground water quality at the site. We will employ predictions of the migration of chloride ion from the vadose zone to ground water then select an appropriate remedy for the land surface and underlying vadose zone. The first simulation is the "no action" alternative, which predicts chloride flux to ground water in the absence of any action by ROC.

For this simulation, we will employ the input parameters to HYDRUS and the mixing model outlined in Table 1. We will assume that vegetation is not present over the release site (no evapotranspiration) and an aquifer thickness of about 35 feet, or whatever value can be justified by examination of the literature and nearby well logs. At other sites, we have found that chloride can be distributed throughout the thickness of the aquifer.

Table 1: Input Parameters for Simulation Modeling

Input Parameter	**Source**
Vadose Zone Thickness – 80 feet	Nearby water supply well logs (Appendix A)
Vadose Zone Texture – caliche and sand	Nearby water supply well logs and on-site borings (Appendix A)
Dispersion Length -	Professional judgment
Soil Moisture - wet	Professional judgment
Vadose Zone Chloride Load – 19 kg/m^2	Appendix B

Length of release perpendicular to ground water flow – 100 meters	Field Measurements (see Plate 2)
Climate	Pearl, NM station (Hobbs)
Background Chloride in Ground Water	City of Lovington water system data
Ground Water Flux	Calculated from regional hydraulic data
Aquifer Thickness	Nearby water supply well logs (Appendix A)

2. Design Remedy and Submit Report

ROC has completed the repair of the pipeline at the site. We do not anticipate additional releases of produced water. Our modeling of similar sites strongly suggests that the relatively small residual chloride loading (19 kg/m^2, Appendix B) in the vadose zone poses a threat to ground water quality. If the modeling described above suggests that a threat does exist, we will use the HYDRUS-1D model predictions to develop a remedy for the vadose zone. If necessary, we will simulate:

1. installation of a low permeability barrier to minimize natural infiltration,
2. surface grading and seeding to eliminate any ponding of precipitation and promote evapotranspiration, thereby minimizing natural infiltration, and
3. a combination of the above potential remedies.

We will select the vadose zone remedy that offers the greatest environmental benefit while causing the least environmental damage.

Once we determine the most appropriate vadose zone remedy, we propose to immediately restore the soil through the addition of fresh water and, if necessary, soil amendments to move the identified chloride mass at the 2-5 foot depth to below the root zone (6-10 feet below land surface). If necessary, we use HYDRUS 1D to simulate this addition of fresh water to determine if any proposed vadose zone remedy might be affected by this soil flushing program. The protocol for the soil restoration program is simple:

1. Sample soils to determine if amendments, such as gypsum, will be necessary to restore soil structure and permeability.

2. If soil amendment is required, we will gently till the surface soil without disturbing the underlying caliche to mix the gypsum with the soil. If amendments are not required, we will forego tilling and the resultant disturbance of the existing soil structure.

3. Then we cover areas of the spill with black plastic to minimize evaporation and apply fresh water to the soil beneath the plastic to flush the chloride from the root zone. When possible, we will irrigate beneath the plastic immediately after precipitation events or immediately before predicted precipitation events. Conducting soil flushing in concert with precipitation events accelerates the process and conserves water.

4. Periodically, we will obtain samples of the soil and underlying material for field chloride analyses. When samples demonstrate that fresh water flushing has moved the chloride to below the root zone, we will remove the plastic and begin the process at another location at the site.

We plan to commence the HYDRUS1D simulations described above immediately. Your approval to move forward with this work plan will speed the implementation of a surface remedy because soil flushing is best conducted in winter when evaporation is low and precipitation is more widespread and easier to predict.

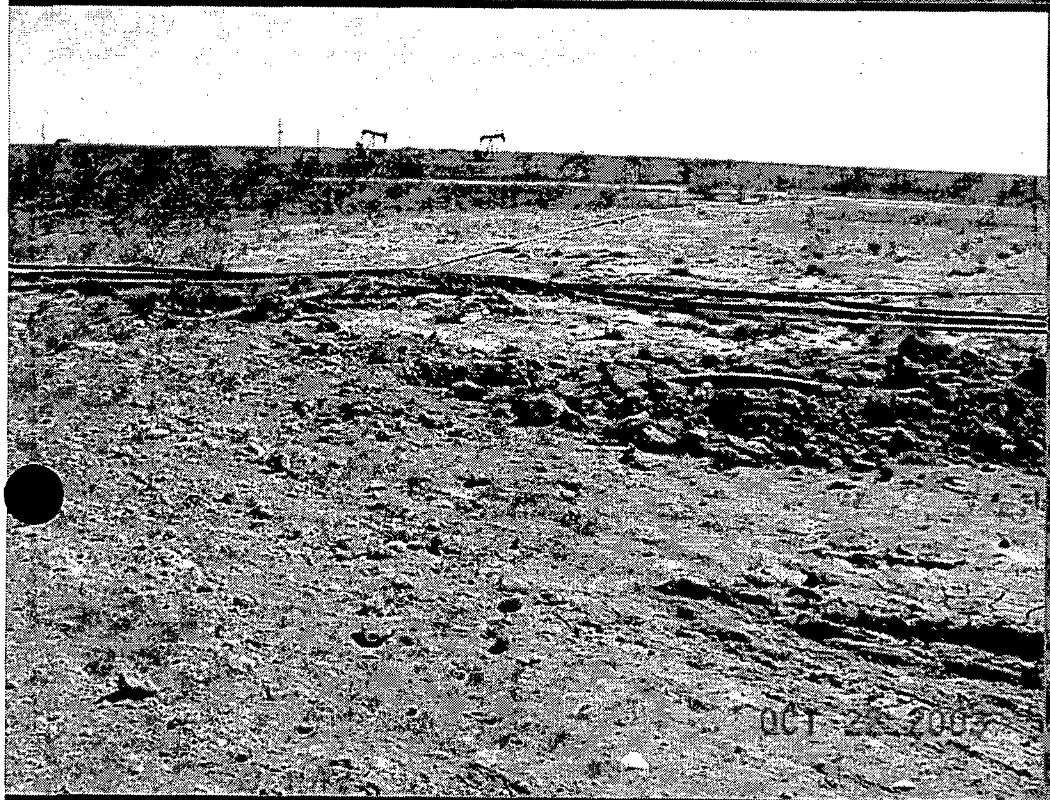
Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T. Hicks
Principal

Copy:
Rice Operating Company

June 7, 2004

Corrective Action Plan



Abo 1G Release Site

R.T. Hicks Consultants, Ltd.

901 Rio Grande Blvd. NW, Suite F-142, Albuquerque, NM

June 7, 2004

Abo 1G Release Site Report

Prepared for:

Rice Operating Company
122 West Taylor
Hobbs, NM 88240

R.T. HICKS CONSULTANTS, LTD.

901 RIO GRANDE BLVD. NW, SUITE F-142, ALBUQUERQUE, NM 87104

1.0 BACKGROUND

The Abo 1G Discharge Site is located about 6 miles southeast of the center of Lovington, New Mexico. Plate 1 shows the location of the site relative to Route 18, the Hobbs-Lovington Highway.

On October 18, 2003, Rice Operating Company (ROC) prepared a Release Notification report that estimated the pipeline failure released 190 barrels of produced water and recovered 130 barrels. The pipeline failure released produced water with little or no hydrocarbons. Plate 2 shows the geometry of this release, which affected about 31,000 square feet of rangeland. Plate 2 also shows the locations of soil borings used to characterize the release. ROC is also aware that a 10 barrel release near this same location on occurred on June 3, 2003 and this earlier release impacted a 2,400 square foot area near SB-1.

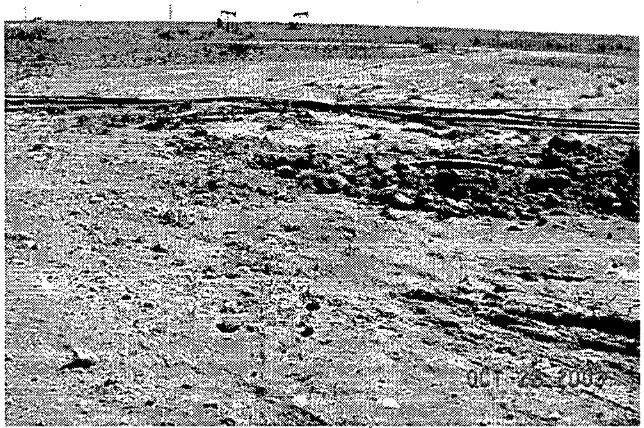


Figure 1. Abo 1G site looking south.

Figure 1 is a photograph of the site in October, 2003 looking south from a caliche road. The line in the foreground ruptured and produced water flowed south.

ROC mobilized to the site on November 10, 2003 and drilled three borings as shown on Plate 2. The field procedures employed by ROC were consistent with industry practice and with previously-submitted ROC characterization plans (e.g. junction box plan). Hicks Consultants used the data collected by ROC and obtained additional data from public sources as input to the HYDRUS-1D vadose zone fate and transport model. Hicks Consultants employed the results of the modeling to predict the potential impact to ground water quality as a result of the release and to develop a remedy to protect ground water quality and to restore the ground surface.

2.0 RESULTS OF FIELD PROGRAMS AND INVESTIGATIONS

CHARACTERISTICS OF VADOSE ZONE AND SATURATED ZONE

Next to the pipeline rupture, SB - 01 was drilled to a depth of 45 feet. From field inspection, the site has several inches of sandy soil covering a high-fractured caliche horizon. We examined borehole samples and the on-site cuttings log from SB-01 and concluded that the subsurface is composed of 24 feet of thin caliche layers within sands and silts. Interbedded with these caliche-rich sands and silts are silty clays. Below this uppermost 24 feet is 20 feet of sand and silt. The logs for each of these three ROC borings are included in Appendix A.

In well L-1716 , about 1 mile west of the release site, the driller's log reports "water sand" from 45 feet to 70 feet underlain by 7 feet of "calcium sand" before penetrating water bearing units. At well L-5014, approximately 5 miles north of the site, the driller log identifies caliche from 2 to 28 feet below surface. Below this upper strata is sand and sandy clay to a depth of 190 feet. From 190 to 205 feet below surface, the driller reports a clay zone. This 15 feet of clay is underlain by 10 feet of clay and gravel. The driller penetrated the Dockum Group red beds at 215 feet below grade. Monitoring wells in the Lea Refinery, one mile to the northeast, driller's logs report a 4 foot caliche bed overlying more than 100 feet of very fine to fine grained sands. At the Lea Refinery, April, 1996 water levels are 90 feet below grade (H+GCL, 1996). These well logs are also included in Appendix A.

We conclude that the vadose zone is about 90 feet thick and is composed of a caliche-rich upper horizon underlain by sand with minor amounts of silt. The saturated Ogallala Aquifer, which underlies the location, is dominantly sand. The saturated thickness of the aquifer is about 130 feet. The screened interval of wells in the area range from 20 feet to more than 100 feet.

According to the USGS (http://water.usgs.gov/GIS/metadata/usgswrd/ofr98-548.html#Identification_Information), the hydraulic conductivity of the High Plains Aquifer ranges from less than 25 feet/day to greater than 300 feet per day with an average hydraulic conductivity of 60 feet/day. At this location, where saturated gravel units are restricted to the base of the Ogallala, we estimate the hydraulic conductivity is about 50 feet per day. Geologists who drilled monitoring wells at the Lea Refinery estimated the saturated hydraulic conductivity as ranging from 25-75 feet per day. At the Lea Refinery, the hydraulic gradient is 0.004 feet/foot to the southeast. The resultant ground water flux is probably about 0.2 feet per day.

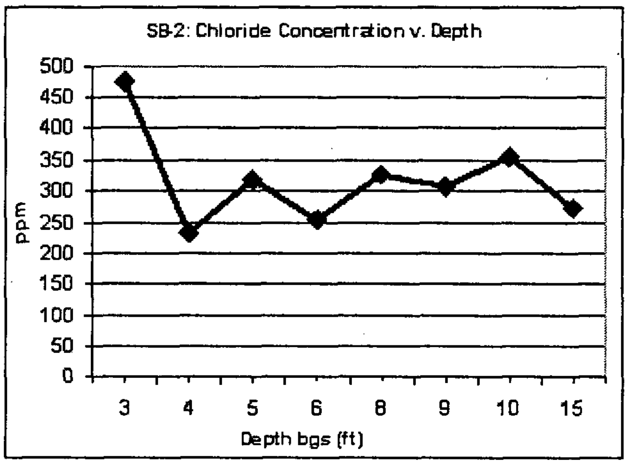


Figure 2. *Chloride vs. depth in soil boring 2.*

We have no site specific or regional data on the moisture content of the vadose zone. Such data are generally rare. As described in a later section of this report, we used HYDRUS-1D to simulate an initial water content of the unsaturated zone.

CHLORIDE DISTRIBUTION IN THE VADOSE ZONE

Soil boring SB-2 is uphill from the spill site and we consider this a "background" location. At this soil boring, the chloride near the ground surface is 475 ppm. From 4 feet below grade to the total depth of 15 feet, chloride in this caliche-rich horizon ranges between 230 and 356 ppm (Figure 2). Other workers suggest that "background" chloride concentration in Lea County soil can be less than 100 ppm. At this site, where the caliche dominates the upper vadose zone, the background is about 300 ppm.

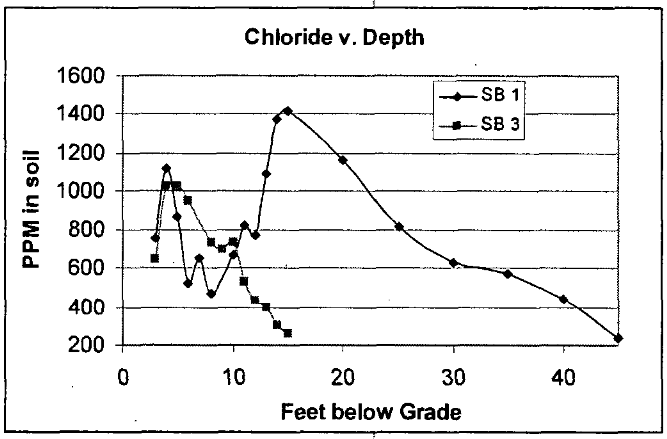


Figure 3. Chloride vs. Depth in soil borings 1 and 3.

The soil borings within the area of the release (#1 and #3) show a decline in chloride concentrations from more than 1000 ppm chloride to background levels at 45 feet and 9 feet below land surface respectively (Figure 3). Because the water table lies about 90 feet below land surface, this observed decrease of chloride concentrations to background suggests that the release did not create saturated conditions between ground surface and ground water.

The pattern for SB-1 shown in Figure 3, which was closest to the pipeline rupture, confirms that the October 2003 release is not the first release at or near this site. An earlier release appears as chloride concentrations above 1000 ppm between 12 and 20 feet below grade and the October release appears as the high chloride between 3 and 6 feet depth. We do not believe that the chloride concentrations between 12 and 20 feet in SB-1 were caused by the 10-barrel release of June 2003.

The data from SB-3 suggests the influence of only the October 2003 release. Data from SB-1 and SB-3 demonstrate that the center of mass from the recent release is at a depth of 4-5 feet below land surface.

Regardless of the source of chloride observed at 12-20 feet below grade in SB-1, we can conclude that these soil boring data show no evidence of imminent ground water impairment. The chloride from the releases remains within the vadose zone. Using these data, and the chloride concentration in the produced water, we can estimate the volume of produced water released at this site.

RELEASE CHARACTERISTICS

ROC provided an analysis of the chloride in the produced water - 19,994 ppm. Because the soil sampling program identified an older spill event at SB-1, we considered the calculated chloride load at SB-3 more representative of the October release. Calculations using the chloride load at SB-3 imply that the spill was 1 in. deep (see Appendix B for these calculations). If 1-inch was the average spill height for the 31,000 square feet of impact (see Plate 2), the total volume of the release would be 440 barrels. However, ROC located SB-3 where the released "pooled", therefore using the chloride load from this boring will probably overestimate the release volume. We suggest that the October event released between 200 and 500 barrels of produced water and 130 barrels were recovered.

Ground water at the Lea Refinery flows toward the southeast. We estimate that the length of the spill parallel to ground water flow is 477 feet.

EVALUATION OF CHLORIDE FLUX FROM THE VADOSE ZONE TO GROUND WATER

We employed the HYDRUS-1D and a simple ground water mixing model to evaluate the potential of residual chloride mass in the vadose zone to materially impair ground water quality at the site. Appendix C presents the background documentation for this modeling approach. We applied the results from the HYDRUS-1D modeling of the migration of chloride ions from the vadose zone to ground water in our selection of an appropriate remedy for the land surface and underlying vadose zone. This simulation is the "no action" alternative, which predicts chloride flux to ground water in the absence of any action by Rice Operating Company.

DATA FOR SIMULATION MODELING

The HYDRUS-1D and mixing model simulation requires input of 11 parameters. As Table 1 shows, site specific data are required for several of these parameters and other data are available from public sources. The source of most of the data is described in the previous section of this report.

Table 1. Input Parameters for Simulation Modeling

Input Parameter	Source
1. Vadose Zone Thickness - 77 feet	Appendix A well logs
2. Vadose Zone Texture - Plate 3	Samples and attached well logs
3. Dispersion Length - 1.85 meters	Professional judgment
4. Soil Moisture	HYDRUS-1D initial condition simulation
5. Chloride in release - 19,994 ppm	Samples of produced water
6. Height of spill on land surface -1.0 inches	Calculated from chloride load at sampling location SB-3 and chloride in released water
7. Length of release parallel to ground water flow - 477 ft	Field Measurements
8. Climate - Arid	Pearl Weather Station near Hobbs Airport
9. Background Chloride in Ground Water - 100 ppm	Professional judgment
10. Ground Water Flux - 6.1 cm/day	Calculated from published data and the Lea Refinery Report
11. Aquifer Thickness - 10 feet	NMOCD suggestion

The vadose zone profile used for the HYDRUS-1D modeling is composed from the well log and samples of SB-1 and information from the logs of wells in the area. For the purpose of this report, we will assume that the ground water is unconfined and is at a depth of 77 feet below land surface. Some driller's logs suggest this depth to water, however we believe that 90 feet is more accurate. The 13-foot difference is probably due to falling water levels in the Ogallala. To be conservative in our approach, we used 77 feet at the thickness of the vadose zone. Plate 3 shows the vadose zone profile (texture) employed in the modeling with the HYDRUS-1D input parameters.

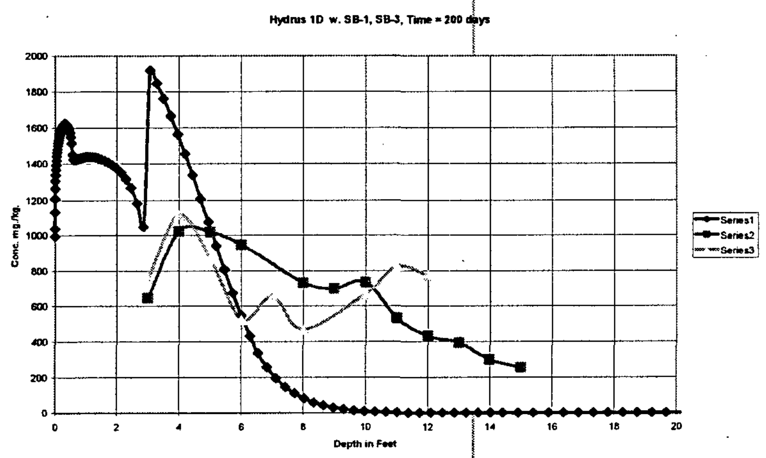
The dispersion length of 1.85 meters is less than 10% of the total length of the HYDRUS-1D model and is consistent with standard modeling protocol.

We installed the profile described above as the initial condition in HYDRUS-1D and ran it with the estimated spill installed as an atmospheric event on day 1 of the simulation. We ran the model for 2 years to create a chloride profile v. depth that we use to "calibrate" the model. Comparison of the solute concentrations computed by HYDRUS-1D with the field measured solute concentrations caused us to simplify the soil profile by using higher hydraulic conductivity in the upper soil profile. The parameters used to model the caliche typically employ a very low saturated hydraulic conductivity. From field inspection, the surface caliche in the area is fractured and filled with fine sands. Because of the stratagraphic location near the ground surface, we believe the caliche at this site has a much higher saturated hydraulic conductivity than that typically used in the HYDRUS-1D model. During intense rainfall events (or produced water spills), water will flow quickly to the subsurface through the fractures via saturated flow. Therefore, we adjusted for this observation and modified the default caliche parameters to behave less like clay and more like sand. Deeper in the vadose zone, fractures become barriers to flow and deeply buried caliche behaves more like clay. From previous modeling experience, the properties of the upper soil profile are the most important in determining flow in the vadose zone. Therefore, adjusting the hydraulic input data for the uppermost vadose zone is relatively important.

The parameters of the lower caliche were also altered to allow the higher hydraulic conductivity. In addition, two intermediate layers were merged using the parameters of the coarser layer. These changes err in favor of ground water protection; they will cause the model to overestimate the flux of chloride from the vadose zone into ground water. After making these adjustments, one can observe the relationship between predicted chloride concentration in soil and actual measurements in Figures 4 and 5.

What are important in the examination of these figures are the distribution of the predicted chloride mass in the vadose zone and

Figure 4. Predicted chloride concentrations in soil at 200 days.



the measured distribution of vadose zone chloride. The simulation of the chloride distribution at 200 days after the release (Figure 4) shows a peak chloride concentration at about 3 feet deep and background concentrations (zero ppm in the model) at 10 feet below grade. The simulation at time=730 days provides a better fit between the predicted chloride concentrations and the measured values. The reason for this "time shift" is due how the model uses the meteorological data from Pearl, New Mexico. The meteorological data consists of 47 years of daily data. Day 1 is NOT the day that the October 2003 release occurred, however. Day 1 of the file is about 50 years ago. The measured values will only correlate exactly with the predicted values if rainfall, wind speed and other atmospheric events between the time of the release and the time of the sampling event were exactly the same as the atmospheric file in the model. We maintain that the "match" between the predicted chloride concentrations and the measured concentrations presented in Figure 5 provide adequate verification of our input parameters for the vadose zone texture.

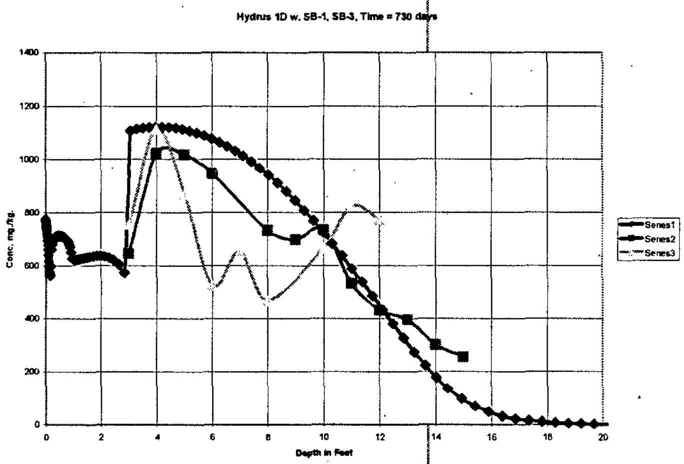


Figure 5. Predicted Chloride concentrations in soil at 730 days.

For the mixing model, the largest dimension of the spill (477 feet) was used for the length of spill parallel to groundwater flow. Climate data from the Pearl Weather Station near the Hobbs, New Mexico airport, approximately 15 miles south of the site, was used. Ground water flux at the Lea refinery is estimated at .4 feet/day to 1.2 feet/ day. (Lea refinery Report) Well logs in Appendix A indicate that 10 feet is a very conservative estimate for the aquifer thickness in that most wells exhibit well screens in excess of 20 feet.

We then ran the HYRDUS-1D model to predict chloride movement through the vadose zone for 71 years. From the output, we found that the center of chloride mass enters the ground water zone between 15 years and 50 years from present.

This flux was then fed into the aquifer mixing model with the resulting output shown in Figure 6. The predicted peak concentration is less than 200 ppm.

In examining Figure 6, it is important to understand that the model assumes that rainfall is distilled water (0 ppm chloride) and that the initial vadose zone water also contains 0 ppm chloride. Attempting to use chloride concentrations other than zero for precipitation and initial soil moisture creates too much complexity in the model. This simplification causes a minor under estimate of the chloride flux to ground water, as described below.

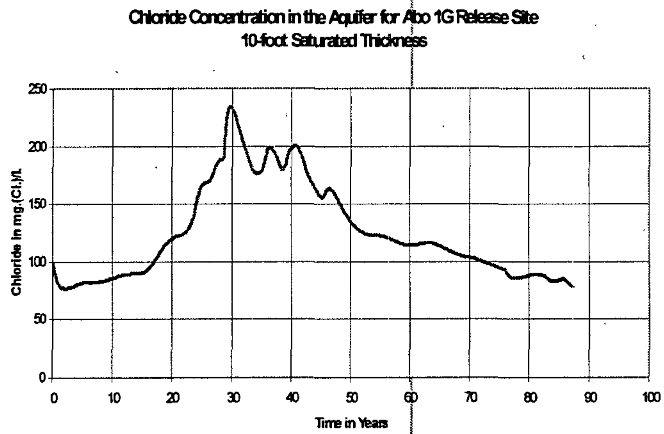


Figure 6. Ground water chloride concentrations in imaginary monitoring well.

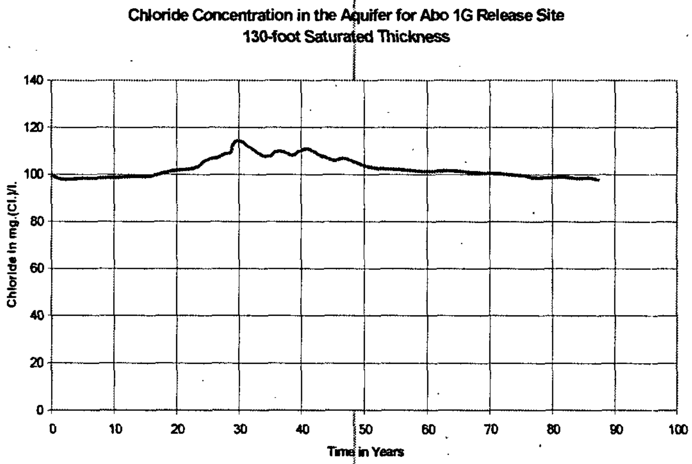
In our model, natural precipitation (0 ppm chloride) moves the released chloride through the vadose zone and dilutes the chloride mass (from above) during transport, just as real rainfall dilutes the real spill. Minor dilution of released chloride also occurs as it moves downward and mixes with 0 ppm pore water. Dilution of the release by pore water also occurs in nature. Thus from time zero to slightly more than 3 years, a flux of 0 ppm chloride enters the aquifer from the vadose zone, diluting the 100 ppm chloride ground water to 75 ppm. This decrease in chloride concentration in the mixing model is due to the relatively high flux through the bottom of the sandy soil vadose zone. After 3 years, the chloride mass from the release begins entering ground water raising chloride concentration. The maximum chloride concentration in a 10-foot thick aquifer beneath the site would occur about 30 years after present and would be less than 200 ppm chloride.

We can confidently conclude that the release(s) that created the chloride load observed in SB-1 will cause minimal impairment of ground water quality at an imaginary well located immediately adjacent to the release. Our predictions show that a well with 20 feet of screened interval located immediately next to the release would observe chloride concentrations less than 150 ppm.

POTENTIAL IMPACT ON CITY OF LOVINGTON WATER SUPPLY WELLS

The water supply wells for the City of Lovington are more than 2000 feet from the release site. These wells do not draw water from only the uppermost 20 feet of the Ogallala Aquifer, but from most or the entire 130-foot thick saturated zone. Let us assume that in the future the City of Lovington or another water user were to install a water supply well at the edge of the release site. The maximum predicted chloride concentration in this fully-penetrating, fully-screened well (130 feet of screen within the 130-foot saturated zone) is 109 ppm or 9 ppm above the assumed 100 ppm background concentration (see Figure 7).

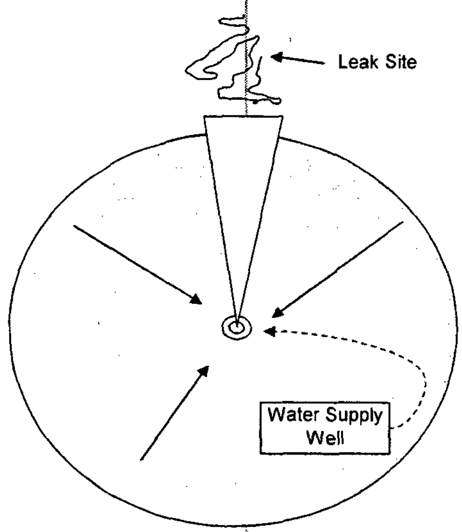
Figure 7. Chloride concentration in imaginary monitoring well with 130 foot saturated thickness



If we wish to predict the potential impact to an existing City of Lovington water supply well that lies 2000 feet from the release site, we must calculate the dilution that will occur as background water is drawn to the well.

For example, let us assume that a City of Lovington supply well creates a cone of depression with a 2000-foot radius and a circumference of 12,560 feet (Figure 8). If we assume this large cone of depression, all of the chloride from the release will eventually be drawn into the well. In our modeling, we assumed that the maximum length of the release parallel to ground water flow was 477 feet. Referring to Plate 2, the maximum width of the release (perpendicular to ground water flow) is 375 feet. Therefore, the supply well will draw in water from the release site (375 feet of the circumference) and background quality water (12,560 feet of the circumference). The water from the site contributes only 3% of the total volume of water pumped by the well. In a simple dilution calculation where 3% of the water drawn into the well will exhibit a chloride concentration of 109 ppm and 97% of the water drawn into the well is background water quality (100 ppm), the resultant concentration in the supply well is 100.27 ppm. In other words, one will not be able to measure the effect of this release on the Lovington water supply wells. Figure 8 shows this hypothetical situation.

Figure 8. Hypothetical situation showing a Lovington water supply well drawing in: i. release ground water containing chloride molecules (represented by the triangular area) and ii. background water.



We conclude that the chloride from this release site will have no impact on the City of Lovington water supply wells.

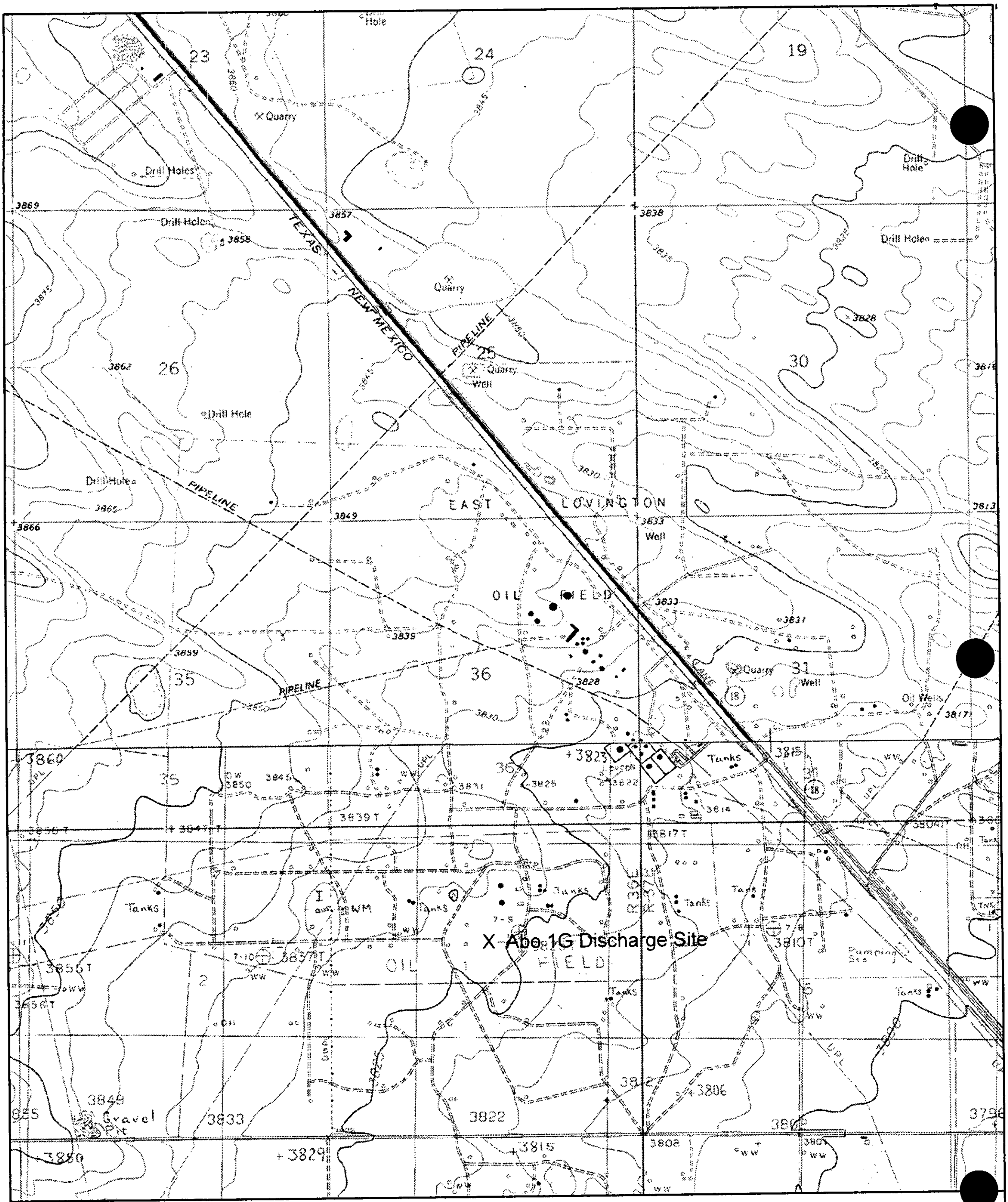
PROPOSED REMEDY

We conclude that the release poses no material threat to ground water quality. Simulations using input parameters that should over-estimate the chloride concentration in ground water show that the release will not cause WQCC Standards to be exceeded at a place of reasonable foreseeable future use.

We recommend closure of the regulatory file.

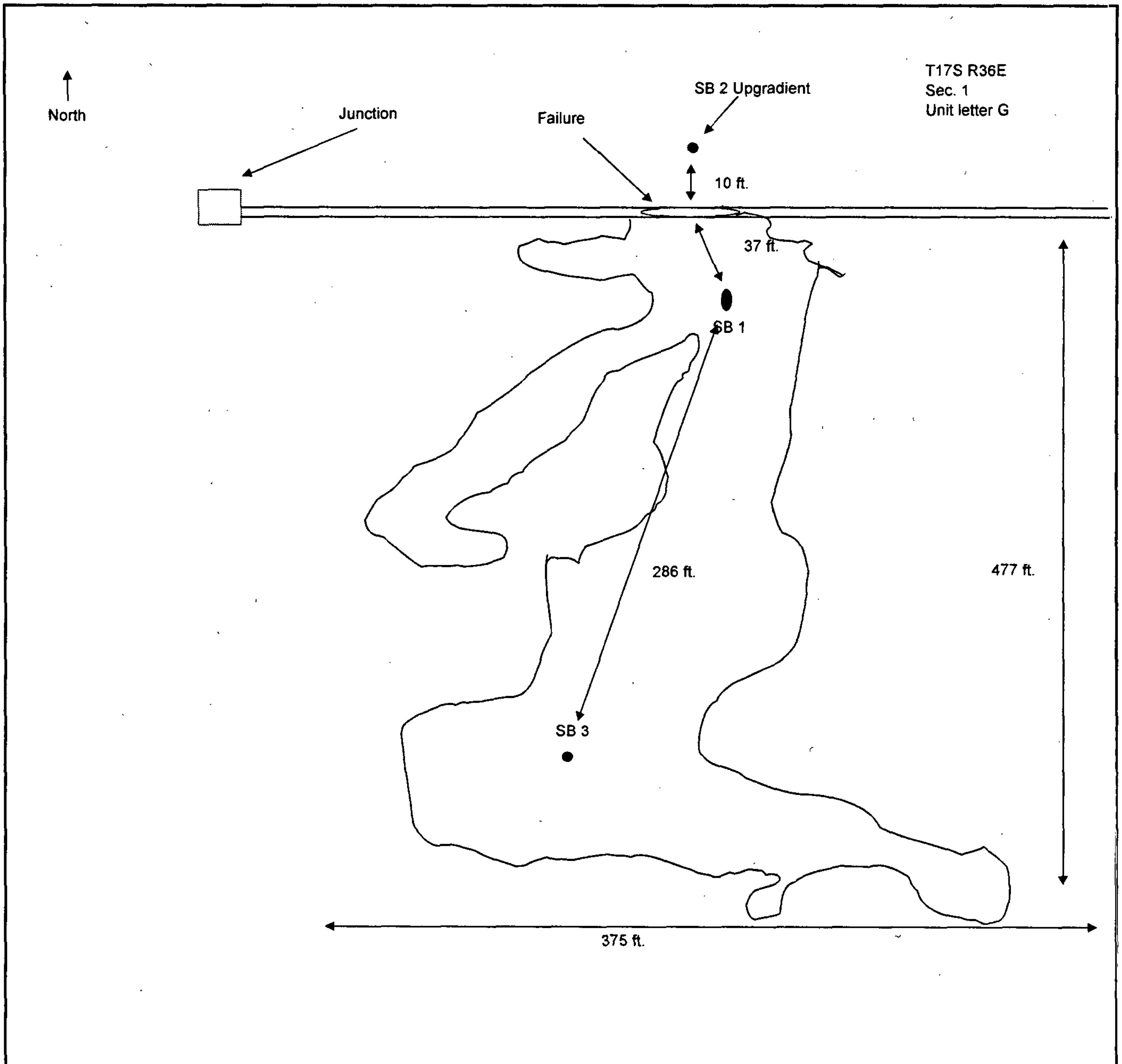
We propose annual inspection of the site and re-seeding when vegetation begins to invade the spill site. Our site visit in April, 2004 showed that the recent heavy rains of the area have permitted some natural re-vegetation of the site.

PLATES



Name: LOVINGTON
Date: 12/18/2003
Scale: 1 inch equals 2000 feet

Location: 032° 52' 53.8" N 103° 18' 23.0" W
Caption: Plate 1: Location Map



R.T. Hicks Consultants 901 Rio Grande NW Albuquerque, NM	**Rice Operating Company**	**Plate 2**
	Abo Release Site Sketch Map	**May-04**

Depth		Lithologic Description	Van Genuchten's parameters as used in adjusted profile	Soil description by USDA soil triangle
0 ft.				
3ft.		0-3ft Top Soil	th_r - .065, th_s -.41, alpha - .075, n - 1.89, Ks - 106.1	sandy loam
16 feet		3 -16 ft Clay - very fine sand, caliche	th_r - .078, th_s -.43, alpha - .038, n - 1.58, Ks - 35	fractured caliche, values modified from Jan Hendrick
19 ft		16 - 19 ft.silt - clay, min. caliche	th_r - .089, th_s -.43, alpha - .01, n - 1.23, Ks - 1.68	silty clay loam
22 ft.		19 - 22 ft. clay - silt, min. caliche		
28 ft.		22 - 28 ft Silt - v.f. sand ,some caliche	th_r - .078, th_s -.43, alpha - .038, n - 1.58, Ks - 35	fractured caliche, values modified from Jan Hendrick
32 ft.		28 - 32 ft. silt - very fine sand, caliche		
45 ft.		32 - 45 ft., silt - very fine sand, some clay	th_r - .095, th_s -.41, alpha - .019, n - 1.31, Ks - 6.24	clay loam
70 ft.		45 - 70 ft. vf sand	th_r - .067, th_s -.45, alpha - .02, n - 1.41, Ks - 10.8	silt loam
77 ft. and water, toc		70 - 77 ft. limey sand	th_r - .095, th_s -.41, alpha - .019, n - 1.31, Ks - 6.24	clay loam

R.T. Hicks Consultants, Ltd. **901 Rio Grande, Suite F-142** **Albuquerque, NM**	**RICE** *Operating Company*	Lovinton Abo Soil Profile at SB-1
	Lovington Abo Release Site	Apr-04

APPENDIX A

Form WR-23

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

#5	730	-20-	13
DPN:	25-	1350	

(Plat of 640 acres)

(A) Owner of well Jack Cayton

Street and Number Box 1021

City Lovington State New Mexico

Well was drilled under Permit No. L-2490-1716 and is located in the NW ¼ NW ¼ NE ¼ of Section 2 Twp. 17 S Rge. 36 E

(B) Drilling Contractor Cayton & Porter License No. WD-163

Street and Number Box 1021

City Lovington State New Mexico

Drilling was commenced Sept. 1 1955

Drilling was completed Sept. 2 1955

Elevation at top of casing in feet above sea level ______ Total depth of well 145

State whether well is shallow or artesian Shallow Depth to water upon completion 50

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
1	77	92	15	Water Sand
2				
3				
4				
5				

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used

Section 5 PLUGGING RECORD

Name of Plugging Contractor ______ License No. ______

Street and Number ______ City ______ State ______

Tons of Clay used ______ Tons of Roughage used ______ Type of roughage ______

Plugging method used ______ Date Plugged ______ 19__

Plugging approved by:

______ Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

Date Received [illegible] 15 1955

OFFICE

File No. L-2490 1716 Use Irrig Location No. 12362

Section 6 LOG OF WELL

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color	Type of Material Encountered
0	1	1		Soil
1	7	6		Rock
7	16	9		Caliche
16	20	4		Boulder
20	26	6		Sand Rock
26	45	19		Sand
45	70	25		Water Sand
70	77	7		Calcium Sand
77	92	15		Quick Sand
92	106	14		Sandy Clay
106	108	2		Sand
108	112	4		Rock
112	134	22		Sandy Clay
134	143	9		Sand
143	145	2		Sandy Clay

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Jack Cayton
Well Driller

LOG FILED

(This form to be executed in triplicate)

WELL RECORD

Renumbered L-4058 Feb 2 1959

Date of Receipt ________ Permit No. L-455A

Name of permittee, Lovington Municipal Utilities

Street or P.O., ________, City and State Lovington, New Mexico

1. Well location and description: The shallow (shallow or artesian) well is located in ____ ¼, SE ¼, Lot 9 ¼ of Section 4, Township 16, Range 36; Elevation of top of casing above sea level, 3979 feet; diameter of hole, 16 inches; total depth, 127 feet; depth to water upon completion, 58 feet; drilling was commenced June 2, 1952, and completed June 4, 1952; name of drilling contractor Aqua Drilling Co. Box 1004; Address, Lovington, N.M.; Driller's License No. WD 35

2. Principal Water-bearing Strata:

	Depth in Feet From	To	Thickness	Description of Water-bearing Formation
No. 1	58	59	1	Water Sand
No. 2	69	71	2	Water Sand
No. 3	82	86	4	Quick Sand & Water
No. 4	112	116	4	Water Sand & Shale
No. 5				

3. Casing Record:

Diameter in inches	Pounds per ft.	Threads per inch	Depth of Casing or Liner Top	Bottom	Feet of Casing	Type of Shoe	Perforations From	To

RECEIVED
OCT 27 1952
STATE ENGINEER

4. If above construction replaces old well to be abandoned, give location: ____ ¼, ____ ¼, ____ ¼ of Section ____, Township ____, Range ____; name and address of plugging contractor,

date of plugging ________ 19____; describe how well was plugged:

FILED
OCT 30 1952
OFFICE
ARTESIAN WELL SUPERVISOR
ROSWELL, NEW MEXICO

FILED
APR 15 1958
OFFICE

5. Log of Well:

Depth in feet From	To	Thickness in feet	Description of Formation
0	2	2	Soil
2	26	24	Caliche & Lime Shale
26	58	32	Sandy Shale
58	59	1	Water Sand
59	69	10	Sand & Shale
69	71	2	Water Sand & Shale
71	82	11	Sand Shale with Streaks of Clay
82	86	4	Quick Sand & Water
86	112	26	Sand & Shale
112	116	4	Tight Water Sand & Clay Shale
116	127	11	Sandy Shale

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Licensed Well Driller

Instructions

This form shall be executed, preferably typewritten, in triplicate and filed with the State Engineer's Office at Roswell, New Mexico, within 10 days after drilling has been completed. Data on water-bearing strata and on all formations encountered should be as complete and accurate as possible.

(This form to be executed in triplicate)

WELL RECORD

Date of Receipt.................................... Permit No. L-265

Name of permittee, Ernest Mahan

Street or P.O., Box 32, City and State Lovington, N. M.

1. Well location and description: The shallow (shallow or artesian) well is located in NW ¼, NW ¼, SW ¼ of Section 11, Township 16 S, Range 36 E; Elevation of top of casing above sea level, ... feet; diameter of hole, 16 inches; total depth, 120 feet; depth to water upon completion, 45 feet; drilling was commenced Jan. 8, 19 48, and completed Jan. 9, 1948; name of drilling contractor Abbott Bros. ....; Address, Box 637, Hobbs, N. M.; Driller's License No. WD-46

2. Principal Water-bearing Strata:

	Depth in Feet From	To	Thickness	Description of Water-bearing Formation
No. 1	45	120	75	Water sand
No. 2				
No. 3				
No. 4				
No. 5				

3. Casing Record:

Diameter in Inches	Pounds per ft.	Threads per inch	Depth of Casing or Liner Top	Bottom	Feet of Casing	Type of Shoe	Perforations From	To
NONE								

4. If above construction replaces old well to be abandoned, give location: .... ¼, ... ¼, ... ¼ of Section........, Township........, Range........; name and address of plugging contractor,

date of plugging........, 19....; describe how well was plugged: ....

FILED
JAN 11 1952
OFFICE
ARTESIAN WELL SUPERVISOR
ROSWELL, NEW MEXICO

5. Log of Well:

Depth in feet From	To	Thickness in feet	Description of Formation
0	4	4	Soil
4	35	31	Caliche
35	45	10	Hard shell
45	120	75	Water sand

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Clyde [illegible]
Licensed Well Driller

Instructions

This form shall be executed, preferably typewritten, in triplicate and filed with the State Engineer's Office at Roswell, New Mexico, within 10 days after drilling has been completed. Data on water-bearing strata and on all formations encountered should be as complete and accurate as possible.

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well Hulda Heidel Owner's Well No. ____
Street or Post Office Address 1018 West Avenue K
City and State Lovington, New Mexico 88260

Well was drilled under Permit No. L-135 enlarged L-135S and is located in the:

a. ____ ¼ ____ ¼ ____ ¼ NW ¼ of Section 11 Township 16S Range 36E N.M.P.M.

b. Tract No. ____ of Map No. ____ of the ____

c. Lot No. ____ of Block No. ____ of the ____
Subdivision, recorded in Lea County.

d. X= ____ feet, Y= ____ feet, N.M. Coordinate System ____ Zone in the ____ Grant.

(B) Drilling Contractor Abbott Bros. License No. WD-46

Address P.O. Box 637, Hobbs, New Mexico 88240

Drilling Began 3/17/77 Completed 3/22/77 Type tools Cable Size of hole 16 in.

Elevation of land surface or ____ at well is ____ ft. Total depth of well 146 ft.

Completed well is ☒ shallow ☐ artesian. Depth to water upon completion of well 58 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
From	To			
58	146	88	Sand	

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet		Length (feet)	Type of Shoe	Perforations	
			Top	Bottom			From	To
12 3/4"	43	Welded	0	146	146	None	66	146

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
From	To				

Section 5. PLUGGING RECORD

Plugging Contractor ____
Address ____
Plugging Method ____
Date Well Plugged ____
Plugging approved by:

____
State Engineer Representative

No.	Depth in Feet		Cubic Feet of Cement
	Top	Bottom	
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received June 14, 1977

Quad ____ FWL ____ FSL ____

Supplemental

File No. L-135 & L-135-Enlgd-S Use Irr Location No. 16.36.11.[illegible]

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	2	2	Surface soil
2	26	24	Caliche
26	58	32	Sand-tight
58	112	54	Sand-water
112	128	16	Sand-tight
128	146	18	Sand-water

Section 7. REMARKS AND ADDITIONAL INFORMATION

'77 JUN 14 AM 8 24
STATE ENGINEER OFFICE
ROSWELL, N.M.

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Murrell Abbott
Driller
H.B

Form WR-23

FIELD ENGR. LOG

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

(Plat of 640 acres)

(A) Owner of well J. W. Taylor Jr.

Street and Number P. O.

City Hope State New Mex.

Well was drilled under Permit No. Comer Hudgens Enlgd. L-135 and is located in the N.W.¼ S.W.¼ N.W.¼ of Section II Twp. I6So Rge. 36 E.

(B) Drilling Contractor G. O. Aldredge License No. W.D.79

Street and Number Box 379

City Lovington State New Mex.

Drilling was commenced Mar. I4 19 64

Drilling was completed Mar. I6 19 64

Elevation at top of casing in feet above sea level Total depth of well II0 Ft

State whether well is shallow or artesian Shallow Depth to water upon completion 75

Section 2

PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
1	95	II0	I5	Small crystlized sand rock & quick sand
2				
3				
4				
5				

Section 3

RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To
			Not cased					

Section 4

RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used
		I6			2 sacks of drilling mud used to
					hold quick sand back
					while cleaning out well

Section 5

PLUGGING RECORD

Name of Plugging Contractor License No.

Street and Number City State

Tons of Clay used Tons of Roughage used Type of roughage

Plugging method used Date Plugged 19

Plugging approved by:

Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

Date Received STATE ENGINEER OFFICE ROSWELL N. MEX. DISTRICT II 1964 MAY 19 AM 8:21

File No. L-135-Enlgd. Use Irr. Location No. 16.36.11.131

Section 6

LOG OF WELL

Depth in Feet		Thickness in Feet	Color	Type of Material Encountered
From	To			
95	110	15	red	small crystilized sa[illegible] rock

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

C. O. Aldredge
Well Driller

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well City of Lovington Owner's Well No. L-9517
Street or Post Office Address P.O. Box 1268
City and State Lovington, N.M. 88260

Well was drilled under Permit No. L 9517 and is located in the:

a. SESE ¼ NE ¼ SESW ¼ SW ½ of Section 3 Township 16S Range 36E N.M.P.M.

b. Tract No. ____ of Map No. ____ of the ____

c. Lot No. ____ of Block No. ____ of the ____
Subdivision, recorded in ____ County.

d. X= ____ feet, Y= ____ feet, N.M. Coordinate System ____ Zone in the ____ Grant.

(B) Drilling Contractor Gene Eades License No. WD982

Address Rt. 4 Tahoka, Tx. 79373

Drilling Began 11-27-84 Completed 11-27-84 Type tools Rotary Size of hole 8 in.

Elevation of land surface or ____ at well is ____ ft. Total depth of well 138 ft.

Completed well is ☒ shallow ☐ artesian. Depth to water upon completion of well 66 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
From	To			
66	138	72	Brown water sand w/ sandstone stringers	30

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet		Length (feet)	Type of Shoe	Perforations	
			Top	Bottom			From	To
5 3/4	160 psi.				134		118	138
5 3/4	Sch. 40 steel	for	pitless adapter		4			

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
From	To				

Section 5. PLUGGING RECORD

Plugging Contractor ____
Address ____
Plugging Method ____
Date Well Plugged ____
Plugging approved by:

____
State Engineer Representative

No.	Depth in Feet		Cubic Feet of Cement
	Top	Bottom	
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received December 10, 1984

Quad ____ FWL ____ FSL ____

File No. L-9517 Use Drinking/Sanitary Location No. 16.36.3.33244

Section 6. LOG OF HOLE

Depth in Feet		Thickness in Feet	Color and Type of Material Encountered
From	To		
0	3	3	Top soil
3	15	12	Caliche
15	21	6	Sandy clay
21	40	19	Sandy clay & sandstone
40	65	25	Sand & sandstone
65	66	1	Hard sandstone
66	138	72	Brown water sand

Section 7. REMARKS AND ADDITIONAL INFORMATION

DEC 10 8 22 AM '84

STATE ENGINEER
ROSWELL, NM

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Gene Eddie

Driller

Form WR-23

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

(Plat of 640 acres)

(A) Owner of well City of Lovington

Street and Number Box 1268

City Lovington State New Mexico

Well was drilled under Permit No. L - 5356 and is located in the

E ½ S ½ ¼ ¼ ¼ of Section 3 Twp. 16 S Rge. 36 E

(B) Drilling Contractor Grady Backus License No. W. D. 322

Street and Number Box 791

City Lovington State New Mexico

Drilling was commenced April 8 19 64

Drilling was completed April 12 19 64

Elevation at top of casing in feet above sea level — Total depth of well 164 ft.

State whether well is shallow or artesian Shallow Depth to water upon completion 70 ft.

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
1	70	84	14 ft.	Sand
2	112	120	10 ft.	Sand
3	138	146	8 ft.	Water Sand
4	153	158	5 ft.	Water Sand
5				

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To
12 in.	30		0	164	164 ft		102	164

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used

Section 5 PLUGGING RECORD

Name of Plugging Contractor ______ License No. ______

Street and Number ______ City ______ State ______

Tons of Clay used ______ Tons of Roughage used ______ Type of roughage ______

Plugging method used ______ Date Plugged ______ 19__

Plugging approved by:

______
Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

Date Received

STATE ENGINEER OFFICE
DISTRICT II
1964 APR 28 AM 8:37

File No. L-5356 Use Expl. Location No. 16.36.3.400

Section 6

LOG OF WELL

Depth in Feet From	To	Thickness in Feet	Color	Type of Material Encountered
0	1	1 ft.		Soil
1	4	3 ft.		Rock
4	18	14 ft.		Caliche
18	62	44 ft.		Sand
62	70	8 ft.		Sand Stone
70	84	14 ft.		Sand
84	98	14 ft.		Sand & Calcum
98	112	14 ft.		Sandy Clay
112	120	8 ft.		Sand
120	138	18 ft.		Sandy Clay
138	146	8 ft.		Water Sand
146	153	7 ft.		Sandy Clay
153	158	5 ft.		Sand
158	164	6 ft.		Sandy Clay

The undersigned hereby certifies that; to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

[signature]
Well Driller

Form WR-23 Orig - in S.F.

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

(Plat of 640 acres)

(A) Owner of well City of Lovington

Street and Number

City Lovington State New Mexico

Well was drilled under Permit No. L-3901 and is located in the SW ¼ NW ¼ SE ¼ of Section 10 Twp. 16 S Rge. 36 E

(B) Drilling Contractor Clayton Drlg. Co. License No. WD-183

Street and Number Box 1021

City Lovington State New Mexico

Drilling was commenced June 26 1958

Drilling was completed June 28 1958

Elevation at top of casing in feet above sea level ______ Total depth of well 104 ft.

State whether well is shallow or artesian Shallow Depth to water upon completion 66 ft.

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
1	66	74	8	Water Sand
2	82	90	8	Quick Sand
3				
4				
5				

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To
7 in. O.D.	25	8	[illegible]	104	105	None	65	100

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used
20	104	8 in.	200 lbs.		Dry Mix

Section 5 PLUGGING RECORD

Name of Plugging Contractor ______ License No. ______

Street and Number ______ City ______ State ______

Tons of Clay used ______ Tons of Roughage used ______ Type of roughage ______

Plugging method used ______ Date Plugged ______ 19____

Plugging approved by:

______

Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

Date Received JUL 9 1958

File No. L-3901 Use Dom. Location No. 16.36.10.413

Section 6

LOG OF WELL

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color	Type of Material Encountered
0	2	2		Soil
2	20	18		Caliche
20	28	8		Boulder
28	66	38		Sand
66	74	8		Water Sand
74	82	8		Sandy Clay
82	90	8		Quick Sand
90	104	14		Sand

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

CAYTON WATER WELL DRILLING COMPANY
Well Driller

Form WR-23 STATE ENGINEER OFFICE

WELL RECORD

FIELD ENGR LOG

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

City of Lovington

(A) Owner of well P. O. Box 1268

Street and Number Lovington New Mex.

City L- 5014 State

Well was drilled under Permit No. 10 and is located in the

¼ ¼ ¼ of Section Twp. Rge. 322

(B) Drilling Contractor Box 791 License No.

Street and Number Lovington New Mex.

City Nov. 27, State 62

Drilling was commenced Dec. 9, 19 62

Drilling was completed 19

1900 216 Ft.

(Plat of 640 acres)

Elevation at top of casing in feet above sea level Shallow Total depth of well 66 Ft.

State whether well is shallow or artesian Depth to water upon completion

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
	70	76	6	Sand
1	82	94	12	Quick Sand
2	112	116	4	Sand
3	132	137	5	Sand
4	164	168	4	Sand ?
5	178	190	12	Sand

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To
12	3/16 Wall							21

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used

Section 5 PLUGGING RECORD

Name of Plugging Contractor License No.

Street and Number City State

Tons of Clay used Tons of Roughage used Type of roughage

Plugging method used Date Plugged 19

Plugging approved by: Cement Plugs were placed as follows:

Basin Supervisor

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

ROSWELL N. MEX.
DISTRICT II
STATE ENGINEER OFFICE

Date Received 1962 DEC 13 AM 8:11

File No. L-5014 Use Expl. Location No. 16.36.10.240

Section 6

LOG OF WELL

Depth in Feet From	To	Thickness in Feet	Color	Type of Material Encountered
0	2	2		Soil
2	8	6		Clachie
8	12	4		Bolder
12	28	16		Clichie
28	70	42		Sandy Clay
70	76	6		Water Sand
76	82	6		Sandy Clay
82	94	12		Quick Sand
94	112	18		Sandy Clay
112	116	4		Sand
116	132	16		Sandy Clay
132	137	5		Sand
137	164	27		Sandy Clay
164	168	4		Sand
168	178	10		Sandy Clay
178	190	12		Band
190	205	15		Clay
205	215	10		Clay & Gravel
215	216	1		Red Bed
				L S Elev
				Depth to K____ Trc____
				Elev of K____ Trc____
				Loc. No.____
				Hydro. Survey Field Check

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Grady Barker
Well Driller

SOURCE OF ALTITUDE GIVEN
Interpolated from Topo. Sheet____
Determined by Inst. Leveling____
Other____

L-5014

16.36.10.240

APPENDIX B

Depth	Lithologic Description	Measured Soil Chloride Concentration mg/kg	Bulk Density of Sample kg/m3	Thickness of Column (ft)	Calculated Chloride Mass in Column (kg/m2)
0 feet	0-1ft Top Soil				
	1-22 ft Caliche	525	1858	10	3.23
10 feet					
20 feet		1088	1858	11	7.37
30 feet	22-31 ft Sand & Caliche	1161	1858	5	3.57
		636	1858	4	1.57
40 feet	31-45 ft Sand	573	1858	7	2.47
		236	1858	7	1.02
		Calculated Chloride Load			19.22

R.T. Hicks Consultants 901 Rio Grande NW Albuquerque, NM	**RICE** *Operating Company*	Soil Bore #1
	Calculation of Chloride Load, Abo Leak, Lea County, New Mexico	Apr-04

Calc. of hydrus cl inputs, C_hyd = a * .003489 mmol/cm^3

CL in mg/kg	Cl in mmol/cm^3	Depth to bndy in ft.	Depth to bndy. in cm.
		1	30.5
525	0.183173	11	335.5
1088	0.379603	22	671
1161	0.405073	27	823.5
636	0.2219	31	945.5
573	0.19992	38	1159
236	0.08234	45	1372.5

Calc. Chloride load in kg./m^2	19.228		
Area of spill in ft^2	30000		
Totial Cl in kg. (= Cl load * area)	53584.98		
Conc. of the spill mg.(Cl)/liter (from field test)	19994		
Volume of spill in liters (= Total Cl * 1000)/ Conc.)	2680.052		
volume of spill in ft.^3	94.63264	Vol. in barrels, assumes a barrel is 42 gal.	16.85587
height of spill in inches (= vol.of spill / area)	0.037853		
Area of spill in m^2	2786.819		

ABO leak

Unit G, Sec. 1, T17S, R36E

Calculation of Lovington Abo Spill Height, SB-1

Calc. Chloride load in kg./m^2	(From calc., see other sheet)	19.228		
Area of spill in ft^2	(Field measurements, ROC)	30818		
Area of spill in m^2		2866.84445	Barrel size	42
Totlal Cl in mg.	(= Cl load * area)	55123685085		
Conc. of the spill mg.(Cl)/cm^3	(from field test)	247.04	theta_v assumed .15	
Volume of spill in liters	(= (Total Cl * 1000)/ Conc.)	223136.6786		
volume of spill in ft.^3		7878.956122	Vol. in barrels, assumes a barrel is 42 gal.	1403.392
height of spill in inches	(= vol.of spill / area)	3.067930218		
height of spill in cm.		7.783354922		

Calculated Chloride load at SB-3

Soil Bore #3

Depth bgs (ft	[Cl] ppm	Soil density Kg./m^3	Depth in ft.	Cl. in each layer in kg.
3	647	1858	3	1.194808711
4	1023	1858	1	0.629721438
5	1018	1858	1	0.626643621
6	947	1858	1	0.582938614
8	733	1858	2	0.902416059
9	700	1858	1	0.430894435
10	736	1858	1	0.45305472
11	533	1858	1	0.328095334
12	432	1858	1	0.265923423
13	396	1858	1	0.243763137
14	301	1858	1	0.185284607
15	256	1858	1	0.15758425
	Total CL. in kg./m^2 for SB-3			6.00112835

Calculation of Lovington Abo Spill Height, SB-3

Calc. Chloride load in kg./m^2	(From calc.)	6.00112835		
Area of spill in ft^2	(Field measurements, ROC)	30818		
Area of spill in m^2		2866.84445		
Totlal Cl in mg.	(= Cl load * area)	17204301503		
Conc. of the spill mg.(Cl)/cm^3	(from field test)	247.04	theta_v assumed .15	
Volume of spill in liters	(= Total Cl / Conc.*1000)	69641.7645		
volume of spill in ft.^3		2459.050705	Vol. in barrels, assumes a barrel is 42 gal.	438.0038
height of spill in inches	(= vol.of spill / area)	0.957512118		
height of spill in cm.		2.429213224		

The SB-3 spill data was used in the HYDRUS-1D runs to calibrate the model to the soil. For the long time run with the adjusted soil, the chloride load at SB-1 was installed as the initial condition in the soil profile. This adds the chloride load from the earlier spill to the long time simulation.

APPENDIX C

1.0 FACTORS INFLUENCING THE MIGRATION OF CHLORIDE FROM A RELEASE

Chloride ion migration is controlled by a combination of factors related to the vadose zone, the aquifer and the characteristics of a release. Eleven factors control chloride ion migration. Here we discuss how these factors affect the movement of the chloride ion through the vadose zone and in the aquifer.

1. Vadose Zone Texture

The proportion of sand, silt, and clay in a soil or sediment defines vadose zone texture. Texture affects the flow of water and the transport of dissolved chloride. In the vadose zone, fine-grained layers containing silt and clay, which generally have relatively high moisture content, can often transmit water more quickly than drier coarse-grained units containing sand and gravel. A vadose zone composed of layers of fine-grained and coarse-grained units will often transmit water more slowly than a homogeneous, fine-grained profile. In the unsaturated zone, open fractures do not transmit water.

2. Water Content in the Vadose Zone

The soil moisture content is the volumetric fraction of water in a soil or sediment. Climate and soil texture influence soil moisture contents. Wetter, more humid environments result in higher moisture contents. Fine grained and heterogeneous soils retain water better than coarse-grained, more homogeneous soils. Therefore, the more heterogeneous and finer grained the material, the greater the water content.

The water content of a soil or sediment affects its ability to transmit fluids because the hydraulic conductivity increases with increasing water content. The hydraulic conductivity of a sandy soil with water content of 20% can be 1,000 times greater than the same soil in an arid climate where water content is only 5%. Although chloride ion from a release may migrate much faster in a wet soil profile, the natural water in the soil also dilutes the chloride concentration and provides some mitigation of its effects on ground water quality.

3. Dispersion Length of Chloride in the Vadose Zone

The dispersion length describes the amount of mixing a solute such as chloride will undergo in the vadose zone. Dispersion causes dilution of solute concentrations through mixing with ambient vadose water or ground water in a longitudinal direction parallel to water flow as well as in a transverse direction perpendicular to water flow. Systems with larger dispersion lengths produce greater mixing. Soil and aquifer heterogeneity tend to increase dispersion.

The dispersion length is very difficult to measure in the field. Researchers and field personnel rely upon professional judgement and published values (from laboratory or field experiments) to arrive at the dispersion length for a particular site. In general, researchers employ a dispersion length that is 7-10% of the total model length. When modeling a ten meter thick vadose zone, one may set the dispersion length at 10% of ten meters (100 cm).

4. Depth to Ground Water or Vadose Zone Thickness

The vadose zone is the region between the land surface and ground water table, and its thickness is defined by the depth to the ground water table. The vadose zone (also referred to as the unsaturated zone) includes the capillary fringe (pore space completely filled with water, under negative soil water pressure) and the overlying soil and sediment where the pore space is partially filled with water. Because ground water table depth rises and falls due to seasonal fluctuations in precipitation, ground water pumping withdrawals, and other factors, the thickness of the vadose zone is not constant. Like soil texture, the thickness of the vadose zone affects the time required for a release at the ground surface to reach the water table. The thicker the vadose zone, generally, the longer the travel time from ground surface to the water table. A relatively thick vadose zone also has more open pore space to temporarily store released fluid. A thick vadose zone can attenuate the effects of a chloride ion release more effectively than a thin vadose zone.

5. Climate

Precipitation and evaporation affect the water content of the vadose zone (before a release) and exert control over the migration of chloride after a release. In a humid climate regular and generous precipitation over the annual cycle can create relatively uniform infiltration patterns and a predictable soil water profile. In arid climates, where rainfall occurs in short-duration thunderstorms punctuated by long periods of drought, the infiltration is not uniform and occurs only immediately after large precipitation events. Arid climates exhibit vadose zones with relatively low water contents.

In humid climates with relatively uniform infiltration patterns, one could employ monthly climate data for simulation modeling. In arid climates, daily precipitation and evaporation data are necessary.

6. Chloride Concentration of Release

Chloride concentration in oil field brine water can be 100,000 ppm, or much lower if the producing formation contains fresh water due to infiltration of precipitation over geologic time. One of the easiest input parameters to measure in the oil and gas fields is the chloride concentration of the produced water. The chloride concentration in other types of released fluids can also be measured. The effect of chloride concentration in a released substance is straightforward: the higher the chloride concentration, the greater the environmental threat.

7. Release Volume and Chloride Mass

The volume of the release multiplied by the chloride concentration of the release yields the total mass of chloride released to the environment. The total mass released is a very important input parameter because it determines for a specific site the risk for ground water impairment. In the absence of reliable data on the volume of a release, the total mass of chloride can generally be estimated by a field investigation.

8. Height of Spill

Chloride ion releases occur in bermed areas when produced water storage tanks fail or within the natural terrain due to transmission line leaks and other transportation accidents. Releases may pond in a berm, pit, or natural depression, or can be dispersed over a large area. If the release is contained within a berm, the spill height is equal to or less than the height of the berm. In an open field, the spill height may vary. For a given site the amount of chloride ion infiltration into the soil is a function of the hydraulic head or ponding depth. As the ponding depth increases, so does the hydraulic head, (pressure, at the soil/chloride ion spill interface). Understanding the depth of ponding and the total amount of infiltration per unit area guides the characterization efforts. A large amount of infiltration may require deep drilling for site characterization while a small release may require sampling with a hand shovel.

9. Ground Water Flux

Ground water moves through an aquifer in response to its capacity for transmitting water, or, hydraulic conductivity (m/day), and the driving force caused by a sloping water table (hydraulic gradient). The hydraulic conductivity of aquifers can be measured in the field, and can be found in publications that often provide estimates of this parameter. The hydraulic gradient can be measured in the field by determining the depth to water at three wells of known surface elevation. Multiplication of the hydraulic conductivity by the hydraulic gradient yields the ground water flux, which is the volume of water flowing through a unit area of aquifer over a specified time period (expressed in $m^3/(m^2 * day) = m/day$). The lower the ground water flux, the higher the probability that a release will cause unacceptable ground water quality impairment.

10. Aquifer Thickness

A thick aquifer contains more water than a thin aquifer. A given amount of chloride that enters from the vadose zone in a thick aquifer will result in a lower chloride concentration than the same amount entering a thin aquifer since aquifers that contain more water can be more effective at diluting contaminates. A thick aquifer that exhibits a large ground water flux may be able to absorb chloride from a large surface release without any severe impact to water quality.

11. Aquifer Ambient Chloride Concentration

Ambient chloride concentrations of ground water will influence whether or not a release causes unacceptable ground water quality impairment. If ground water has a low chloride concentration, even a considerable release may not cause chloride concentrations to exceed the US EPA Secondary Standard of 250 ppm or preclude the use of the water for agricultural needs. A high chloride concentration in ground water increases the risk that a chloride ion release will render the groundwater unfit for use. Simple field measurements from nearby well water or published data can supply an accurate estimate of the ambient chloride concentration in an aquifer.

1.1 HETEROGENEITY

Heterogeneity, most often caused by the layering of different sediment or soil types within a vadose zone, is more common in nature than not. Heterogeneity affects the distribution of chloride and other solutes through its strong influence on dispersion and hydraulic permeability.

One of the most common simplifying assumptions employed by regulators and guidance manuals is the assumption of homogeneity. However, a clay lens one meter thick found 3 meters below a release in a sandy soil will have a profound effect on the migration of chloride through the vadose zone. Heterogeneity can increase the attenuation of a release and help mitigate the effects on ground water quality.

1.2 RELEASE VOLUME, SPILL HEIGHT, AND CHLORIDE CONCENTRATION OF THE RELEASE

We have found that knowledge of the volume of a release is less important than understanding (1) the chloride load per unit area and (2) the geometry of the release with respect to ground water flow. Because release volume is seldom known with accuracy, we have combined chloride concentration in the release and spill height into a single parameter: chloride load/ unit area. We then used the release volume and spill height to calculate the size of a circular release. As described below, we used the diameter of the release as the length of a release parallel to ground water flow. If an oblong release geometry is oriented parallel to ground water flow, more chloride will enter the aquifer along a specific flow line, yeilding a higher chloride concentration in the down gradient well. If the long axis of the oval release is perpendicular to ground water flow, the impact to a well will be less. By re-arranging and combining these factors, we reduced the total number of factors from 11 to 10.

2.0 Modeling Approach

The modeling of chloride ion migration from the soil surface through the vadose zone into a shallow aquifer towards a monitoring well would require a sophisticated three-dimensional model, which takes into account the full coupling between unsaturated flow in the vadose zone and saturated flow in the aquifer. Such an approach is outside the scope of this study since generally acceptable three-dimensional models capable of such simulations are still being developed. Moreover, the computer time necessary to conduct such simulations would have been prohibitive for regulators and oil field personnel.

We used an approach based upon the assumption that flow through the vadose zone is mainly downward. This assumption is reasonable for humid climates where precipitation exceeds evapotranspiration most of the year. It is also reasonable in arid climates when the ground water table is so deep that no upward flow due to capillary rise can be maintained. Under these conditions, it is possible to de-couple the modeling of water flow and chloride transport in the vadose zone from the modeling of water flow and chloride transport in the aquifer. We assume that flow in the vadose zone is one-dimensional downward and flow in the aquifer is one-dimensional horizontal. This assumption allows us to first simulate water flow and chloride transport through the vadose zone using the model HYDRUS-1D. The output from HYDRUS-1D is the downward water flow seeping out of the vadose zone and the downward chloride flux over time. These outputs are used as inputs into the model for the aquifer. In this study, we used two models for the aquifer: MODFLOW and a simple groundwater mixing model. MODFLOW is a standard code for modeling water flow and solute transport through aquifers (Domenico & Schwartz, 1998). Since it takes quite some time to setup a simulation in MODFLOW, we used a validated excel spreadsheet mixing model to generate results more cost effectively.

2.1 VADOSE ZONE MODEL: HYDRUS-1D

2.1.1 Model Overview

HYDRUS-1D (Simunek et. al, 1998) is used to simulate one-dimensional transport of water, heat, and solute movement in variably saturated porous media. The HYDRUS- 1D model was developed by the George E. Brown Jr., Salinity Laboratory, USDA, ARS, Riverside, California and is distributed by the International

Ground Water Modeling Center (IGWMC), Golden, Colorado. A Microsoft Windows™ based Graphics User Interface (GUI) supports HYDRUS-1D.

The HYDRUS-1D model numerically solves the Richards' equation for water flow and Fickian-based advection-dispersion equations for heat and solute transport. The HYDRUS-1D flow equation includes a sink term (a term used to specify water leaving the system) to account for transpiration by plants. The solute transport equation considers advective, dispersive transport in the liquid phase, diffusion in the gaseous phase, nonlinear and non-equilibrium sorption, linear equilibrium reactions between the liquid and gaseous phases, zero-order production, and first-order degradation. The heat transport equation describes conduction as well as convection.

HYDRUS-1D can handle large numbers of soil layers, and uses the van Genuchten-Mualem, Brooks-Corey, Kosugi lognormal, and Durner dual porosity models to describe soil hydraulic properties. When values of soil hydraulic properties are unavailable, HYDRUS-1D can estimate them from a small catalog of values based on major textural classes (e.g., sand, sandy loam, etc.) or neural network based predictions.

The HYDRUS-1D code can simulate a wide range of boundary conditions. These are constant and time-variable pressure heads and fluxes, free drainage, seepage face, and an atmospheric boundary condition. An atmospheric boundary condition can be used to either generate run-off when the precipitation rate exceeds the infiltration capacity of the soil, or store excess water on the land surface allowing the water to infiltrate when precipitation stops. Time-variable conditions can be entered hourly, daily, or any general time interval.

We used HYDRUS-1D for the vadose zone simulations of this research project because we are interested in the vertical transport of water and chloride through the vadose zone. The outputs from HYDRUS-1D are the daily water flow and chloride flux from the vadose zone over the time period of the simulation expressed as cm day^{-1} and mg cm^{-2} day^{-1} respectively. These outputs are used as inputs into the simple mixing model.

2.1.2 Applicability of HYDRUS-1D for Chloride ion Releases

Surface or near surface releases of chloride ion migrate through the vadose zone under variably saturated conditions as a function of release volume, topography, and climatic conditions (i.e., precipitation and evapotranspiration). Although other vadose zone models exist that satisfy this criterion, we selected HYDRUS-1D over other models for the following three reasons:

1. It can simulate water and solute transport through heterogeneous porous media: horizons and sediments of varying geology;
2. It can incorporate daily climatic data; and
3. We are familiar with the model.

Dr. Jirka Šimùnek of our team developed the HYDRUS-1D model with his colleagues Dr. van Genuchten and Dr. Sejna; Dr. Jan Hendrickx, another team member, has used the HYDRUS-1D model for many years for evaluation of groundwater recharge and salt movement through the vadose zone.

2.2 SATURATED ZONE MODEL: MIXING MODEL AND MODFLOW

As stated, the objective of this part of this study is to evaluate the impact of choride releases on ground water quality as measured in a well adjacent to and down gradient of the release. The chloride flux leaving the vadose zone, the horizontal flux in the unconfined aquifer, the original chloride concentration in the ground water, and the thickness of the unconfined aquifer also affect the chloride concentration of the aquifer. Since the water flux seeping from the vadose zone and its chloride concentration vary with time, no simple analytical solutions are available for determination of the time-varying chloride concentration in the well.

Therefore, we implemented a simple spreadsheet ground water mixing model for the determination of the chloride concentration in the well. This mixing model uses the output of the HYDRUS-1D model as input. We have to define the aquifer volume, (the mixing compartment underneath the spill) as a first step in the ground water mixing modeling process. Assuming a circular spill area and a unidirectional horizontal flux in the aquifer, the highest impact will occur where the ground water has the longest exposure to the incoming chloride from the vadose zone. This takes place along the diameter of the circular spill. Therefore, the length of the mixing compartment is made equal to the diameter of the spill area, *D*. The depth of the mixing compartment is the thickness of the aquifer, *H*. The width, *W*, of the mixing compartment is taken equal to unity (one) to simplify the calculations.

Now we will develop the relation between the water flux seeping out of the vadose q_v, the chloride concentration in the vadose zone flux , C_v, the horizontal flux in the aquifer underneath the release entering the compartment, $q_{in,}$ the original chloride concentration in the aquifer, C_{in}, the horizontal flux in the aquifer underneath the release leaving the compartment, q_{out}, and the chloride concentration of the aquifer flux leaving the area underneath the chloride ion release, C_{out}. The latter concentration is the one that will be monitored in the down gradient well. We make the following reasonable assumptions to determine C_{out}:

1. Ground water flow is in steady state. The discharge entering into the mixing compartment from the vadose zone, q_vHDHW, plus the horizontal discharge in the aquifer entering the mixing compartment at its up-gradient side, q_{in}HHHW, are equal to the discharge leaving the mixing compartment, q_{out}HHHW.

2. Changes in thickness of the saturated aquifer are small compared to the total thickness of the aquifer H.

3. The thickness of the aquifer, H, and its porosity, n, are constant.

4. Mixing of the chloride entering the mixing compartment is complete and immediate. This assumption appears invalid from data published in the recent literature (LeBlanc et al., 1991; Zhang et al., 1998). We can use the results of the mixing model as an excellent indicator of the mean chloride concentration in a supply well penetrating the aquifer underlying the release, but not as an indicator of the chloride distribution in the aquifer.

The volume of the mixing compartment, V, will be constant under these assumptions, and is equal to:

$$V = D \times H \times W \times n \qquad \textbf{(2-1)}$$

The water balance of the mixing compartment is equal to:

$$q_{in} \times H \times W + q_v \times D \times W = q_{out} \times H \times W \qquad \textbf{(2-2)}$$

We can eliminate variable W from Eqs. [2-1] and [2-2] by putting W= 1 m.

The chloride balance of this mixing compartment during any time period dt is:

$$[(q_{in} \times C_{in} \times H + q_v \times C_v \times D) - (q_{in} \times H + q_v \times D) \times C_{out}]dt = [D \times H \times n]dC$$

(2-3)

where dC is the change of chloride concentration occurring during time period dt.

Rearranging Eq. [2-3] we obtain the ordinary differential equation:

$$\frac{dC}{dt} = \frac{q_{in} \times C_{in} \times H + q_v \times C_v \times D - (q_{in} \times H \times q_v \times D) \times C_{out}}{H \times D \times n}$$

(2-4)

As soon as chloride from the release enters the ground water, the volume average concentration in the mixing compartment is C_{out} after complete mixing has occurred. Thus the chloride concentration of the water leaving the department, C_{out}, becomes:

$$C = C_{out} \qquad \text{and} \qquad dC = dC_{out}$$

(2-5)

Therefore, we can convert Eq. [2-4] in a forward finite difference expression:

$$\frac{C_{out}^{i+1} - C_{out}^{i}}{t^{i+1} - t^{i}} = \frac{q_{in}^{i} \times C_{in}^{i} \times H + q_v^{i} \times C_v^{i} \times D - (q_{in}^{i} \times H + q_v^{i} \times D) \times C_{out}^{i}}{H \times D \times n}$$

(2-6)

which yields an explicit expression for C_{out}^{i+1},

$$C_{out}^{i+1} = C_{out}^{i} + \frac{[q_{in}^{i} \times C_{in}^{i} \times H + q_v^{i} \times C_v^{i} \times D - (q_{in}^{i} \times H + q_v^{i} \times D) \times C_{out}^{i}] \times [t^{i+1} - t^{i}]}{H \times D \times n}$$

(2-7)

Using the output from HYDRUS-1D: the chloride concentration, C_v^i, of the water, q_v^i, entering the ground water table on day, t^i, we have put into a spreadsheet the mixing model of Eq.

[2-7]. By changing the values for spill diameter, *D*, ground water flux, q_{in}, original chloride concentration in the aquifer, C_{in}, and the aquifer thickness, *H*, we have evaluated the effect of these four factors of an unconfined aquifer.

Figure 2-1 *Comparison between MODFLOW and the Mixing Model*

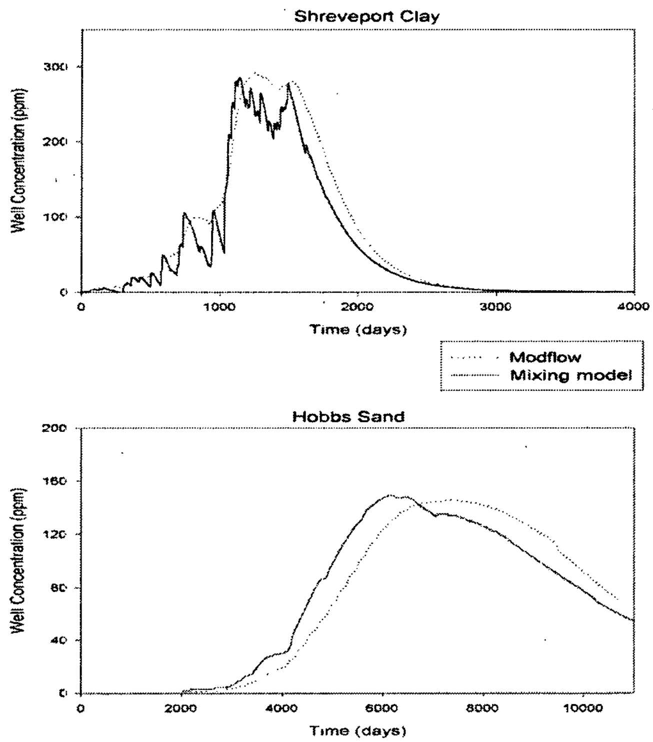


Figure 2-1 presents two comparisons between the chloride concentrations in the well located down gradient of the entry point of the release obtained with the mixing model Eq. [2-7] and those obtained with the model MODFLOW. The two comparisons deal with two complete different sets of environmental and release factors. In Shreveport the vadose zone texture is clay, the dispersion length 0.1 m, release chloride concentration 10,000 ppm, spill height 0.6 m, and aquifer flux 0.05 m/day. In Hobbs, vadose zone texture is sand, dispersion length 2.0 m, release chloride concentration 100,000 ppm, spill height 0.025 m, and aquifer flux 0.004 m/day. The maximum chloride concentrations predicted by the two models is quite similar, although the time of arrival to the maximum concentration is different between the two models. We have conducted this part of the study using the less expensive mixing model Eq. [2-7]. (Our approach using HYDRUS-1D in combination with MODFLOW and Eq. [2-7] is valid for situations where the vadose zone seepage flux, q_v, is downward. A downward flux in the vadose zone is always found in the profiles with a deep ground water table depth. However, in the profiles with a ground water table depth between **0 – (+/-) 10** m an upward flux from ground water table towards the soil surface does occur as a result of capillary rise. The magnitude of the upward capillary flux depends on soil type and climate.

A large amount of precipitation enables the downward vadose zone flux to dominate the chloride transport in both the sandy and clayey soil in the humid climate of Shreveport. Occasionally in the clayey soil an upward flux is encountered during short periods without rain.

An upward flux is sometimes found in the sanyd soil but is prevalent in the clay soil in the arid climate of Hobbs. For example, when the ground water table depth is 3 m, the average upward flux in a clay profile would be 0.04 cm/day or 13.5 cm/year; this upward capillary flux causes the chloride and soil water from the release to stay in the vadose zone and protects the ground water from impairment. In hydrogeological situations where capillary rise is common, vadose zone water movement towards ground water is sporadic. However, a big storm can push chloride ion into a shallow aquifer very quickly.

There is a strong dynamic interaction between all eleven factors, outlined in section 1.1., when water leaving the vadose zone, q_v, changes direction frequently in response to precipitation events (downward movement) and evapotranspiration (upward movement). In dry climates with shallow ground water (less than 3 m), upward movement of ground water into the vadose zone thnce to the atmosphere is common. The only manner to correctly simulate the interaction between these factors is by employing a two- or three-dimensional model, such as HYDRUS-2D. However, since the main objective of this study is ground water impairment and the effect of capillary rise in diminishing the leaching of chloride to the ground water, and is not the chloride ion concentration in the root zone, we used the mixing model Eq. [2-7] for ground water table depths of 3 m. We used the equation only for downward fluxes and made it inactive when the vadose zone flux q_v, goes upward. It was initiated again with the next occurrence of a downward flux, q_v, taking the C_{out} value of the previous occurrence of a downward q_v. In this manner a conservative estimate is obtained of the chloride concentration in the monitoring well assuming perfect mixing for shallow groundwater tables.

3.0 SENSITIVITY ANALYSIS OF FACTORS DETERMINING CHLORIDE ION FATE

3.1 PURPOSE

After a brine release, the concentration of chloride in the vadose zone decreases with time and distance traveled through the vadose zone towards ground water because of dilution with ambient soil water. Further dilution occurs in the aquifer after the chloride reaches the ground water. The maximum chloride concentration occurring at a well down gradient from the release will depend on all the factors that affect chloride transport through the vadose zone and shallow aquifer. Understanding these factors is critical for the design and implementation of a site characterization program after a chloride ion release. The degree of ground water quality impairment determines to a large extent the need for a ground water remedy. The purpose of this sensitivity study is to evaluate which of the eleven factors have the greatest effect on prediction of maximum chloride concentration in the well down gradient of the release.

3.2 MODELING SPECIFICS

We needed to optimize our simulation efforts in order to obtain the maximum amount of information from the modeling. Statistics of experimental designs (e.g. Law & Kelton, 2000; Snedecor & Cochran, 1967; Steel & Torrie, 1980) allow us to decide which combination of factors to simulate so that the desired information can be obtained with the lowest possible number of simulations.

The factors used in experimental design statistics are the input variables to our simulation models. The outputs of our simulations are the responses. The responses that we consider in this study are the maximum chloride concentration, C_{max}, occurring in the well and the time at which the maximum chloride concentration reaches the well, T_{max}.

We have opted for a 2^k *factorial design* that requires us to choose two levels of each factor in this study. This design results in a total of 2^k simulation runs, where k is the number of factors. We chose the two values for each factor so that they represent two opposite conditions such as an arid and a humid climate. The factors can be qualitative like climate or quantitative like depth to ground water. The two input values should not be too extreme or unrealistic. Additionally, the two values should not be too similar or the simulations may not adequately evaluate important aspects of the transport process under consideration. The 11 factors of this sensitivity analysis (see Table 3-1) resulted in 2^{11} or 2,048 different chloride ion release scenarios.

3.2.1 VADOSE ZONE FACTORS

Climate

We selected the two contrasting climates of Lea County, New Mexico, and Shreveport, Louisiana for the sensitivity analysis. Lea County is located in the arid southwest, and Shreveport is in the humid south. Lea County's annual precipitation and potential evapotranspiration is 14 inches and 59 inches, respectively, while annual precipitation and potential evapotranspiration for Shreveport is 46 inches and 67 inches, respectively. Lea County and Shreveport also differ in how precipitation occurs. In Lea County, the majority of precipitation occurs during the "monsoon" of July-August and much of the remainder of the year resembles drought conditions. Shreveport's precipitation falls throughout the year.

***Table 3-1:** Vadose zone, aquifer, and brine release factors determining maximum chloride concentration arriving at a monitoring well down gradient.*

Factor	Factor	Factor	Maximum Chloride Concentration	
#	Description	Abbreviation	Decrease	Increase
1	Climate	clim	Arid	Humid
2	Soil Texture	soil	Clay	Sand
3	Initial Water Content	wcin	Wet	Dry
4	Chloride Dispersion Length	disp	2.0 m	0.1 m
5	Ground Water Depth	gwl	30 m	3 m
6	Ground Water Flux	qaq	0.05 m/day	0.001 m/day
7	Ambient Aquifer Cl Concentration	cin	0 ppm	100 ppm
8	Aquifer Thickness	thick	30 m	3 m
9	Release Volume	vol	100 barrels	10,000 barrels
10	Release Height	depth	0.025 m	.6m
11	Release Chloride Concentration	clcon	10,000 ppm	100,000 ppm
10*11	Release Chloride Mass	clmass	250 g/m^2	60,000 g/m^2

Vadose Zone Texture

We selected sand and clay as contrasting soil textures for the sensitivity analysis. Sand and clay differ not only in grain size but also in their ability to retain and transmit water. Sand has a relatively high-saturated hydraulic conductivity and low water retention; whereas clay has a relatively low saturated hydraulic conductivity and high water retention.

Water Content in Vadose Zone

We hypothesized that higher initial water content in the vadose zone would result in slower chloride ion movement because the initial moisture must be displaced before the chloride ion can move downward through the vadose zone. We used HYDRUS-1D to predict initial water contents for both vadose zone textures in both Lea County and Shreveport. We used these predictions as initial conditions in the sensitivity analysis.

We ran simulations for one hundred years or until we achieved dynamic equilibrium between soil water content and climatic conditions for both the wet and dry initial conditions. To create *wet* conditions, we ran simulations without any vegetation (low evapotranspiration); and ran simulations with vegetation (high evapotranspiration) in *dry* conditions. We used evergreen plants capable of transpiring soil water all year round with a 3 meter (~10 ft) deep root zone. Transpiration of soil water created a drier soil profile than simulations without vegetation.

Dispersion Length of Chloride in Vadose Zone

For the sensitivity analysis, we selected minimum and maximum chloride dispersion lengths of 0.10 m (0.33 ft) and 2.0 m (6.6 ft), respectively. The larger dispersion length will produce greater mixing of chloride ion with ambient soil water in the vadose zone, and it is expected to result in a lower maximum chloride concentration in the well. Conversely, the smaller dispersion length will result in minimal mixing, e.g. minimal attenuation of the release, and larger maximum chloride concentrations. We based our selection of dispersion lengths on values reported in the literature (Gelhar, 1993).

Depth to Ground Water

Deep ground water allows for more storage of chloride ion and more attenuation of the maximum chloride concentration during its downward migration. We selected ground water depths of 3.0 m (9.8 ft) and 30 m (98 ft) for the sensitivity analysis. These depths represent reasonable values for a shallow and deep aquifer, respectively.

3.2.2 AQUIFER FACTORS

Ground Water Flux

Ground water flux represents the rate of ground water movement and effects the ability of an aquifer to dilute chloride and other constituents of a chloride ion release. A large ground water flux produces greater dilution.

We based our selection of minimum and maximum groundwater fluxes on literature values for the Ogalalla aquifer, Southern Lea County, New Mexico (Native and Smith, 1987). We used 0.10 cm/day (0.0033 ft/day) and 5.0 cm/day (0.16 ft/day) as minimum and maximum values, respectively. The maximum flux is lower than some of the ground water fluxes reported in the literature (e.g. 40 cm/day by Zhang et al., 1998) and, thus, is a conservative estimate.

Aquifer Ambient Chloride Concentration

We selected ambient chloride concentrations for ground water of 0 ppm and 100 ppm. One hundred parts per million or less is typical for ground water of the Ogallala aquifer (Nicholson and Clebsch, 1961) and the Carrizo-Wilcox aquifer in Caddo Parish, Louisiana (Rapp, 1992). Although 10-ppm chloride is a more characteristic minimum value for the Ogallala and Carrizo-Wilcox aquifers, we selected 0.0 ppm to create a greater difference between minimum and maximum chloride concentrations of ground water.

Aquifer Thickness

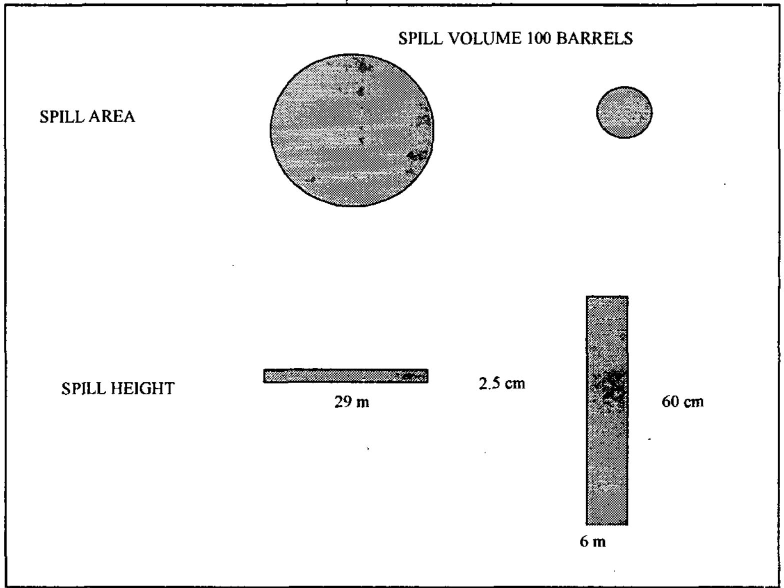
The thicker the aquifer, the more opportunity for mixing (dilution), and the lower the predicted chloride concentration will be in the aquifer. We selected two aquifer thicknesses, 3.0 m (9.8 ft) and 30 m (98 ft). Three meters are approximately equal to the length of most well screens used to monitor the chloride changes. Therefore, an aquifer thickness of 3 meters provides a good estimate of expected chloride concentrations at a monitor well in a thicker aquifer under conditions of limited vertical mixing. Many unconfined, alluvial aquifers are greater than 30 m thick, but we have selected 30 m as the maximum value. A 30 m thick saturated sandy formation with a hydraulic conductivity of at least 0.0005 m/s (140 ft/day) is classified as a good aquifer (Freeze and Cherry, 1979).

3.2.3 CHLORIDE ION RELEASE FACTORS

Release Volume

We used minimum and maximum release volumes of 100 bbl (16 m^3) and 10,000 bbl (1,600 m^3), respectively. These release volumes are representative of large and very large releases based on the experience of oil and gas industry personnel.

Figure 3-1. Schematic of Two Possible Brine Release Characteristics After a Release of 100 Barrels.



In the one-dimensional HYDRUS-1D model we used only spill height as an input variable. The spill volume was introduced into the mixing model using the diameter of the spill. For example, a 100 barrel release resulting in a chloride ion release of 0.025 m height with circular shape will have a diameter of 29 m while a release of 0.6m height will have a diameter of only 6m (Figure 3-1). Table 3-2 summarizes the four chloride ion release areas evaluated with the mixing model. These four release areas are combinations of the two spill heights (0.025 and 0.6 m) and two release volumes (large: 100 barrels and very large: 10,000 barrels).

We represented all spill areas as circles, and then, used the mixing model to evaluate mixing along the diameter of each circular spill (see Table 3-2). The diameter of each circle represents the longest path groundwater must flow beneath each release area, and thus provides a conservative estimate of groundwater quality impairment at a well immediately down gradient of a release.

Table 3-2. Characteristics of brine releases in this study.

Volume	Depth		Area		Diameter
Barrels	m^3	m	m^2	acres	m
100	16	0.025	640	0.16	29
		0.6	26.67	0.007	6
10000	1600	0.025	64000	16	285
		0.6	2666.67	0.7	58

Chloride Concentration of Release

We selected chloride concentrations of 10,000 and 100,000 ppm, as the minimum and maximum concentrations for the chloride ion release input parameter in consultation with experienced professionals. These concentrations are representative of most chloride ion releases.

The mixing model does not consider density differences between the density of the chloride ion arriving at the aquifer and the density of the water in the aquifer. These differences (even if small) may cause chloride ion to sink in an aquifer (LeBlanc et al., 1991; Zhang et al., 1998) and would influence the distribution of chloride ion in the aquifer. Since our approach assumes complete mixing in the aquifer, the chloride distribution is not taken into account. Water extracted from a well by bailing or pumping typically would represent a well mixed sample. The results of the mixing model help to identify environmental and release characteristics that cause groundwater quality impairment and provide a measure of the overall impact of a chloride ion release on an aquifer.

Height of Spill

We selected 0.025 m (1 inch) and 0.6 m (2 ft) as the minimum and maximum spill heights, respectively, of brine water on the land surface, based on observations of oil and gas industry personnel. A 0.6 m (two-foot) height represents a discharge of 1600 m^3 (10,000-bbls) of chloride ion to a 2670 m^2 (0.7 acre) bermed area or large depression. Releases to flat or gently sloped areas are likely to result in initial heights of 0.025m (an inch) or less.

Chloride Mass

Table 3-1 presents a final factor, "Release Chloride Mass". This factor, which is the product of "Release Height" and "Release Chloride Concentration", is the mass of chloride released to the ground surface per unit area. As Table 3-1 shows, a chloride ion release (see Release Chloride Concentration) of 100,000 ppm chloride that ponds to a depth of 0.6 meters (see Release Height) causes a subsurface chloride input of 60,000 grams per square meter (the Release Chloride Mass).

3.3 SIMULATION RESPONSES

The simulations with the HYDRUS-1D code and the mixing model yield large amounts of information about the flow of water and the transport of chloride through the vadose zone and the underlying aquifer. As mentioned above, we have selected two critical response variables for the sensitivity analysis: (i) the maximum chloride concentration in a down gradient monitoring well, C_{max}, and (ii) the time of arrival of the maximum chloride concentration at the monitoring well, T_{max}.

Maximum Chloride Concentration

The maximum chloride concentration defines the center of mass of a release as it migrates through the vadose zone into the aquifer and reaches a well. For this reason, we used the maximum chloride concentration, C_{max}, to identify those factors listed in Table 3-1 that have a significant influence on chloride migration through the vadose zone and the aquifer as the release moves toward the well. Evaluation of C_{max} can also identify the environmental conditions that result in significant attenuation of chloride ion. For example, for those simulations where C_{max} is much less than the original chloride concentration of released chloride ion, environmental factors cause significant chloride ion attenuation. Additionally, an evaluation of C_{max} can be used to identify release scenarios that pose little or no threat to groundwater quality. For instance, simulations that predict a C_{max} less than the EPA Secondary Water Quality Standard of 250-ppm chloride will not cause water quality impairment. On the other hand, when predictions of C_{max} are greater than 250-ppm, ground water quality may be threatened by the release. Thus, the maximum chloride concentration in the well informs us about the risk for ground water impairment and its severity.

Time of Arrival of Maximum Concentration at the Well

Time of arrival of maximum concentration, T_{max}, is the time required for the chloride center of mass to reach the well. It dictates the urgency to implement a field investigation and possible remedy. A relatively rapid response is required if simulations suggest a chloride concentration of 250 ppm or more at a well within a few years. However, when input factors combine to predict that decades or centuries are required for a well to show ground water impairment, an immediate ground water investigation may be of little value.

3.4 STATISTICAL ANALYSIS OF THE RESPONSES AT MONITORING WELL

Following the statistical approach by Law & Kelton (2000) for simulation modeling and analysis, we determined the impact of each factor presented in Table 3-1 on the migration of chloride ion through the vadose zone and aquifer. We did this by inspecting the effect of each factor on the maximum chloride concentration in a down gradient well, C_{max}, and the arrival time of this concentration, T_{max}, at the well.

Table 3-3. *Main effects of the vadose zone, aquifer, and brine release factors on the maximum chloride concentration*

Factor	Effect on Cmax	
	ppm	Relative Effect
Height of Brine Release	4,340	1
Release Chloride Concentration	4,017	0.93
Thickness of Aquifer	3,237	0.75
Soil	2,070	0.48
Aquifer Flux	1,994	0.46
Dispersion Length	1,545	0.36
Climate	1,184	0.27
Ground Water Depth	1,081	0.25
Volume of Brine Release	932	0.21
Ambient Cl Concentration	76	0.02
Initial Water Content of Soil	25	0.01

3.4.1 MAXIMUM CHLORIDE CONCENTRATION

Table 3-3 presents the sensitivity of C_{max} to each of the 11 factors considered in this study (Table 3-1). The factors are sorted according to their impact on C_{max} in Table 3-3. The most important factors are the Height of Chloride ion Release and the Release Chloride Concentration. Changing the Height of Chloride ion Release from 0.025 to 0.6 m while holding all other factors fixed results in an average increase of maximum chloride concentration of 4,340 ppm. Changing the Release Chloride Concentration from 10,000 to 100,000 ppm results in an average increase of 4,017 ppm in maximum chloride concentration in the well. The absolute concentration values depend on the set up of the simulation experiment. We have added the relative effects of each factor in Table 3-3. The factors Height of Chloride ion Release and Release Chloride Concentration have relative effects of 1.00 and 0.93 respectively, much higher than of any other factor. The predicted difference in C_{max} due to the difference in Release Chloride Concentration is 93% of predicted difference for the Height of Chloride ion Release. The predicted difference in C_{max} for the two climate's indices, however, was only 27% of predicted difference for the Height of Chloride ion Release. As Table 3-3 shows, Initial Water Content of Soil exerts the smallest influence on the prediction of C_{max}.

The two most important factors, Height of Chloride ion Release and the Release Chloride Concentration, determine the Mass of Chloride entering the soil surface during a release. If the Height of Chloride ion Release or the Release Chloride Concentration increases, the Mass of Chloride increases and consequently, the maximum chloride concentration increases. Because the Mass of Chloride appears to be the key factor in determining the maximum chloride concentration arriving at a down gradient monitoring well, we repeated the sensitivity analysis using Mass of Chloride instead of Height of Chloride ion Release and Release Chloride Concentration. We eliminated the Initial Water Content of Soil in the second sensitivity analysis since this factor has very little impact on C_{max}.

The results of the second analysis are presented in Table 3-4 and in Figure 3-2. The mean chloride concentration of all 256 scenarios with

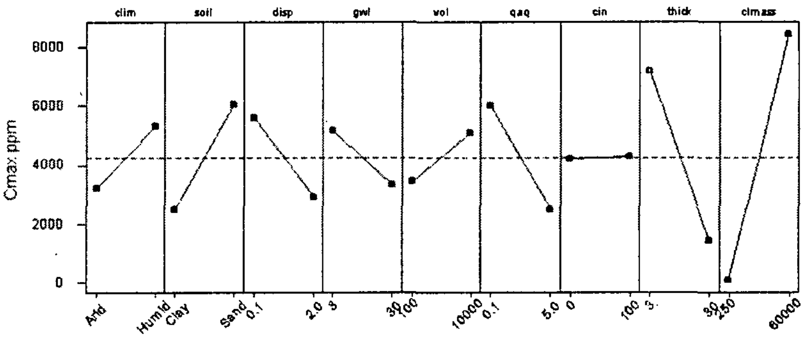


Figure 3-2 *The effect of nine brine release, vadose zone, and aquifer factors*

Mass of Chloride 250 g/m^2 is 89 ppm and that of all 256 scenarios with Mass of Chloride 60,000 g/m^2 is 8,446 ppm (See Figure 3-2). The difference between these two values is 8,357 ppm, which is the predicted sensitivity of the maximum chloride concentration for an increase of factors fixed.

Table 3-4. *Main effects and important interactions of the vadose zone, aquifer, and brine release factors on the maximum chloride concentration arriving at the monitoring well C_{max} and the time of arrival of the maximum concentration T_{max}.*

Factor	Effect on C_{max}		Effect on T_{max}	
	ppm	Relative Effect	Years	Relative Effect
Main Effects				
Chloride Mass	8357	1	52	0.46
Aquifer Thickness	5632	0.67	5	0.04
Soil	3560	0.43	106	0.93
Aquifer Flux	3525	0.42	7	0.06
Dispersion Length	2699	0.32	11	0.06
Climate	2099	0.25	114	1
Ground Water Depth	1826	0.22	104	0.91
Volume of Brine Release	1631	0.2	0	0
Ambient Cl Concentration	82	0.01	44	0.39
Interaction Effects				
Chloride Mass x Aquifer Thickness	5573	0.67		
Chloride Mass x Soil	3519	0.42		
Chloride Mass x Aquifer Flux	3509	0.42		
Aquifer Thickness x Aquifer Flux	2529	0.3		
Aquifer Thickness x Soil	2509	0.3		
Soil x Aquifer Flux	1223	0.15		
Soil x Climate			98	0.86
Climate x Depth Ground Water			95	0.83
Soil x Depth Ground Water			90	0.79

The Thickness of Aquifer also has a large impact with a sensitivity of 5,632 ppm for a change from 3 to 30 m. All other factors are less important. For comparison, we have determined the relative impacts of each factor by dividing each affect by the influence of the Mass of Chloride (Table 3-4). The most important factors Mass of Chloride and Thickness of Aquifer with relative affects of 1.00 and 0.67, respectively. The factors Soil, Aquifer Flux, and Dispersion Length have relative affects of 0.43, 0.42, and 0.32, respectively. The factors Climate, Ground Water Depth, and Volume of Chloride ion Release have much less impact with relative affects of 0.25, 0.22, and 0.20. Ambient Chloride Concentration (Relative effect 0.01) has virtually no effect.

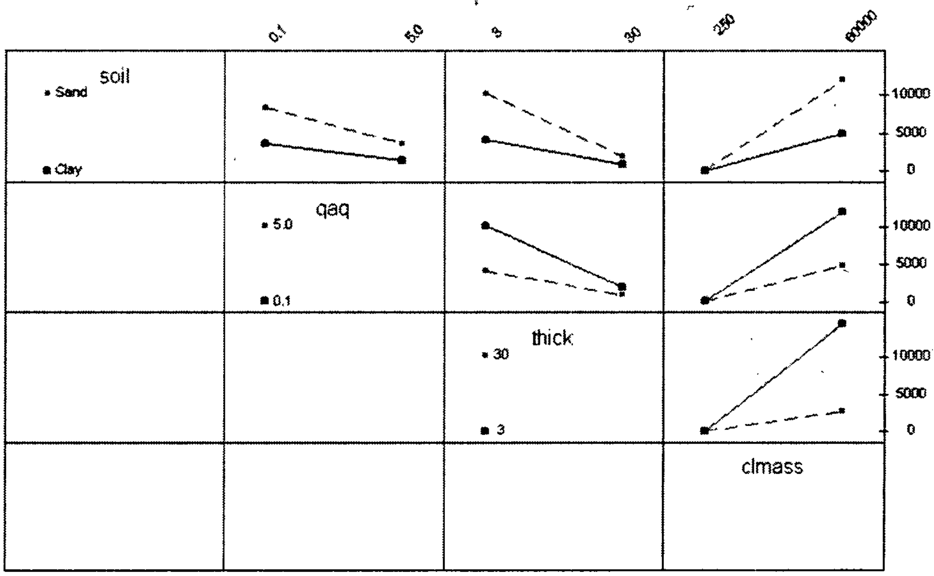
We know that the predicted maximum and minimum values of C_{max} for a factor of interest can depend on the values of other factors. Where this is the case, the two factors are said to interact. An Analysis of Variance revealed that six interactions affect the maximum chloride concentration. These are the interactions be-

- Chloride Mass and Thickness of Aquifer,
- Chloride Mass and Vadose zone texture,
- Chloride Mass and Aquifer Flux,

- Thickness of Aquifer and Aquifer Flux,
- Thickness of Aquifer and Vadose zone texture, and
- Vadose Zone Texture and Aquifer Flux.

Table 3-4 shows the relative importance of each interaction and the interactions are presented in Figure 3-3. As shown in Figure 3-3, if Mass of Chloride increases from 250 to 60,000 g/m^2 above an aquifer with a thickness of 3 m, the maximum chloride concentration at the well increases from 118 to 14,501 ppm. The same increase of Mass of Chloride occurring above an aquifer with a thickness of 30 m causes only a modest chloride increase from 60 to 2,757 ppm. In a sandy vadose zone, C_{max} increases from 110 to 11,985 ppm in response to the different chloride loads to the ground surface. However, different chloride ion releases to a clay result in smaller differences, 68 to 4,906 ppm, but fall within the range of responses in a sandy zone.

Figure 3-3. Interaction effects between the factors soil, flux in aquifer, thickness of aquifer, and chloride load on the maximum chloride concentration in a downgradient monitoring well.



The implication of the results of our sensitivity analysis is that determination of Mass of Chloride per unit surface area and Thickness of Aquifer is critical for the evaluation of ground water impairment. Knowledge of Vadose Zone Texture Conditions, Aquifer Flux, Dispersion length, Climate, Ground Water Depth, and Volume of Chloride ion Release can provide useful additional information, while ambient Chloride Concentration and Initial Water Content of Soil provide little relevant information.

The results of the sensitivity analysis cannot be used to directly evaluate field sites because they are based on the average change of maximum chloride concentration. For each factor, the maximum chloride concentration exhibits a wide range of values as is shown in Table 3-5.

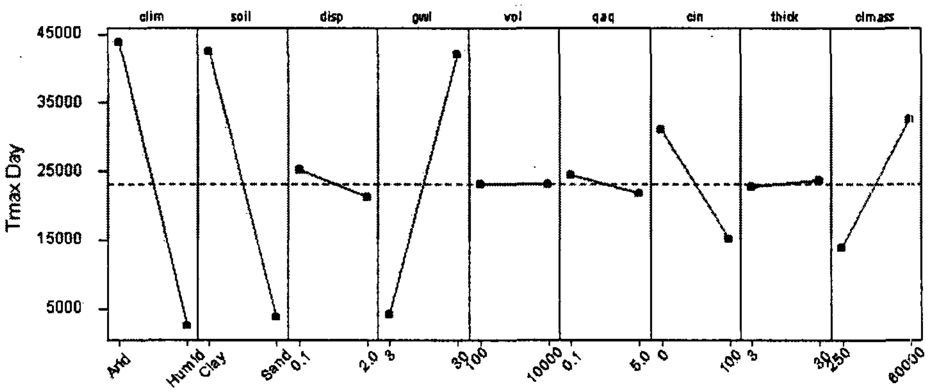
Table 3-5. *Statistics of maximum chloride concentrations (ppm) determined in the sensitivity analysis.*

Main Effect	Level	Mean	Minimum	Maximum
Mass of Chloride	250 g/m2	89	0	303
	60,000 g/m2	8,446	0	46,633
Thickness of Aquifer	30 m	1,429	0	15,354
	3 m	7,195	0	46,633
Soil	Clay	2,487	0	37,233
	Sand	6,047	2	46,633
Aquifer Flux	0.05 m/day	2,505	0	29,779
	0.001 m/day	6,030	0	46,633
Climate	Arid	3,218	0	44,372
	Humid	5,317	0	46,633
Ground Water Depth	30 m	3,354	0	40,758
	3 m	5,181	0	46,633
Volume of Brine Release	100 barrels	3,452	0	41,603
	10,000 barrels	5,083	0	46,633
Dispersion Length	2.0 m	2,918	0	25,653
	0.1 m	5,617	0	46,633
Ambient Cl Concentration	0 ppm	4,226	0	46,593
	100 ppm	4,308	0	46,633

3.4.2 ARRIVAL TIME OF MAXIMUM CHLORIDE CONCENTRATION

We present the effects of the factors on the arrival time of the maximum chloride concentration at the well in Table 3-4. The arrival time strongly depends on climate (relative effect of 1.0 in Table 3-4), vadose zone texture, and depth of ground water. In the arid climate of Lea County, New Mexico, a chloride ion release will require an additional 114 years (40,515 days) for the maximum concentration to arrive at a well than a similar release in the humid climate of Shreveport, Louisiana. The vadose zone texture and ground water table effects are of the same order of magnitude (106 and 104 years respectively). Other factors are less important. Figure 3-4 graphically displays this same information. Our Analysis of Variance identified three important interactions that effect the length of time required

Figure 3-4 *The effect of nine brine release, vadose zone, and aquifer factors on the time when the maximum chloride concentration arrives in a downgradient monitoring well.*

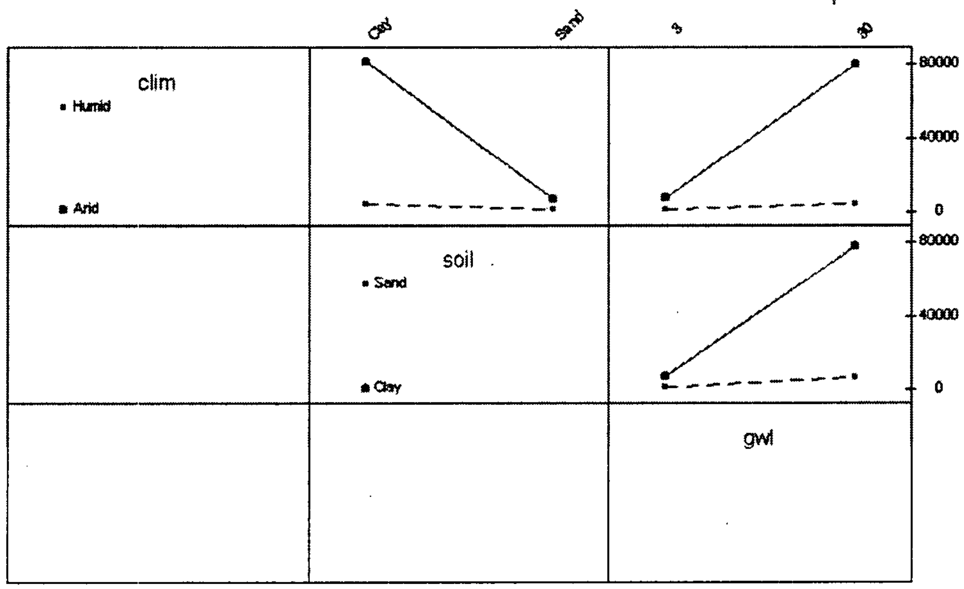


for C_{max} to reach a well:

- Vadose Zone Texture and Climate,
- Climate and Depth to Ground Water, and
- Vadose Zone Texture and Depth to Ground Water.

The lower right section of Figure 3-5 shows that the depth to ground water has little effect on the arrival time of C_{max} if the texture of the vadose zone is sand. In a clay profile, however, the time of arrival is very different: nearly 80,000 days (219 years). This same relationship is expressed with the interaction between Climate and Depth to Ground Water (plotted in the upper right portion of Figure 3-5). In a humid climate, the texture of the vadose zone has little impact on the arrival time of C_{max}. However, in the arid Lea County, a release to a clay profile will require over 200 years longer for C_{max} to reach a well than the same release to a sandy vadose zone would.

Figure 3-5. *Interaction effects between the factors climate, soil, and ground water depth on the time when the maximum chloride concentration arrives in a down gradient monitoring well.*



R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

June 11, 2004

Wayne Price
NMOCD Environmental Bureau
1220 South St. Francis Drive
Santa Fe, New Mexico 87505
Via E-mail

RE: Abo 1G Pipeline Release Corrective Action Plan
Section 1, 17S, 36E, Unit G

Dear Wayne:

On behalf of Rice Operating Company, R.T. Hicks Consultants, Ltd. is pleased to submit the attached Corrective Action Plan for the above-referenced site. We have followed the same approach with this site as in our previously-submitted CAP for the Zachary Hinton site. We would appreciate your comments on this and the Zachary Hinton report as soon as possible to allow us to address your concerns before we complete our reports on the following ROC sites:

B-29	(NMOCD approved work plan)
N-29	(NMOCD approved work plan)
M-5	(NMOCD approved work plan)
Hobbs SWD system	(work plan submitted to NMOCD)
Vacuum G-35	(work plan forthcoming)

Your comments on or approval of the Hobbs SWD system abandonment work plan will allow us to begin the characterization process of this important site. Please expect the work plan for the Vacuum G-35 site shortly.

Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T. Hicks

Randall Hicks
Principal

Copy: Rice Operating Company

R. T. HICKS CONSULTANTS, LTD.
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

August 31, 2004

Mr. Wayne Price
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Abo 1G Leak Site: Section 1, 17S 36E Unit G

Dear Wayne:

Due to the close proximity of the City of Lovington water supply wells to this release, we prepared the Corrective Action Plan of June 7, 2004 using highly "conservative" input values for the HYDRUS-1D model simulation. Specifically, we employed:

- the highest observed chloride values observed in boreholes
- a 10-foot aquifer thickness rather than the full thickness penetrated by the nearby supply wells,
- the absence of a vegetative cover that would reduce infiltration.

The predicted chloride concentration in an imaginary ground water monitoring well located immediately down gradient from the release site was less than 250 mg/L. We also predicted the potential impact to the closest Lovington water supply wells if the simulated chloride flux from this release actually intercepted ground water. Our predictions suggest the impact to the City of Lovington wells is smaller than the measurement error of most laboratory instruments.

We expected these results. Our modeling study for the American Petroleum Institute examined over 2000 brine release scenarios, many of which were similar to the Abo 1G release. We found that in an arid climate, such as Lovington, these types of releases rarely impair ground water quality. We also knew that many "dig and haul" responses to produced water releases actually cause more environmental damage than they cure. Therefore, we counseled Rice Operating Company (ROC) to examine the science first and then implement a remedy. This remains good advice for brine releases.

August 2004 Field Event

On August 16, 2004, ROC staff obtained shallow soil samples from the release site. Plate 1 shows the location of these samples and the field chloride values. ROC designed this field program to identify areas of residual chloride in shallow soil.

We can see from Figure 1 that recent rainfall has driven some of the chloride mass below the root zone, permitting vegetation. As our work with API and the site-specific modeling demonstrates, the relatively small mass of chloride below the root zone represents no threat to fresh water, human health or the environment. This evidence of natural restoration is good news. Vegetation over this spill site will reduce infiltration of precipitation and reduce the chloride flux to ground water.

Remedy Amendment

Rice Operating Company and Hicks Consultants were surprised and pleased by the rapid natural restoration of the ground surface at this site. However, despite the recent rains, some areas remain barren due to high chloride in soil (See also Plate 1). ROC proposes to accelerate the surface restoration process and establish a vegetative cap over the release. As stated above, a vegetative cove will significantly reduce the infiltration of precipitation and thereby reduce the flux of chloride to ground water, creating a "belt and suspenders" response action.

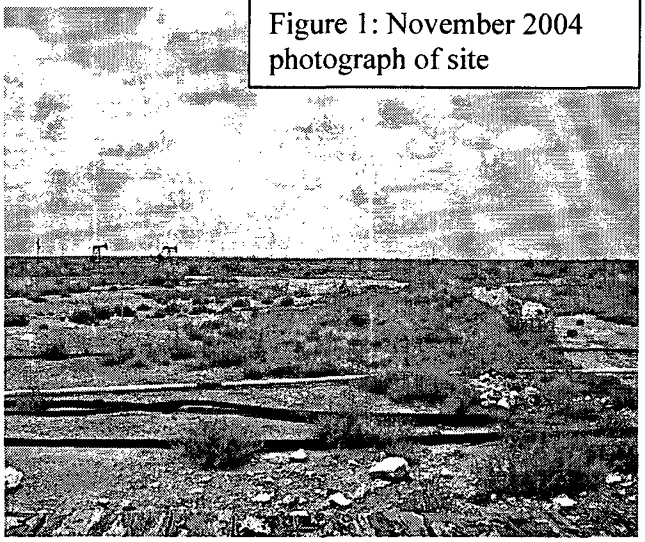


Figure 1: November 2004 photograph of site

ROC proposes the following actions:

1. Remove as much of sterile topsoil from the site as possible without tearing the underlying caliche.
2. Remove any weeds with seed and till the areas now supporting growth.
3. Import sufficient topsoil to cover the spill site and raise the elevation of the site to prevent any ponding of stormwater.
4. Seed the site with an appropriate mix.
5. Monitor the progress of vegetation growth at the site on a monthly basis and add fresh water to assist the growth if necessary.
6. Provide NMOCD with a brief letter report upon completion of this proposed action.
7. Provide NMOCD with photographic evidence of re-vegetation in 12 months.

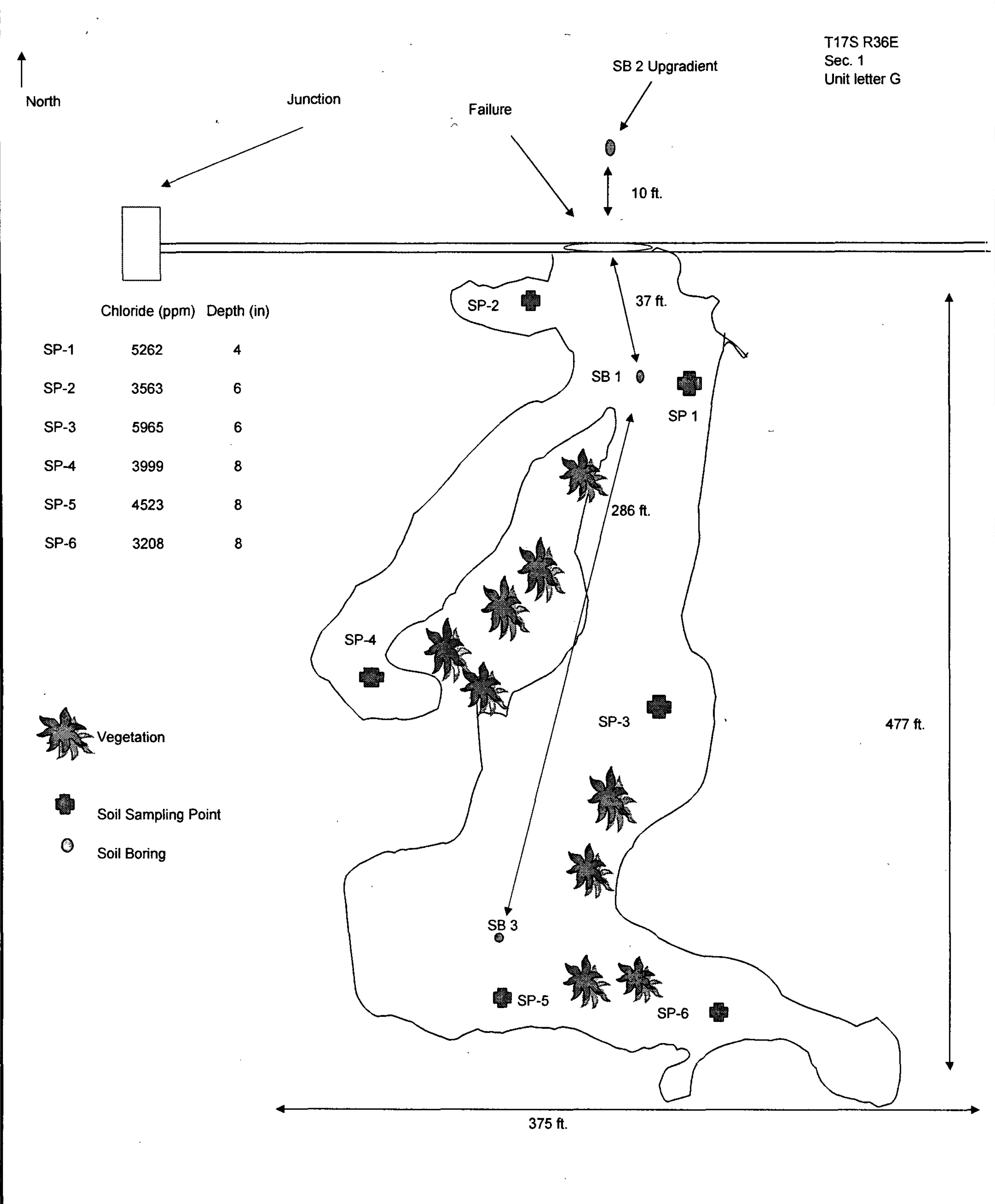
We look forward to NMOCD approval of this supplement to our Corrective Action Plan. Please contact Kristin Pope or me if you have any questions regarding this proposed action.

Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T Hicks

Randall Hicks
Principal

Copy: Kristin Pope, Rice Operating Company



	Chloride (ppm)	Depth (in)
SP-1	5262	4
SP-2	3563	6
SP-3	5965	6
SP-4	3999	8
SP-5	4523	8
SP-6	3208	8

R.T. Hicks Consultants 901 Rio Grande NW Albuquerque, NM	**Rice Operating Company**	**Plate 1**
	Abo Release Site Sketch Map	**Aug-04**

R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

October 28, 2004

Mr. Wayne Price
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Abo 1G Leak Site:
Section 1, 17S 36E Unit G
Response to NMOCD email and Notification of Field Activities

Dear Wayne:

Rice Operating Company (ROC) intends to move forward with the construction of a ground water monitoring well as we discussed at our meeting last week. Please accept this letter as our notification of field activities, which we will commence on November 4 or 5. You or individuals in the Hobbs District Office may contact Dave Hamilton on his cell phone (505-977-4671) on Wednesday November 3 to determine the start date for this monitoring well.

Comment: Should this be me instead of Andrew?

We intend to perform the following actions to respond to your recent comments on the Corrective Action Plan.

1. We will construct a 2-inch monitoring well with 5 feet of screen above the observed water table and 15 feet of screen within the water table. Because the water levels in the Ogallala Aquifer are generally declining, we are placing more screen in the saturated zone than typically requested by NMOCD. We will locate this well adjacent to SB-1 (see Plate 1 of our August 31, 2004 letter, attached)
2. During the air-rotary boring of this well, we will collect 2.5-foot split spoon samples at five-foot intervals from 5 feet bgs to 50 feet bgs. From 50 feet bgs to the water table (about 77 feet).
3. We will examine the split spoon samples and cuttings and create a lithologic profile of the vadose zone.
4. ROC staff will evaluate the split spoon samples in the field for chloride concentration using the silver nitrate titration method.
5. We will submit two sample splits to a laboratory for analysis of chloride in soil as quality assurance for the field sampling protocol.
6. At least two weeks after completion of the well, ROC will collect a water sample for analysis of chloride and TDS.
7. After completion of the boring/well, ROC will remove the high-chloride, thin soil zone remaining on the caliche sub-strata. ROC will specifically instruct the contractor to avoid removal of the caliche substrata and soil

that shows evidence of re-vegetation. ROC will then import top soil, grade the site to avoid ponding after precipitation events, and seed the area.

8. We will submit a letter report with the results of the vadose zone sampling, the initial water sampling results, documentation of the soil importation/exportation program, and a short discussion that compares the vadose zone chloride results to the previous results from SB-1.

If we find that this proposed vadose zone sampling shows that the migration of chloride is similar to that predicted by the HYDRUS-1D model presented in our June 7, 2004 report, we will conclude that this previously-submitted simulation and prediction is field-verified. We will then recommend closure of the regulatory file for this spill site. We remind NMOCD that the input parameters employed in our June 7, 2004 report were highly conservative. For example, the model in our report does not consider re-vegetation of the site. Establishing a vegetative cap over the site will greatly reduce infiltration and the resultant chloride flux to ground water will be much less than the input value used in our prediction.

Regardless of our conclusion regarding the accuracy of the previously-submitted HYDRUS-1D simulation, ROC will monitor chloride concentration in ground water at the site on a quarterly basis for two years. If chloride concentrations remain consistent with background values, we will plug and abandon this well. If chloride concentrations in ground water are greater than 250 mg/L during the proposed 2-year monitoring program, ROC will discuss the need for additional action with the NMOCD.

We trust this field program will meet with your approval and that any comments by the City of Lovington will be forthcoming prior to the proposed field activities.

Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T Hicks

Randall Hicks
Principal

Copy: Kristin Farris Pope

ENVIRONMENTAL
LAB OF
12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: Apache LA Leak MW 1

Project Number: None Given

Location: Abo

Lab Order Number: 4K10011

Report Date: 11/16/04

Rice Operating Co.	Project: Apache LA Leak MW 1	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	11/16/04 14:13

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
SB @ 91'	4K10011-01	Soil	11/05/04 11:35	11/10/04 07:50

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: Apache LA Leak MW 1
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
11/16/04 14:13

Organics by GC
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
SB @ 91' (4K10011-01) Soil									
Benzene	ND	0.0250	mg/kg dry	25	EK41501	11/12/04	11/12/04	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		*86.5 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*106 %*	*80-120*		"	"	"	"	
Gasoline Range Organics C6-C12	ND	10.0	mg/kg dry	1	EK41006	11/10/04	11/11/04	EPA 8015M	
Diesel Range Organics >C12-C35	ND	10.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	10.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*97.8 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*110 %*	*70-130*		"	"	"	"	

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: Apache LA Leak MW 1 Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 11/16/04 14:13

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
SB @ 91' (4K10011-01) Soil									
Chloride	ND	20.0	mg/kg Wet	2	EK41210	11/10/04	11/11/04	SW 846 9253	
% Moisture	**3.0**		%	1	EK41101	11/10/04	11/11/04	% calculation	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: Apache LA Leak MW 1
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471
Reported:
11/16/04 14:13

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 EK41006 - Solvent Extraction (GC)										
Blank (EK41006-BLK1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	ND	10.0	mg/kg wet							
Diesel Range Organics >C12-C35	ND	10.0	"							
Total Hydrocarbon C6-C35	ND	10.0	"							
Surrogate: 1-Chlorooctane	*38.3*		*mg/kg*	*50.0*		*76.6*	*70-130*			
Surrogate: 1-Chlorooctadecane	*44.6*		*"*	*50.0*		*89.2*	*70-130*			
LCS (EK41006-BS1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	422	10.0	mg/kg wet	500		84.4	75-125			
Diesel Range Organics >C12-C35	471	10.0	"	500		94.2	75-125			
Total Hydrocarbon C6-C35	893	10.0	"	1000		89.3	75-125			
Surrogate: 1-Chlorooctane	*46.3*		*mg/kg*	*50.0*		*92.6*	*70-130*			
Surrogate: 1-Chlorooctadecane	*45.6*		*"*	*50.0*		*91.2*	*70-130*			
Calibration Check (EK41006-CCV1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	503		mg/kg	500		101	80-120			
Diesel Range Organics >C12-C35	564		"	500		113	80-120			
Total Hydrocarbon C6-C35	1070		"	1000		107	80-120			
Surrogate: 1-Chlorooctane	*51.2*		*"*	*50.0*		*102*	*70-130*			
Surrogate: 1-Chlorooctadecane	*54.2*		*"*	*50.0*		*108*	*70-130*			
Matrix Spike (EK41006-MS1)	**Source: 4K10009-02**			Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	522	10.0	mg/kg dry	521	ND	100	75-125			
Diesel Range Organics >C12-C35	586	10.0	"	521	ND	112	75-125			
Total Hydrocarbon C6-C35	1110	10.0	"	1040	ND	107	75-125			
Surrogate: 1-Chlorooctane	*55.6*		*mg/kg*	*50.0*		*111*	*70-130*			
Surrogate: 1-Chlorooctadecane	*51.8*		*"*	*50.0*		*104*	*70-130*			
Matrix Spike Dup (EK41006-MSD1)	**Source: 4K10009-02**			Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	538	10.0	mg/kg dry	521	ND	103	75-125	3.02	20	
Diesel Range Organics >C12-C35	595	10.0	"	521	ND	114	75-125	1.52	20	
Total Hydrocarbon C6-C35	1130	10.0	"	1040	ND	109	75-125	1.79	20	
Surrogate: 1-Chlorooctane	*58.2*		*mg/kg*	*50.0*		*116*	*70-130*			
Surrogate: 1-Chlorooctadecane	*59.9*		*"*	*50.0*		*120*	*70-130*			

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: Apache LA Leak MW 1
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
11/16/04 14:13

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 EK41501 - EPA 5030C (GC)										
Blank (EK41501-BLK1)				Prepared & Analyzed: 11/12/04						
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	*91.3*		*ug/kg*	*100*		*91.3*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*96.4*		*"*	*100*		*96.4*	*80-120*			
LCS (EK41501-BS1)				Prepared & Analyzed: 11/12/04						
Benzene	95.0		ug/kg	100		95.0	80-120			
Toluene	96.5		"	100		96.5	80-120			
Ethylbenzene	97.7		"	100		97.7	80-120			
Xylene (p/m)	216		"	200		108	80-120			
Xylene (o)	101		"	100		101	80-120			
Surrogate: a,a,a-Trifluorotoluene	*103*		*"*	*100*		*103*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*109*		*"*	*100*		*109*	*80-120*			
Calibration Check (EK41501-CCV1)				Prepared: 11/12/04		Analyzed: 11/15/04				
Benzene	102		ug/kg	100		102	80-120			
Toluene	103		"	100		103	80-120			
Ethylbenzene	109		"	100		109	80-120			
Xylene (p/m)	237		"	200		118	80-120			
Xylene (o)	116		"	100		116	80-120			
Surrogate: a,a,a-Trifluorotoluene	*112*		*"*	*100*		*112*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*119*		*"*	*100*		*119*	*80-120*			
Matrix Spike (EK41501-MS1)		**Source: 4K12001-07**		Prepared & Analyzed: 11/12/04						
Benzene	2760		ug/kg	2500	83.0	107	80-120			
Toluene	2770		"	2500	235	101	80-120			
Ethylbenzene	2720		"	2500	222	99.9	80-120			
Xylene (p/m)	6780		"	5000	1210	111	80-120			
Xylene (o)	4350		"	2500	1730	105	80-120			
Surrogate: a,a,a-Trifluorotoluene	*101*		*"*	*100*		*101*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*111*		*"*	*100*		*111*	*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 EK41501 - EPA 5030C (GC)										
Matrix Spike Dup (EK41501-MSD1)		**Source: 4K12001-07**		Prepared & Analyzed: 11/12/04						
Benzene	2890		ug/kg	2500	83.0	112	80-120	4.57	20	
Toluene	2900		"	2500	235	107	80-120	5.77	20	
Ethylbenzene	2850		"	2500	222	105	80-120	4.98	20	
Xylene (p/m)	7040		"	5000	1210	117	80-120	5.26	20	
Xylene (o)	4490		"	2500	1730	110	80-120	4.65	20	
Surrogate: a,a,a-Trifluorotoluene	*94.3*		"	*100*		*94.3*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*108*		"	*100*		*108*	*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 EK41101 - General Preparation (Prep)										
Blank (EK41101-BLK1)				Prepared: 11/10/04		Analyzed: 11/11/04				
% Moisture	0.0		%							
Duplicate (EK41101-DUP1)		**Source: 4K10004-01**		Prepared: 11/10/04		Analyzed: 11/11/04				
% Moisture	7.0		%		7.0			0.00	20	
Batch EK41210 - Water Extraction										
Blank (EK41210-BLK1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Chloride	ND	20.0	mg/kg Wet							
Matrix Spike (EK41210-MS1)		**Source: 4K10010-01**		Prepared: 11/10/04		Analyzed: 11/11/04				
Chloride	1060	20.0	mg/kg Wet	500	510	110	80-120			
Matrix Spike Dup (EK41210-MSD1)		**Source: 4K10010-01**		Prepared: 11/10/04		Analyzed: 11/11/04				
Chloride	1040	20.0	mg/kg Wet	500	510	106	80-120	1.90	20	
Reference (EK41210-SRM1)				Prepared & Analyzed: 11/11/04						
Chloride	5050	10.0	mg/kg Wet	5000		101	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: 11/16/2004

Raland K. Tuttle, Lab Manager	Jeanne Mc Murrey, Inorg. Tech Director
Celey D. Keene, Lab Director, Org. Tech Director	James L. Hawkins, Chemist/Geologist
Peggy Allen, QA Officer	Sandra Sanchez, Lab Tech.

This material is intended only for the use of the individual (s) or entity to whom it is addressed, and may contain information that is privileged and confidential.

If you have received this material in error, please notify us immediately at 432-563-1800.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon

Company Name: RICE Operating

Company Address: 122 W. Taylor

City/State/Zip: Hobbs, NM 88240

Telephone No: (505) 393-9174

Fax No: (505) 397-1471

Sampler Signature: Israel Juarez

Project Name: Apache LA Leak MW 1

Project #:

Project Loc: ABO

PO #: 500

Analyze For: TCLP: / TOTAL: X (BTEX 8021B/5030)

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO₃	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify)	~~TDS~~ Cl ~~SAR/ES~~	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030							RUSH TAT (Pre-Schedule)	Standard TAT
4K10011 -01	SB @ 91'	11/5/04	11:35	1	X									X		X			X				X								

Special Instructions:

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	11/9/04	7:25			
Relinquished by: Drop box	11/10/04	7:50	Received by ELOT: Sandra Sanchez	11/11/04	7:50

Sample Containers Intact? Y N

Temperature Upon Receipt:

Laboratory Comments:

2.5°C

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

Client: Rice Operating Co.

Date/Time: 11-10-04 @ 1000

Order #: 4K10011

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	2.5 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:

ENVIRONMENTAL LAB OF TEXAS
12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: Apache LA Leak MW 1

Project Number: None Given

Location: Abo

Lab Order Number: 4K10011

Report Date: 11/16/04

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: Apache LA Leak MW 1
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471
Reported:
11/16/04 14:13

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
SB @ 91'	4K10011-01	Soil	11/05/04 11:35	11/10/04 07:50

Organics by GC
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
SB @ 91' (4K10011-01) Soil									
Benzene	ND	0.0250	mg/kg dry	25	EK41501	11/12/04	11/12/04	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		*86.5 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*106 %*	*80-120*		"	"	"	"	
Gasoline Range Organics C6-C12	ND	10.0	mg/kg dry	1	EK41006	11/10/04	11/11/04	EPA 8015M	
Diesel Range Organics >C12-C35	ND	10.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	10.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*97.8 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*110 %*	*70-130*		"	"	"	"	

Rice Operating Co.	Project: Apache LA Leak MW 1	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	11/16/04 14:13

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
SB @ 91' (4K10011-01) Soil									
Chloride	ND	20.0	mg/kg Wet	2	EK41210	11/10/04	11/11/04	SW 846 9253	
% Moisture	**3.0**		%	1	EK41101	11/10/04	11/11/04	% calculation	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: Apache LA Leak MW 1
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
11/16/04 14:13

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 EK41006 - Solvent Extraction (GC)										
Blank (EK41006-BLK1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	ND	10.0	mg/kg wet							
Diesel Range Organics >C12-C35	ND	10.0	"							
Total Hydrocarbon C6-C35	ND	10.0	"							
Surrogate: 1-Chlorooctane	*38.3*		*mg/kg*	*50.0*		*76.6*	*70-130*			
Surrogate: 1-Chlorooctadecane	*44.6*		*"*	*50.0*		*89.2*	*70-130*			
LCS (EK41006-BS1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	422	10.0	mg/kg wet	500		84.4	75-125			
Diesel Range Organics >C12-C35	471	10.0	"	500		94.2	75-125			
Total Hydrocarbon C6-C35	893	10.0	"	1000		89.3	75-125			
Surrogate: 1-Chlorooctane	*46.3*		*mg/kg*	*50.0*		*92.6*	*70-130*			
Surrogate: 1-Chlorooctadecane	*45.6*		*"*	*50.0*		*91.2*	*70-130*			
Calibration Check (EK41006-CCV1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	503		mg/kg	500		101	80-120			
Diesel Range Organics >C12-C35	564		"	500		113	80-120			
Total Hydrocarbon C6-C35	1070		"	1000		107	80-120			
Surrogate: 1-Chlorooctane	*51.2*		*"*	*50.0*		*102*	*70-130*			
Surrogate: 1-Chlorooctadecane	*54.2*		*"*	*50.0*		*108*	*70-130*			
Matrix Spike (EK41006-MS1)	**Source: 4K10009-02**			Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	522	10.0	mg/kg dry	521	ND	100	75-125			
Diesel Range Organics >C12-C35	586	10.0	"	521	ND	112	75-125			
Total Hydrocarbon C6-C35	1110	10.0	"	1040	ND	107	75-125			
Surrogate: 1-Chlorooctane	*55.6*		*mg/kg*	*50.0*		*111*	*70-130*			
Surrogate: 1-Chlorooctadecane	*51.8*		*"*	*50.0*		*104*	*70-130*			
Matrix Spike Dup (EK41006-MSD1)	**Source: 4K10009-02**			Prepared: 11/10/04		Analyzed: 11/11/04				
Gasoline Range Organics C6-C12	538	10.0	mg/kg dry	521	ND	103	75-125	3.02	20	
Diesel Range Organics >C12-C35	595	10.0	"	521	ND	114	75-125	1.52	20	
Total Hydrocarbon C6-C35	1130	10.0	"	1040	ND	109	75-125	1.79	20	
Surrogate: 1-Chlorooctane	*58.2*		*mg/kg*	*50.0*		*116*	*70-130*			
Surrogate: 1-Chlorooctadecane	*59.9*		*"*	*50.0*		*120*	*70-130*			

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 EK41501 - EPA 5030C (GC)										
Blank (EK41501-BLK1)				Prepared & Analyzed: 11/12/04						
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	*91.3*		*ug/kg*	*100*		*91.3*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*96.4*		"	*100*		*96.4*	*80-120*			
LCS (EK41501-BS1)				Prepared & Analyzed: 11/12/04						
Benzene	95.0		ug/kg	100		95.0	80-120			
Toluene	96.5		"	100		96.5	80-120			
Ethylbenzene	97.7		"	100		97.7	80-120			
Xylene (p/m)	216		"	200		108	80-120			
Xylene (o)	101		"	100		101	80-120			
Surrogate: a,a,a-Trifluorotoluene	*103*		"	*100*		*103*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*109*		"	*100*		*109*	*80-120*			
Calibration Check (EK41501-CCV1)				Prepared: 11/12/04		Analyzed: 11/15/04				
Benzene	102		ug/kg	100		102	80-120			
Toluene	103		"	100		103	80-120			
Ethylbenzene	109		"	100		109	80-120			
Xylene (p/m)	237		"	200		118	80-120			
Xylene (o)	116		"	100		116	80-120			
Surrogate: a,a,a-Trifluorotoluene	*112*		"	*100*		*112*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*119*		"	*100*		*119*	*80-120*			
Matrix Spike (EK41501-MS1)	**Source: 4K12001-07**			Prepared & Analyzed: 11/12/04						
Benzene	2760		ug/kg	2500	83.0	107	80-120			
Toluene	2770		"	2500	235	101	80-120			
Ethylbenzene	2720		"	2500	222	99.9	80-120			
Xylene (p/m)	6780		"	5000	1210	111	80-120			
Xylene (o)	4350		"	2500	1730	105	80-120			
Surrogate: a,a,a-Trifluorotoluene	*101*		"	*100*		*101*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*111*		"	*100*		*111*	*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 EK41501 - EPA 5030C (GC)										
Matrix Spike Dup (EK41501-MSD1)		**Source: 4K12001-07**		Prepared & Analyzed: 11/12/04						
Benzene	2890		ug/kg	2500	83.0	112	80-120	4.57	20	
Toluene	2900		"	2500	235	107	80-120	5.77	20	
Ethylbenzene	2850		"	2500	222	105	80-120	4.98	20	
Xylene (p/m)	7040		"	5000	1210	117	80-120	5.26	20	
Xylene (o)	4490		"	2500	1730	110	80-120	4.65	20	
Surrogate: a,a,a-Trifluorotoluene	*94.3*		"	*100*		*94.3*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*108*		"	*100*		*108*	*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 EK41101 - General Preparation (Prep)										
Blank (EK41101-BLK1)				Prepared: 11/10/04		Analyzed: 11/11/04				
% Moisture	0.0		%							
Duplicate (EK41101-DUP1)		**Source: 4K10004-01**		Prepared: 11/10/04		Analyzed: 11/11/04				
% Moisture	7.0		%		7.0			0.00	20	
Batch EK41210 - Water Extraction										
Blank (EK41210-BLK1)				Prepared: 11/10/04		Analyzed: 11/11/04				
Chloride	ND	20.0	mg/kg Wet							
Matrix Spike (EK41210-MS1)		**Source: 4K10010-01**		Prepared: 11/10/04		Analyzed: 11/11/04				
Chloride	1060	20.0	mg/kg Wet	500	510	110	80-120			
Matrix Spike Dup (EK41210-MSD1)		**Source: 4K10010-01**		Prepared: 11/10/04		Analyzed: 11/11/04				
Chloride	1040	20.0	mg/kg Wet	500	510	106	80-120	1.90	20	
Reference (EK41210-SRM1)				Prepared & Analyzed: 11/11/04						
Chloride	5050	10.0	mg/kg Wet	5000		101	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: 11/16/2004

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer
Jeanne Mc Murrey, Inorg. Tech Director
James L. Hawkins, Chemist/Geologist
Sandra Sanchez, Lab Tech.

This material is intended only for the use of the individual (s) or entity to whom it is addressed, and may contain information that is privileged and confidential.

If you have received this material in error, please notify us immediately at 432-563-1800.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: RICE Operating
Company Address: 122 W. Taylor
City/State/Zip: Hobbs, NM 88240
Telephone No: (505) 393-9174
Fax No: (505) 397-1471
Sampler Signature: Israel Juarez

Project Name: Apache LA Leak MW 1
Project #:
Project Loc: ABD
PO #: 500

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify)	Analyze For: ~~TDS~~ (Cl) ~~SAR/ESP~~	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030							RUSH TAT (Pre-Schedule)	Standard TAT
4K10011 -01	SB @ 91'	11/5/04	11:35	1	X									X		X			X				X								

TCLP: / TOTAL: X

Special Instructions:

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	11/9/04	7:25			
Relinquished by: Drop box	11/10/04	7:50	Received by ELOT: Sandra Sanchez	11/10/04	7:50

Sample Containers Intact? (Y) N
Temperature Upon Receipt:
Laboratory Comments:
2.5°C

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

Client: Rice Operating Co.

Date/Time: 11-10-04 @ 1000

Order #: 4K10011

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	2.5 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:

R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

December 20, 2004

Mr. Wayne Price
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Abo 1G Leak Site:
Section 1, 17S 36E Unit G
NMOCD Case #1R0414

Dear Wayne:

Included with this letter is the well log for our drilling event of November 5th and 6th, 2004. The well log features lithology, drilling notes, well construction, and field chloride and PID data. We have also included laboratory results from soil samples collected during the drilling and a site map with the position of this monitoring well, LA MW-1. In addition, the attached laboratory results of the first ground water sample from this well show no impact to ground water.

Sincerely,
R.T. Hicks Consultants, Ltd.

David Hamilton

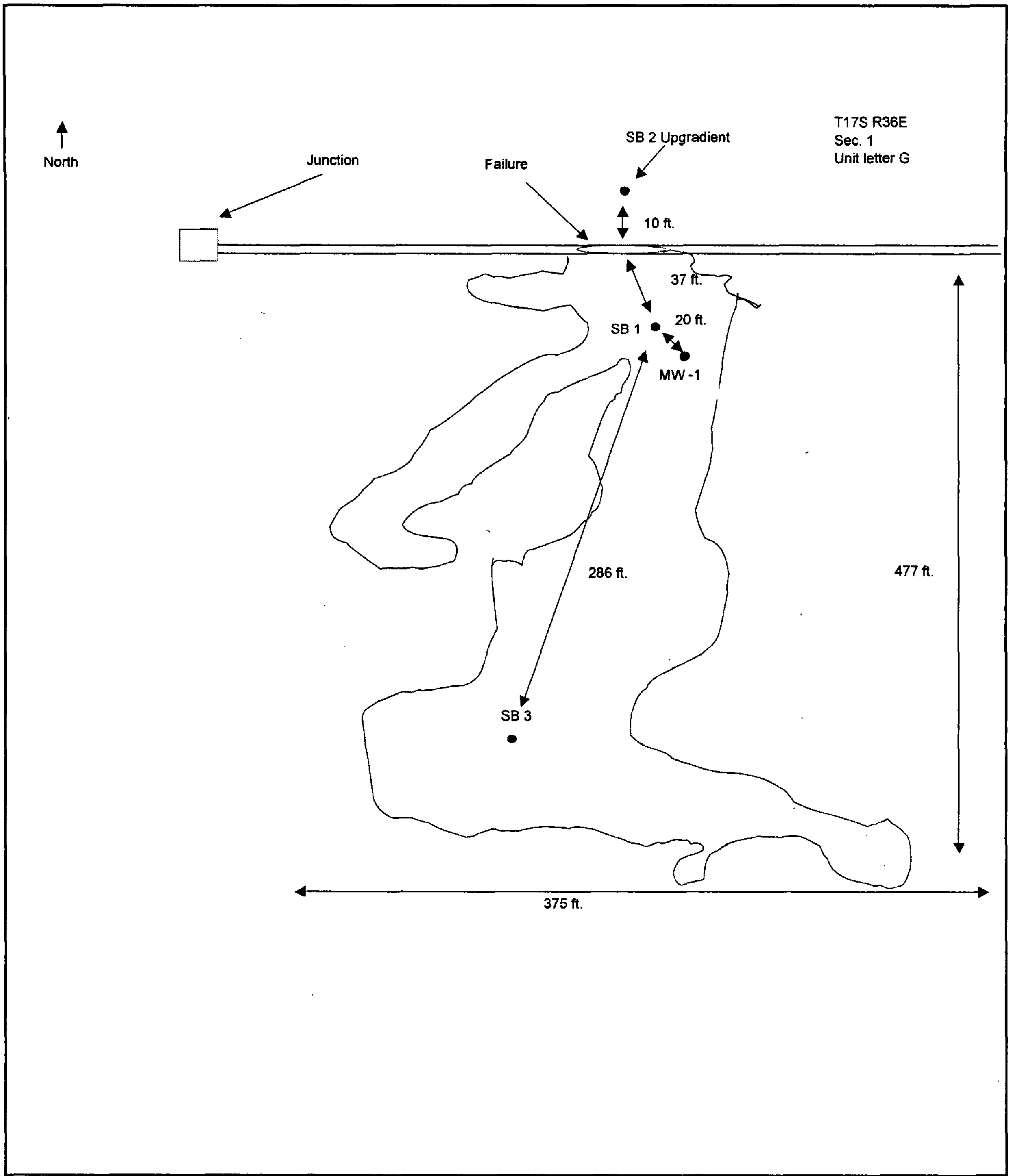
David Hamilton
Project Hydrologist

Copy: Kristin Farris Pope

Logger:	David Hamilton	**Client:** ROC	**Well ID:** LA MW-1
Driller:	Eades Drilling		
Drilling Method:	Air Rotary	**Project Name:** Lovington Abo Release Site	
Start Date:	11/5/2004		
End Date:	11/6/2004	**Location:** Section 1, 17S, 36E, Unit 1G	

Depth (feet)	Description	Comments	Well Construction	Field data Depth	Field data Chloride mg/kg	Field data PID
0.0	Surface, 0 - .5 feet	Hard drilling	Cement, 0-3 feet			
2.0	Frac. caliche, sand, clay, .5 - 3 feet, tan					
4.0	Sand and caliche, 3 - 5 feet, tan					
6.0	Very fine grained sand, silt, some caliche, 5 - 10 feet, tan			6.0	1245	6.3
8.0						
10.0	Very fine grained sand, silt, little caliche, 10 - 15 feet, tan			11.0	553	7.3
12.0						
14.0	Indurated caliche, 15 - 17 feet					
16.0	Very fine grained sand, silt, little caliche, 17 - 20 feet			16.0	1307	5.2
18.0						
20.0	Thin caliche layers in sand, 20 - 22 feet			21.0	905	8.2
22.0						
24.0						
26.0	Very fine grained sand, silt, 22 - 33 feet, tan with reddish tinge			26.0	741	1.1
28.0		Samples fell out of spoon, collected with shovel				
30.0				31.0	493	0.8
32.0						
34.0						
36.0	Very fine grained sand, silt, caliche, 33 -44 feet, light tan. Well indurated caliche layer from 35 to 36 feet.			36.0	566	0.8
38.0						
40.0				41.0	126	3.3
42.0						
44.0			Hydrated bentonite, 3-87 feet			
46.0	Very fine grained sand, silt, 44 - 53 feet, tan			46.0	83	2.0
48.0						
50.0				51.0	49	1.0
52.0						
54.0	Very fine grained sand, silt, some caliche, 53 - 60 feet, tan					
56.0						
58.0						
60.0				61.0	59	2.4
62.0	Very fine grained sand, silt, 60 - 67 feet, tan					
64.0						
66.0	Indurated sand, silt, 67 - 68 feet	Hard drilling				
68.0						
70.0				71.0	50	2.9
72.0						
74.0						
76.0						
78.0						
80.0				81.0	59	3.7
82.0	Very fine grained sand, silt, 68 - 100 feet tan. Slightly redder below 83 feet.					
84.0						
86.0						
88.0						
90.0				91.0	55	2.7
92.0						
94.0						
96.0		Soil moist at 100 feet				
98.0						
100.0						
102.0						
104.0			Sand, 87-122 feet			
106.0						
108.0						
110.0	Very fine grained sand, silt, 100 - 122 feet	Hole was drilled with water below 100 feet due to borehole collapse				
112.0						
114.0						
116.0						
118.0						
120.0						
122.0						

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 505-266-5004	**ROC Lovington Abo Site**	**Plate 1**
	Monitoring Well Boring	**Dec. 2004**



R.T. Hicks Consultants 901 Rio Grande NW Albuquerque, NM	**Rice Operating Company**	**Plate 2**
	Abo Release Site Sketch Map	**Dec-03**

BASIN ENVIRONMENTAL

FIELD MEASUREMENT/OBSERVATION LOG

PROJECT NAME:	PROJECT NUMBER:	LEAK NUMBER:
Rice Operating Company	ABO Apacke LA Leak	

PROJECT MANAGER:	FIELD TECHNICIAN:	Notes:
Kristin Farris Pope - Rice Operating Company	Rozanne Johnson - Basin Environmental	Water was disposed of at Cooper's Water Station

WELL # /SAMPLE LOCATION	TOTAL WELL DEPTH (feet)	DEPTH TO PRODUCT (feet)	DEPTH TO WATER (feet)	HEIGHT WATER COLUMN (feet)	PSH THICKNESS (feet)	WELL FACTOR 2"=.16 4"=.65 6"=1.5	CALC. WELL VOLUME (gal)	# OF WELL VOLUMES PURGED	TOTAL PURGED (gal)	Temp (°C)	pH	Cond. (µs)	TIME/DATE SAMPLE TAKEN	SAMPLE CHARACTERISTICS (odor, color, sheen)
MW-1	122.6		92.1	30.5		0.16	4.9	3	14.6	16.8	7.78	714	11/24/04 @ 12:30	No Odor / Clear Color

Chain-Of-Custody

I certify that the samples listed above were transferred from ______________ to ______________

at (location) ______________ on (date) ______________ at (time) ______________

Signatures: ______________ (Sampler) ______________ (Client or Lab)

ENVIRONMENTAL LAB OF
12600 West I-20 East - Odessa, Texas 79765

Analytical Report

<u>Prepared for</u>:

Kristin Pope

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak

Project Number: None Given

Location: Lovington

Lab Order Number: 4L06004

Report Date: 12/16/04

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW-1	4L06004-01	Water	12/03/04 08:30	12/06/04 10:35

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Benzene	ND	0.00100	mg/L	1	EL40913	12/08/04	12/08/04	EPA 8021B	
Toluene	ND	0.00100	"	"	"	"	"	"	
Ethylbenzene	ND	0.00100	"	"	"	"	"	"	
Xylene (p/m)	ND	0.00100	"	"	"	"	"	"	
Xylene (o)	ND	0.00100	"	"	"	"	"	"	
Surrogate: a,a,a-Trifluorotoluene		*101 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*96.0 %*	*80-120*		"	"	"	"	

Rice Operating Co.	Project: ABO-Apache LA Leak	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Kristin Pope	12/16/04 09:21

General Chemistry Parameters by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Total Alkalinity	**142**	2.00	mg/L	1	EL41406	12/10/04	12/10/04	EPA 310.2M	
Chloride	**80.5**	5.00	"	10	EL40916	12/08/04	12/08/04	EPA 300.0	
Total Dissolved Solids	**329**	5.00	"	1	EL40702	12/06/04	12/07/04	EPA 160.1	
Sulfate	**85.7**	5.00	"	10	EL40916	12/08/04	12/08/04	EPA 300.0	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

Total Metals by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Calcium	**60.0**	0.100	mg/L	10	EL41408	12/14/04	12/14/04	EPA 6010B	
Magnesium	**12.9**	0.0100	"	"	"	"	"	"	
Potassium	**2.67**	0.500	"	"	"	"	"	"	
Sodium	**42.4**	0.100	"	"	"	"	"	"	

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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 EL40913 - EPA 5030C (GC)										
Blank (EL40913-BLK1)				Prepared & Analyzed: 12/08/04						
Benzene	ND	0.00100	mg/L							
Toluene	ND	0.00100	"							
Ethylbenzene	ND	0.00100	"							
Xylene (p/m)	ND	0.00100	"							
Xylene (o)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	*19.8*		*ug/l*	*20.0*		*99.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*17.4*		*"*	*20.0*		*87.0*	*80-120*			
LCS (EL40913-BS1)				Prepared & Analyzed: 12/08/04						
Benzene	94.3		ug/l	100		94.3	80-120			
Toluene	97.6		"	100		97.6	80-120			
Ethylbenzene	96.2		"	100		96.2	80-120			
Xylene (p/m)	194		"	200		97.0	80-120			
Xylene (o)	99.5		"	100		99.5	80-120			
Surrogate: a,a,a-Trifluorotoluene	*17.8*		*"*	*20.0*		*89.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*22.1*		*"*	*20.0*		*110*	*80-120*			
LCS Dup (EL40913-BSD1)				Prepared & Analyzed: 12/08/04						
Benzene	97.4		ug/l	100		97.4	80-120	3.23	20	
Toluene	100		"	100		100	80-120	2.43	20	
Ethylbenzene	102		"	100		102	80-120	5.85	20	
Xylene (p/m)	202		"	200		101	80-120	4.04	20	
Xylene (o)	103		"	100		103	80-120	3.46	20	
Surrogate: a,a,a-Trifluorotoluene	*18.7*		*"*	*20.0*		*93.5*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*22.2*		*"*	*20.0*		*111*	*80-120*			
Calibration Check (EL40913-CCV1)				Prepared & Analyzed: 12/08/04						
Benzene	97.0		ug/l	100		97.0	80-120			
Toluene	99.1		"	100		99.1	80-120			
Ethylbenzene	101		"	100		101	80-120			
Xylene (p/m)	199		"	200		99.5	80-120			
Xylene (o)	101		"	100		101	80-120			
Surrogate: a,a,a-Trifluorotoluene	*19.4*		*"*	*20.0*		*97.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*21.5*		*"*	*20.0*		*108*	*80-120*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL40913 - EPA 5030C (GC)										
Matrix Spike (EL40913-MS1)	**Source: 4L06002-01**		Prepared & Analyzed: 12/08/04							
Benzene	102		ug/l	100	ND	102	80-120			
Toluene	102		"	100	ND	102	80-120			
Ethylbenzene	101		"	100	ND	101	80-120			
Xylene (p/m)	203		"	200	ND	102	80-120			
Xylene (o)	111		"	100	ND	111	80-120			
Surrogate: a,a,a-Trifluorotoluene	*18.4*		"	*20.0*		*92.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*19.5*		"	*20.0*		*97.5*	*80-120*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL40702 - General Preparation (WetChem)										
Blank (EL40702-BLK1)				Prepared: 12/06/04		Analyzed: 12/07/04				
Total Dissolved Solids	ND	5.00	mg/L							
Duplicate (EL40702-DUP1)		**Source: 4L03001-01**		Prepared: 12/06/04		Analyzed: 12/07/04				
Total Dissolved Solids	4120	5.00	mg/L		4030			2.21	20	
Batch EL40916 - General Preparation (WetChem)										
Blank (EL40916-BLK1)				Prepared & Analyzed: 12/08/04						
Chloride	0.00	0.500	mg/L							
Sulfate	0.00	0.500	"							
Blank (EL40916-BLK2)				Prepared & Analyzed: 12/08/04						
Sulfate	0.00	0.500	mg/L							
Chloride	0.00	0.500	"							
LCS (EL40916-BS1)				Prepared & Analyzed: 12/08/04						
Chloride	9.75	0.500	mg/L	10.0		97.5	80-120			
Sulfate	11.7	0.500	"	10.0		117	80-120			
LCS (EL40916-BS2)				Prepared & Analyzed: 12/08/04						
Chloride	9.77	0.500	mg/L	10.0		97.7	80-120			
Sulfate	11.8	0.500	"	10.0		118	80-120			
LCS Dup (EL40916-BSD1)				Prepared & Analyzed: 12/08/04						
Sulfate	11.8	0.500	mg/L	10.0		118	80-120	0.851	20	
Chloride	9.83	0.500	"	10.0		98.3	80-120	0.817	20	

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL40916 - General Preparation (WetChem)										
LCS Dup (EL40916-BSD2)				Prepared & Analyzed: 12/08/04						
Chloride	9.74	0.500	mg/L	10.0		97.4	80-120	0.308	20	
Sulfate	11.7	0.500	"	10.0		117	80-120	0.851	20	
Calibration Check (EL40916-CCV1)				Prepared & Analyzed: 12/08/04						
Chloride	9.79		mg/L	10.0		97.9	80-120			
Sulfate	11.7		"	10.0		117	80-120			
Calibration Check (EL40916-CCV2)				Prepared & Analyzed: 12/08/04						
Chloride	9.80		mg/L	10.0		98.0	80-120			
Sulfate	11.7		"	10.0		117	80-120			
Duplicate (EL40916-DUP1)		**Source: 4L03001-01**		Prepared & Analyzed: 12/08/04						
Chloride	1570	20.0	mg/L		1330			16.6	20	
Sulfate	809	20.0	"		682			17.0	20	
Duplicate (EL40916-DUP2)		**Source: 4L06003-02**		Prepared & Analyzed: 12/08/04						
Chloride	731	20.0	mg/L		725			0.824	20	
Sulfate	1210	20.0	"		1200			0.830	20	
Batch EL41406 - General Preparation (WetChem)										
Blank (EL41406-BLK1)				Prepared & Analyzed: 12/10/04						
Total Alkalinity	ND	2.00	mg/L							
Duplicate (EL41406-DUP1)		**Source: 4L06003-01**		Prepared & Analyzed: 12/10/04						
Total Alkalinity	161	2.00	mg/L		160			0.623	20	

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL41406 - General Preparation (WetChem)										
Reference (EL41406-SRM1)				Prepared & Analyzed: 12/10/04						
Carbonate Alkalinity	0.0501		mg/L	0.0500		100	80-120			

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471
Reported:
12/16/04 09:21

Total Metals 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 EL41408 - 6010B/No Digestion										
Blank (EL41408-BLK1)				Prepared & Analyzed: 12/14/04						
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Calibration Check (EL41408-CCV1)				Prepared & Analyzed: 12/14/04						
Calcium	1.95		mg/L	2.00		97.5	85-115			
Magnesium	2.06		"	2.00		103	85-115			
Potassium	2.18		"	2.00		109	85-115			
Sodium	1.77		"	2.00		88.5	85-115			
Duplicate (EL41408-DUP1)	**Source: 4L03004-01**			Prepared & Analyzed: 12/14/04						
Calcium	120	1.00	mg/L		127			5.67	20	
Magnesium	73.9	0.100	"		75.1			1.61	20	
Potassium	5.29	0.500	"		5.37			1.50	20	
Sodium	102	1.00	"		97.9			4.10	20	

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: Celey D. Keene Date: 12/16/2004

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer
Jeanne Mc Murrey, Inorg. Tech Director
James L. Hawkins, Chemist/Geologist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas

12600 West I-20 East
Odessa, Texas 79765

Phone: 432-563-1800
Fax: 432-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris Pope

Company Name: Rice Operating

Company Address: 122 W. Taylor St.

City/State/Zip: Hobbs, NM 88240

Telephone No: (505) 393-9174

Fax No: (505) 397-1471

Sampler Signature: [signature]

Project Name: ABO-APACHE LA Leak

Project #:

Project Loc: Lovington

PO #:

LAB # (lab use only) 4L06004	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	Analyze For (TCLP: / TOTAL:): TPH: 418.1 8015M 1005 1006	Cations (Ca, Mg, Na, K)	Anions (Cl, SO4, CO3, HCO3)	SAR / ESP / CEC	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030 or BTEX 8260	RCI	N.O.R.M.	TDS			RUSH TAT (Pre-Schedule)	Standard TAT
-01	MW-1	12-3-04	8:30	3	X		X					X					X	X					X			X				X

Special Instructions: Please email analysis to Kristin enviro@leaco.net

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	12-6-04	9:35			
Relinquished by:	Date	Time	Received by ELOT: [signature]	12-06-04	10:35

Sample Containers Intact? Y N

Temperature Upon Receipt:

Laboratory Comments: Ice -3°C

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

Client: Rice Operating

Date/Time: 12/6/04 11:58

Order #: 4L06004

Initials: JLH

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	-3 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	No label on 1L Poly
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:

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

Client: Rice Operating Co.

Date/Time: 11-10-04 @ 1000

Order #: 4K10011

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	2.5 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:

R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

December 20, 2004

Mr. Wayne Price
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Abo 1G Leak Site:
Section 1, 17S 36E Unit G
NMOCD Case #1R0415

Dear Wayne:

Included with this letter is the well log for our drilling event of November 5th and 6th, 2004. The well log features lithology, drilling notes, well construction, and field chloride and PID data. We have also included laboratory results from soil samples collected during the drilling and a site map with the position of this monitoring well, LA MW-1. In addition, the attached laboratory results of the first ground water sample from this well show no impact to ground water.

Sincerely,
R.T. Hicks Consultants, Ltd.

David Hamilton

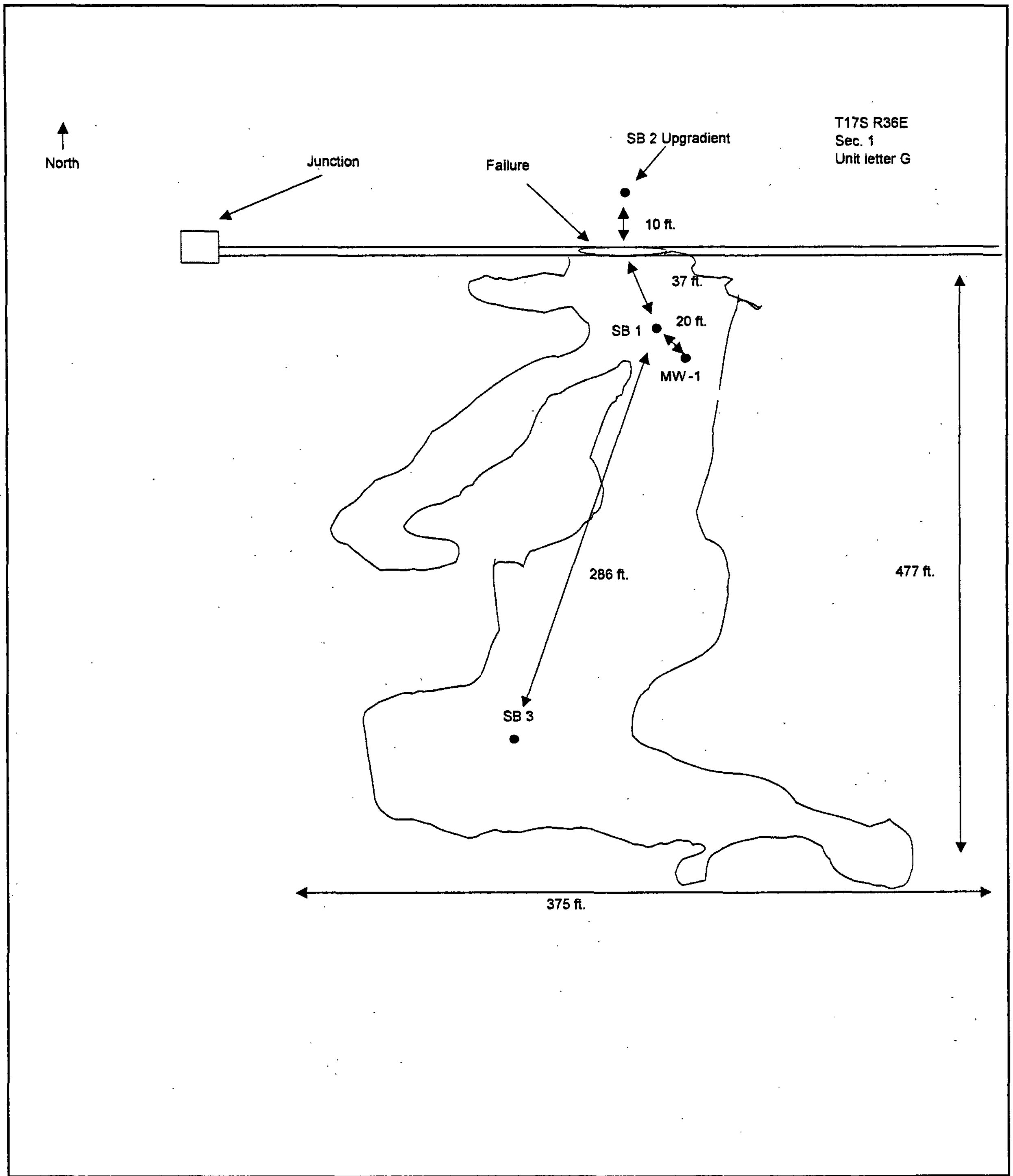
David Hamilton
Project Hydrologist

Copy: Kristin Farris Pope

Logger:	David Hamilton	Client:	Well ID:
Driller:	Eades Drilling	ROC	LA MW-1
Drilling Method:	Air Rotary	Project Name:	
Start Date:	11/5/2004	Lovington Abo Release Site	
End Date:	11/6/2004	Location:	
		Section 1, 17S, 36E, Unit 1G	

Depth (feet)	Description	Comments	Well Construction	Field data Depth	Field data Chloride mg/kg	Field data PID
0.0	Surface, 0 - .5 feet	Hard drilling	Cement, 0-3 feet			
2.0	Frac. caliche, sand, clay, .5 - 3 feet, tan					
4.0	Sand and caliche, 3 - 5 feet, tan		Hydrated bentonite, 3-87 feet			
6.0	Very fine grained sand, silt, some caliche, 5 - 10 feet, tan			6.0	1245	6.3
8.0						
10.0	Very fine grained sand, silt, little caliche, 10 - 15 feet, tan			11.0	553	7.3
12.0						
14.0	Indurated caliche, 15 - 17 feet					
16.0	Very fine grained sand, silt, little caliche, 17 - 20 feet			16.0	1307	5.2
18.0						
20.0	Thin caliche layers in sand, 20 - 22 feet			21.0	905	8.2
22.0	Very fine grained sand, silt, 22 - 33 feet, tan with reddish tinge					
24.0						
26.0				26.0	741	1.1
28.0		Samples fell out of spoon, collected with shovel				
30.0				31.0	493	0.8
32.0						
34.0	Very fine grained sand, silt, caliche , 33 -44 feet, light tan. Well indurated caliche layer from 35 to 36 feet.					
36.0				36.0	566	0.8
38.0						
40.0				41.0	126	3.3
42.0						
44.0	Very fine grained sand, silt, 44 - 53 feet, tan					
46.0				46.0	83	2.0
48.0						
50.0				51.0	49	1.0
52.0	Very fine grained sand, silt, some caliche, 53 - 60 feet, tan					
54.0						
56.0						
58.0						
60.0	Very fine grained sand, silt, 60 - 67 feet, tan			61.0	59	2.4
62.0						
64.0						
66.0	Indurated sand, silt, 67 - 68 feet	Hard drilling				
68.0	Very fine grained sand, silt, 68 - 100 feet tan. Slightly redder below 83 feet.					
70.0				71.0	50	2.9
72.0						
74.0						
76.0						
78.0						
80.0				81.0	59	3.7
82.0						
84.0						
86.0						
88.0			Sand, 87-122 feet			
90.0				91.0	55	2.7
92.0						
94.0						
96.0		Soil moist at 100 feet				
98.0						
100.0	Very fine grained sand, silt, 100 - 122 feet					
102.0						
104.0						
106.0						
108.0		Hole was drilled with water below 100 feet due to borehole collapse				
110.0						
112.0						
114.0						
116.0						
118.0						
120.0						
122.0						

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 505-266-5004	ROC Lovington Abo Site	Plate 1
	Monitoring Well Boring	Dec. 2004



R.T. Hicks Consultants 901 Rio Grande NW Albuquerque, NM	Rice Operating Company	Plate 2
	Abo Release Site Sketch Map	Dec-03

BASIN ENVIRONMENTAL

FIELD MEASUREMENT/OBSERVATION LOG

PROJECT NAME: Rice Operating Company

PROJECT NUMBER: ABO Apacke LA Leak

LEAK NUMBER:

PROJECT MANAGER: Kristin Farris Pope - Rice Operating Company

FIELD TECHNICIAN: Rozanne Johnson - Basin Environmental

Notes: Water was disposed of at Cooper's Water Station

WELL # /SAMPLE LOCATION	TOTAL WELL DEPTH (feet)	DEPTH TO PRODUCT (feet)	DEPTH TO WATER (feet)	HEIGHT WATER COLUMN (feet)	PSH THICKNESS (feet)	WELL FACTOR 2"=.16 4"=.65 6"=1.5	CALC. WELL VOLUME (gal)	# OF WELL VOLUMES PURGED	TOTAL PURGED (gal)	Temp (°C)	pH	Cond. (µs)	TIME/DATE SAMPLE TAKEN	SAMPLE CHARACTERISTICS (odor, color, sheen)
MW-1	122.6		92.1	30.5		0.16	4.9	3	14.6	16.8	7.78	714	11/24/04 @ 12:30	No Odor / Clear Color

Chain-Of-Custody

I certify that the samples listed above were transferred from ____________ to

at (location) ____________ on (date) ____________ at (time) ____________

Signatures: ____________ (Sampler) ____________ (Client or Lab)

ENVIRONMENTAL LAB OF TEXAS

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Kristin Pope

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak

Project Number: None Given

Location: Lovington

Lab Order Number: 4L06004

Report Date: 12/16/04

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Project Number: None Given Project Manager: Kristin Pope	Fax: (505) 397-1471 **Reported:** 12/16/04 09:21

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW-1	4L06004-01	Water	12/03/04 08:30	12/06/04 10:35

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471
Reported:
12/16/04 09:21

Organics by GC
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Benzene	ND	0.00100	mg/L	1	EL40913	12/08/04	12/08/04	EPA 8021B	
Toluene	ND	0.00100	"	"	"	"	"	"	
Ethylbenzene	ND	0.00100	"	"	"	"	"	"	
Xylene (p/m)	ND	0.00100	"	"	"	"	"	"	
Xylene (o)	ND	0.00100	"	"	"	"	"	"	
Surrogate: a,a,a-Trifluorotoluene		*101 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*96.0 %*	*80-120*		"	"	"	"	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Project Number: None Given Project Manager: Kristin Pope	Fax: (505) 397-1471 **Reported:** 12/16/04 09:21

General Chemistry Parameters by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Total Alkalinity	**142**	2.00	mg/L	1	EL41406	12/10/04	12/10/04	EPA 310.2M	
Chloride	**80.5**	5.00	"	10	EL40916	12/08/04	12/08/04	EPA 300.0	
Total Dissolved Solids	**329**	5.00	"	1	EL40702	12/06/04	12/07/04	EPA 160.1	
Sulfate	**85.7**	5.00	"	10	EL40916	12/08/04	12/08/04	EPA 300.0	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.	Project: ABO-Apache LA Leak	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Kristin Pope	12/16/04 09:21

Total Metals by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Calcium	**60.0**	0.100	mg/L	10	EL41408	12/14/04	12/14/04	EPA 6010B	
Magnesium	**12.9**	0.0100	"	"	"	"	"	"	
Potassium	**2.67**	0.500	"	"	"	"	"	"	
Sodium	**42.4**	0.100	"	"	"	"	"	"	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL40913 - EPA 5030C (GC)										
Blank (EL40913-BLK1)				Prepared & Analyzed: 12/08/04						
Benzene	ND	0.00100	mg/L							
Toluene	ND	0.00100	"							
Ethylbenzene	ND	0.00100	"							
Xylene (p/m)	ND	0.00100	"							
Xylene (o)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	*19.8*		*ug/l*	*20.0*		*99.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*17.4*		"	*20.0*		*87.0*	*80-120*			
LCS (EL40913-BS1)				Prepared & Analyzed: 12/08/04						
Benzene	94.3		ug/l	100		94.3	80-120			
Toluene	97.6		"	100		97.6	80-120			
Ethylbenzene	96.2		"	100		96.2	80-120			
Xylene (p/m)	194		"	200		97.0	80-120			
Xylene (o)	99.5		"	100		99.5	80-120			
Surrogate: a,a,a-Trifluorotoluene	*17.8*		"	*20.0*		*89.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*22.1*		"	*20.0*		*110*	*80-120*			
LCS Dup (EL40913-BSD1)				Prepared & Analyzed: 12/08/04						
Benzene	97.4		ug/l	100		97.4	80-120	3.23	20	
Toluene	100		"	100		100	80-120	2.43	20	
Ethylbenzene	102		"	100		102	80-120	5.85	20	
Xylene (p/m)	202		"	200		101	80-120	4.04	20	
Xylene (o)	103		"	100		103	80-120	3.46	20	
Surrogate: a,a,a-Trifluorotoluene	*18.7*		"	*20.0*		*93.5*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*22.2*		"	*20.0*		*111*	*80-120*			
Calibration Check (EL40913-CCV1)				Prepared & Analyzed: 12/08/04						
Benzene	97.0		ug/l	100		97.0	80-120			
Toluene	99.1		"	100		99.1	80-120			
Ethylbenzene	101		"	100		101	80-120			
Xylene (p/m)	199		"	200		99.5	80-120			
Xylene (o)	101		"	100		101	80-120			
Surrogate: a,a,a-Trifluorotoluene	*19.4*		"	*20.0*		*97.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*21.5*		"	*20.0*		*108*	*80-120*			

Rice Operating Co.	Project: ABO-Apache LA Leak	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Kristin Pope	12/16/04 09:21

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 EL40913 - EPA 5030C (GC)										
Matrix Spike (EL40913-MS1)	**Source: 4L06002-01**			Prepared & Analyzed: 12/08/04						
Benzene	102		ug/l	100	ND	102	80-120			
Toluene	102		"	100	ND	102	80-120			
Ethylbenzene	101		"	100	ND	101	80-120			
Xylene (p/m)	203		"	200	ND	102	80-120			
Xylene (o)	111		"	100	ND	111	80-120			
Surrogate: a,a,a-Trifluorotoluene	*18.4*		"	*20.0*		*92.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*19.5*		"	*20.0*		*97.5*	*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 EL40702 - General Preparation (WetChem)										
Blank (EL40702-BLK1)				Prepared: 12/06/04		Analyzed: 12/07/04				
Total Dissolved Solids	ND	5.00	mg/L							
Duplicate (EL40702-DUP1)		**Source: 4L03001-01**		Prepared: 12/06/04		Analyzed: 12/07/04				
Total Dissolved Solids	4120	5.00	mg/L		4030			2.21	20	
Batch EL40916 - General Preparation (WetChem)										
Blank (EL40916-BLK1)				Prepared & Analyzed: 12/08/04						
Chloride	0.00	0.500	mg/L							
Sulfate	0.00	0.500	"							
Blank (EL40916-BLK2)				Prepared & Analyzed: 12/08/04						
Sulfate	0.00	0.500	mg/L							
Chloride	0.00	0.500	"							
LCS (EL40916-BS1)				Prepared & Analyzed: 12/08/04						
Chloride	9.75	0.500	mg/L	10.0		97.5	80-120			
Sulfate	11.7	0.500	"	10.0		117	80-120			
LCS (EL40916-BS2)				Prepared & Analyzed: 12/08/04						
Chloride	9.77	0.500	mg/L	10.0		97.7	80-120			
Sulfate	11.8	0.500	"	10.0		118	80-120			
LCS Dup (EL40916-BSD1)				Prepared & Analyzed: 12/08/04						
Sulfate	11.8	0.500	mg/L	10.0		118	80-120	0.851	20	
Chloride	9.83	0.500	"	10.0		98.3	80-120	0.817	20	

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 EL40916 - General Preparation (WetChem)										
LCS Dup (EL40916-BSD2)				**Prepared & Analyzed: 12/08/04**						
Chloride	9.74	0.500	mg/L	10.0		97.4	80-120	0.308	20	
Sulfate	11.7	0.500	"	10.0		117	80-120	0.851	20	
Calibration Check (EL40916-CCV1)				**Prepared & Analyzed: 12/08/04**						
Chloride	9.79		mg/L	10.0		97.9	80-120			
Sulfate	11.7		"	10.0		117	80-120			
Calibration Check (EL40916-CCV2)				**Prepared & Analyzed: 12/08/04**						
Chloride	9.80		mg/L	10.0		98.0	80-120			
Sulfate	11.7		"	10.0		117	80-120			
Duplicate (EL40916-DUP1)		**Source: 4L03001-01**		**Prepared & Analyzed: 12/08/04**						
Chloride	1570	20.0	mg/L		1330			16.6	20	
Sulfate	809	20.0	"		682			17.0	20	
Duplicate (EL40916-DUP2)		**Source: 4L06003-02**		**Prepared & Analyzed: 12/08/04**						
Chloride	731	20.0	mg/L		725			0.824	20	
Sulfate	1210	20.0	"		1200			0.830	20	
Batch EL41406 - General Preparation (WetChem)										
Blank (EL41406-BLK1)				**Prepared & Analyzed: 12/10/04**						
Total Alkalinity	ND	2.00	mg/L							
Duplicate (EL41406-DUP1)		**Source: 4L06003-01**		**Prepared & Analyzed: 12/10/04**						
Total Alkalinity	161	2.00	mg/L		160			0.623	20	

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 EL41406 - General Preparation (WetChem)										
Reference (EL41406-SRM1)				Prepared & Analyzed: 12/10/04						
Carbonate Alkalinity	0.0501		mg/L	0.0500		100	80-120			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

Total Metals 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 EL41408 - 6010B/No Digestion										
Blank (EL41408-BLK1)				Prepared & Analyzed: 12/14/04						
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Calibration Check (EL41408-CCV1)				Prepared & Analyzed: 12/14/04						
Calcium	1.95		mg/L	2.00		97.5	85-115			
Magnesium	2.06		"	2.00		103	85-115			
Potassium	2.18		"	2.00		109	85-115			
Sodium	1.77		"	2.00		88.5	85-115			
Duplicate (EL41408-DUP1)	Source: 4L03004-01			Prepared & Analyzed: 12/14/04						
Calcium	120	1.00	mg/L		127			5.67	20	
Magnesium	73.9	0.100	"		75.1			1.61	20	
Potassium	5.29	0.500	"		5.37			1.50	20	
Sodium	102	1.00	"		97.9			4.10	20	

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: Celey D. Keene Date: 12/16/2004

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer
Jeanne Mc Murrey, Inorg. Tech Director
James L. Hawkins, Chemist/Geologist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas

12600 West I-20 East
Odessa, Texas 79765
Phone: 432-563-1800
Fax: 432-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris Pope

Company Name: Rice Operating

Company Address: 122 W. Taylor St.

City/State/Zip: Hobbs, NM 88240

Telephone No: (505) 393-9174

Fax No: (505) 397-1471

Sampler Signature: [signature]

Project Name: ABO-APACHE LA Leak

Project #:

Project Loc: Lovington

PO #:

4L06004

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	Analyze For (TCLP: / TOTAL:): TPH: 418.1 8015M 1005 1006	Cations (Ca, Mg, Na, K)	Anions (Cl, SO4, CO3, HCO3)	SAR / ESP / CEC	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030 or BTEX 8260	RCI	N.O.R.M.	TDS				RUSH TAT (Pre-Schedule)	Standard TAT
-01	MW-1	12-3-04	8:30	3	X		X					X					X	X					X			X					X

Special Instructions:

Please email analysis to Kristin enviro@leaco.net

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	12-6-04	9:35			
Relinquished by:	Date	Time	Received by ELOT:	Date	Time
			[signature]	12-06-04	10:35

Sample Containers Intact? Y N

Temperature Upon Receipt:

Laboratory Comments:

Rec -3°C

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

Client: Rice Operating

Date/Time: 12/6/04 11:58

Order #: 4L06004

Initials: JLH

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	-3 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	No label on 1L Poly
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:

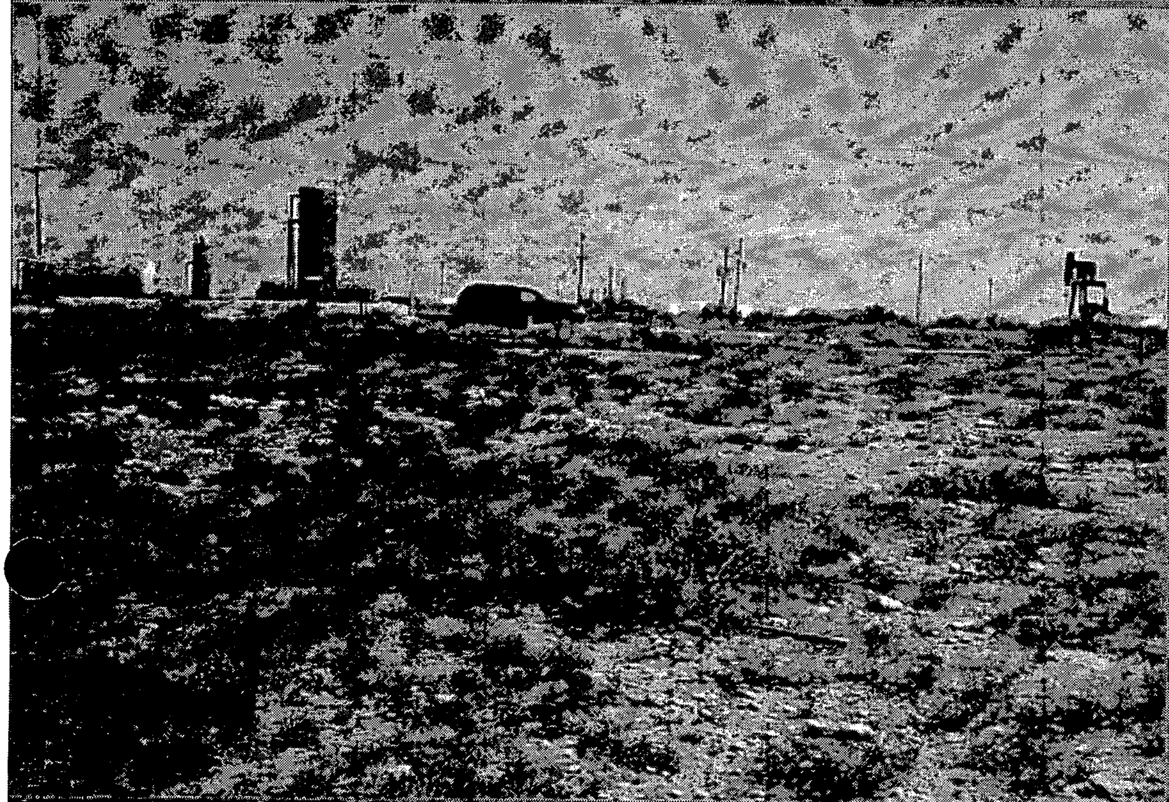
Contact Person: - Date/Time: Contacted by:

Regarding:

Corrective Action Taken:

August 2005

Amended Corrective Action Plan



Lovington Abo 1G Release Site

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142, Albuquerque, NM 87104

August 31, 2005

Amended Corrective Action Plan

LOVINGTON ABO 1G RELEASE SITE

Prepared for:

Rice Operating Company
122 West Taylor
Hobbs, NM 88240

R.T. HICKS CONSULTANTS, LTD.

901 RIO GRANDE BLVD. NW, SUITE F-142, ALBUQUERQUE, NM 87104

1.0 SUMMARY

1. ROC mobilized to the Abo 1-G release site on November 10, 2003 and drilled three borings. The ROC field procedures were consistent with industry practice and with previously-submitted ROC characterization plans (e.g. junction box plan). Approximately 40 samples were collected.

2. In November 2005, Hicks Consultants completed a sampling boring and monitor well adjacent to SB-1 in accordance with an NMOCD-approved workplan. Approximately 15 samples were collected from the boring.

3. In July 2005, ROC implemented a deep soil sampling (about 130 samples) and surface soil sampling program (about 70 samples) to provide better characterization of the 1992 release and the 2003 release.

4. Chloride concentration data show a center of mass at depths of 3 to 6-feet below grade and a second mass at depths of 12- to 20-feet below grade. While the chloride from both spills is generally present at points near the source of the releases; at greater distances or release margins, the effects of only one of the releases may be present.

5. Samples from the bore holes, the deep soil sampling and the surface sampling yielded peak chloride concentrations of approximately 8,500 ppm, 1,500 ppm, and 1,400 ppm at respective depths of 0 feet, 4- to 6-feet below grade and 14- to 16-feet below grade. Area weighted average chloride concentrations were approximately 2,400 ppm, 850 ppm, and 475 ppm at these same respective depths.

6. Laboratory analyses confirm that regulated petroleum hydrocarbons are not present above screening levels employed by the PST Bureau of the New Mexico Environment Department.

7. Five potential remedies were evaluated using HYDRUS-1D and a simple mixing model to predict ground water chloride concentrations in an imaginary monitoring well with a 10-foot screened interval that is located at the edge of the release. Simulation experiments predict that only the simple vegetative cap remedy will cause ground water to exceed the 250 ppm chloride standard in the imaginary monitoring well.

8. A simple vegetative cap is sufficient to prevent impairment of ground water that would be produced from a windmill with a 40-foot screened interval located at the edge of the spill.

9. Ease of construction, long-term viability and other environmental considerations cause us to recommend the following remedy:
   a. Excavate and stockpile the areas of high-chloride surface soil that do not currently support vegetation.
   b. Excavate, characterize and segregate by chloride concentration the uppermost 2-feet of the vadose zone that overlies about 35% of the subsurface chloride load. This translates to removal of material where the average chloride concentration over the thickness of the impact is greater than about 1000 mg/kg.
   c. Blend clean soil (imported or excavated from the site) with higher chloride stockpiles to create a mixture that will support vegetation (i.e. about 1000 ppm chloride).
   d. Place a 1-foot thick clay barrier in the excavation in 6-inch lifts such that the saturated hydraulic conductivity of this clay barrier is less than 5×10^{-6} cm/sec.
   e. Place at least 2-feet of the blended stockpiled soil and any imported soil over the clay barrier and over the remaining unexcavated portion of the spill to create a small swale that will shed excess precipitation.
   f. Seed the site with native plants and fence the area to enhance re-vegetation

The selected remedy protects fresh water, human health and the environment. It complies with NMOCD rules and we believe it provides the greatest net environmental benefit.

2.0 BACKGROUND

The Abo 1G Discharge Site is located about 6 miles southeast of the center of Lovington, New Mexico. Plate 1 is a 1:24,000 topographic map showing the location of the site relative to Route 18, the Hobbs-Lovington Highway. Plate 2 is a 1:6,000 image (2004) of the site location and nearby features such as the Navajo Lovington Refinery and the Lovington-Hobbs highway.

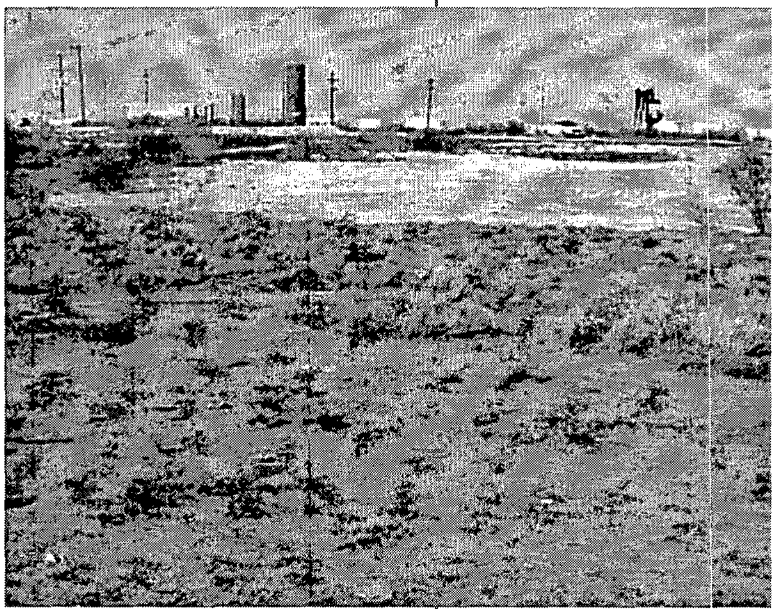


Figure 1. View of Abo 1G Leak site

In 2003, a line near the pick-up truck in Figure 1 ruptured and produced water flowed south. This 2003 release was the impetus for the investigations described herein. This final corrective action plan summarizes all of the data available for the site and recommends a remedy to protect fresh water, public health and the environment.

On October 18, 2003, Rice Operating Company (ROC) prepared a Release Notification report that estimated a pipeline failure released 190 barrels of produced water and ROC recovered 130 barrels. The pipeline failure released produced water with little or no hydrocarbons. Plate 3a is the same image as Plate 2 at a 1:600 scale. This image shows the geometry of the 2003 release, which affected about 31,000 square feet of rangeland. ROC is also aware that a 10 barrel release near this same location occurred on June 3, 2003 and this earlier release impacted a 2,400 square foot area near SB-1. In August 2005, ROC conducted an internal records search and discovered a release report dated October 21, 1992. This report documents a release of produced water that covered about 17,000 square feet at this same location. Plate 3b is an aerial photograph taken between 1996-1999 at the same scale as Plate 3a showing our interpretation of the extent of the 1992 release. Plate 3a & 3b demonstrates that both spills occurred at essentially the same location. The 1992 report suggests that the release was principally water with little or no hydrocarbons and ROC recovered about 500 barrels of the release. This search of older records became feasible in mid 2005 due to the efforts of ROC to categorize and organize their older files in various storerooms.

ROC mobilized to the site on November 10, 2003 and drilled three borings. The field procedures employed by ROC were consistent with industry practice and with previously-submitted ROC characterization plans (e.g. junction box plan). In November 2004, Hicks Consultants completed a sampling boring and monitor well adjacent to SB-1 in accordance with an NMOCD-approved workplan. In July 2005, ROC implemented a deep soil sampling and surface soil sampling program to provide better characterization of the 1992 release and the 2003 release. Plate 4 is a sketch map that shows the outline of the 1992 and 2003 spills (based upon the imagery), 2003 borings, the 2004 monitor well and the 2005 trench samples. In 2005, ROC also collected surface soil samples on a 25-foot grid, which are not displayed on Plate 4.

Hicks Consultants used the data collected by ROC, the data from our 2004 field program and obtained additional data from public sources as input to the HYDRUS-1D vadose zone fate and transport model. Hicks Consultants employed the results of the modeling to develop a remedy to protect ground water quality and to restore the ground surface.

3.0 RESULTS OF FIELD PROGRAMS & INVESTIGATIONS

Next to the pipeline rupture, ROC drilled SB - 01 in 2003 to a depth of 45-feet. From field inspection, the site has several inches of sandy soil covering a highly-fractured caliche horizon. We examined borehole samples and the on-site cuttings log from SB-01 and concluded that the subsurface is composed of 24-feet of thin caliche layers within sands and silts. Interbedded with these caliche-rich sands and silts are silty clays. Below this uppermost 24-feet is 20-feet of sand and silt.

The lithologic log of MW-1 confirms the observations of 2003 for SB-1. Lithologic logs for both borings are included in Plates 5 & 6. Plate 5 also displays the calculated chloride load for the boring. The lithology of MW-1 is primarily a very fine-grained sand silt interbedded with a complex series of caliche beds. Layers featuring some caliche exist from 0.5- to 10-feet bgs, 33- to 44-feet bgs, and 53- to 60-feet bgs. In addition to these zones, three well indurated layers of caliche exist at 0.5- to 3-feet bgs, 15- to 17-feet bgs, 20- to 22-feet bgs, and 35- to 36-feet bgs. There also exists a well indurated layer of sandstone at 67- to 68-feet bgs.

We have no site specific or regional data on the moisture content of the vadose zone. Such data are generally rare. As described in a later section of this report, we used HYDRUS-1D to simulate an initial water content of the unsaturated zone.

We conclude that the vadose zone is about 90-feet thick and is composed of a caliche-rich upper horizon underlain by sand with minor amounts of silt.

Characteristics of Saturated Zone

In well L-1716 , about 1 mile west of the release site, the driller's log reports "water sand" from 45-feet to 70-feet underlain by 7-feet of "calcium sand" before penetrating water bearing units. At well L-5014, approximately 5 miles north of the site, the driller log identifies caliche from 2- to 28-feet below surface. Below this upper strata is sand and sandy clay to a depth of 190-feet. From 190- to 205-feet below surface, the driller reports a clay zone. This 15-feet of clay is underlain by 10-feet of clay and gravel. The driller penetrated the Dockum Group red beds at 215-feet below grade. For monitoring wells in the Lea Refinery, one mile to the northeast, driller's logs report a 4-foot caliche bed overlying more than 100-feet of very fine to fine grained sands. At the Lea Refinery, April 1996 water levels are 90-feet below grade (H+GCL, 1996). These well logs are included in Appendix A.

The saturated Ogallala Aquifer, which underlies the location, is dominantly sand. The saturated thickness of the aquifer is about 130-feet. The screened interval of wells in the area range from 20-feet to more than 100-feet. According to the USGS (http://water.usgs.gov/GIS/metadata/usgswrd/ofr98-548.html#Identification_Information), the hydraulic conductivity of the High Plains Aquifer ranges from less than 25-feet/day to greater than 300-feet per day with an average hydraulic conductivity of 60-feet/day. At this location, where saturated gravel units are restricted to the base of the Ogallala, we estimate the hydraulic conductivity is about 50-feet per day. Geologists who drilled monitoring wells at the Lea Refinery estimated the saturated hydraulic conductivity as ranging from 25- to 75-feet per day. At the Lea Refinery, the hydraulic gradient is 0.004 feet/foot to the southeast. The resultant ground water flux is probably about 10 cm per day.

Basin Environmental obtained samples from LA MW-1 on December 3, 2004, March 1, 2005 and June 16, 2005. The results of these samples are presented in Appendix B. The results show no evidence of ground water impact. Please note that the results of all analysis are in general agreement. The TDS result from the March 1, 2005 sampling was analyzed outside of the "hold time", but reproducibility of the results shows that all samples are representative of ground water quality.

Chloride Distribution in the Vadose Zone

Appendix C presents the analyses of field samples from the vadose zone during the 2005 field events. Earlier submissions present the analytical data for soils from previous sampling campaigns.

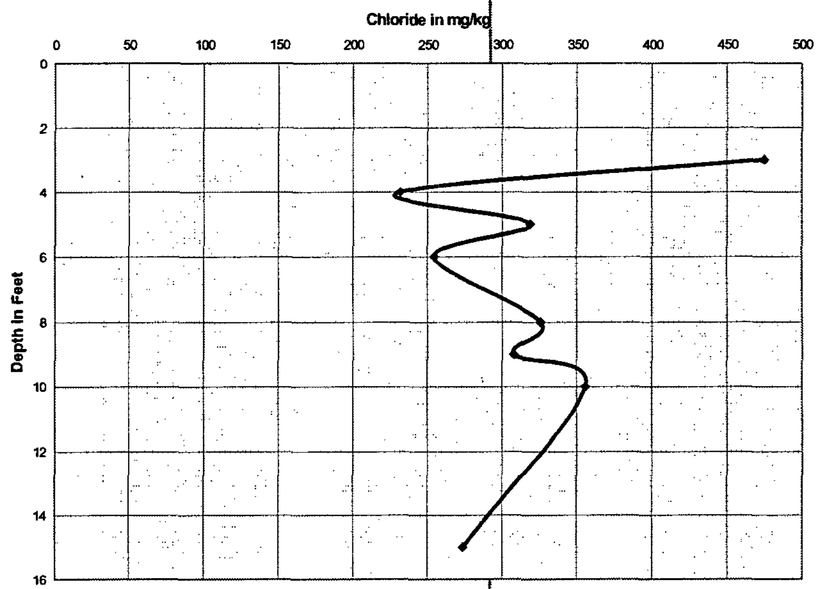


Figure 2. SB-2 Field Chloride concentrations

Soil boring SB-2 is uphill from the spill site and we considered this a "background" location, however the term "ambient" is more accurate. At this soil boring, the chloride near the ground surface is 475 ppm. From 4-feet below grade to the total depth of 15-feet, chloride in this caliche-rich horizon ranges between 230 and 356 ppm (Figure 2). Other scientists suggest that "background" chloride concentration in Lea County soil can be less than 100 ppm. At this site, caliche dominates the upper vadose zone and oil and gas activities may have released small amounts of chloride to the environment for decades in the form of small spills that are subsequently re-distributed by wind. At this release site, the ambient chloride concentration in the upper vadose zone is about 300 ppm. In the deep vadose zone, below about 45-feet, chloride concentrations are less than 100 ppm (See Plates 5 and 6). We believe these low chloride concentrations below 45-feet are due to the sand lithology combined with our hypothesis that anthropogenic chloride originating from decades of oil and gas production has penetrated only 41-feet of the vadose zone.

Plate 7 compares the chloride concentration versus depth for SB-1 and SB-3 (November 2003) with MW-1 (November 2004). These three borings, which provide the deepest vertical characterization for the site, show two distinct chloride masses - one from 3- to 6-feet below land surface and a second mass at 12- to 20-feet below land surface. These soil borings show a decline in chloride concentrations to ambient levels (i.e. 300 ppm) at 45-feet, 9-feet and about 40-feet below land surface respectively. Because the water table lies about 90-feet below land surface, this observed decrease of chloride concentrations to background suggests that the release did not create saturated conditions between ground surface and ground water.

As stated in earlier submissions to NMOCD, the patterns for SB-1 and MW-1 shown in Plate 7, which are closest to the pipeline rupture, confirm that the October 2003 release was not the first release at or near this site. An earlier release appears as chloride concentrations above 1,000 ppm between 12- and 20-feet below grade and the October release appears as the high chloride between 3- and 6-feet depth. We stated in our earlier reports that we did not believe that the chloride concentrations between 12- and 20-feet in SB-1 and MW-1 were caused by the 10-barrel release of June 2003. As suggested earlier in this report, the recent examination of ROC files identified the source of this deeper center of mass as a 1992 release.

Plate 8 shows the results of the deep soil sampling at the 12 sampling trenches, 3 soil borings and the monitor well. In general, chloride concentration profiles of points closest to the junction box (Points A, C, E, G and SB-1 and LA MW-1) demonstrate both the shallow and the deeper chloride masses. Points further away may demonstrate only the most recent spills (Points H, I, J and SB-3). Other points (B and K) have a chloride profile showing relatively low concentrations near the surface and higher concentrations at intermediate depths (8- to 14-feet bgs). The site has little relief and is located in an active oil field with considerable human activity. We believe that over the course of the last 15 years, small topographic changes due to rainfall events, human activities, and the variation in source location and flows of the different releases explains the variation in chloride distribution at the site.

4.0 SIMULATION MODELING EXPERIMENTS

4.1 HYDRUS-1D CALIBRATION INPUT DATA

Because the chloride center of mass at SB-1/LA MW-1 (from the 1992 release) resides at a depth of about 15-feet below land surface, chloride movement is not temporarily perturbed by upward wicking due to evapotranspiration or individual rainfall events. This mass resides above and within the well indurated caliche at 15- to 17-feet bgs. We compared the observed chloride transport rates at these depths and within these known lithologies with the predictions of the model, then adjusted the input characteristics to calibrate the HYDRUS-1D simulation.

The density of chloride measurements from the ROC November 2003 field program is quite good and clearly defines the location of the chloride center of mass at the SB-1 location. The data from the November 2004 event at MW-1 does not allow us to identify the center of chloride mass with the same degree of precision, but for the purposes of our modeling experiment, the data are more than sufficient.

Plate 9 is similar to Plate 7 but more clearly shows that peak measured chloride concentration of the upper chloride center of mass has migrated approximately two feet downward during the 12-month period (November 2003 to November 2004) that separates these two deep sampling programs. We believe that the recent rain events may have temporarily created saturated flow in the upper soil profile moving the chloride into the sand and caliche layer below the upper fractured caliche.

The minimum chloride concentration between the two masses was at a depth of approximately 8-feet bgs in November 2003 and was located at approximately 11-feet bgs in November 2004. The chloride at these depths is within a very fine-grained sand silt featuring little caliche. Considering sampling depth approximations, this suggests a chloride migration rate of two to three feet per year.

The recent precipitation did not affect the downward migration of the peak chloride concentration at 15-feet in the same manner. As Plate 9 implies, the peak chloride concentration is at a depth of 16-feet in 2004, suggesting a migration rate of approximately one foot per year. At 35- to 36-feet bgs we note virtually identical chloride concentrations from both drilling events. At this depth, a hard caliche layer exists and the downward migration of chloride is less than 1-foot per year.

At the 35- to 36-foot depth the low moisture content of the caliche creates extremely low vertical hydraulic conductivities, thus these units act as barriers to vertical flow. Below this caliche layer, chloride concentrations decline to ambient levels.

We conclude that the recent precipitation events have resulted in movement of the upper chloride mass downwards about 2-feet. The minimum chloride concentration has migrated downwards two to three feet. The lower mass of chloride has migrated downwards about one foot through the caliche at this horizon. A lower rate of chloride migration is present at the 35- to 36-foot caliche layer. The rates of chloride migration, when weighted by thickness of soil material, suggest a rate of chloride migration of about one to two feet per year.

The data for the calibration included our acquisition and installation of weather data for Hobbs, New Mexico from October 1, 2003 to November 6, 2004. This data is collected approximately 12 miles south of the spill site because the data from the Lovington Airport is not complete for these dates and this is the closest available weather data to the site. We then began our simulations using weather data for October 2003, when the release actually occurred. We then added the 46 year weather record from the Pearl, New Mexico weather station to create a representative atmospheric file for the HYDRUS-1D simulations.

Our 2004 monitor well boring program allowed us to collect a very detailed description of the vadose zone for the MW-1 boring (See Plate 6). This improved vadose zone profile data was used in all simulations.

Table 1 summarizes the data employed in the final calibration simulation, attached. Appendix D is a CD with the data in a format that will allow the reader to verify the results of the simulations using HYDRUS-1D or a similar code.

4.2 HYDRUS-1D MODEL CALIBRATION

To calibrate the model, we installed the chloride concentration data obtained by ROC at SB-1 in their November 2003 field event as the initial condition. We then ran the model for one year with the November to November Hobbs weather data discussed above. We made slight adjustments to the hydraulic properties in order to calibrate the model predictions to the chloride migration observed in the 2004 MW-1 field data.

Plate 10 adds the predicted chloride concentrations of the calibrated simulation, (line marked with diamonds) to the observed field data shown in Plate 9.

To obtain the match shown in Plate 10 (i.e. to calibrate our HYDRUS-1D simulation) we adjusted the hydraulic properties of the caliche and sand zones such that the center of the upper chloride mass migrated about 1.5 feet downwards from November 2003 to November 2004. In the calibration simulation, the minimum chloride concentration observed at about 8-feet bgs in SB-1 migrated slightly over one foot downwards. The center of the lower chloride mass (15 feet bgs in SB-1) migrated 1.1-feet in the same time interval, about 10 percent more than observed.

We used extremely conservative dispersion coefficients for our calibration, which would tend to over-estimate the resultant chloride concentration in ground water. As stated earlier, we believe that the rate of movement of chloride in the upper ten feet of the soil profile is affected by the weather, such as large rainfall events, rather than the long-term climate of the site. Compounding the effects of day-long rainfall events is the difficulty of accounting for the hydraulic properties of the uppermost fractured caliche bed. These fractures act as aids to flow in saturated conditions and as a hindrance to flow during the unsaturated conditions between severe precipitation events. After infiltrated water (and entrained chloride) passes beyond this uppermost vadose zone, unsaturated flow is the dominant type of transport. Climate, not weather, is the principal influence of this rate of flow.

Because we see a match between the 2004 field chloride concentrations and the predicted chloride concentration of calibrated simulation, we believe that HYDRUS-1D is a reasonable representation of the flow regime. Vertical migration rates and preservation of the two separate chloride concentrations are a good match to field data. In our calibrated HYDRUS-1D simulation, the center of the upper chloride mass migrated about 1.5-feet downwards from November 2003 to November 2004. The minimum chloride concentration has migrated slightly over one foot downwards. The center of the lower chloride mass migrated 1.1-feet in the same time interval, about 10 percent more than observed. We believe that the rate of movement of the lower chloride mass demonstrates a good agreement of the model with the field data because these short-term influences are not active at this depth.

4.3 SIMULATION AND DESIGN OF CORRECTIVE ACTION

Before design of a final corrective action for the site, we evaluated the following possible remedies:

1. Vegetation Cap without any excavation and chloride exportation.

2. Excavation and placement of chloride impacted surface soil beneath a synthetic liner which covers 100% of the site, then covering the liner with imported topsoil and vegetation cap.

3. Excavation and exportation of 35% of the chloride load, which translates to removal of material where the average chloride concentration over the thickness of the impact is greater than about 1,000 mg/kg.

4. Excavation and placement of chloride impacted surface soil beneath synthetic liner strips that would cover 35% of the total spill area, then covering the lined and unlined portions of the spill site with imported topsoil and vegetation cap.

5. The selected remedy:
   a) Excavate and stockpile the areas of high-chloride surface soil that do not currently support vegetation.
   b) Excavate, characterize and segregate by chloride concentration the uppermost 2-feet of the vadose zone that overlies about 35% of the subsurface chloride load. This translates to removal of material where the average chloride concentration over the thickness of the impact is greater than about 1,000 mg/kg (see Plate 6).
   c) Blend clean soil (imported or excavated from the site) with higher chloride stockpiles to create a mixture that will support vegetation (i.e. about 1,000 ppm chloride).
   d) Place a 1-foot thick clay barrier in the excavation in 6-inch lifts such that the saturated hydraulic conductivity of this clay barrier is less than 5×10^{-6} cm/sec.
   e) Place at least 1.5 feet of the blended stockpiled soil and any imported soil over the clay barrier and over the remaining unexcavated portion of the spill to create a small swale that will shed excess precipitation.
   f) Seed the site with native plants and fence the area to enhance re-vegetation.

For the preliminary design of all remedies we employed field-calibrated HYDRUS-1D simulations. We followed the following protocol to calculate and install an average chloride load from the releases. We compiled all of the chloride concentration data from the trench samples, the bore hole samples, and the surface samples. As this data is from different depths at the various locations, we linearly interpolated depth discrete samples for each of the trench sites and each of the bore holes to create complete chloride profiles at each site. We gave these profiles an area weighting allowing for the calculation of an averaged chloride concentration profile representative of the entire spill area. This profile was used in the HYDRUS-1D modeling.

We calibrated the mixing model to the observed conditions in ground water. To do this, we assumed that the pore water in the capillary fringe (from 0- to 8-feet above the water table) equaled the ambient water quality documented by the existing monitoring well, which is about 100 ppm and compared the model output for the first 10 years of the simulation with the observed ground water data. We selected the period 0-10 years for the calibration because we are confident that only true "background" chloride in soil water (from 50- to 90- feet below land surface) is entering the aquifer during this time. In other words, we are confident that chloride from the 1992 release does not enter ground water from years 0-10 in our simulation experiment.

To determine the area of the spill that overlies 35% of the chloride load, we employed the same area-weighting protocol discussed above to map the area planned for the clay barrier. Using this method, we identified a clay barrier strategy that covers 35% of the chloride load by creating a barrier over two areas. The largest area is defined by trenches A, B, and D and MW-1 (see Plate 11). A smaller area defined by SB-3 and trench I completes this cover strategy.

Table 2 summarizes the output of the simulation experiments. HYDRUS-1D predicts that only the vegetative cap remedy allows chloride concentrations above the state standard of 250 mg/L for the imaginary well with a 10-foot screen located at the edge of the spill site. Because of the simulation methodology will exaggerate the chloride concentration in ground water, we are confident that the predicted maximum chloride in the imaginary well is what we say: a maximum concen-

Table 2. Simulation experiment outputs

Remedy	Maximum Chloride Concentration (mg/l)			Duration of ground water chloride conentration above 250 mg/l (yrs.)	Time from present to Max. Concentration (yrs.)
	10 ft screen	*40 ft screen*	*100 ft screen*	*10 ft screen*	
Vegetative Cap only	405	188	137	19	29
Synthetic Barrier over 100% of the spill area, cover with topsoil and vegetative cap	100	100	100	0	Not Applicable
Excavtion and Exportation of 35% of the chloride load	243	140	116	0	29
Excavation of surface chloride and placement of synthetic barriers over 35% of the spill area and	243	140	116	0	29
Excavation of upper 3-feet. Replace with 1-foot of clay underlying 1.5 foot of loam and	243	140	116	0	29

tration. At other sites, we have found that chloride is distributed throughout the underlying aquifer provided that geologic barriers to flow, such as silt-clay horizons, do not exist. At this site, MW-1 did not detect such barriers within the uppermost 30-feet of the saturated zone and the screened interval of nearby supply wells is 20- to 100-feet. Table 2 includes an evaluation of different mixing zones.

For the selected remedy, the simulated response of an imaginary monitoring well located at the edge of the spill that draws from an aquifer with a 10-foot thick mixing zone is shown below in Figure 3. After year 10, the chloride from the 1992 begins to enter ground water. After year 50, the released chloride from below the vegegative cap has effectively moved through the vadose zone. Released chloride that lies below the clay barrier is effectively sequestered in the vadose zone for more than a century. The maximum predicted chloride concentration in ground water caused by the slow release from beneath the clay barrier is less than 105 ppm, which is observed more than 410 years from now.

Although installation of a synthetic liner over 100% of the spill area permanently sequesters the chloride in the upper vadose zone and results in a better simulation result, we did not select this option. This remedy demands that the liner maintain integrity for hundreds of years. We favored the clay liner remedy which allows a very slow release of chloride to ground water that remains compliant with NMOCD Rules.

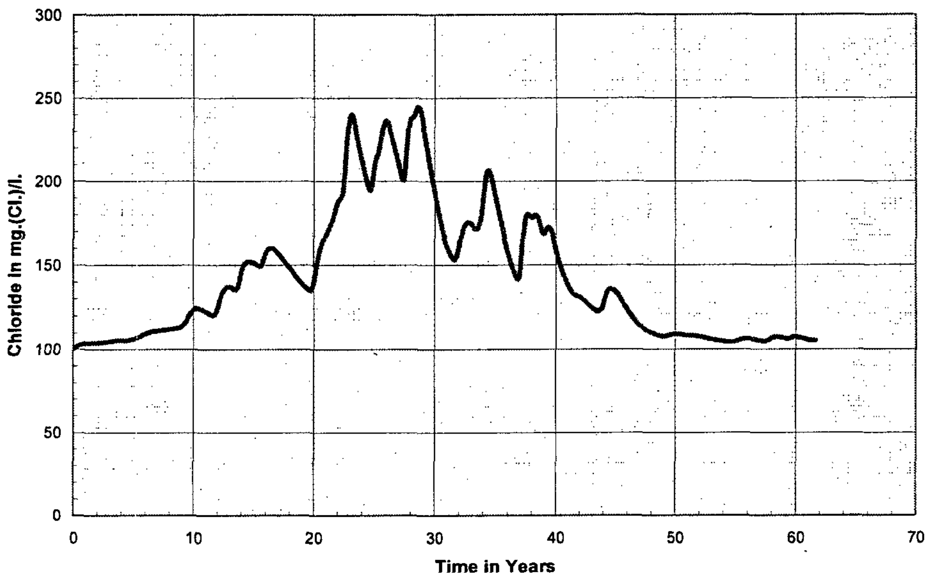


Figure 3. Chloride concentration in the aquifer for the Abo 1G Release Site, averaged chloride load from entire site, vegetation, 35% clay cap

4.4 SCHEDULE

Sixty days after NMOCD approval of this remedy, we will submit detailed plans and specifications for this remedy. The plans will include hydraulic conductivity testing of the material selected for the clay barrier, a plot plan showing the area to be capped with clay, a detailed description of the proposed field methods, a quality assurance plan for the remedy, and a post-remedy monitoring plan. Thirty days after NMOCD approval of the detailed plans, ROC will begin field activities to implement the remedy, with completion of the remedy 60 days after NMOCD approval of the detailed plans.

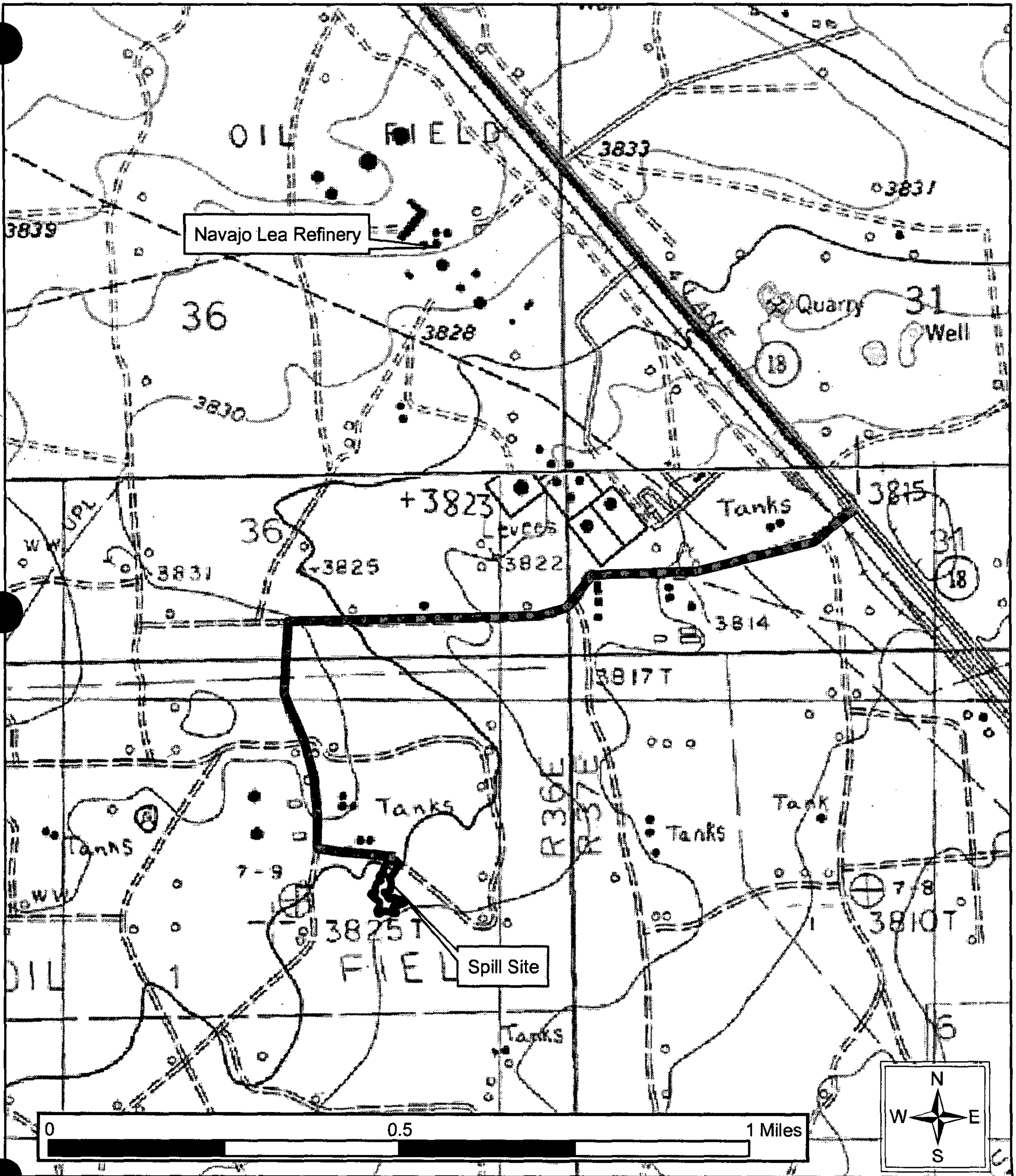
TABLES

Table 1: Input Parameters for Simulation Modeling

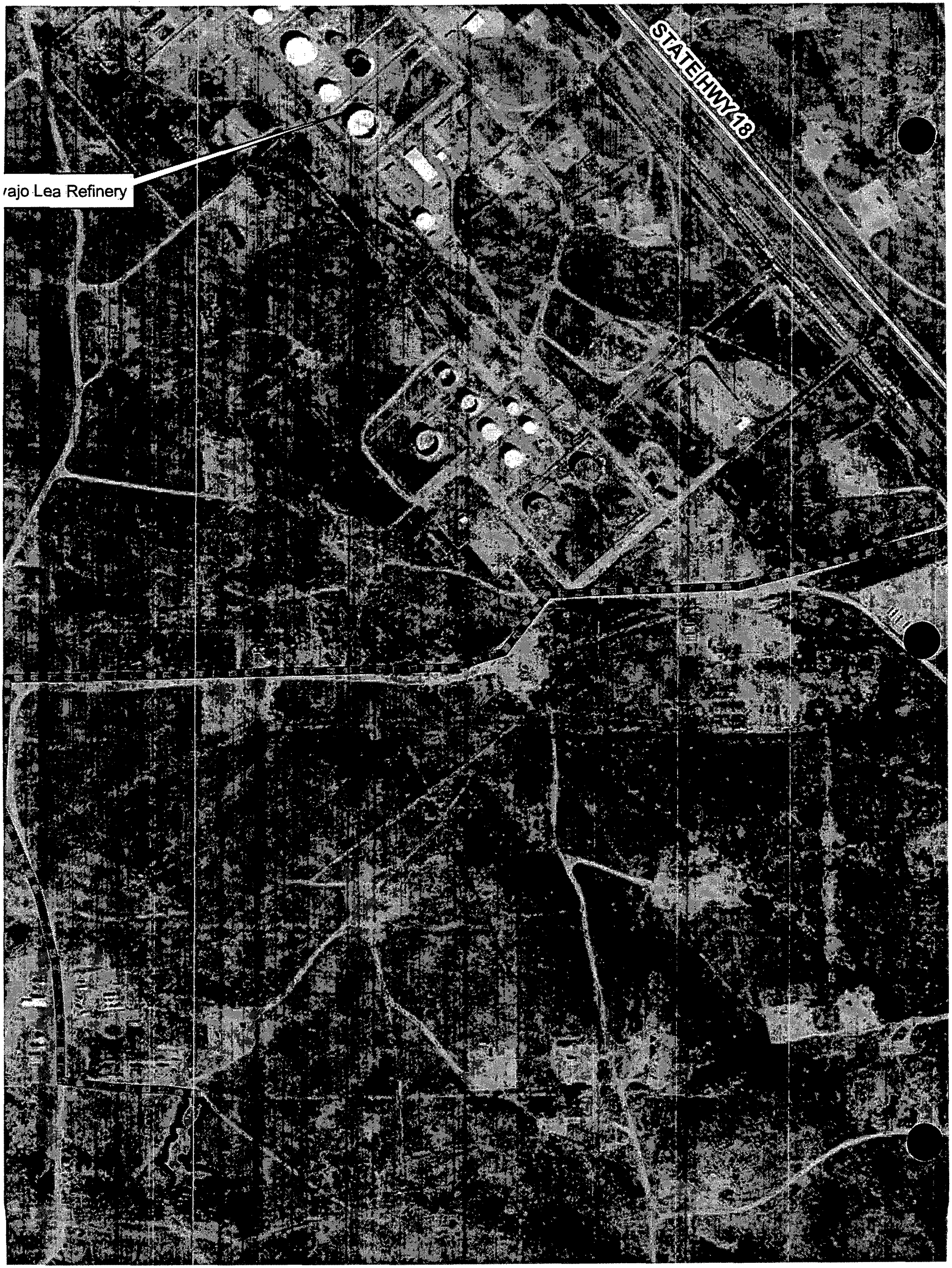
Input Parameter	Source
1. Vadose Zone Thickness – 91 feet	Appendix A well logs
2. Vadose Zone Texture – Plate 6	Samples and attached well logs
3. Dispersion Length - < 10%	Professional judgment
4. Soil Moisture	HYDRUS-1D initial condition simulation
5. Chloride in release – 19,994 ppm	Samples of produced water
6. Height of spill on land surface –1.0 inches	Calculated from chloride load at sampling location SB-3 and chloride in released water
7. Length of release parallel to ground water flow – 477 ft	Field Measurements
8. Climate – Arid	Pearl Weather Station near Hobbs Airport
9. Background Chloride in Ground Water – 100 ppm	Professional judgment
10. Ground Water Flux – 10 cm/day	Calculated from published data and the Lea Refinery Report
11. Aquifer Thickness – 10 feet	NMOCD suggestion

PLATES

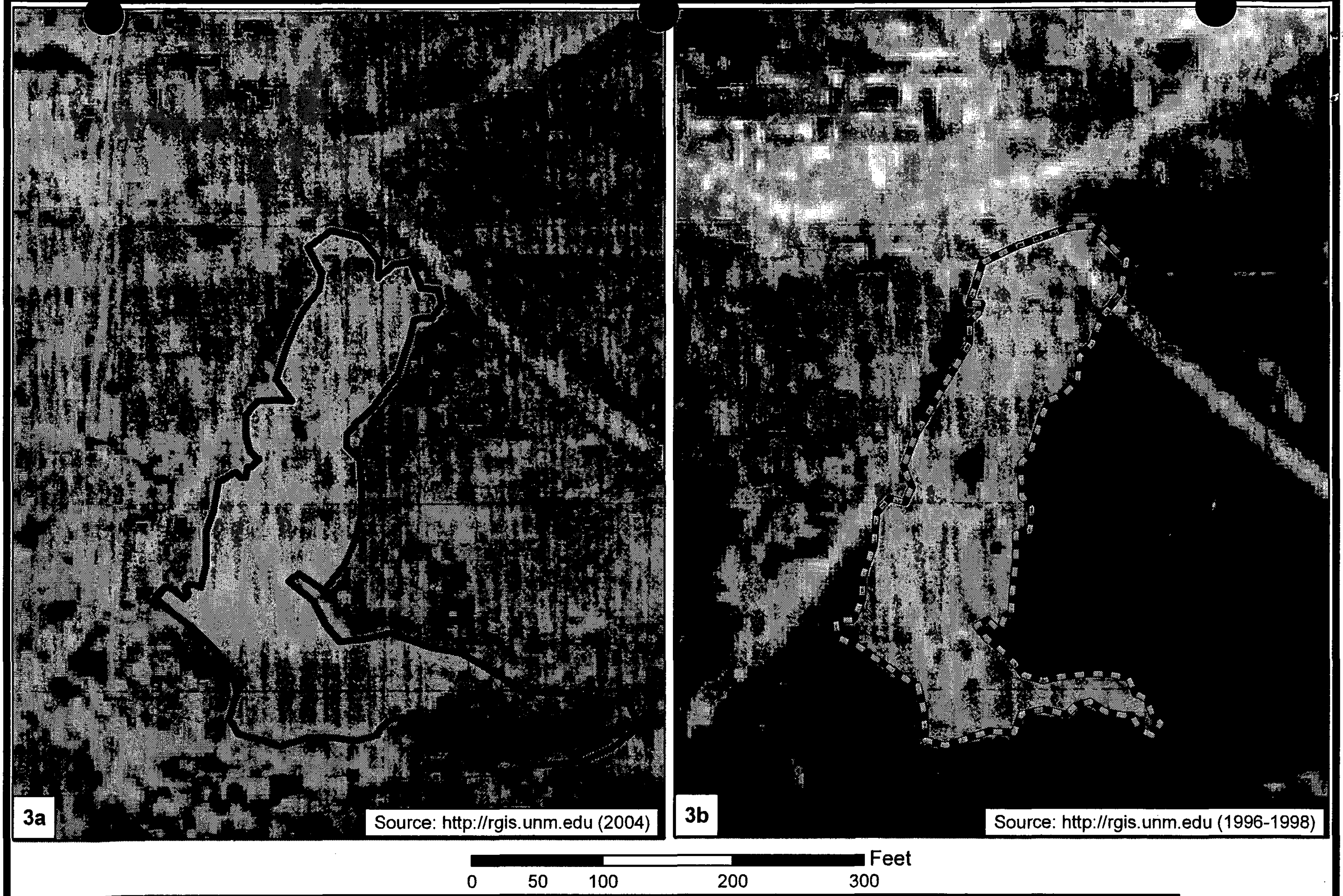
Directions: From Lovington, NM, proceed on Highway 18 for approximatly 5.3 miles. Head southwest on an unnamed dirt road (0.5 miles southeast of the Navajo Lea Refinery. Proceed on the dirt road for approximately 0.8 miles. Head south on an unamed dirt road for approximately 0.3 miles. Head east on an unnamed dirt road immediatley south of a tank battery. Proceed east for approximately 550 feet. The spill site is on the south side of the road.



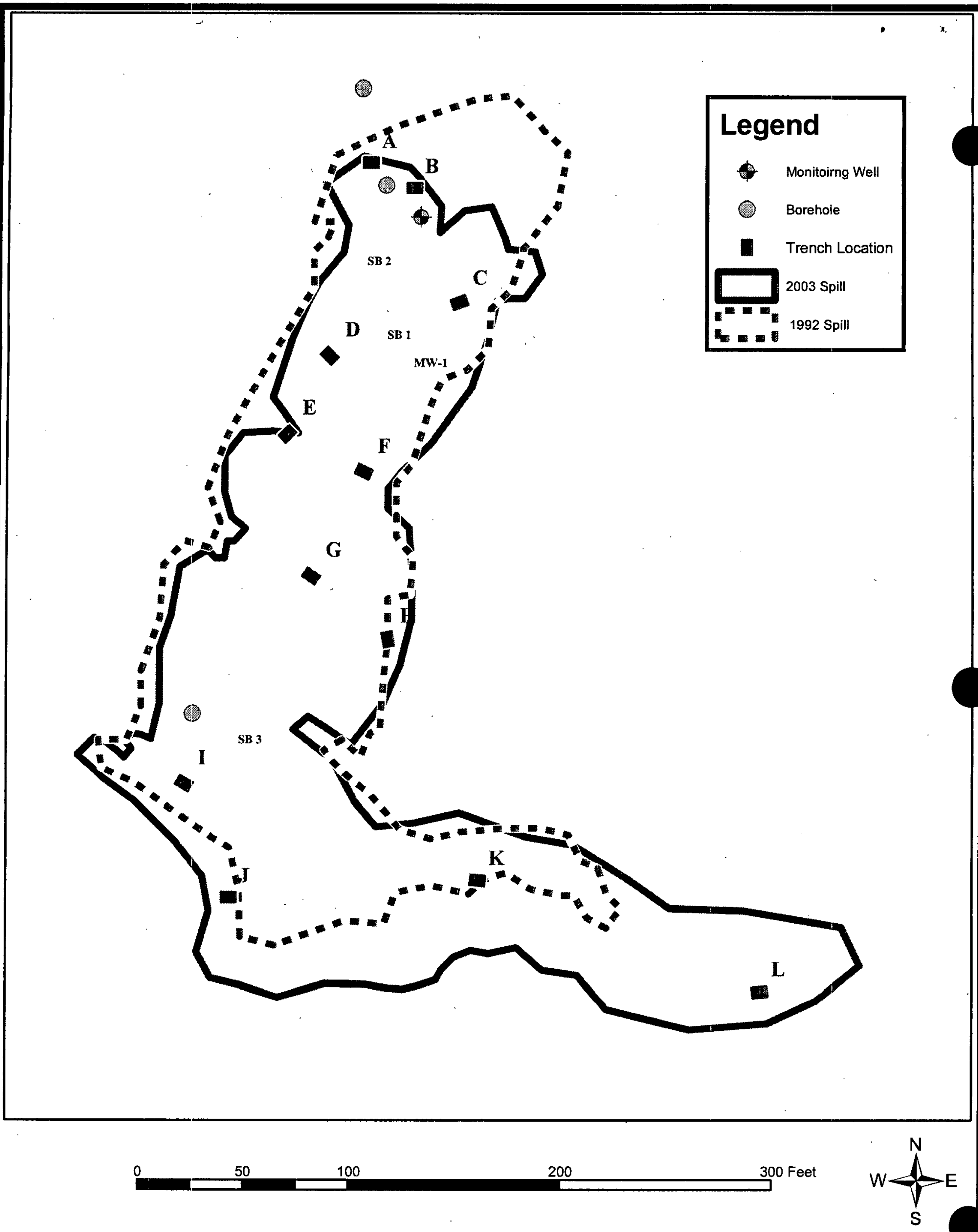
R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Site Location Map (USGS Lovington SE 7.5' Quad)	Plate 1
	ABO 1G Realease Site, OCD Case #1R0415	August 2005



vajo Lea Refinery
STATE HWY 18



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Geometry of 2003 and 1992 Releases	Plates 3a & 3b
	ABO 1G Realease Site, OCD Case #1R0415	August 2005



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Geometry of 1992 & 2003 Releases with Trenches, Soil Borings & Monitoring Well	Plate 4
	ABO 1G Realease Site, OCD Case #1R0415	August 2005

Depth	Lithologic Description	Measured Soil Chloride Concentration mg/kg	Bulk Density of Sample kg/m3	Thickness of Column (ft)	Calculated Chloride Mass in Column (kg/m2)
0 feet	0-1ft Top Soil				
10 feet	1-22 ft Caliche	525	1858	10	3.23
20 feet		1088	1858	11	7.37
30 feet	22-31 ft Sand & Caliche	1161	1858	5	3.57
		636	1858	4	1.57
40 feet	31-45 ft Sand	573	1858	7	2.47
		236	1858	7	1.02
		Calculated Chloride Load			19.22

R.T. Hicks Consultants
901 Rio Grande NW
Albuquerque, NM

RICE *Operating Company*

Soil Bore #1 - Calculation of Chloride Load, Abo Leak, Lea County, New Mexico

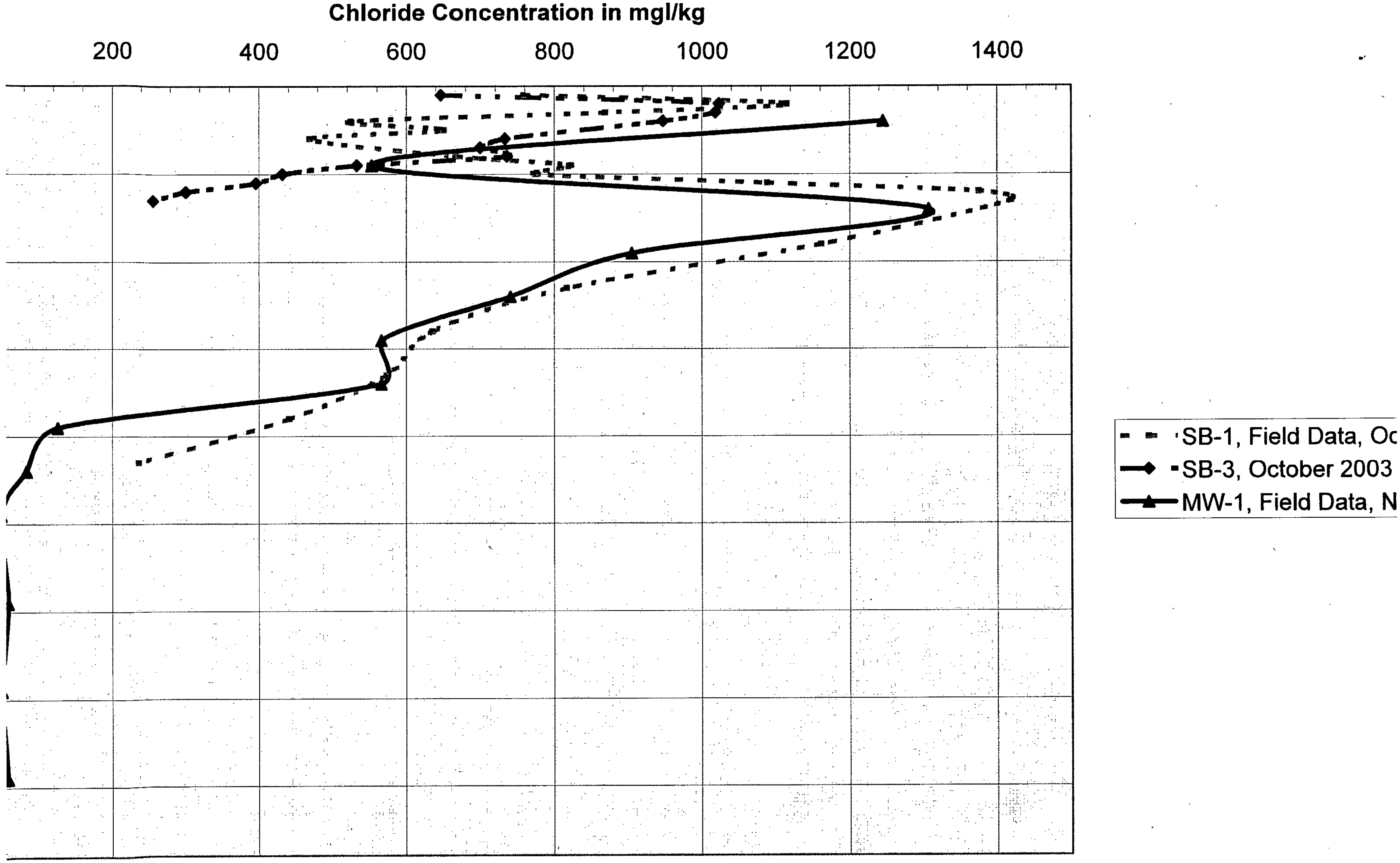
Plate 5

Aug-05

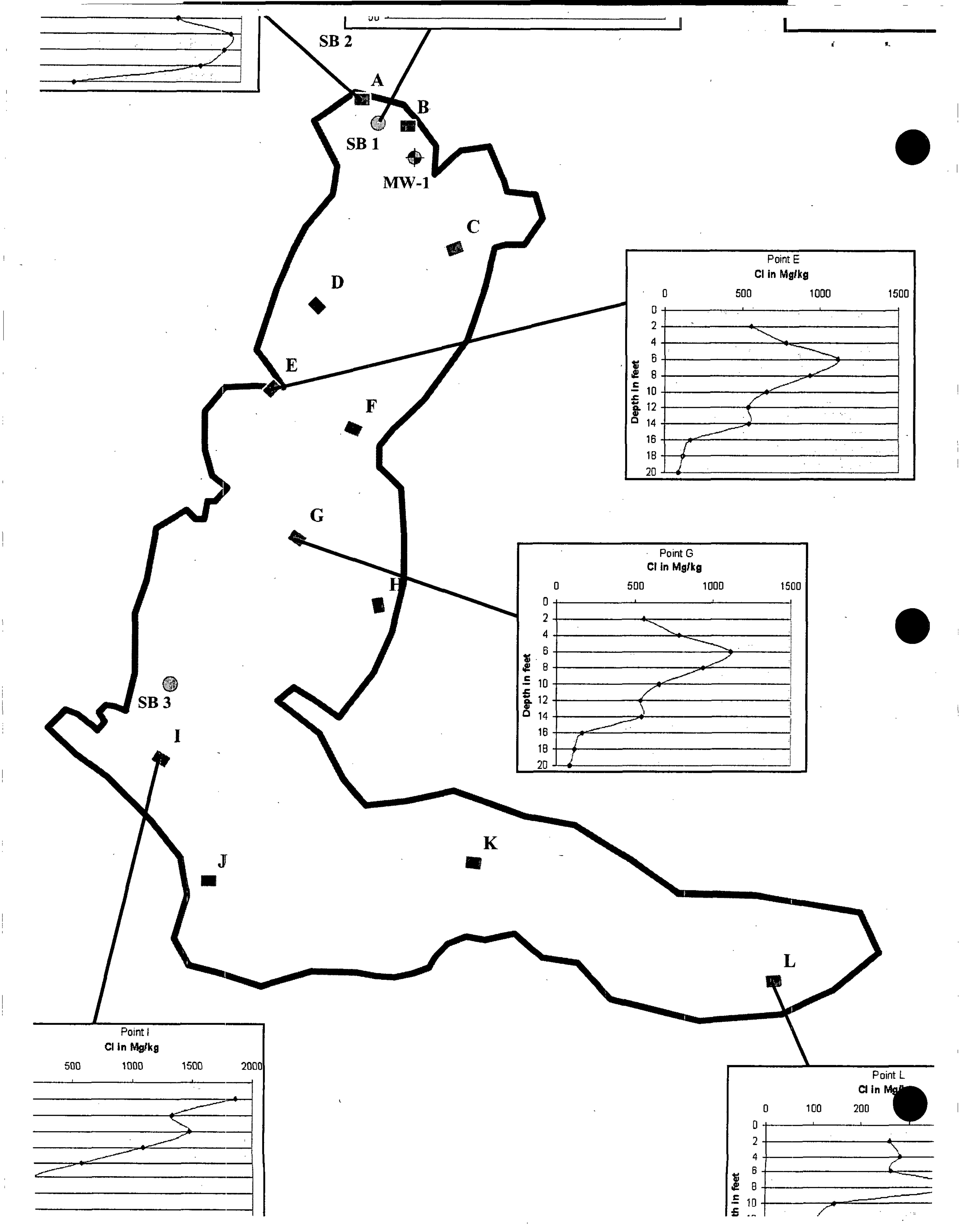
Logger:	David Hamilton	**Client:**	**Well ID:**
Driller:	Eades Drilling	ROC	
Drilling Method:	Air Rotary	**Project Name:**	
Start Date:	11/5/2004	Abo Apache LA 1-G Release Site	
End Date:	11/6/2004	**Location:**	LA MW-1
		Section 1, 17S, 36E, Unit 1G	

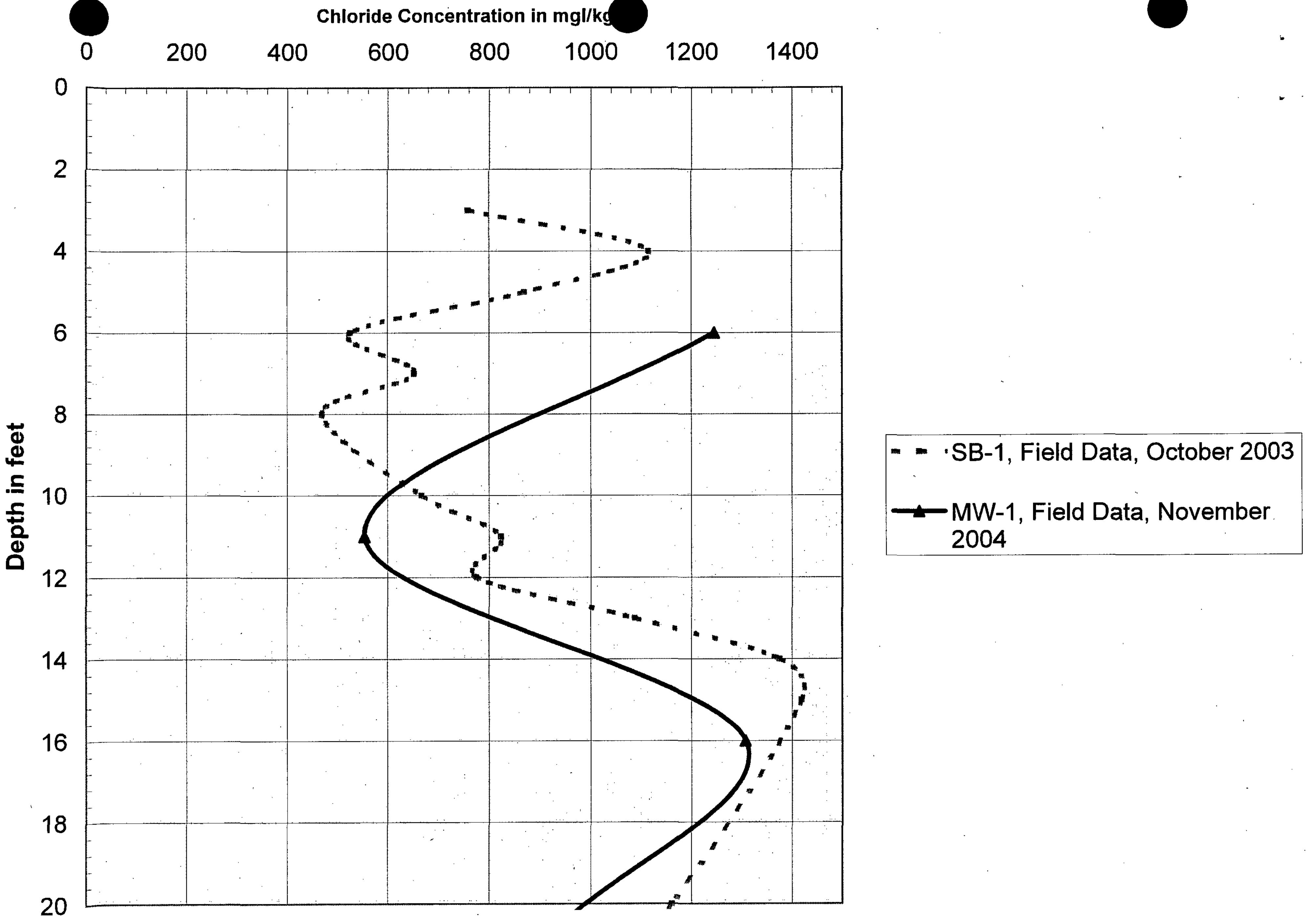
Depth (feet)	Description	Lithology	Comments	Well Construction	Field data: Depth	Field data: Chloride mg/kg	Field data: PID
0.0	Surface, 0 - .5 feet		Hard drilling	Cement, 0-3 feet			
2.0	Frac. caliche, sand, clay, .5 - 3 feet, tan						
4.0	Sand and caliche, 3 - 5 feet, tan						
6.0	Very fine grained sand, silt, some caliche, 5 - 10 feet, tan				6.0	1245	6.3
8.0							
10.0	Very fine grained sand, silt, little caliche, 10 - 15 feet, tan				11.0	553	7.3
12.0							
14.0	Indurated caliche, 15 - 17 feet						
16.0	Very fine grained sand, silt, little caliche, 17 - 20 feet				16.0	1307	5.2
18.0							
20.0	Thin caliche layers in sand, 20 - 22 feet				21.0	905	8.2
22.0	Very fine grained sand, silt, 22 - 33 feet, tan with reddish tinge						
24.0							
26.0					26.0	741	1.1
28.0			Samples fell out of spoon, collected with shovel				
30.0					31.0	493	0.8
32.0							
34.0	Very fine grained sand, silt, caliche , 33 -44 feet, light tan. Well indurated caliche layer from 35 to 36 feet.						
36.0					36.0	566	0.8
38.0							
40.0					41.0	126	3.3
42.0							
44.0	Very fine grained sand, silt, 44 - 53 feet, tan			Hydrated bentonite, 3-87 feet			
46.0					46.0	83	2.0
48.0							
50.0					51.0	49	1.0
52.0	Very fine grained sand, silt, some caliche, 53 - 60 feet, tan						
54.0							
56.0							
58.0							
60.0	Very fine grained sand, silt, 60 - 67 feet, tan				61.0	59	2.4
62.0							
64.0							
66.0	Indurated sand, silt, 67 - 68 feet		Hard drilling				
68.0	Very fine grained sand, silt, 68 - 100 feet tan. Slightly redder below 83 feet.						
70.0					71.0	50	2.9
72.0							
74.0							
76.0							
78.0							
80.0					81.0	59	3.7
82.0							
84.0							
86.0							
88.0							
90.0					91.0	55	2.7
92.0							
94.0							
96.0			Soil moist at 100 feet				
98.0							
100.0	Very fine grained sand, silt, 100 - 122 feet						
102.0							
104.0				Sand, 87-122 feet			
106.0							
108.0			Hole was drilled with water below 100 feet due to borehole collapse				
110.0							
112.0							
114.0							
116.0							
118.0							
120.0							
122.0							

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 505-266-5004	**ROC Lovington Abo 1-G Site**	**Plate 6**
	Monitoring Well Boring	**August 2005**

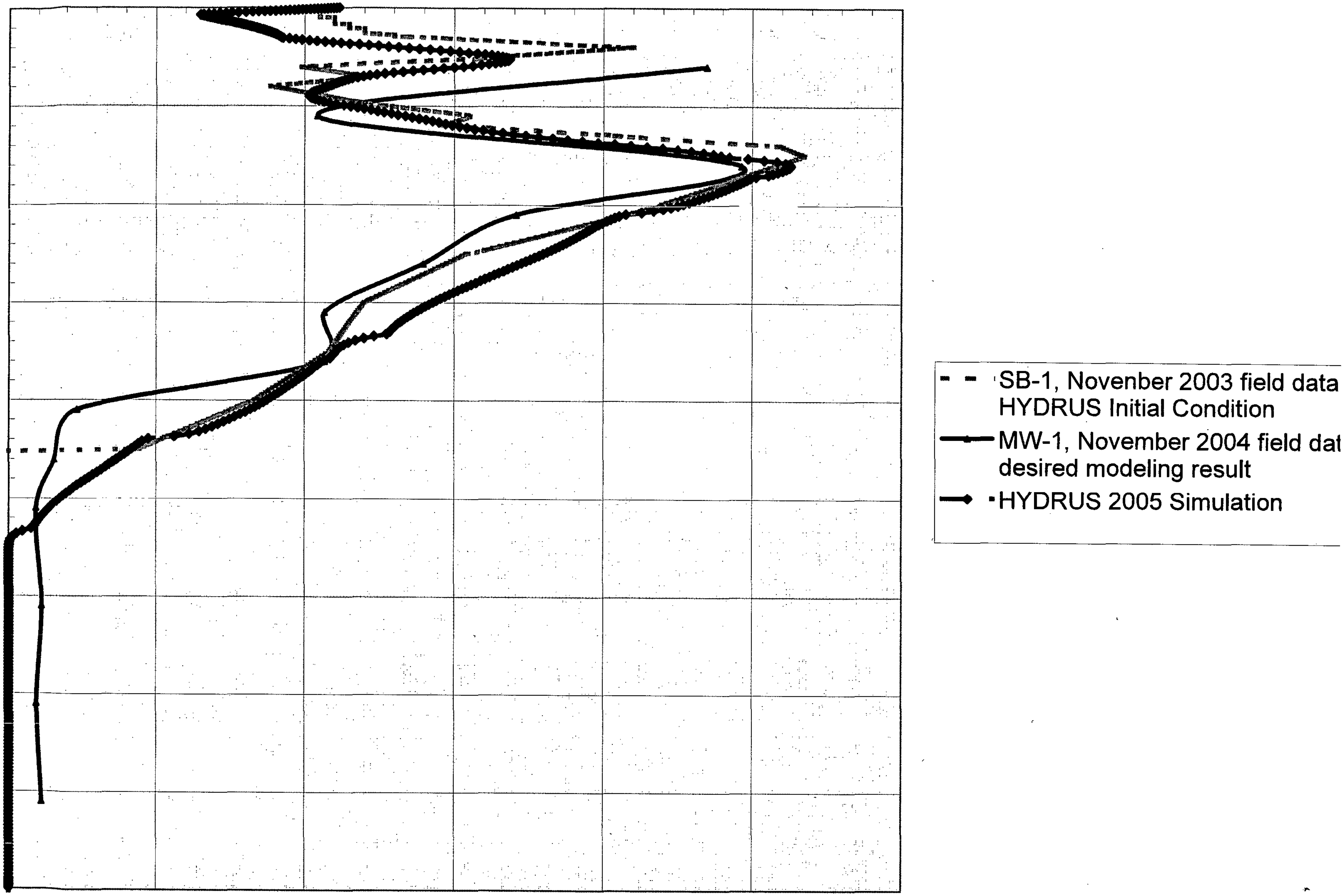


Chloride Loading in SB-1 and MW-1 Field Data

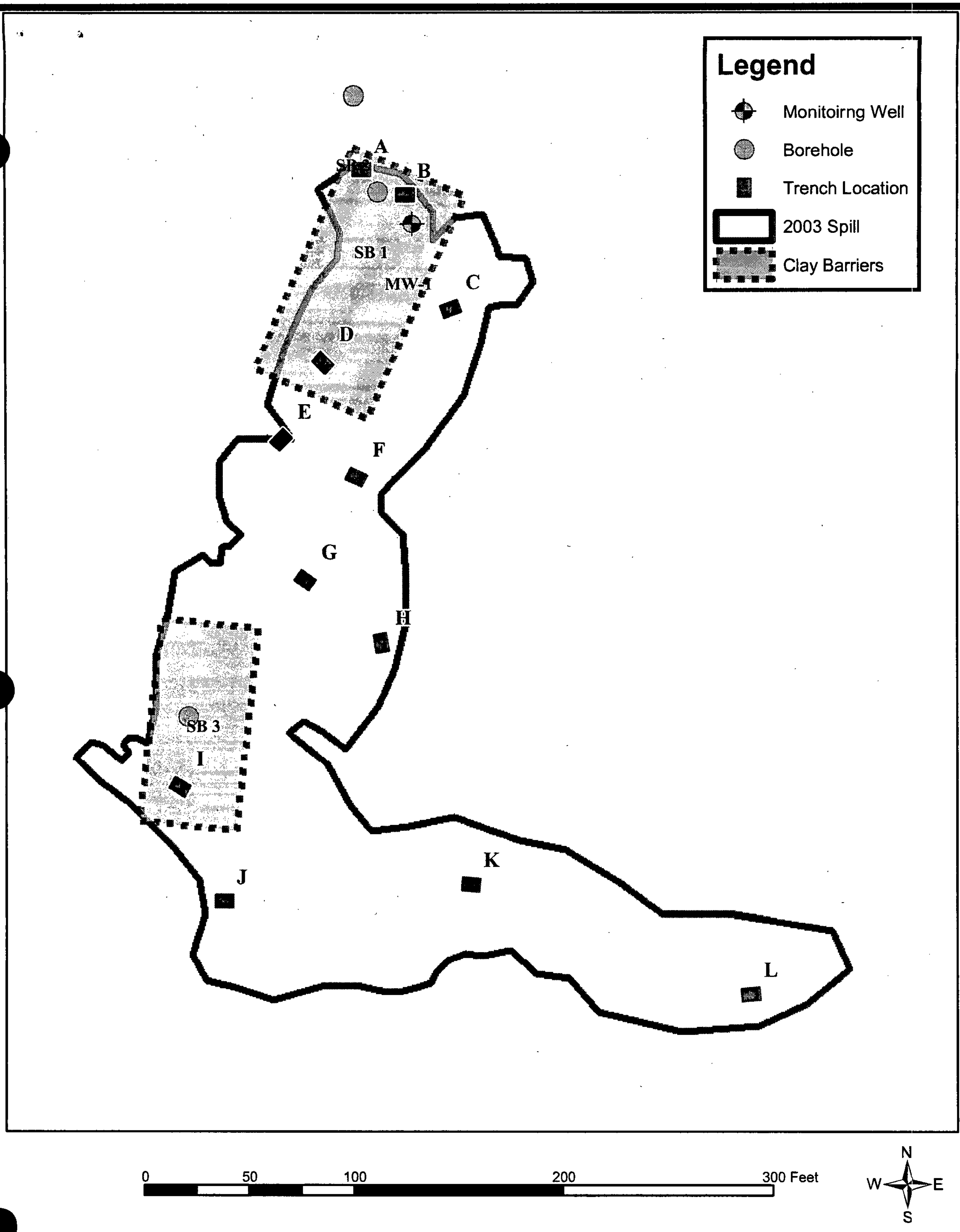

SB 2
A
B
SB 1
MW-1
C
D
E
F
G
H
SB 3
I
J
K
L
Point E
Cl in Mg/kg
0
500
1000
1500
Depth in feet
0
2
4
6
8
10
12
14
16
18
20
Point G
Cl in Mg/kg
0
500
1000
1500
Depth in feet
0
2
4
6
8
10
12
14
16
18
20
Point I
Cl in Mg/kg
500
1000
1500
2000
Point L
0
100
200
0
2
4
6
8
10



Detail of Chloride Loading in SB-1 and MW-1 Field Data



Comparison of HYDRUS 1D Modeling with Field Data



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Areas Proposed for Clay Barriers	Plate 11
	ABO 1G Realease Site, OCD Case #1R0415	August 2005

APPENDIX A

Form WR-23

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

# 5	n 730	-20-	13
DPN.	25-	11350	

(Plat of 640 acres)

(A) Owner of well Jack Gayton

Street and Number Box 1021

City Lovington State New Mexico

Well was drilled under Permit No. L-2480 L-1716 and is located in the NW ¼ NW ¼ NE ¼ of Section 2 Twp. 17 S Rge. 36 E

(B) Drilling Contractor Gayton & Porter License No. WD-163

Street and Number Box 1021

City Lovington State New Mexico

Drilling was commenced Sept. 1 1955

Drilling was completed Sept. 2 1955

Elevation at top of casing in feet above sea level .... Total depth of well 145

State whether well is shallow or artesian Shallow Depth to water upon completion 50

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
1	77	92	15	Water Sand
2				
3				
4				
5				

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used

Section 5 PLUGGING RECORD

Name of Plugging Contractor .... License No. ....

Street and Number .... City .... State ....

Tons of Clay used .... Tons of Roughage used .... Type of roughage ....

Plugging method used .... Date Plugged .... 19....

Plugging approved by:

....
Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

Date Received [stamp: ... 1955 OFFICE ...]

File No. L-2480 1716 Use Irrig Location No. 12362

Section 6

LOG OF WELL

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color	Type of Material Encountered
0	1	1		Soil
1	7	6		Rock
7	16	9		Caliche
16	20	4		Boulder
20	26	6		Sand Rock
26	45	19		Sand
45	70	25		Water Sand
70	77	7		Calcium Sand
77	92	15		Quick Sand
92	106	14		Sandy Clay
106	108	2		Sand
108	112	4		Rock
112	134	22		Sandy Clay
134	143	9		Sand
143	145	2		Sandy Clay

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Jack Clayton
Well Driller

LOG FILED

(This form to be executed in triplicate)

WELL RECORD

Renumbered L-4058
Feb 2
1959

Date of Receipt .... Permit No. L-455A

Name of permittee, Lovington Municipal Utilities

Street or P.O., ... City and State Lovington, New Mexico

1. Well location and description: The shallow (shallow or artesian) well is located in ..... ¼, ... ¼, Lot 9 ..... of Section 4, Township 16, Range 36; Elevation of top of casing above sea level, 3979 feet; diameter of hole, 16 inches; total depth, 127 feet; depth to water upon completion, 58 feet; drilling was commenced June 2, 1952, and completed June 4, 1952; name of drilling contractor Aqua Drilling Co. Box 1004; Address, Lovington, N.M.; Driller's License No. WD 35

2. Principal Water-bearing Strata:

	Depth in Feet From	To	Thickness	Description of Water-bearing Formation
No. 1	58	59	1	Water Sand
No. 2	69	71	2	Water Sand
No. 3	82	86	4	Quick Sand & Water
No. 4	112	116	4	Water Sand & Shale
No. 5				

3. Casing Record:

Diameter in inches	Pounds per ft.	Threads per inch	Depth of Casing or Liner Top	Bottom	Feet of Casing	Type of Shoe	Perforations From	To

RECEIVED
OCT 27 1952
STATE ENGINEER

4. If above construction replaces old well to be abandoned, give location: ..... ¼, ... ¼, ... ¼ of Section ....., Township ....., Range .....; name and address of plugging contractor, ...

date of plugging ....., 19.....; describe how well was plugged: ....

FILED
OCT 30 1952
OFFICE
ARTESIAN WELL SUPERVISOR
ROSWELL, NEW MEXICO

FILED
APR 15 1958
STATE
GROUND WATER SUPERVISOR
ROSWELL, NEW MEXICO

5. Log of Well:

Depth in feet From	To	Thickness in feet	Description of Formation
0	2	2	Soil
2	26	24	Caliche & Lime Shale
26	58	32	Sandy Shale
58	59	1	Water Sand
59	69	10	Sand & Shale
69	71	2	Water Sand & Shale
71	82	11	Sand Shale with Streaks of Clay
82	86	4	Quick Sand & Water
86	112	26	Sand & Shale
112	116	4	Tight Water Sand & Clay Shale
116	127	11	Sandy Shale

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Licensed Well Driller

Instructions

This form shall be executed, preferably typewritten, in triplicate and filed with the State Engineer's Office at Roswell, New Mexico, within 10 days after drilling has been completed. Data on water-bearing strata and on all formations encountered should be as complete and accurate as possible.

(This form to be executed in triplicate)

WELL RECORD

Date of Receipt.. Permit No. L-265

Name of permittee, Ernest Mahan

Street or P.O., Box 32, City and State Lovington, N. M.

1. Well location and description: The shallow (shallow or artesian) well is located in NW ¼, NW ¼, SW ¼ of Section 11, Township 16 S, Range 36 E; Elevation of top of casing above sea level, ... feet; diameter of hole, 16 inches; total depth, 120 feet; depth to water upon completion, 45 feet; drilling was commenced Jan. 8, 19 48, and completed Jan. 9, 1948; name of drilling contractor Abbott Bros. ....; Address, Box 637, Hobbs, N. M.; Driller's License No. WD-46

2. Principal Water-bearing Strata:

	Depth in Feet From	To	Thickness	Description of Water-bearing Formation
No. 1	45	120	75	Water sand
No. 2				
No. 3				
No. 4				
No. 5				

3. Casing Record:

Diameter in inches	Pounds per ft.	Threads per inch	Depth of Casing or Liner Top	Bottom	Feet of Casing	Type of Shoe	Perforations From	To
NONE								

4. If above construction replaces old well to be abandoned, give location: .... ¼, ... ¼, ... ¼ of Section........, Township........, Range........; name and address of plugging contractor,

....

....

date of plugging...................., 19......; describe how well was plugged:

....

....

....

FILED
JAN 11 1952
OFFICE
ARTESIAN WELL SUPERVISOR
ROSWELL, NEW MEXICO

5. Log of Well:

Depth in feet From	To	Thickness in feet	Description of Formation
0	4	4	Soil
4	35	31	Caliche
35	45	10	Hard shell
45	120	75	Water sand

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Clyde [illegible]
Licensed Well Driller

Instructions

This form shall be executed, preferably typewritten, in triplicate and filed with the State Engineer's Office at Roswell, New Mexico, within 10 days after drilling has been completed. Data on water-bearing strata and on all formations encountered should be as complete and accurate as possible.

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well Hulda Heidel Owner's Well No. ______

Street or Post Office Address 1018 West Avenue K

City and State Lovington, New Mexico 88260

Well was drilled under Permit No. L-135 enlarged L-135S and is located in the:

a. ___ ¼ ___ ¼ ___ ¼ NW ¼ of Section 11 Township 16S Range 36E N.M.P.M.

b. Tract No. ______ of Map No. ______ of the ______

c. Lot No. ______ of Block No. ______ of the ______
Subdivision, recorded in Lea County.

d. X= ______ feet, Y= ______ feet, N.M. Coordinate System ______ Zone in the ______ Grant.

(B) Drilling Contractor Abbott Bros. License No. WD-46

Address P.O. Box 637, Hobbs, New Mexico 88240

Drilling Began 3/17/77 Completed 3/22/77 Type tools Cable Size of hole 16 in.

Elevation of land surface or ______ at well is ______ ft. Total depth of well 146 ft.

Completed well is ☒ shallow ☐ artesian. Depth to water upon completion of well 58 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
From	To			
58	146	88	Sand	

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet		Length (feet)	Type of Shoe	Perforations	
			Top	Bottom			From	To
12 3/4"	43	Welded	0	146	146	None	66	146

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
From	To				

Section 5. PLUGGING RECORD

Plugging Contractor ______

Address ______

Plugging Method ______

Date Well Plugged ______

Plugging approved by:

______
State Engineer Representative

No.	Depth in Feet		Cubic Feet of Cement
	Top	Bottom	
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received June 14, 1977

Quad ______ FWL ______ FSL ______

Supplemental

File No. L-135 & L-135-Enlgd-S Use Irr Location No. 16.36.11.

Section 6. LOG OF HOLE

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color and Type of Material Encountered
0	2	2	Surface soil
2	26	24	Caliche
26	58	32	Sand-tight
58	112	54	Sand-water
112	128	16	Sand-tight
128	146	18	Sand-water

STATE ENGINEER OFFICE
ROSWELL, N.M.
'77 JUN 14 AM 8 24

Section 7. REMARKS AND ADDITIONAL INFORMATION

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Murrell Abbott H.B.
Driller

Form WR-23

FIELD ENGR. LOG

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

(Plat of 640 acres)

(A) Owner of well J. W. Taylor Jr.

Street and Number P.O.

City Hope State New Mex.

Well was drilled under Permit No. Comer Hudgens Enlgd. L-135 and is located in the N.W.¼ S.W.¼ N.W. ¼ of Section II Twp. I6So Rge. 36 E.

(B) Drilling Contractor C.O. Aldredge License No. W.D.79

Street and Number Box 379

City LOvington State New Mex.

Drilling was commenced Mar. I4 1964

Drilling was completed Mar.I6 1964

Elevation at top of casing in feet above sea level ______ Total depth of well II0 Ft.

State whether well is shallow or artesian Shallow Depth to water upon completion 75

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation
	From	To		
1	95	II0	I5	Small crystlized sand rock & quick sand
2				
3				
4				
5				

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth		Feet	Type Shoe	Perforations	
			Top	Bottom			From	To
			Not	cased				

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet		Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used
From	To				
		I6			2 sacks of drilling mud used to
					hold quick sand back
					while cleaning out well

Section 5 PLUGGING RECORD

Name of Plugging Contractor ______ License No. ______

Street and Number ______ City ______ State ______

Tons of Clay used ______ Tons of Roughage used ______ Type of roughage ______

Plugging method used ______ Date Plugged ______ 19____

Plugging approved by:

______
Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug		No. of Sacks Used
	From	To	

FOR USE OF STATE ENGINEER ONLY

Date Received STATE ENGINEER OFFICE ROSWELL N MEX DISTRICT II 1964 MAY 19 AM 8:21 ✓

File No. L-135-Enlgd. Use Irr. Location No. 16.36.11.131

Section 6

LOG OF WELL

Depth in Feet		Thickness in Feet	Color	Type of Material Encountered
From	To			
95	110	15	red	small crystalized sand rock

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

C. O. Aldredge
Well Driller

Revised June 1972

STATE ENGINEER OFFICE

WELL RECORD

Section 1. GENERAL INFORMATION

(A) Owner of well City of Lovington Owner's Well No. L-9517
Street or Post Office Address P.O. Box 1268
City and State Lovington, N.M. 88260

Well was drilled under Permit No. L 9517 and is located in the:

a. SESE ¼ NE ¼ SESW ¼ SW ¼ of Section 3 Township 16S Range 36E N.M.P.M.

b. Tract No. ______ of Map No. ______ of the ______

c. Lot No. ______ of Block No. ______ of the ______
Subdivision, recorded in ______ County.

d. X= ______ feet, Y= ______ feet, N.M. Coordinate System ______ Zone in the ______ Grant.

(B) Drilling Contractor Gene Eades License No. WD982

Address Rt. 4 Tahoka, Tx. 79373

Drilling Began 11-27-84 Completed 11-27-84 Type tools Rotary Size of hole 8 in.

Elevation of land surface or ______ at well is ______ ft. Total depth of well 138 ft.

Completed well is ☒ shallow ☐ artesian. Depth to water upon completion of well 66 ft.

Section 2. PRINCIPAL WATER-BEARING STRATA

Depth in Feet		Thickness in Feet	Description of Water-Bearing Formation	Estimated Yield (gallons per minute)
From	To			
66	138	72	Brown water sand w/ sandstone stringers	30

Section 3. RECORD OF CASING

Diameter (inches)	Pounds per foot	Threads per in.	Depth in Feet		Length (feet)	Type of Shoe	Perforations	
			Top	Bottom			From	To
5 3/4	160 psi.				134		118	138
5 3/4	Sch. 40 steel	for	pitless adapter		4			

Section 4. RECORD OF MUDDING AND CEMENTING

Depth in Feet		Hole Diameter	Sacks of Mud	Cubic Feet of Cement	Method of Placement
From	To				

Section 5. PLUGGING RECORD

Plugging Contractor ______
Address ______
Plugging Method ______
Date Well Plugged ______
Plugging approved by:

______
State Engineer Representative

No.	Depth in Feet		Cubic Feet of Cement
	Top	Bottom	
1			
2			
3			
4			

FOR USE OF STATE ENGINEER ONLY

Date Received December 10, 1984

Quad ______ FWL ______ FSL ______

File No. L-9517 Use Drinking/Sanitary Location No. 16.36.3.33244

Section 6. LOG OF HOLE

Depth in Feet		Thickness in Feet	Color and Type of Material Encountered
From	To		
0	3	3	Top soil
3	15	12	Caliche
15	21	6	Sandy clay
21	40	19	Sandy clay & sandstone
40	65	25	Sand & sandstone
65	66	1	Hard sandstone
66	138	72	Brown water sand

Section 7. REMARKS AND ADDITIONAL INFORMATION

DEC 10 8 22 AM '84

STATE ENGINEER
ROSWELL, NM

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described hole.

Driller

Form WR-23

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

(Plat of 640 acres)

(A) Owner of well City of Lovington

Street and Number Box 1268

City Lovington State New Mexico

Well was drilled under Permit No. L - 5356 and is located in the

E ½ S ½ ¼ ¼ of Section 3 Twp. 16 S Rge. 36 E

(B) Drilling Contractor Grady Buckius License No. W. D. 322

Street and Number Box 791

City Lovington State New Mexico

Drilling was commenced April 8 19 64

Drilling was completed April 12 19 64

Elevation at top of casing in feet above sea level Total depth of well 164 ft.

State whether well is shallow or artesian Shallow Depth to water upon completion 70 ft.

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
1	70	84	14 ft.	Sand
2	112	129	18 ft.	Sand
3	138	146	8 ft.	Water Sand
4	153	158	5 ft.	Water Sand
5				

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To
12 in.	30		0	164	164 ft		102	164

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used

Section 5 PLUGGING RECORD

Name of Plugging Contractor License No.

Street and Number City State

Tons of Clay used Tons of Roughage used Type of roughage

Plugging method used Date Plugged 19

Plugging approved by:

Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

Date Received

1964 APR 28 AM 8:37

File No. L-5356 Use Expl. Location No. 16.36.3.400

Section 6

LOG OF WELL

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color	Type of Material Encountered
0	1	1 ft.		Soil
1	4	3 ft.		Rock
4	18	14 ft.		Caliche
18	62	44 ft.		Sand
62	70	8 ft.		Sand Stone
70	84	14 ft.		Sand
84	98	14 ft.		Sand & Calcum
98	112	14 ft.		Sandy Clay
112	120	8 ft.		Sand
120	138	18 ft.		Sandy Clay
138	146	8 ft.		Water Sand
146	153	7 ft.		Sandy Clay
153	158	5 ft.		Sand
158	164	6 ft.		Sandy Clay

The undersigned hereby certifies that; to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Hardy Barton

Well Driller

Form WR-23 Orig. in S.F.

STATE ENGINEER OFFICE

WELL RECORD

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

(Plat of 640 acres)

(A) Owner of well City of Lovington

Street and Number

City Lovington State New Mexico

Well was drilled under Permit No. L-3901 and is located in the S W ¼ N W ¼ S E ¼ of Section 10 Twp. 16 S Rge. 36 E

(B) Drilling Contractor Clayton Drlg. Co. License No. WD-183

Street and Number Box 1021

City Lovington State New Mexico

Drilling was commenced June 26 1958

Drilling was completed June 28 1958

Elevation at top of casing in feet above sea level ________ Total depth of well 104 ft.

State whether well is shallow or artesian Shallow Depth to water upon completion 66 ft.

Section 2 PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	Depth in Feet To	Thickness in Feet	Description of Water-Bearing Formation
1	66	74	8	Water Sand
2	82	90	8	Quick Sand
3				
4				
5				

Section 3 RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Depth Bottom	Feet	Type Shoe	Perforations From	Perforations To
7 in. O.D.	25	8	[illegible]	104	105	None	65	100

Section 4 RECORD OF MUDDING AND CEMENTING

Depth in Feet From	Depth in Feet To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used
20	104	8 in.	200 lbs.		Dry Mix

Section 5 PLUGGING RECORD

Name of Plugging Contractor ________ License No. ________

Street and Number ________ City ________ State ________

Tons of Clay used ________ Tons of Roughage used ________ Type of roughage ________

Plugging method used ________ Date Plugged ________ 19__

Plugging approved by:

____
Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	Depth of Plug To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

Date Received JUL 9 1958

File No. L-3901 Use Dom. Location No. 16.36.10.413

Section 6

LOG OF WELL

Depth in Feet		Thickness in Feet	Color	Type of Material Encountered
From	To			
0	2	2		Soil
2	20	18		Caliche
20	28	8		Boulder
28	66	38		Sand
66	74	8		Water Sand
74	82	8		Sandy Clay
82	90	8		Quick Sand
90	104	14		Sand

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing, is a true and correct record of the above described well.

CAYTON WATER WELL DRILLING COMPANY
Well Driller

Form WR-23

STATE ENGINEER OFFICE

WELL RECORD

FIELD ENGR LOG

INSTRUCTIONS: This form should be executed in triplicate, preferably typewritten, and submitted to the nearest district office of the State Engineer. All sections, except Section 5, shall be answered as completely and accurately as possible when any well is drilled, repaired or deepened. When this form is used as a plugging record, only Section 1A and Section 5 need be completed.

Section 1

(Plat of 640 acres)

City of Lovington

(A) Owner of well P. O. Box 1268

Street and Number Lovington New Mex.

City L-5014 State

Well was drilled under Permit No. 10 land is located in the

¼ ¼ ¼ of Section Twp. Rge. 322

(B) Drilling Contractor Box 791 License No.

Street and Number Lovington New Mex.

City Nov. 27, State 62

Drilling was commenced Dec. 9, 19 62

Drilling was completed 19

3900 216 Ft.

Elevation at top of casing in feet above sea level Shallow Total depth of well 66 Ft.

State whether well is shallow or artesian Depth to water upon completion

Section 2

PRINCIPAL WATER-BEARING STRATA

No.	Depth in Feet From	To	Thickness in Feet	Description of Water-Bearing Formation
	70	76	6	Sand
1	82	94	12	Quick Sand
2	112	116	4	Sand
3	132	137	5	Sand
4	164	168	4	Sand ?
5	170	190	12	Sand

Section 3

RECORD OF CASING

Dia in.	Pounds ft.	Threads in	Depth Top	Bottom	Feet	Type Shoe	Perforations From	To
12	3/16 Wall							21

Section 4

RECORD OF MUDDING AND CEMENTING

Depth in Feet From	To	Diameter Hole in in.	Tons Clay	No. Sacks of Cement	Methods Used

Section 5

PLUGGING RECORD

Name of Plugging Contractor License No.

Street and Number City State

Tons of Clay used Tons of Roughage used Type of roughage

Plugging method used Date Plugged 19

Plugging approved by:

Basin Supervisor

Cement Plugs were placed as follows:

No.	Depth of Plug From	To	No. of Sacks Used

FOR USE OF STATE ENGINEER ONLY

ROSWELL, N. MEX. DISTRICT II STATE ENGINEER OFFICE

Date Received 1962 DEC 13 AM 8:11

File No. L-5014 Use Expl. Location No. 16.36.10.240.

Section 6 LOG OF WELL

Depth in Feet From	Depth in Feet To	Thickness in Feet	Color	Type of Material Encountered
0	2	2		Soil
2	8	6		Clachie
8	12	4		Bolder
12	28	16		Clichie
28	70	42		Sandy Clay
70	76	6		Water Sand
76	82	6		Sandy Clay
82	94	12		Quick Sand
94	112	18		Sandy Clay
112	116	4		Sand
116	132	16		Sandy Clay
132	137	5		Sand
137	164	27		Sandy Clay
164	168	4		Sand
168	178	10		Sandy Clay
178	190	12		Sand
190	205	15		Clay
205	215	10		Clay & Gravel
215	216	1		Red Bed
				L S Elev
				Depth to K____ Trc____
				Elev of K____ Trc____
				Loc. No.
				Hydro. Survey Field Check

The undersigned hereby certifies that, to the best of his knowledge and belief, the foregoing is a true and correct record of the above described well.

Grady Barker
Well Driller

SOURCE OF ALTITUDE GIVEN
Interpolated from Topo. Sheet____
Determined by Inst. Leveling____
Other____

L-5014 16.36.10.240

APPENDIX B

ENVIRONMENTAL LAB OF TEXAS
12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Kristin Pope

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: None Given

Location: Lovington

Lab Order Number: 5H11001

Report Date: 08/23/05

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
08/23/05 10:09

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Monitor Well #1	5H11001-01	Water	08/10/05 09:30	08/11/05 07:45

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (5H11001-01) Water									
Benzene	ND	0.00100	mg/L	1	EH51609	08/16/05	08/16/05	EPA 8021B	
Toluene	ND	0.00100	"	"	"	"	"	"	
Ethylbenzene	ND	0.00100	"	"	"	"	"	"	
Xylene (p/m)	ND	0.00100	"	"	"	"	"	"	
Xylene (o)	ND	0.00100	"	"	"	"	"	"	
Surrogate: a,a,a-Trifluorotoluene		*105 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*95.0 %*	*80-120*		"	"	"	"	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
08/23/05 10:09

General Chemistry Parameters by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (5H11001-01) Water									
Total Alkalinity	**159**	2.00	mg/L	1	EH51208	08/11/05	08/11/05	EPA 310.2M	
Chloride	**91.1**	2.50	"	5	EH51906	08/15/05	08/15/05	EPA 300.0	
Total Dissolved Solids	**603**	5.00	"	1	EH51210	08/16/05	08/17/05	EPA 160.1	
Sulfate	**66.3**	2.50	"	5	EH51906	08/15/05	08/15/05	EPA 300.0	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471
Reported:
08/23/05 10:09

Total Metals by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (5H11001-01) Water									
Calcium	**99.1**	0.100	mg/L	10	EH51103	08/11/05	08/11/05	EPA 6010B	
Magnesium	**15.3**	0.0100	"	"	"	"	"	"	
Potassium	**4.87**	0.0500	"	1	"	"	"	"	
Sodium	**56.5**	0.100	"	10	"	"	"	"	

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 EH51609 - EPA 5030C (GC)										
Blank (EH51609-BLK1)				Prepared & Analyzed: 08/16/05						
Benzene	ND	0.00100	mg/L							
Toluene	ND	0.00100	"							
Ethylbenzene	ND	0.00100	"							
Xylene (p/m)	ND	0.00100	"							
Xylene (o)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	*97.9*		*ug/l*	*100*		*97.9*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*81.4*		*"*	*100*		*81.4*	*80-120*			
LCS (EH51609-BS1)				Prepared & Analyzed: 08/16/05						
Benzene	98.4		ug/l	100		98.4	80-120			
Toluene	97.0		"	100		97.0	80-120			
Ethylbenzene	106		"	100		106	80-120			
Xylene (p/m)	204		"	200		102	80-120			
Xylene (o)	104		"	100		104	80-120			
Surrogate: a,a,a-Trifluorotoluene	*104*		*"*	*100*		*104*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*95.4*		*"*	*100*		*95.4*	*80-120*			
Calibration Check (EH51609-CCV1)				Prepared: 08/16/05		Analyzed: 08/17/05				
Benzene	94.2		ug/l	100		94.2	80-120			
Toluene	94.5		"	100		94.5	80-120			
Ethylbenzene	106		"	100		106	80-120			
Xylene (p/m)	203		"	200		102	80-120			
Xylene (o)	109		"	100		109	80-120			
Surrogate: a,a,a-Trifluorotoluene	*94.9*		*"*	*100*		*94.9*	*0-200*			
Surrogate: 4-Bromofluorobenzene	*102*		*"*	*100*		*102*	*0-200*			
Matrix Spike (EH51609-MS1)	**Source: 5H11006-01**			Prepared: 08/16/05		Analyzed: 08/17/05				
Benzene	91.6		ug/l	100	ND	91.6	80-120			
Toluene	90.2		"	100	ND	90.2	80-120			
Ethylbenzene	101		"	100	ND	101	80-120			
Xylene (p/m)	191		"	200	ND	95.5	80-120			
Xylene (o)	102		"	100	ND	102	80-120			
Surrogate: a,a,a-Trifluorotoluene	*91.5*		*"*	*100*		*91.5*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*97.9*		*"*	*100*		*97.9*	*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 EH51609 - EPA 5030C (GC)										
Matrix Spike Dup (EH51609-MSD1)		**Source: 5H11006-01**		**Prepared: 08/16/05**		**Analyzed: 08/17/05**				
Benzene	95.5		ug/l	100	ND	95.5	80-120	4.17	20	
Toluene	94.5		"	100	ND	94.5	80-120	4.66	20	
Ethylbenzene	106		"	100	ND	106	80-120	4.83	20	
Xylene (p/m)	201		"	200	ND	100	80-120	4.60	20	
Xylene (o)	108		"	100	ND	108	80-120	5.71	20	
Surrogate: a,a,a-Trifluorotoluene	*82.3*		"	*100*		*82.3*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*92.9*		"	*100*		*92.9*	*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 EH51208 - General Preparation (WetChem)										
Blank (EH51208-BLK1)				Prepared & Analyzed: 08/11/05						
Total Alkalinity	ND	2.00	mg/L							
Duplicate (EH51208-DUP1)	**Source: 5H11001-01**			Prepared & Analyzed: 08/11/05						
Total Alkalinity	0.00	2.00	mg/L		159				20	
Reference (EH51208-SRM1)				Prepared & Analyzed: 08/11/05						
Bicarbonate Alkalinity	230		mg/L	200		115	80-120			
Batch EH51210 - General Preparation (WetChem)										
Blank (EH51210-BLK1)				Prepared: 08/16/05 Analyzed: 08/17/05						
Total Dissolved Solids	ND	5.00	mg/L							
Duplicate (EH51210-DUP1)	**Source: 5H11001-01**			Prepared: 08/16/05 Analyzed: 08/17/05						
Total Dissolved Solids	628	5.00	mg/L		603			4.06	5	
Batch EH51906 - General Preparation (WetChem)										
Blank (EH51906-BLK1)				Prepared & Analyzed: 08/15/05						
Chloride	ND	0.500	mg/L							
Sulfate	ND	0.500	"							
LCS (EH51906-BS1)				Prepared & Analyzed: 08/15/05						
Chloride	8.36		mg/L	10.0		83.6	80-120			
Sulfate	9.43		"	10.0		94.3	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 EH51906 - General Preparation (WetChem)										
Calibration Check (EH51906-CCV1)				Prepared & Analyzed: 08/15/05						
Chloride	9.85		mg/L	10.0		98.5	80-120			
Sulfate	11.4		"	10.0		114	80-120			
Duplicate (EH51906-DUP1)	**Source: 5H09007-02**			Prepared & Analyzed: 08/15/05						
Sulfate	122	5.00	mg/L		122			0.00	20	
Chloride	202	5.00	"		203			0.494	20	

Total Metals 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 EH51103 - 6010B/No Digestion										
Blank (EH51103-BLK1)				Prepared & Analyzed: 08/11/05						
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Calibration Check (EH51103-CCV1)				Prepared & Analyzed: 08/11/05						
Calcium	1.95		mg/L	2.00		97.5	85-115			
Magnesium	2.17		"	2.00		108	85-115			
Potassium	1.90		"	2.00		95.0	85-115			
Sodium	1.84		"	2.00		92.0	85-115			
Duplicate (EH51103-DUP1)	Source: 5H09005-01			Prepared & Analyzed: 08/11/05						
Calcium	148	0.500	mg/L		153			3.32	20	
Magnesium	24.3	0.0100	"		24.7			1.63	20	
Potassium	5.97	0.0500	"		5.92			0.841	20	
Sodium	80.0	0.100	"		81.4			1.73	20	

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: 8/23/2005

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas

12600 West I-20 East
Odessa, Texas 79765

Phone: 432-563-1800
Fax: 432-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris Pope
Company Name: Rice Operating
Company Address: 122 W. Taylor St.
City/State/Zip: Hobbs, NM 88240
Telephone No: (505) 393-9174 631-5075
Fax No: (505) 397-1471
Sampler Signature: [signature]

Project Name: ABO Apache LA Leak
Project #:
Project Loc: Lovington
PO #:

Analyze For: TCLP: / TOTAL: X (BTEX)

LAB # (lab use only) 5H11001	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl (2) 40mL glass	NaOH	H_2SO_4	None (1) L HDPE	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	TPH: 418.1 8015M 1005 1006	Cations (Ca, Mg, Na, K)	Anions (Cl, SO4, CO3, HCO3)	SAR / ESP / CEC	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030 or BTEX 8260	RCI	N.O.R.M.	T.D.S.				RUSH TAT (Pre-Schedule)	Standard TAT
-01	Monitor Well #1	8-10-05	09:30	3	X		X			X		X					X	X					X			X					X

Special Instructions:
Please email analysis to Kristin: Kpriceswd@valornet.com

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	8-10-05	12:25	K Pope	8-10-05	1230
Relinquished by:	Date	Time	Received by ELOT:	Date	Time
[signature]	8/11	7:45	Jeanne McMurrey	8-11-05	0745

Sample Containers Intact? Y N (Y)
Temperature Upon Receipt: 2.0°C
Laboratory Comments:
Labels + seals on containers
Seal on cooler

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

Client: Rice Operating

Date/Time: 08-11-05 @ 0745

Order #: 5H11001

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	2.0 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:
H11001-01 Neutral pH. AA 8/11/05

Variance Documentation:

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

Regarding:

Corrective Action Taken:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Kristin Pope

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak

Project Number: None Given

Location: None Given

Lab Order Number: 5F16009

Report Date: 06/28/05

Rice Operating Co.	Project: ABO-Apache LA Leak	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Kristin Pope	06/28/05 14:04

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW-1	5F16009-01	Water	06/16/05 09:42	06/16/05 15:20

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
06/28/05 14:04

Organics by GC
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5F16009-01) Water									
Benzene	ND	0.00100	mg/L	1	EF51701	06/17/05	06/17/05	EPA 8021B	
Toluene	ND	0.00100	"	"	"	"	"	"	
Ethylbenzene	ND	0.00100	"	"	"	"	"	"	
Xylene (p/m)	ND	0.00100	"	"	"	"	"	"	
Xylene (o)	ND	0.00100	"	"	"	"	"	"	
Surrogate: a,a,a-Trifluorotoluene		*119 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*95.0 %*	*80-120*		"	"	"	"	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Project Number: None Given Project Manager: Kristin Pope	Fax: (505) 397-1471 **Reported:** 06/28/05 14:04

General Chemistry Parameters by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5F16009-01) Water									
Total Alkalinity	**153**	2.00	mg/L	1	EF52213	06/22/05	06/22/05	EPA 310.2M	
Chloride	**71.8**	2.50	"	5	EF52001	06/17/05	06/17/05	EPA 300.0	
Total Dissolved Solids	**389**	5.00	"	1	EF52212	06/22/05	06/23/05	EPA 160.1	
Sulfate	**84.0**	2.50	"	5	EF52001	06/17/05	06/17/05	EPA 300.0	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471
Reported:
06/28/05 14:04

Total Metals by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5F16009-01) Water									
Calcium	**69.2**	0.100	mg/L	10	EF52114	06/21/05	06/21/05	EPA 6010B	
Magnesium	**10.9**	0.0100	"	"	"	"	"	"	
Potassium	**4.70**	0.0500	"	1	"	"	"	"	
Sodium	**49.7**	0.100	"	10	"	"	"	"	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
06/28/05 14:04

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 EF51701 - EPA 5030C (GC)										
Blank (EF51701-BLK1)				Prepared & Analyzed: 06/17/05						
Benzene	ND	0.00100	mg/L							
Toluene	ND	0.00100	"							
Ethylbenzene	ND	0.00100	"							
Xylene (p/m)	ND	0.00100	"							
Xylene (o)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	*21.5*		*ug/l*	*20.0*		*108*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*16.4*		*"*	*20.0*		*82.0*	*80-120*			
LCS (EF51701-BS1)				Prepared & Analyzed: 06/17/05						
Benzene	98.2		ug/l	100		98.2	80-120			
Toluene	99.0		"	100		99.0	80-120			
Ethylbenzene	89.8		"	100		89.8	80-120			
Xylene (p/m)	177		"	200		88.5	80-120			
Xylene (o)	82.1		"	100		82.1	80-120			
Surrogate: a,a,a-Trifluorotoluene	*18.2*		*"*	*20.0*		*91.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*19.0*		*"*	*20.0*		*95.0*	*80-120*			
LCS Dup (EF51701-BSD1)				Prepared & Analyzed: 06/17/05						
Benzene	112		ug/l	100		112	80-120	13.1	20	
Toluene	113		"	100		113	80-120	13.2	20	
Ethylbenzene	103		"	100		103	80-120	13.7	20	
Xylene (p/m)	199		"	200		99.5	80-120	11.7	20	
Xylene (o)	94.3		"	100		94.3	80-120	13.8	20	
Surrogate: a,a,a-Trifluorotoluene	*20.1*		*"*	*20.0*		*100*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*17.2*		*"*	*20.0*		*86.0*	*80-120*			
Calibration Check (EF51701-CCV1)				Prepared & Analyzed: 06/17/05						
Benzene	112		ug/l	100		112	80-120			
Toluene	112		"	100		112	80-120			
Ethylbenzene	108		"	100		108	80-120			
Xylene (p/m)	201		"	200		100	80-120			
Xylene (o)	93.6		"	100		93.6	80-120			
Surrogate: a,a,a-Trifluorotoluene	*20.7*		*"*	*20.0*		*104*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*21.1*		*"*	*20.0*		*106*	*80-120*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
06/28/05 14:04

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 EF51701 - EPA 5030C (GC)										
Matrix Spike (EF51701-MS1)	**Source: 5F17006-01**		Prepared & Analyzed: 06/17/05							
Benzene	103		ug/l	100	ND	103	80-120			
Toluene	114		"	100	ND	114	80-120			
Ethylbenzene	105		"	100	ND	105	80-120			
Xylene (p/m)	203		"	200	ND	102	80-120			
Xylene (o)	91.9		"	100	ND	91.9	80-120			
Surrogate: a,a,a-Trifluorotoluene	*20.6*		"	*20.0*		*103*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*20.0*		"	*20.0*		*100*	*80-120*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
06/28/05 14:04

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 EF52001 - General Preparation (WetChem)										
Blank (EF52001-BLK1)				Prepared & Analyzed: 06/17/05						
Chloride	ND	0.500	mg/L							
Sulfate	ND	0.500	"							
LCS (EF52001-BS1)				Prepared & Analyzed: 06/17/05						
Chloride	11.5		mg/L	10.0		115	80-120			
Sulfate	11.1		"	10.0		111	80-120			
Calibration Check (EF52001-CCV1)				Prepared & Analyzed: 06/17/05						
Chloride	11.1		mg/L	10.0		111	80-120			
Sulfate	10.4		"	10.0		104	80-120			
Duplicate (EF52001-DUP1)	**Source: 5F16004-02**			Prepared & Analyzed: 06/17/05						
Chloride	90.7	2.50	mg/L		96.5			6.20	20	
Sulfate	70.2	2.50	"		76.0			7.93	20	
Batch EF52212 - Filtration Preparation										
Blank (EF52212-BLK1)				Prepared: 06/22/05 Analyzed: 06/23/05						
Total Dissolved Solids	ND	5.00	mg/L							
Duplicate (EF52212-DUP1)	**Source: 5F16004-04**			Prepared: 06/22/05 Analyzed: 06/23/05						
Total Dissolved Solids	277	5.00	mg/L		276			0.362	20	
Batch EF52213 - General Preparation (WetChem)										
Blank (EF52213-BLK1)				Prepared & Analyzed: 06/22/05						
Total Alkalinity	ND	2.00	mg/L							

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 EF52213 - General Preparation (WetChem)										
Duplicate (EF52213-DUP1)		**Source: 5F16009-01**		Prepared & Analyzed: 06/22/05						
Total Alkalinity	153	2.00	mg/L		153			0.00	20	
Reference (EF52213-SRM1)				Prepared & Analyzed: 06/22/05						
Bicarbonate Alkalinity	230		mg/L	200		115	80-120			

Total Metals 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 EF52114 - 6010B/No Digestion										
Blank (EF52114-BLK1)				Prepared & Analyzed: 06/21/05						
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Calibration Check (EF52114-CCV1)				Prepared & Analyzed: 06/21/05						
Calcium	1.94		mg/L	2.00		97.0	85-115			
Magnesium	2.14		"	2.00		107	85-115			
Potassium	1.75		"	2.00		87.5	85-115			
Sodium	1.73		"	2.00		86.5	85-115			
Duplicate (EF52114-DUP1)	Source: 5F16004-01			Prepared & Analyzed: 06/21/05						
Calcium	20.4	0.100	mg/L		21.8			6.64	20	
Magnesium	19.6	0.0100	"		21.9			11.1	20	
Potassium	10.1	0.500	"		10.5			3.88	20	
Sodium	64.0	0.100	"		65.2			1.86	20	

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Project Number: None Given Project Manager: Kristin Pope	Fax: (505) 397-1471 **Reported:** 06/28/05 14:04

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: 6/28/2005

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

This material is intended only for the use of the individual (s) or entity to whom it is addressed, and may contain information that is privileged and confidential.

If you have received this material in error, please notify us immediately at 432-563-1800.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris Pope
Company Name: Rice Operating
Company Address: 122 W. Taylor
City/State/Zip: Hobbs NM 88240
Telephone No: (505) 393-9174
Fax No: (505) 397-1471
Sampler Signature:

Project Name: Abo Apache CA Leak
Project #:
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify):	TDS / CL / SAR / EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	Cations	Anions					RUSH TAT (Pre-Schedule)	Standard TAT
5F16007 -01	MW-1	2005 June 16	9:42am	3	X		X					X											X	X	X						X

Preservative / Matrix / Analyze For: TCLP: TOTAL:

Special Instructions: Please E-mail analysis to Kristin enviro@leaco.net

Relinquished by:	Date	Time	Received by:	Date	Time
Roy R. Rascon	6-16-05	11:54	Norma Brady	6.16.05	11:54
Relinquished by: Norma Brady	6-16-05	15:20	Received by ELOT: [signature]	6/16/05	15:20

Sample Containers Intact? (Y) N
Temperature Upon Receipt:
Laboratory Comments: 1.0
2-VOA HCl
1-16

Environmental Lab of Texas

Variance / Corrective Action Report – Sample Log-In

Client: RICE

Date/Time: 6/16/05 15:20

Order #: 5F16009

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:

ENVIRONMENTAL LAB OF TEXAS

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Kristin Pope

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak

Project Number: None Given

Location: Hobbs

Lab Order Number: 5E24015

Report Date: 06/07/05

Rice Operating Co.	Project: ABO-Apache LA Leak	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Kristin Pope	06/07/05 14:09

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW-1	5E24015-01	Water	05/23/05 09:23	05/24/05 15:40

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported: 06/07/05 14:09

Organics by GC
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5E24015-01) Water									
Benzene	ND	0.00100	mg/L	1	EE52604	05/26/05	05/26/05	EPA 8021B	
Toluene	ND	0.00100	"	"	"	"	"	"	
Ethylbenzene	ND	0.00100	"	"	"	"	"	"	
Xylene (p/m)	ND	0.00100	"	"	"	"	"	"	
Xylene (o)	ND	0.00100	"	"	"	"	"	"	
Surrogate: a,a,a-Trifluorotoluene		*98.0 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*97.0 %*	*80-120*		"	"	"	"	

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5E24015-01) Water									
Total Alkalinity	**170**	2.00	mg/L	1	EE52509	05/24/05	05/24/05	EPA 310.2M	
Chloride	**98.4**	2.50	"	5	EE52703	05/27/05	05/27/05	EPA 300.0	
Total Dissolved Solids	**573**	5.00	"	1	EF50109	05/27/05	05/27/05	EPA 160.1	
Sulfate	**82.2**	2.50	"	5	EE52703	05/27/05	05/27/05	EPA 300.0	

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Project Number: None Given Project Manager: Kristin Pope	Fax: (505) 397-1471 **Reported:** 06/07/05 14:09

Total Metals by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5E24015-01) Water									
Calcium	**78.3**	0.100	mg/L	10	EE52518	05/25/05	05/25/05	EPA 6010B	
Magnesium	**13.3**	0.0100	"	"	"	"	"	"	
Potassium	**4.83**	0.0500	"	1	"	"	"	"	
Sodium	**56.4**	0.100	"	10	"	"	"	"	

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 EE52604 - EPA 5030C (GC)										
Blank (EE52604-BLK1)				Prepared & Analyzed: 05/26/05						
Benzene	ND	0.00100	mg/L							
Toluene	ND	0.00100	"							
Ethylbenzene	ND	0.00100	"							
Xylene (p/m)	ND	0.00100	"							
Xylene (o)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	*20.2*		*ug/l*	*20.0*		*101*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*17.1*		*"*	*20.0*		*85.5*	*80-120*			
LCS (EE52604-BS1)				Prepared & Analyzed: 05/26/05						
Benzene	93.7		ug/l	100		93.7	80-120			
Toluene	100		"	100		100	80-120			
Ethylbenzene	102		"	100		102	80-120			
Xylene (p/m)	205		"	200		102	80-120			
Xylene (o)	101		"	100		101	80-120			
Surrogate: a,a,a-Trifluorotoluene	*21.3*		*"*	*20.0*		*106*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*22.6*		*"*	*20.0*		*113*	*80-120*			
Calibration Check (EE52604-CCV1)				Prepared: 05/26/05		Analyzed: 05/27/05				
Benzene	87.9		ug/l	100		87.9	80-120			
Toluene	96.3		"	100		96.3	80-120			
Ethylbenzene	98.2		"	100		98.2	80-120			
Xylene (p/m)	197		"	200		98.5	80-120			
Xylene (o)	96.2		"	100		96.2	80-120			
Surrogate: a,a,a-Trifluorotoluene	*19.4*		*"*	*20.0*		*97.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*23.3*		*"*	*20.0*		*116*	*80-120*			
Matrix Spike (EE52604-MS1)	**Source: 5E23014-01**			Prepared & Analyzed: 05/26/05						
Benzene	95.4		ug/l	100	ND	95.4	80-120			
Toluene	101		"	100	ND	101	80-120			
Ethylbenzene	100		"	100	ND	100	80-120			
Xylene (p/m)	203		"	200	ND	102	80-120			
Xylene (o)	98.2		"	100	ND	98.2	80-120			
Surrogate: a,a,a-Trifluorotoluene	*19.8*		*"*	*20.0*		*99.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*20.3*		*"*	*20.0*		*102*	*80-120*			

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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 EE52604 - EPA 5030C (GC)										
Matrix Spike Dup (EE52604-MSD1)	**Source: 5E23014-01**			Prepared & Analyzed: 05/26/05						
Benzene	92.8		ug/l	100	ND	92.8	80-120	2.76	20	
Toluene	97.3		"	100	ND	97.3	80-120	3.73	20	
Ethylbenzene	98.9		"	100	ND	98.9	80-120	1.11	20	
Xylene (p/m)	202		"	200	ND	101	80-120	0.985	20	
Xylene (o)	99.1		"	100	ND	99.1	80-120	0.912	20	
Surrogate: a,a,a-Trifluorotoluene	*19.8*		"	*20.0*		*99.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*21.8*		"	*20.0*		*109*	*80-120*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
06/07/05 14:09

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 EE52509 - General Preparation (WetChem)										
Blank (EE52509-BLK1)				Prepared & Analyzed: 05/24/05						
Total Alkalinity	ND	2.00	mg/L							
Duplicate (EE52509-DUP1)	**Source: 5E19001-01**			Prepared & Analyzed: 05/24/05						
Total Alkalinity	215	2.00	mg/L		214			0.466	20	
Reference (EE52509-SRM1)				Prepared & Analyzed: 05/24/05						
Bicarbonate Alkalinity	230		mg/L	200		115	80-120			
Batch EE52703 - General Preparation (WetChem)										
Blank (EE52703-BLK1)				Prepared & Analyzed: 05/27/05						
Chloride	ND	0.500	mg/L							
Sulfate	ND	0.500	"							
LCS (EE52703-BS1)				Prepared & Analyzed: 05/27/05						
Chloride	10.9		mg/L	10.0		109	80-120			
Sulfate	9.99		"	10.0		99.9	80-120			
Calibration Check (EE52703-CCV1)				Prepared & Analyzed: 05/27/05						
Chloride	10.6		mg/L	10.0		106	80-120			
Sulfate	9.87		"	10.0		98.7	80-120			
Duplicate (EE52703-DUP1)	**Source: 5E24015-01**			Prepared & Analyzed: 05/27/05						
Chloride	100	2.50	mg/L		98.4			1.61	20	
Sulfate	82.3	2.50	"		82.2			0.122	20	

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471
Reported:
06/07/05 14:09

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 EF50109 - Filtration Preparation										
Blank (EF50109-BLK1)				Prepared & Analyzed: 05/27/05						
Total Dissolved Solids	ND	5.00	mg/L							
Duplicate (EF50109-DUP1)	**Source: 5E24015-01**			Prepared & Analyzed: 05/27/05						
Total Dissolved Solids	567	5.00	mg/L		573			1.05	20	

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
06/07/05 14:09

Total Metals 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 EE52518 - 6010B/No Digestion										
Blank (EE52518-BLK1)				Prepared & Analyzed: 05/25/05						
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Blank (EE52518-BLK2)				Prepared & Analyzed: 05/25/05						
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Calibration Check (EE52518-CCV1)				Prepared & Analyzed: 05/25/05						
Calcium	1.86		mg/L	2.00		93.0	85-115			
Magnesium	2.10		"	2.00		105	85-115			
Potassium	1.93		"	2.00		96.5	85-115			
Sodium	2.18		"	2.00		109	85-115			
Duplicate (EE52518-DUP1)	**Source: 5E19001-01**			Prepared & Analyzed: 05/25/05						
Calcium	51.6	0.500	mg/L		56.0			8.18	20	
Magnesium	26.4	0.0100	"		27.2			2.99	20	
Potassium	5.70	0.0500	"		5.69			0.176	20	
Sodium	109	0.100	"		110			0.913	20	
Duplicate (EE52518-DUP2)	**Source: 5E24016-01**			Prepared & Analyzed: 05/25/05						
Calcium	90.2	0.100	mg/L		89.5			0.779	20	
Magnesium	50.6	0.0100	"		50.5			0.198	20	
Potassium	10.7	0.500	"		11.0			2.76	20	
Sodium	244	0.500	"		248			1.63	20	

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: 6/7/2005

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer
Jeanne Mc Murrey, Inorg. Tech Director
James L. Hawkins, Chemist/Geologist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas I, Ltd.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris Pope

Company Name: Rice Operating

Company Address: 122 W Taylor St.

City/State/Zip: Hobbs, NM 88240

Telephone No: (505) 393-9174

Fax No: (505) 397-1471

Sampler Signature:

Project Name: Abo Apache LA Leak

Project #:

Project Loc: Hobbs

PO #:

5E24015

LAB # (lab use only)	FIELD CODE	Date Sampled (2005)	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	Analyze For (TCLP: / TOTAL:): TPH: 418.1 8015M 1005 1006	Cations (Ca, Mg, Na, K)	Anions (Cl, SO4, CO3, HCO3)	SAR / ESP / CEC	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RCI	N.O.R.M.	Total Gamma	Total Dissolved Solids			RUSH TAT (Pre-Schedule)	Standard TAT
-01	MW-1	May 23	9:23	3	X		X					X					X	X					X				X				X

Special Instructions: Please email analysis to Kristin enviro@leaco.net

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	5-23-05	13:23	K. Pope	5-23-05	13:23
Kristin Pope	5-24-05	15:40	Received by ELOT: Connie Kelly	5/24/05	15:40

Sample Containers Intact? Y N

Temperature Upon Receipt:

Laboratory Comments:

-2.0
2 - VOA
1 - 1L

Environmental Lab of Texas

Variance / Corrective Action Report – Sample Log-In

Client: Rice Operating

Date/Time: 5/24/05 3:55

Order #: 5E24015

Initials: CK

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	-2.0 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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Kristin Pope

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak

Project Number: None Given

Location: Lovington

Lab Order Number: 5C02003

Report Date: 03/15/05

Rice Operating Co.	Project: ABO-Apache LA Leak	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Kristin Pope	03/15/05 12:19

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW-1	5C02003-01	Water	03/01/05 14:10	03/01/05 18:45

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5C02003-01) Water									
Total Alkalinity	**148**	2.00	mg/L	1	EC50405	03/03/05	03/03/05	EPA 310.2M	
Chloride	**120**	2.50	"	5	EC50903	03/03/05	03/03/05	EPA 300.0	
Sulfate	**91.8**	2.50	"	"	"	"	"	"	
MW-1 (5C02003-01RE1) Water									
Total Dissolved Solids	**532**	5.00	mg/L	1	EC50311	03/11/05	03/11/05	EPA 160.1	O-04, QC-08

Total Metals by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5C02003-01) Water									
Calcium	**85.2**	0.100	mg/L	10	EC50412	03/03/05	03/04/05	EPA 6010B	
Magnesium	**13.5**	0.0100	"	"	"	"	"	"	
Potassium	**5.10**	0.100	"	2	"	"	"	"	
Sodium	**48.3**	0.100	"	10	"	"	"	"	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
03/15/05 12:19

Volatile Organic Compounds by EPA Method 8260B

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (5C02003-01) Water									
Benzene	ND	1.00	ug/l	1	EC50703	03/04/05	03/04/05	EPA 8260B	
Toluene	ND	1.00	"	"	"	"	"	"	
Ethylbenzene	ND	1.00	"	"	"	"	"	"	
Xylene (p/m)	ND	1.00	"	"	"	"	"	"	
Xylene (o)	ND	1.00	"	"	"	"	"	"	
Surrogate: Dibromofluoromethane		*112 %*	*68-129*		"	"	"	"	
Surrogate: 1,2-Dichloroethane-d4		*90.2 %*	*72-132*		"	"	"	"	
Surrogate: Toluene-d8		*104 %*	*74-118*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*101 %*	*65-140*		"	"	"	"	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
03/15/05 12:19

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 EC50311 - 410.4										
Blank (EC50311-BLK1)				Prepared: 03/02/05	Analyzed: 03/03/05					
Total Dissolved Solids	ND	5.00	mg/L							
Duplicate (EC50311-DUP1)	**Source: 5C02003-01**			Prepared: 03/02/05	Analyzed: 03/03/05					
Total Dissolved Solids	1150	5.00	mg/L		1080			6.28	20	
Duplicate (EC50311-DUP2)	**Source: 5C02003-01RE1**			Prepared & Analyzed: 03/11/05						
Total Dissolved Solids	556	5.00	mg/L		532			4.41	20	
Batch EC50405 - General Preparation (WetChem)										
Blank (EC50405-BLK1)				Prepared & Analyzed: 03/03/05						
Total Alkalinity	ND	2.00	mg/L							
Calibration Check (EC50405-CCV1)				Prepared & Analyzed: 03/03/05						
Carbonate Alkalinity	0.0500		mg/L	0.0500		100	80-120			
Duplicate (EC50405-DUP1)	**Source: 5C02003-01**			Prepared & Analyzed: 03/03/05						
Total Alkalinity	149	2.00	mg/L		148			0.673	20	
Batch EC50903 - General Preparation (WetChem)										
Blank (EC50903-BLK1)				Prepared & Analyzed: 03/03/05						
Chloride	ND	0.500	mg/L							
Sulfate	ND	0.500	"							
LCS (EC50903-BS1)				Prepared & Analyzed: 03/03/05						
Chloride	10.2		mg/L	10.0		102	80-120			
Sulfate	10.5		"	10.0		105	80-120			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
03/15/05 12:19

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 EC50903 - General Preparation (WetChem)										
Calibration Check (EC50903-CCV1)				Prepared & Analyzed: 03/03/05						
Chloride	10.5		mg/L	10.0		105	80-120			
Sulfate	10.8		"	10.0		108	80-120			
Duplicate (EC50903-DUP1)		**Source: 5C02010-01**		Prepared & Analyzed: 03/03/05						
Sulfate	87.5	2.50	mg/L		87.9			0.456	20	
Chloride	529	10.0	"		577			8.68	20	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471
Reported:
03/15/05 12:19

Total Metals 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 EC50412 - 6010B/No Digestion										
Blank (EC50412-BLK1)				Prepared: 03/03/05		Analyzed: 03/04/05				
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Calibration Check (EC50412-CCV1)				Prepared: 03/03/05		Analyzed: 03/04/05				
Calcium	2.25		mg/L	2.00		112	85-115			
Magnesium	2.30		"	2.00		115	85-115			
Potassium	1.85		"	2.00		92.5	85-115			
Sodium	1.82		"	2.00		91.0	85-115			
Duplicate (EC50412-DUP1)		Source: 5B25005-01		Prepared: 03/03/05		Analyzed: 03/04/05				
Calcium	104	0.100	mg/L		99.2			4.72	20	
Magnesium	38.9	0.0100	"		41.0			5.26	20	
Potassium	10.8	0.500	"		11.1			2.74	20	
Sodium	267	1.00	"		252			5.78	20	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
03/15/05 12:19

Volatile Organic Compounds by EPA Method 8260B - Quality Control

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EC50703 - EPA 5030C (GCMS)										
Blank (EC50703-BLK1)				Prepared & Analyzed: 03/04/05						
Benzene	ND	1.00	ug/l							
Toluene	ND	1.00	"							
Ethylbenzene	ND	1.00	"							
Xylene (p/m)	ND	1.00	"							
Xylene (o)	ND	1.00	"							
Surrogate: Dibromofluoromethane	*50.5*		"	*50.0*		*101*	*68-129*			
Surrogate: 1,2-Dichloroethane-d4	*42.6*		"	*50.0*		*85.2*	*72-132*			
Surrogate: Toluene-d8	*48.6*		"	*50.0*		*97.2*	*74-118*			
Surrogate: 4-Bromofluorobenzene	*48.1*		"	*50.0*		*96.2*	*65-140*			
LCS (EC50703-BS1)				Prepared & Analyzed: 03/04/05						
Benzene	55.7		ug/l	50.0		111	70-130			
Toluene	56.6		"	50.0		113	70-130			
Ethylbenzene	54.5		"	50.0		109	70-130			
Xylene (p/m)	95.6		"	100		95.6	70-130			
Xylene (o)	56.0		"	50.0		112	70-130			
Surrogate: Dibromofluoromethane	*51.0*		"	*50.0*		*102*	*68-129*			
Surrogate: 1,2-Dichloroethane-d4	*47.6*		"	*50.0*		*95.2*	*72-132*			
Surrogate: Toluene-d8	*50.1*		"	*50.0*		*100*	*74-118*			
Surrogate: 4-Bromofluorobenzene	*50.2*		"	*50.0*		*100*	*65-140*			
Calibration Check (EC50703-CCV1)				Prepared & Analyzed: 03/04/05						
Toluene	54.0		ug/l	50.0		108	70-130			
Ethylbenzene	50.7		"	50.0		101	70-130			
Surrogate: Dibromofluoromethane	*51.1*		"	*50.0*		*102*	*68-129*			
Surrogate: 1,2-Dichloroethane-d4	*44.2*		"	*50.0*		*88.4*	*72-132*			
Surrogate: Toluene-d8	*50.4*		"	*50.0*		*101*	*74-118*			
Surrogate: 4-Bromofluorobenzene	*48.6*		"	*50.0*		*97.2*	*65-140*			

Volatile Organic Compounds by EPA Method 8260B - Quality Control

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EC50703 - EPA 5030C (GCMS)										
Matrix Spike (EC50703-MS1)	**Source: 5C02003-01**			Prepared & Analyzed: 03/04/05						
Benzene	56.9		ug/l	50.0	ND	114	80-120			
Toluene	58.8		"	50.0	ND	118	80-120			
Ethylbenzene	58.3		"	50.0	ND	117	80-120			
Xylene (p/m)	104		"	100	ND	104	80-120			
Xylene (o)	58.7		"	50.0	ND	117	80-120			
Surrogate: Dibromofluoromethane	*51.3*		"	*50.0*		*103*	*68-129*			
Surrogate: 1,2-Dichloroethane-d4	*48.4*		"	*50.0*		*96.8*	*72-132*			
Surrogate: Toluene-d8	*50.3*		"	*50.0*		*101*	*74-118*			
Surrogate: 4-Bromofluorobenzene	*49.7*		"	*50.0*		*99.4*	*65-140*			
Matrix Spike Dup (EC50703-MSD1)	**Source: 5C02003-01**			Prepared & Analyzed: 03/04/05						
Benzene	56.2		ug/l	50.0	ND	112	80-120	1.24	20	
Toluene	58.1		"	50.0	ND	116	80-120	1.20	20	
Ethylbenzene	57.1		"	50.0	ND	114	80-120	2.08	20	
Xylene (p/m)	100		"	100	ND	100	80-120	3.92	20	
Xylene (o)	58.4		"	50.0	ND	117	80-120	0.512	20	
Surrogate: Dibromofluoromethane	*49.2*		"	*50.0*		*98.4*	*68-129*			
Surrogate: 1,2-Dichloroethane-d4	*47.0*		"	*50.0*		*94.0*	*72-132*			
Surrogate: Toluene-d8	*49.2*		"	*50.0*		*98.4*	*74-118*			
Surrogate: 4-Bromofluorobenzene	*48.5*		"	*50.0*		*97.0*	*65-140*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
03/15/05 12:19

Notes and Definitions

QC-08	Sample was originally analyzed within holding time. However, it was determined that positive interferences contributed to the sample results. The sample was rerun with lower volume of sample.
O-04	This sample was analyzed outside the EPA recommended holding time.
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: 3/15/05

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer
Jeanne Mc Murrey, Inorg. Tech Director
James L. Hawkins, Chemist/Geologist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas

12600 West I-20 East
Odessa, Texas 79765
Phone: 432-563-1800
Fax: 432-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris Pope
Company Name: Rice Operating
Company Address: 122 W Taylor
City/State/Zip: Hobbs, NM 88240
Telephone No: (505) 393-9174
Fax No: (505) 397-1471
Sampler Signature: Jake Vance

Project Name: ABO - APACHE LA LEAK
Project #:
Project Loc: LOVINGTON
PO #:

5C02003

Preservative: Ice, HNO_3, HCl, NaOH, H_2SO_4, None, Other (Specify). Matrix: Water, Sludge, Soil, Other (specify). Analyze For (TCLP: / TOTAL:): TPH through the unnamed columns after TDS.

LAB # (lab use only)	FIELD CODE	Date Sampled (2005)	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify):	TPH: 418.1 8015M 1005 1006	Cations (Ca, Mg, Na, K)	Anions (Cl, SO4, CO3, HCO3)	SAR / ESP / CEC	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030 or BTEX 8260	RCI	N.O.R.M.	TDS				RUSH TAT (Pre-Schedule)	Standard TAT
-01	MW-1	3/1/2005	14:10	3	X		X					X					X	X					X			X					

Special Instructions: Please email analysis to Kristin enviro@leaco.net

Relinquished by:	Date	Time	Received by:	Date	Time
Jake Vance	3-1-05	14:34	Kristin Pope	3-1-05	14:35
Kristin Pope	3-1-05	4:30pm	Received by ELOT: [illegible signature]	3-1-05	18:45

MST Rol c/c 3-1-05 1845

Sample Containers Intact? Y N
Temperature Upon Receipt:
Laboratory Comments:
Rec 3.0°C
2 VOA
1 L HDPE

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

Client: Rice Operating

Date/Time: 3/2/05 8:20

Order #: 5C02003

Initials: CK

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	3.0 C
Shipping container/cooler in good condition?	Yes	No	
Custody Seals intact on shipping container/cooler?	Yes	No	~~Not present~~ CK 3-02-05
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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Kristin Pope

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak

Project Number: None Given

Location: Lovington

Lab Order Number: 4L06004

Report Date: 12/16/04

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW-1	4L06004-01	Water	12/03/04 08:30	12/06/04 10:35

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471
Reported:
12/16/04 09:21

Organics by GC
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Benzene	ND	0.00100	mg/L	1	EL40913	12/08/04	12/08/04	EPA 8021B	
Toluene	ND	0.00100	"	"	"	"	"	"	
Ethylbenzene	ND	0.00100	"	"	"	"	"	"	
Xylene (p/m)	ND	0.00100	"	"	"	"	"	"	
Xylene (o)	ND	0.00100	"	"	"	"	"	"	
Surrogate: a,a,a-Trifluorotoluene		*101 %*	*80-120*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*96.0 %*	*80-120*		"	"	"	"	

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Total Alkalinity	**142**	2.00	mg/L	1	EL41406	12/10/04	12/10/04	EPA 310.2M	
Chloride	**80.5**	5.00	"	10	EL40916	12/08/04	12/08/04	EPA 300.0	
Total Dissolved Solids	**329**	5.00	"	1	EL40702	12/06/04	12/07/04	EPA 160.1	
Sulfate	**85.7**	5.00	"	10	EL40916	12/08/04	12/08/04	EPA 300.0	

Total Metals by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
MW-1 (4L06004-01) Water									
Calcium	**60.0**	0.100	mg/L	10	EL41408	12/14/04	12/14/04	EPA 6010B	
Magnesium	**12.9**	0.0100	"	"	"	"	"	"	
Potassium	**2.67**	0.500	"	"	"	"	"	"	
Sodium	**42.4**	0.100	"	"	"	"	"	"	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL40913 - EPA 5030C (GC)										
Blank (EL40913-BLK1)				Prepared & Analyzed: 12/08/04						
Benzene	ND	0.00100	mg/L							
Toluene	ND	0.00100	"							
Ethylbenzene	ND	0.00100	"							
Xylene (p/m)	ND	0.00100	"							
Xylene (o)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	*19.8*		*ug/l*	*20.0*		*99.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*17.4*		*"*	*20.0*		*87.0*	*80-120*			
LCS (EL40913-BS1)				Prepared & Analyzed: 12/08/04						
Benzene	94.3		ug/l	100		94.3	80-120			
Toluene	97.6		"	100		97.6	80-120			
Ethylbenzene	96.2		"	100		96.2	80-120			
Xylene (p/m)	194		"	200		97.0	80-120			
Xylene (o)	99.5		"	100		99.5	80-120			
Surrogate: a,a,a-Trifluorotoluene	*17.8*		*"*	*20.0*		*89.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*22.1*		*"*	*20.0*		*110*	*80-120*			
LCS Dup (EL40913-BSD1)				Prepared & Analyzed: 12/08/04						
Benzene	97.4		ug/l	100		97.4	80-120	3.23	20	
Toluene	100		"	100		100	80-120	2.43	20	
Ethylbenzene	102		"	100		102	80-120	5.85	20	
Xylene (p/m)	202		"	200		101	80-120	4.04	20	
Xylene (o)	103		"	100		103	80-120	3.46	20	
Surrogate: a,a,a-Trifluorotoluene	*18.7*		*"*	*20.0*		*93.5*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*22.2*		*"*	*20.0*		*111*	*80-120*			
Calibration Check (EL40913-CCV1)				Prepared & Analyzed: 12/08/04						
Benzene	97.0		ug/l	100		97.0	80-120			
Toluene	99.1		"	100		99.1	80-120			
Ethylbenzene	101		"	100		101	80-120			
Xylene (p/m)	199		"	200		99.5	80-120			
Xylene (o)	101		"	100		101	80-120			
Surrogate: a,a,a-Trifluorotoluene	*19.4*		*"*	*20.0*		*97.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*21.5*		*"*	*20.0*		*108*	*80-120*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL40913 - EPA 5030C (GC)										
Matrix Spike (EL40913-MS1)	**Source: 4L06002-01**		Prepared & Analyzed: 12/08/04							
Benzene	102		ug/l	100	ND	102	80-120			
Toluene	102		"	100	ND	102	80-120			
Ethylbenzene	101		"	100	ND	101	80-120			
Xylene (p/m)	203		"	200	ND	102	80-120			
Xylene (o)	111		"	100	ND	111	80-120			
Surrogate: a,a,a-Trifluorotoluene	*18.4*		"	*20.0*		*92.0*	*80-120*			
Surrogate: 4-Bromofluorobenzene	*19.5*		"	*20.0*		*97.5*	*80-120*			

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak
Project Number: None Given
Project Manager: Kristin Pope

Fax: (505) 397-1471

Reported:
12/16/04 09:21

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 EL40702 - General Preparation (WetChem)										
Blank (EL40702-BLK1)				Prepared: 12/06/04	Analyzed: 12/07/04					
Total Dissolved Solids	ND	5.00	mg/L							
Duplicate (EL40702-DUP1)	**Source: 4L03001-01**			Prepared: 12/06/04	Analyzed: 12/07/04					
Total Dissolved Solids	4120	5.00	mg/L		4030			2.21	20	
Batch EL40916 - General Preparation (WetChem)										
Blank (EL40916-BLK1)				Prepared & Analyzed: 12/08/04						
Chloride	0.00	0.500	mg/L							
Sulfate	0.00	0.500	"							
Blank (EL40916-BLK2)				Prepared & Analyzed: 12/08/04						
Sulfate	0.00	0.500	mg/L							
Chloride	0.00	0.500	"							
LCS (EL40916-BS1)				Prepared & Analyzed: 12/08/04						
Chloride	9.75	0.500	mg/L	10.0		97.5	80-120			
Sulfate	11.7	0.500	"	10.0		117	80-120			
LCS (EL40916-BS2)				Prepared & Analyzed: 12/08/04						
Chloride	9.77	0.500	mg/L	10.0		97.7	80-120			
Sulfate	11.8	0.500	"	10.0		118	80-120			
LCS Dup (EL40916-BSD1)				Prepared & Analyzed: 12/08/04						
Sulfate	11.8	0.500	mg/L	10.0		118	80-120	0.851	20	
Chloride	9.83	0.500	"	10.0		98.3	80-120	0.817	20	

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 EL40916 - General Preparation (WetChem)										
LCS Dup (EL40916-BSD2)				Prepared & Analyzed: 12/08/04						
Chloride	9.74	0.500	mg/L	10.0		97.4	80-120	0.308	20	
Sulfate	11.7	0.500	"	10.0		117	80-120	0.851	20	
Calibration Check (EL40916-CCV1)				Prepared & Analyzed: 12/08/04						
Chloride	9.79		mg/L	10.0		97.9	80-120			
Sulfate	11.7		"	10.0		117	80-120			
Calibration Check (EL40916-CCV2)				Prepared & Analyzed: 12/08/04						
Chloride	9.80		mg/L	10.0		98.0	80-120			
Sulfate	11.7		"	10.0		117	80-120			
Duplicate (EL40916-DUP1)	**Source: 4L03001-01**			Prepared & Analyzed: 12/08/04						
Chloride	1570	20.0	mg/L		1330			16.6	20	
Sulfate	809	20.0	"		682			17.0	20	
Duplicate (EL40916-DUP2)	**Source: 4L06003-02**			Prepared & Analyzed: 12/08/04						
Chloride	731	20.0	mg/L		725			0.824	20	
Sulfate	1210	20.0	"		1200			0.830	20	
Batch EL41406 - General Preparation (WetChem)										
Blank (EL41406-BLK1)				Prepared & Analyzed: 12/10/04						
Total Alkalinity	ND	2.00	mg/L							
Duplicate (EL41406-DUP1)	**Source: 4L06003-01**			Prepared & Analyzed: 12/10/04						
Total Alkalinity	161	2.00	mg/L		160			0.623	20	

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 EL41406 - General Preparation (WetChem)										
Reference (EL41406-SRM1)				Prepared & Analyzed: 12/10/04						
Carbonate Alkalinity	0.0501		mg/L	0.0500		100	80-120			

Total Metals 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 EL41408 - 6010B/No Digestion										
Blank (EL41408-BLK1)				Prepared & Analyzed: 12/14/04						
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	"							
Calibration Check (EL41408-CCV1)				Prepared & Analyzed: 12/14/04						
Calcium	1.95		mg/L	2.00		97.5	85-115			
Magnesium	2.06		"	2.00		103	85-115			
Potassium	2.18		"	2.00		109	85-115			
Sodium	1.77		"	2.00		88.5	85-115			
Duplicate (EL41408-DUP1)		**Source: 4L03004-01**		Prepared & Analyzed: 12/14/04						
Calcium	120	1.00	mg/L		127			5.67	20	
Magnesium	73.9	0.100	"		75.1			1.61	20	
Potassium	5.29	0.500	"		5.37			1.50	20	
Sodium	102	1.00	"		97.9			4.10	20	

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: Celey D. Keene Date: 12/16/2004

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer
Jeanne Mc Murrey, Inorg. Tech Director
James L. Hawkins, Chemist/Geologist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas

12600 West I-20 East
Odessa, Texas 79765
Phone: 432-563-1800
Fax: 432-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Kristin Farris Pope
Company Name: Rice Operating
Company Address: 122 W. Taylor St.
City/State/Zip: Hobbs, NM 88240
Telephone No: (505) 393-9174
Fax No: (505) 397-1471
Sampler Signature: [signature]

Project Name: ABO-APACHE LA Lea
Project #:
Project Loc: Lovington
PO #:

4L06004

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	Analyze For (TCLP: / TOTAL:): TPH: 418.1 8015M 1005 1006	Cations (Ca, Mg, Na, K)	Anions (Cl, SO4, CO3, HCO3)	SAR / ESP / CEC	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030 or BTEX 8260	RCI	N.O.R.M.	TDS				RUSH TAT (Pre-Schedule)	Standard TAT
-01	MW-1	12-3-04	8:30	3	X		X					X					X	X					X			X					X

Special Instructions:
Please email analysis to Kristin enviro@leaco.net

Sample Containers Intact? Y N
Temperature Upon Receipt:
Laboratory Comments:
Kee -3°C

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	12-6-04	9:35			
Relinquished by:	**Date**	**Time**	**Received by ELOT:**	**Date**	**Time**
			[signature]	12-06-04	10:35

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

Client: Rice Operation

Date/Time: 12/6/04 11:58

Order #: 4L06004

Initials: JLH

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	-3 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	No label on 1L Poly
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:

APPENDIX C & D

On attached CD

R. T. HICKS CONSULTANTS, LTD.
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

August 12, 2005

Roger Anderson
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Re: ABO 1G Release Site OCD Case #1R0415
Unit Letter G, Sec. 1, T17S, R36E
Lea County, NM

Dear Mr. Anderson:

On Monday, August 11 R.T. Hicks Consultants received the data from the extensive characterization conducted by Rice Operating Company for the above-referenced site. Plate 1 shows the level of effort expended by ROC: analysis of 73 near surface soil samples and 120 samples from 12 20-foot deep sampling trenches. The characterization program began on July 26.

In our July meeting, we stated that the inclusion of this earlier release in the modeling experiments would likely cause the model ground water to exceed the WQCC standards. Today, we completed the data preparation and input and are initiating the first of several simulation experiments. We will employ these new data from the upper vadose zone (0-20 feet below land surface) with the data from the deeper borings in new HYDRUS-1D simulations. We will include the chloride load caused by what we now know is a 1992 release from the site and the chloride load from the 2003 release. We will also account for the increased chloride load due to man's activity in the area that raised the chloride concentration in deep soil from near 90 ppm (pre-Columbian background) to the 100-200 ppm observed in the up gradient soil boring SB-2.

The first simulation planned assumes removal of chloride from the thin soil horizon overlying the caliche and the installation of a synthetic liner on the caliche layer to prevent infiltration of precipitation. A second experiment will assume that we excavate and export the topsoil and a portion of the underlying caliche, install a sloped clay layer, import clean fill, and create a sloped vegetative cap. We plan to examine other excavation remedies in order to select the remedy that is based upon sound science, compliant with the regulations, and effectively protects ground water quality.

By August 31, we propose to submit to NMOCD an amended Corrective Action Plan (CAP) for the site that will address not only the 2003 release but the effects of the 1992 release. In this report we will provide an explanation of our modeling protocol, a summary of the ROC investigation, data discs that will allow NNMOCD to verify the our predictions using HYDRUS-1D, and a schedule for the proposed remedy based upon the date that NMOCD approves the CAP.

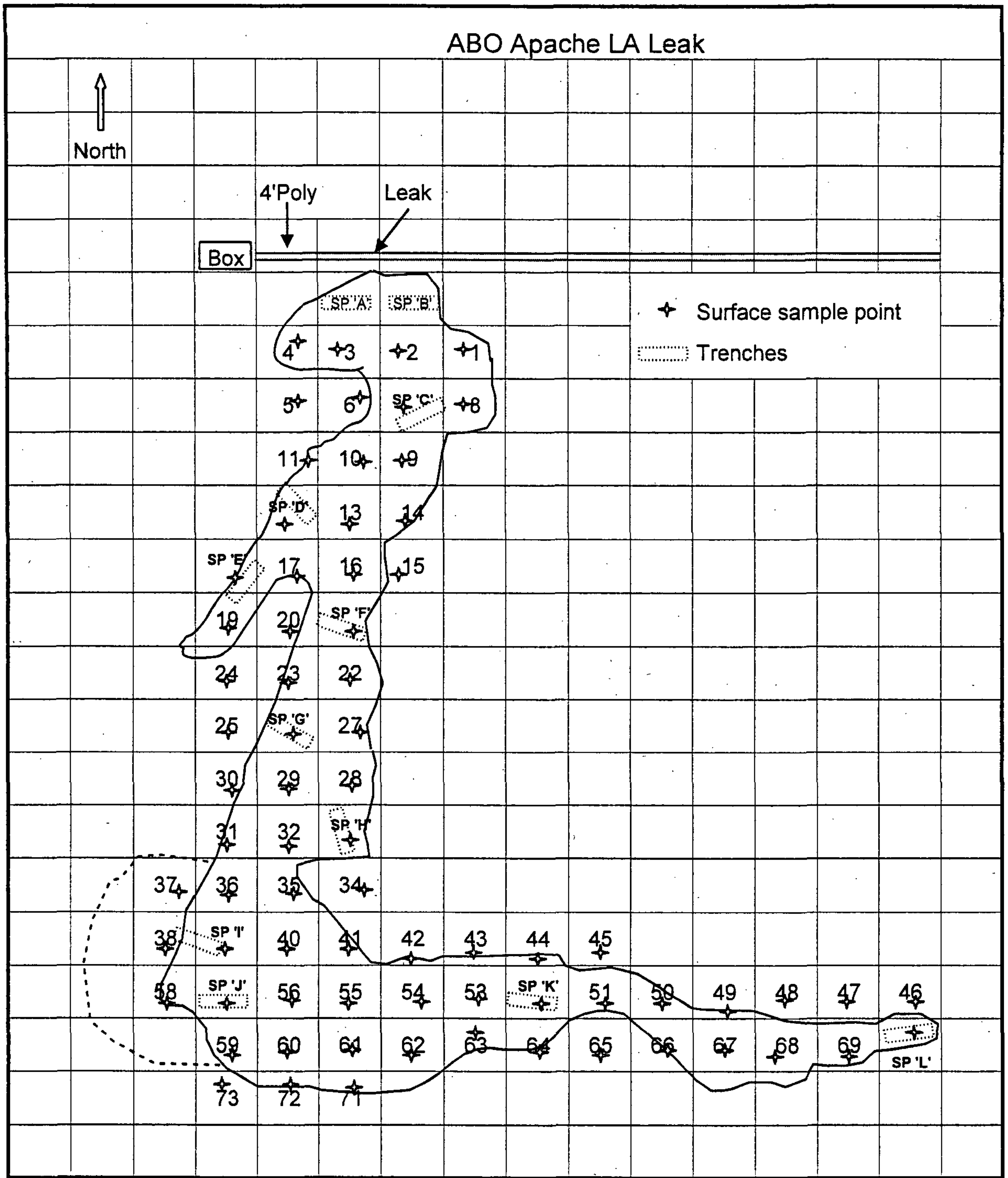
Please contact Kristin Pope if you have any questions regarding this progress report.

Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T Hicks

Randall Hicks
Principal

Copy:
Kristin Pope
William Carr
Carolyn Haynes



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 505-266-5004	**Abo Apache 1-G Release Site**	**Plate 1**
	Surface Sample and Trenching Locations	**Aug., 2005**

R. T. HICKS CONSULTANTS, LTD.
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

August 31, 2005

Wayne Price
NMOCD Environmental Bureau
1220 South St. Francis Drive
Santa Fe, New Mexico 87505
Via E-mail and Federal Express

RE: Amended Corrective Action Plan
Abo 1G Pipeline Release NMOCD Case #1R0415
Section 1, 17S, 36E, Unit G

Dear Wayne:

On behalf of Rice Operating Company, R.T. Hicks Consultants, Ltd. is pleased to submit the attached Amended Corrective Action Plan for the above-referenced site.

If you have any questions or concerns about the enclosed report, please let us know. Thank you for your time.

Sincerely,
R.T. Hicks Consultants, Ltd.

Katie Lee

Katie Lee
Staff Scientist

Copy: Rice Operating Company

R. T. HICKS CONSULTANTS, LTD.
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

December 19, 2005

Wayne Price
NMOCD Environmental Bureau
1220 South St. Francis Drive
Santa Fe, New Mexico 87505
Via E-mail and Federal Express

RE: Amended Corrective Action Plan
Abo 1G Pipeline Release NMOCD Case #1R0415
Section 1, 17S, 36E, Unit G

Dear Wayne:

We offer the following idea for NMOCD consideration. Underlying the surface soil at the site is about 1-3 feet of hard caliche with an average chloride concentration of 1,200 mg/kg (see Table 1). As part of the conditional approval of the remedy proposed in the August 2005 Amended Corrective Action Plan, NMOCD requires disposal of this material to reduce the chloride mass that exists at this spill site. Rather than dispose of this material at a landfill, we propose to excavate and remove this caliche material in the area of the excavation and cap and use the caliche for the repair of nearby roads or minor repairs to well pads. Rather than create a waste for disposal at a landfill, we propose to create a product: road gravel. ROC will work with the City of Lovington to identify nearby roads in need of repair. ROC will spread this caliche gravel on 15-foot wide roads that run perpendicular to ground water flow (essentially north-south roads) to a thickness that will not exceed an average of 6-inches.

We employed the data and assumptions discussed below and the modeling protocol outlined in the Amended Corrective Action Plan to predict the potential impact of this reduce-reuse-recycle program. Using this caliche as road gravel at nearby locations is consistent with NMOCD's stated goal of reducing the mass of chloride present at this site.

HYDRUS-1D Modeling Experiment

We employed the same modeling protocol outlined in the Amended CAP. The following assumptions and data apply to the prediction of minor well pad repairs or gravel repair of north-south running roads:

- Table 1 synopsizes the results of Rice Operating Company's chloride sampling at the Abo Apache 1-G site. From interpolated data points. We calculated an average chloride concentration of approximately 1200 mg/kg from 0.5 feet below ground surface (bgs) to 3.5 feet bgs.
- A 6-inch thickness of 1,200 mg/kg chloride material creates a chloride load of 0.34 kg/m^2.

- A comparison with the well logs from the nearby Navajo refinery allows us to conclude that the vadose zone in the area near Abo-1G is similar to that represented in the well logs at the site.
- For this HYDRUS-1D modeling experiment we used the soil profile derived from the logs of MW-1 and SB-1. Within this soil profile we installed a chloride concentration of 1200 mg/kg within the top 6 inches of the soil profile and an ambient chloride concentration of 60 mg/kg from below this horizon to ground water.
- From examination of the chloride data obtained below 50 feet bgs during the drilling of MW-1, we conclude that ambient chloride concentration beneath a road or well pad in the area is approximately 60 mg/kg.
- The field-calibrated HYDRUS-1D model used in the August 2005 Amended Corrective Action Plan adequately predicts the chloride flux to ground water in the area of the Abo-1G site
- The calibrated HYDRUS-1D model can predict the chloride flux to ground water by placing a chloride load of 0.34 kg/m^2 on the top of the lithologic and chloride profile of the background soil boring then allowing precipitation on this flat, un-vegetated surface.
- Because ground water flow is east to southeast in this area, we can assume that the maximum distance parallel to ground water flow beneath a 15 foot wide north-south road or similar well pad repair is no more than 30 feet.
- From water quality data obtained at MW-1, we calculated an average chloride concentration of 93 mg/l with in ground water and a natural variation between 72 mg/l and 120mg/l.

Careful examination of HYDRUS-1D output files from the Abo 1-G site Amended Correction Action Plan demonstrate that chloride from the spill events first reaches ground water after about 20 years from present with the center of chloride mass from the releases reaching ground water about 29 years from now.

As discussed in the Amended CAP, the HYDRUS-1D model for this area is calibrated with chloride migration data in the upper vadose zone. These data suggest migration rates of approximately 1-foot per year in well indurated caliches and approximately 3-feet per year within sand layers. The lower layers of the vadose zone in this area are dominated by sands resulting in faster migration rates through the lower horizon.

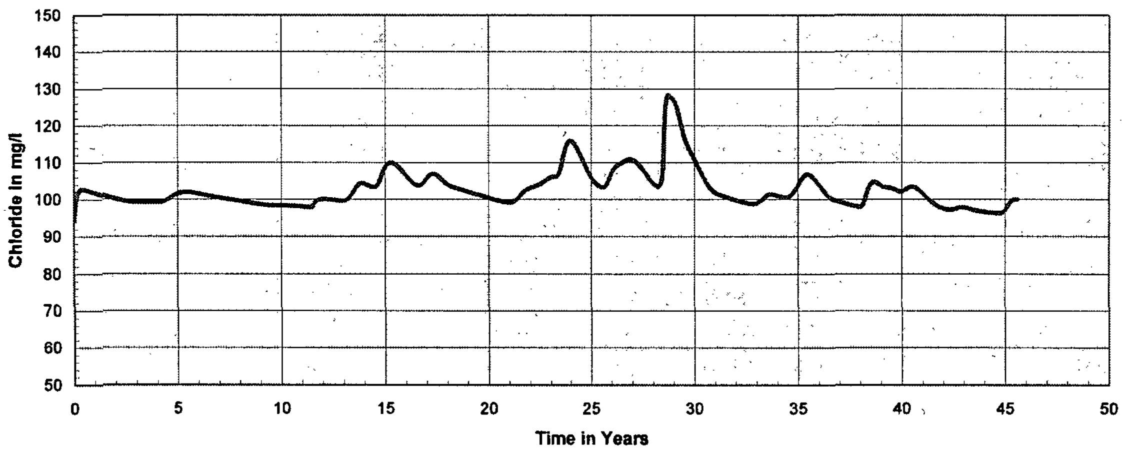
We know from the drilling and installation of MW-1 that there exists a well indurated caliche layer between 36 and 37 feet bgs. Field chloride data obtained during the 2004 and 2005 field programs shows that the hydraulic conductivity of this layer is quite low. Below this layer, chloride concentrations rapidly decline to background concentrations. The chloride at this horizon may represent the leading edge of the 1993 spill event given migration rates predicted by Hydrus 1-D (about 3.1 feet/year migration rate). However, the concentration gradient may be a result of earlier (1960s?) anthropomorphic oilfield effects in this area, which would yield a chloride migration rate of about 1-foot per year. While we can not say which the case is, the Hydrus 1-D modeling is necessarily constructed of choices conservative of ground water quality whenever field data does not provide evidence for choice of input parameters. Because we have elected to employ a average migration rate through the vadose zone of about 3-feet per year, the modeling will over predict maximum chloride concentration in ground if the migration rate is actually 1-foot per year.

A similar examination of HYDRUS-1D output files for this proposal demonstrate chloride from the road repair first reaches ground water in approximately 24 years with the center of the chloride mass entering ground water about 29 years from time=0 in agreement with the Abo 1-G results.

Figure 1 presents the model's prediction of chloride concentration in a monitoring well immediately down gradient of a road that is repaired by the application of 6 inches of caliche from the site. Within the mixing model at time = 0, ground water that enters the mixing zone has a chloride concentration of 93 mg/L, the value of the input discussed above. Soon after time=0, the additional natural chloride flux from the vadose zone to the aquifer causes the predicted chloride concentration in ground water to vary between 102 and 99 ppm until about year 12. Between year 12 and year 22, the natural flux of chloride into the aquifer increases as a result of "wet" years within the atmospheric data, causing an additional predicted increase of chloride to about 110 ppm. To reiterate, these variations in chloride concentrations predicted in the model for years 0-22 result from natural conditions and are not due to the installation of caliche road repairs.

Our analysis of the model output shows that chloride molecules from the caliche pad begin to enter ground water about year 24. The center of mass of chloride leached from the caliche road repair intercepts ground water about year 29 and creates a maximum chloride concentration of 128 mg/l or about 19 mg/L greater than the maximum concentration due to natural causes. Although the highly-conservative model predicts a natural chloride variation from 93 to 110 mg/L, the natural variation of chloride concentration is documented at MW-1 as a variation between 72 mg/L and 120 mg/L. Because the natural variation is 48 ppm, the theoretical contribution of chloride to the aquifer (19 mg/L) from the caliche road repair is too small to be detected.

Figure1 : Chloride Concentration Observed in the Aquifer at the Down Gradient Edge of a North-South Road with a 6 inch thick Layer of 1200 ppm Caliche



After year 29, predicted ground water chloride concentrations decrease and approach the model input value of 93 mg/L. This prediction is due to the model's assumption that precipitation is essentially distilled water and, therefore, salt does not accumulate in the root zone due to evapotranspiration. As the model predictions trend toward the input value of 93 mg/L, we know that the effect of the chloride load of 0.34 kg/m2 has passed through the model.

Because HYDRUS-1D over estimates the potential impact to ground water and because the example employs other conservative input, we believe this model demonstrates that the proposed reduce-reuse-recycle program protects fresh water, public health and the environment. In fact, this submittal shows that the theoretical contribution of chloride to ground water is too small to detect by ground water monitoring. Finally, we conclude that this reduce-reuse-recycle program could result in a total chloride contribution to ground water of zero because of the highly-conservative input parameters employed in our simulation.

If NMOCD concurs with this overall approach but needs additional data and/or simulations to gain the degree of assurance required for this program in an area that overlies the water supply of the City of Lovington, we would be pleased to oblige. The alternative of hauling the caliche to a landfill appears to create a greater impact to the environment and public safety than this proposal. We believe this relocation of the chloride load (i.e. caliche) from the site and dispersal of the chloride to appropriately small areas of well pads or north-south roads provides better protection of ground water than the remedy originally proposed in August 2005.

As you recall, the HYDRUS-1D model of the remedy in the Amended CAP demonstrated (to our satisfaction) that the proposed clay cap and no exportation of impacted material was protective of fresh water, public health and the environment. The exportation of the caliche from the site and landfill disposal of sandy-clay material that exceeds 2,000 mg/kg removes some of the chloride mass from the site and provides a higher degree of certainty that the proposed remedy is fully consistent with NMOCD Rules. We respectfully request you consider this reduce-reuse-recycle proposal in lieu of landfill disposal of the caliche (as suggested in your conditional approval) and the blending action as proposed in the Amended CAP.

Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T. Hicks

David J. Hamilton

Randall Hicks
Principal

David Hamilton
Staff Hydrogeologist

Copy: Rice Operating Company

R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

March 3, 2006

Wayne Price
NMOCD Environmental Bureau
1220 South St. Francis Drive
Santa Fe, New Mexico 87505
Via E-mail and Federal Express

RE: Closure Report
Abo 1G Pipeline Release NMOCD Case #1R0415
Section 1, 17S, 36E, Unit G

Dear Wayne:

Attached are photographs that document the completion of all construction (soil excavation, exportation and importation of clay). Because electronic files of the final analytical results are quite large, please expect them with the paper copy of this letter, which will be sent on Monday.

Our progress report of January 31, 2006 provided the following post-closure monitoring plant:

> We propose plugging and abandonment of the monitoring well and sampling the vadose zone monitoring devices two times per year for three years.

We will submit annual reports to NMOCD. After your approval of this closure report; we will notify NMOCD of the date for plugging the well.

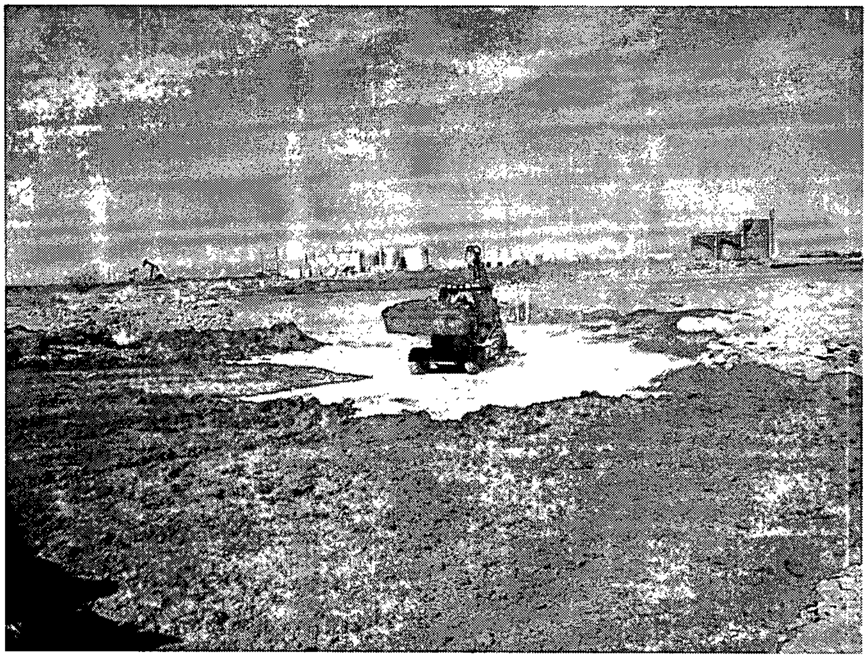
Sincerely,
R.T. Hicks Consultants, Ltd.

Randall T. Hicks

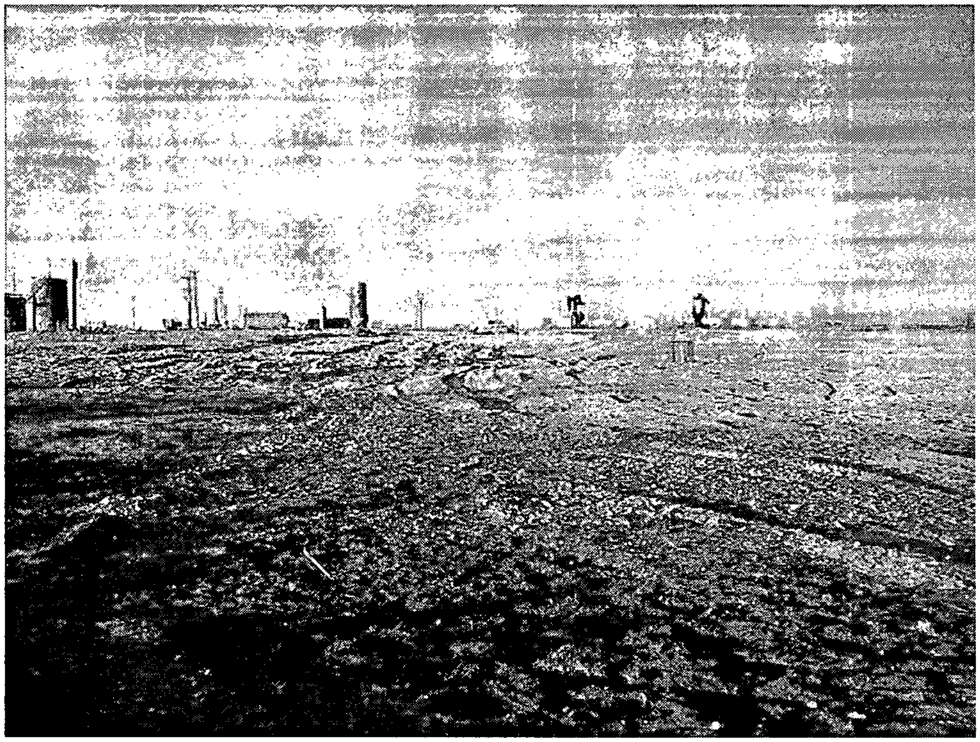
Randall Hicks
Principal

Copy: Rice Operating Company

Construction photographs showing clay placement excavation



Photographs showing final cover



ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: None Given

Location: None Given

Lab Order Number: 6A11001

Report Date: 01/17/06

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
01/17/06 07:56

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
#45@ 1'bgs	6A11001-01	Soil	01/05/06 12:12	01/11/06 08:00
#54@ 1'bgs	6A11001-02	Soil	01/05/06 12:30	01/11/06 08:00
#27@ 1'bgs	6A11001-03	Soil	01/06/06 15:05	01/11/06 08:00
#13@ 1'bgs	6A11001-04	Soil	01/06/06 08:30	01/11/06 08:00
#62@ 1'bgs	6A11001-05	Soil	01/05/06 13:00	01/11/06 08:00
#39@ 1'bgs	6A11001-06	Soil	01/04/06 11:05	01/11/06 08:00
#57@ 1'bgs	6A11001-07	Soil	01/04/06 11:20	01/11/06 08:00
#14@ 1'bgs	6A11001-08	Soil	01/06/06 08:32	01/11/06 08:00
#44@ 1'bgs	6A11001-09	Soil	01/05/06 12:15	01/11/06 08:00
#60@ 3'bgs	6A11001-10	Soil	01/06/06 14:30	01/11/06 08:00
#58@ 5'bgs	6A11001-11	Soil	01/04/06 11:10	01/11/06 08:00
#10@ 1'bgs	6A11001-12	Soil	01/06/06 08:40	01/11/06 08:00
#55@ 4'bgs	6A11001-13	Soil	01/09/06 08:56	01/11/06 08:00
#28@ 1'bgs	6A11001-14	Soil	01/06/06 14:52	01/11/06 08:00
#52@ 1'bgs	6A11001-15	Soil	01/05/06 12:45	01/11/06 08:00
#22@ 1'bgs	6A11001-16	Soil	01/06/06 15:10	01/11/06 08:00
#63@ 1'bgs	6A11001-17	Soil	01/05/06 12:25	01/11/06 08:00
#38@ 5'bgs	6A11001-18	Soil	01/04/06 13:40	01/11/06 08:00
#33@ 1'bgs	6A11001-19	Soil	01/06/06 14:57	01/11/06 08:00
#53@ 1'bgs	6A11001-20	Soil	01/05/06 12:20	01/11/06 08:00
#56@ 1'bgs	6A11001-21	Soil	01/05/06 14:45	01/11/06 08:00
#61@ 3'bgs	6A11001-22	Soil	01/06/06 14:45	01/11/06 08:00
#26@ 1'bgs	6A11001-23	Soil	01/06/06 14:54	01/11/06 08:00
#32@ 1'bgs	6A11001-24	Soil	01/06/06 15:00	01/11/06 08:00
#74@ 5'bgs	6A11001-25	Soil	01/04/06 10:55	01/11/06 08:00
#75@ 5'bgs	6A11001-26	Soil	01/04/06 11:00	01/11/06 08:00
#59@ 5'bgs	6A11001-27	Soil	01/04/06 13:47	01/11/06 08:00
#9@ 1'bgs	6A11001-28	Soil	01/06/06 08:35	01/11/06 08:00

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471
Reported: 01/17/06 07:56

Organics by GC
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#62@ 1'bgs (6A11001-05) Soil									
Gasoline Range Organics C6-C12	ND	25.0	mg/kg dry	1	EA61214	01/12/06	01/13/06	TX 1005	
Diesel Range Organics >C12-C35	ND	25.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	25.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*77.8 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*77.4 %*	*70-130*		"	"	"	"	
#14@ 1'bgs (6A11001-08) Soil									
Gasoline Range Organics C6-C12	ND	25.0	mg/kg dry	1	EA61214	01/12/06	01/13/06	TX 1005	
Diesel Range Organics >C12-C35	ND	25.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	25.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*82.8 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*82.4 %*	*70-130*		"	"	"	"	
#55@ 4'bgs (6A11001-13) Soil									
Gasoline Range Organics C6-C12	ND	25.0	mg/kg dry	1	EA61214	01/12/06	01/13/06	TX 1005	
Diesel Range Organics >C12-C35	ND	25.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	25.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*79.4 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*78.8 %*	*70-130*		"	"	"	"	
#38@ 5'bgs (6A11001-18) Soil									
Gasoline Range Organics C6-C12	ND	25.0	mg/kg dry	1	EA61214	01/12/06	01/13/06	TX 1005	
Diesel Range Organics >C12-C35	ND	25.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	25.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*77.6 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*76.8 %*	*70-130*		"	"	"	"	
#61@ 3'bgs (6A11001-22) Soil									
Gasoline Range Organics C6-C12	ND	25.0	mg/kg dry	1	EA61214	01/12/06	01/13/06	TX 1005	
Diesel Range Organics >C12-C35	ND	25.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	25.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*87.0 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*86.2 %*	*70-130*		"	"	"	"	

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 01/17/06 07:56

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#75@ 5'bgs (6A11001-26) Soil									
Gasoline Range Organics C6-C12	ND	25.0	mg/kg dry	1	EA61214	01/12/06	01/13/06	TX 1005	
Diesel Range Organics >C12-C35	ND	25.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	25.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*88.6 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*88.2 %*	*70-130*		"	"	"	"	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
01/17/06 07:56

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#45@ 1'bgs (6A11001-01) Soil									
Chloride	267	10.0	mg/kg	20	EA61303	01/11/06	01/13/06	EPA 300.0	
#54@ 1'bgs (6A11001-02) Soil									
Chloride	1960	50.0	mg/kg	100	EA61303	01/11/06	01/13/06	EPA 300.0	
#27@ 1'bgs (6A11001-03) Soil									
Chloride	756	20.0	mg/kg	40	EA61303	01/11/06	01/13/06	EPA 300.0	
#13@ 1'bgs (6A11001-04) Soil									
Chloride	604	20.0	mg/kg	40	EA61303	01/11/06	01/13/06	EPA 300.0	
#62@ 1'bgs (6A11001-05) Soil									
Chloride	785	20.0	mg/kg	40	EA61303	01/11/06	01/13/06	EPA 300.0	
% Moisture	7.6	0.1	%	1	EA61202	01/11/06	01/12/06	% calculation	
#39@ 1'bgs (6A11001-06) Soil									
Chloride	1360	20.0	mg/kg	40	EA61303	01/11/06	01/13/06	EPA 300.0	
#57@ 1'bgs (6A11001-07) Soil									
Chloride	1560	25.0	mg/kg	50	EA61303	01/11/06	01/13/06	EPA 300.0	
#14@ 1'bgs (6A11001-08) Soil									
Chloride	706	10.0	mg/kg	20	EA61303	01/11/06	01/13/06	EPA 300.0	
% Moisture	5.9	0.1	%	1	EA61202	01/11/06	01/12/06	% calculation	
#44@ 1'bgs (6A11001-09) Soil									
Chloride	290	10.0	mg/kg	20	EA61303	01/11/06	01/13/06	EPA 300.0	
#60@ 3'bgs (6A11001-10) Soil									
Chloride	1130	20.0	mg/kg	40	EA61303	01/11/06	01/13/06	EPA 300.0	

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#58@ 5'bgs (6A11001-11) Soil									
Chloride	**1720**	25.0	mg/kg	50	EA61303	01/11/06	01/13/06	EPA 300.0	
#10@ 1'bgs (6A11001-12) Soil									
Chloride	**1240**	25.0	mg/kg	50	EA61303	01/11/06	01/13/06	EPA 300.0	
#55@ 4'bgs (6A11001-13) Soil									
Chloride	**1220**	20.0	mg/kg	40	EA61303	01/11/06	01/13/06	EPA 300.0	
% Moisture	**7.5**	0.1	%	1	EA61202	01/11/06	01/12/06	% calculation	
#28@ 1'bgs (6A11001-14) Soil									
Chloride	**908**	20.0	mg/kg	40	EA61303	01/11/06	01/13/06	EPA 300.0	
#52@ 1'bgs (6A11001-15) Soil									
Chloride	**625**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
#22@ 1'bgs (6A11001-16) Soil									
Chloride	**948**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
#63@ 1'bgs (6A11001-17) Soil									
Chloride	**1260**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
#38@ 5'bgs (6A11001-18) Soil									
Chloride	**1330**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
% Moisture	**9.0**	0.1	%	1	EA61202	01/11/06	01/12/06	% calculation	
#33@ 1'bgs (6A11001-19) Soil									
Chloride	**1020**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
#53@ 1'bgs (6A11001-20) Soil									
Chloride	**734**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/17/06 07:56

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#56@ 1'bgs (6A11001-21) Soil									
Chloride	**2750**	50.0	mg/kg	100	EA61304	01/12/06	01/13/06	EPA 300.0	
#61@ 3'bgs (6A11001-22) Soil									
Chloride	**1320**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
% Moisture	**7.7**	0.1	%	1	EA61202	01/11/06	01/12/06	% calculation	
#26@ 1'bgs (6A11001-23) Soil									
Chloride	**754**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
#32@ 1'bgs (6A11001-24) Soil									
Chloride	**1960**	25.0	mg/kg	50	EA61304	01/12/06	01/13/06	EPA 300.0	
#74@ 5'bgs (6A11001-25) Soil									
Chloride	**424**	10.0	mg/kg	20	EA61304	01/12/06	01/13/06	EPA 300.0	
#75@ 5'bgs (6A11001-26) Soil									
Chloride	**712**	10.0	mg/kg	20	EA61304	01/12/06	01/13/06	EPA 300.0	
% Moisture	**5.9**	0.1	%	1	EA61202	01/11/06	01/12/06	% calculation	
#59@ 5'bgs (6A11001-27) Soil									
Chloride	**1100**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	
#9@ 1'bgs (6A11001-28) Soil									
Chloride	**2010**	20.0	mg/kg	40	EA61304	01/12/06	01/13/06	EPA 300.0	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
01/17/06 07:56

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 EA61214 - Solvent Extraction (GC)										
Blank (EA61214-BLK1)				Prepared & Analyzed: 01/12/06						
Gasoline Range Organics C6-C12	ND	25.0	mg/kg wet							
Diesel Range Organics >C12-C35	ND	25.0	"							
Total Hydrocarbon C6-C35	ND	25.0	"							
Surrogate: 1-Chlorooctane	*41.8*		*mg/kg*	*50.0*		*83.6*	*70-130*			
Surrogate: 1-Chlorooctadecane	*42.2*		*"*	*50.0*		*84.4*	*70-130*			
LCS (EA61214-BS1)				Prepared: 01/12/06 Analyzed: 01/13/06						
Gasoline Range Organics C6-C12	435	25.0	mg/kg wet	500		87.0	75-125			
Diesel Range Organics >C12-C35	526	25.0	"	500		105	75-125			
Total Hydrocarbon C6-C35	961	25.0	"	1000		96.1	75-125			
Surrogate: 1-Chlorooctane	*59.8*		*mg/kg*	*50.0*		*120*	*70-130*			
Surrogate: 1-Chlorooctadecane	*52.3*		*"*	*50.0*		*105*	*70-130*			
Calibration Check (EA61214-CCV1)				Prepared: 01/12/06 Analyzed: 01/13/06						
Gasoline Range Organics C6-C12	447		mg/kg	500		89.4	80-120			
Diesel Range Organics >C12-C35	518		"	500		104	80-120			
Total Hydrocarbon C6-C35	965		"	1000		96.5	80-120			
Surrogate: 1-Chlorooctane	*55.8*		*"*	*50.0*		*112*	*70-130*			
Surrogate: 1-Chlorooctadecane	*52.0*		*"*	*50.0*		*104*	*70-130*			
Matrix Spike (EA61214-MS1)	**Source: 6A11001-26**			Prepared & Analyzed: 01/12/06						
Gasoline Range Organics C6-C12	478	25.0	mg/kg dry	531	ND	90.0	75-125			
Diesel Range Organics >C12-C35	531	25.0	"	531	ND	100	75-125			
Total Hydrocarbon C6-C35	1010	25.0	"	1060	ND	95.3	75-125			
Surrogate: 1-Chlorooctane	*58.3*		*mg/kg*	*50.0*		*117*	*70-130*			
Surrogate: 1-Chlorooctadecane	*47.8*		*"*	*50.0*		*95.6*	*70-130*			
Matrix Spike Dup (EA61214-MSD1)	**Source: 6A11001-26**			Prepared: 01/12/06 Analyzed: 01/13/06						
Gasoline Range Organics C6-C12	469	25.0	mg/kg dry	531	ND	88.3	75-125	1.90	20	
Diesel Range Organics >C12-C35	504	25.0	"	531	ND	94.9	75-125	5.22	20	
Total Hydrocarbon C6-C35	973	25.0	"	1060	ND	91.8	75-125	3.73	20	
Surrogate: 1-Chlorooctane	*57.8*		*mg/kg*	*50.0*		*116*	*70-130*			
Surrogate: 1-Chlorooctadecane	*46.7*		*"*	*50.0*		*93.4*	*70-130*			

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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 EA61202 - General Preparation (Prep)										
Blank (EA61202-BLK1)				Prepared: 01/11/06 Analyzed: 01/12/06						
% Solids	100		%							
Duplicate (EA61202-DUP1)		**Source: 6A10012-01**		Prepared: 01/11/06 Analyzed: 01/12/06						
% Solids	88.6		%		90.4			2.01	20	
Duplicate (EA61202-DUP2)		**Source: 6A10016-04**		Prepared: 01/11/06 Analyzed: 01/12/06						
% Solids	93.3		%		93.6			0.321	20	
Duplicate (EA61202-DUP3)		**Source: 6A11007-01**		Prepared: 01/11/06 Analyzed: 01/12/06						
% Solids	96.6		%		97.0			0.413	20	
Batch EA61303 - Water Extraction										
Blank (EA61303-BLK1)				Prepared: 01/11/06 Analyzed: 01/13/06						
Chloride	ND	0.500	mg/kg							
LCS (EA61303-BS1)				Prepared: 01/11/06 Analyzed: 01/13/06						
Chloride	8.58		mg/L	10.0		85.8	80-120			
Calibration Check (EA61303-CCV1)				Prepared: 01/11/06 Analyzed: 01/13/06						
Chloride	8.75		mg/L	10.0		87.5	80-120			
Duplicate (EA61303-DUP1)		**Source: 6A10017-01**		Prepared: 01/11/06 Analyzed: 01/13/06						
Chloride	3850	100	mg/kg		3790			1.57	20	
Batch EA61304 - Water Extraction										
Blank (EA61304-BLK1)				Prepared: 01/12/06 Analyzed: 01/13/06						
Chloride	ND	0.500	mg/kg							

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 EA61304 - Water Extraction										
LCS (EA61304-BS1)				Prepared: 01/12/06 Analyzed: 01/13/06						
Chloride	8.60		mg/L	10.0		86.0	80-120			
Calibration Check (EA61304-CCV1)				Prepared: 01/12/06 Analyzed: 01/13/06						
Chloride	9.66		mg/L	10.0		96.6	80-120			
Duplicate (EA61304-DUP1)		**Source: 6A11001-15**		Prepared: 01/12/06 Analyzed: 01/13/06						
Chloride	639	20.0	mg/kg		625			2.22	20	

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: 1/17/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

This material is intended only for the use of the individual (s) or entity to whom it is addressed, and may contain information that is privileged and confidential.

If you have received this material in error, please notify us immediately at 432-563-1800.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Rice Operating
Company Address: 122 W Taylor
City/State/Zip: Hobbs NM 88240
Telephone No: (505) 393-9174 631-1278
Fax No:
Sampler Signature: Jennifer Johnson

Project Name: ABD APACHE LALAGE
Project #:
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify)	TDS / CL / SAR / EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
01	#45 @ 1' bgs	1/5/06	12:12	1	X									X		X			X					
02	#54 @ 1' bgs	1/5/06	12:30	1	X									X		X			X					
03	#27 @ 1' bgs	1/6/06	3:05	1	X									X		X			X					
04	#13 @ 1' bgs	1/6/06	8:30	1	X									X		X			X					
05	#62 @ 1' bgs	1/5/06	1:00	1	X									X		X			X					
06	#39 @ 1' bgs	1/4/06	11:05	1	X									X		X			X					
07	#57 @ 1' bgs	1/4/06	11:20	1	X									X		X			X					
08	#14 @ 1' bgs	1/6/06	8:32	1	X									X		X			X					
09	#44 @ 1' bgs	1/5/06	12:15	1	X									X		X			X					
10	#60 @ 3' bgs	1/6/06	2:30	1	X									X		X			X					

Special Instructions: TPH – please do the circled first: if non-detect, call before continuing

Sample Containers Intact? Y N
Temperature Upon Receipt:
Laboratory Comments:
1.5 402
cooler label

Relinquished by:	Date	Time	Received by:	Date	Time
Jennifer Johnson	1/10/06	5:00	[illegible]	1/10	17:00
[illegible]	1/11	7:30	Received by ELOT: [illegible]	1/11/06	[illegible]

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon

Company Name: Rice Operating

Company Address: 122 W Taylor

City/State/Zip: Hobbs NM 88240

Telephone No: 505 393-9174

Fax No:

Sampler Signature: Jennifer A Johnson

Project Name: ABD N Apache Lateral

Project #:

Project Loc:

PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify)	Analyze For (TCLP: / TOTAL:): TDS/ CL /SAR/EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
-11	#58 @ 5' bgs	1/4/06	11:10	1	X									X		X			X					
-12	#10 @ 1' bgs	1/6/06	8:40	1	X									X		X			X					
-13	#55 @ 4' bgs	1/9/06	8:56	1	X									X		X			X					
-14	#28 @ 1' bgs	1/6/06	2:52	1	X									X		X			X					
-15	#52 @ 1' bgs	1/5/06	12:45	1	X									X		X			X					
-16	#22 @ 1' bgs	1/6/06	3:10	1	X									X		X			X					
-17	#63 @ 1' bgs	1/5/05	12:25	1	X									X		X			X					
-18	#38 @ 5' bgs	1/4/05	1:40	1	X									X		X			X					
-19	#33 @ 1' bgs	1/6/05	2:57	1	X									X		X			X					
-20	#53 @ 1' bgs	1/5/06	12:20	1	X									X		X			X					

Special Instructions:
TPH Please do circled first; if non-detect, call before continuing. CDH

Relinquished by:	Date	Time	Received by:	Date	Time
Jennifer A Johnson	1/10/06	5:30pm	C Haynes	1/10	17:00

Relinquished by:	Date	Time	Received by ELOT:	Date	Time
C Haynes	1/11	7:30	Drop Box / [illegible]	1/11/06	8:00

Sample Containers Intact? Y
Temperature Upon Receipt:
Laboratory Comments:

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Rice Operating
Company Address: 122 W Taylor
City/State/Zip: Hobbs NM 88240
Telephone No: (505) 393-9174
Fax No:
Sampler Signature: Jennifer A Johnson

Project Name: ABD APACHE GA Leak
Project #:
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify)	Analyze For: TDS/Cl/SAR/EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
-21	#56 1' bgs	1/5/06	2:45	1	X									X		X			X					
-22	#61 @ 3' bgs	1/6/06	2:45	1	X									X		X			X					
-23	#26 @ 1' bgs	1/6/05	2:54	1	X									X		X			X					
-24	#32 @ 1' bgs	1/6/06	3:00	1	X									X		X			X					
-25	#74 @ 5' bgs	1/4/06	10:55	1	X									X		X			X					
-26	#75 @ 5' bgs	1/4/06	11:00	1	X									X		X			X					
-27	#59 @ 5' bgs	1/4/06	1:47	1	X									X		X			X					
-28	#9 @ 1' bgs	1/6/06	8:35	1	X									X		X			X					

Special Instructions: TPH - please do circled first; if non-detect, call before continuing. Cait

Sample Containers Intact?
Temperature Upon Receipt:
Laboratory Comments:

Relinquished by:	Date	Time	Received by:	Date	Time
Jennifer A Johnson	1/10/06	5:00pm	C D Hagan	1/10	17:00

Relinquished by:	Date	Time	Received by ELOT:	Date	Time
C D Hagan	1/11	7:30	Drop Box / Celia Kelly	1/11/06	8:00

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

Client: Rice Op.

Date/Time: 1/11/06 8:00

Order #: 6A1100

Initials: CK

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	1.5 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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: None Given

Location: None Given

Lab Order Number: 6A17001

Report Date: 01/18/06

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/18/06 09:45

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
#37 @ 5' bgs	6A17001-04	Soil	01/10/06 14:00	01/17/06 08:00
#40 @ 5' bgs	6A17001-07	Soil	01/12/06 11:30	01/17/06 08:00

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Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/18/06 09:45

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#37 @ 5' bgs (6A17001-04) Soil									
Chloride	594	10.0	mg/kg	20	EA61708	01/17/06	01/17/06	EPA 300.0	
#40 @ 5' bgs (6A17001-07) Soil									
Chloride	1440	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
% Moisture	6.2	0.1	%	1	EA61801	01/17/06	01/18/06	% calculation	

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Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 01/18/06 09:45

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 EA61708 - Water Extraction										
Blank (EA61708-BLK1)				Prepared & Analyzed: 01/17/06						
Chloride	ND	0.500	mg/kg							
LCS (EA61708-BS1)				Prepared & Analyzed: 01/17/06						
Chloride	8.48		mg/L	10.0		84.8	80-120			
Calibration Check (EA61708-CCV1)				Prepared & Analyzed: 01/17/06						
Chloride	8.71		mg/L	10.0		87.1	80-120			
Duplicate (EA61708-DUP1)	**Source: 6A16008-01**			Prepared & Analyzed: 01/17/06						
Chloride	3020	50.0	mg/kg		3010			0.332	20	
Batch EA61801 - General Preparation (Prep)										
Blank (EA61801-BLK1)				Prepared: 01/17/06 Analyzed: 01/18/06						
% Solids	100		%							
Duplicate (EA61801-DUP1)	**Source: 6A17001-02**			Prepared: 01/17/06 Analyzed: 01/18/06						
% Solids	95.2		%		95.1			0.105	20	

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: 1/18/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

This material is intended only for the use of the individual (s) or entity to whom it is addressed, and may contain information that is privileged and confidential.

If you have received this material in error, please notify us immediately at 432-563-1800.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Rice Operating
Company Address: 122 W Taylor
City/State/Zip: Hobbs, NM 88240
Telephone No: (505) 393-9174
Fax No: (505) 393-1471
Sampler Signature: Jennifer Johnson

Project Name: Abo Apache LA Loo
Project #:
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify)	TDS / CL / SAR / EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
[illegible]	#26 @ 2' bgs	1/11/06	1:05pm	1	X									X		X								
[illegible]	#25 @ 2' bgs	1/11/06	1:00pm	1	X									X		X			X					X
[illegible]	#35 @ 1' bgs	1/11/06	2:10pm	1	X									X		X								
[illegible]	#31 @ 5' bgs	1/10/06	2:00pm	1	X									X		X								X
[illegible]	~~Pit From #40~~ RRR	~~1/12/06~~	~~1:29pm~~	~~1~~	~~X~~									~~X~~		~~X~~								
[illegible]	#30 @ 3' bgs	1/12/06	9:15Am	1	X									X		X								
[illegible]	#29 @ 3' bgs	1/12/06	9:11Am	1	X									X		X			X					X
[illegible]	#40 @ 5' bgs	1/12/06	11:30Am	1	X									X		X			X					X
[illegible]	#31 @ 3' bgs	1/12/06	10:30Am	1	X									X		X								
[illegible]	#1 @ 1' bgs	1/13/06	10:50Am	1	X									X		X			X					X

Special Instructions: PLEASE Run TPH on Designated sample if clean call 505-631-1278 Roy, & Rush samples marked Red, Disregard samples slashed & Initialed RRR

Relinquished by:	Date	Time	Received by:	Date	Time
Melanie Franks	1/16/06	4:00pm	[signature]	1/16	17:30
Relinquished by: [signature]	1/17	8:05	Received by ELOT: [signature]	[illegible]	[illegible]

Sample Containers Intact? Y N
Temperature Upon Receipt: 0.5 C
Laboratory Comments:
[illegible]

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon

Company Name: Rice Operating

Company Address: 122 W Taylor

City/State/Zip: Hobbs, NM 88240

Telephone No: (505) 393-9174

Fax No: (505) 393-1471

Sampler Signature: Jennifer Johnson

Project Name: ABO Apache LA Local

Project #:

Project Loc:

PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	Analyze For: TDS / CL / SAR / EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
	#5 @ 1' bgs	1/13/06	10:55am	1	X									X		X								
	#6 @ 1' bgs	1/13/06	11:00am	1	X									X		X								
	#11 @ 1' bgs	1/13/06	11:05am	1	X									X		X								
	#18 @ 1' bgs	1/13/06	1:05pm	1	X									X		X								
	~~Pile from 1 11~~ FRR	~~1/13/06~~	~~2:30pm~~	~~1~~	~~X~~									~~X~~		~~X~~								
	Blend #1	1/13/06	1:06pm	1	X									X		X								
	Blend #2	1/13/06	2:10pm	1	X									X		X								

Special Instructions:

Relinquished by:	Date	Time	Received by:	Date	Time
Melanie Franko	1/16/06	4:00pm	C. [illegible]	1/16	17:30
Relinquished by:	Date	Time	Received by ELOT:	Date	Time
C. [illegible]	1/17	8:00	[illegible]	[illegible]	[illegible]

Sample Containers Intact?
Temperature Upon Receipt:
Laboratory Comments:

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

Client: Rice Operating Co.

Date/Time: 01-17-06 @0800

Order #: 6A17001

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	0.5 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	
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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: None Given

Location: None Given

Lab Order Number: 6A17001

Report Date: 01/18/06

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 01/18/06 11:31

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
#26 @ 2' bgs	6A17001-01	Soil	01/11/06 13:05	01/17/06 08:00
#25 @ 2' bgs	6A17001-02	Soil	01/11/06 13:00	01/17/06 08:00
#35 @ 1' bgs	6A17001-03	Soil	01/11/06 14:10	01/17/06 08:00
#37 @ 5' bgs	6A17001-04	Soil	01/10/06 14:00	01/17/06 08:00
#30 @ 3' bgs	6A17001-05	Soil	01/12/06 09:15	01/17/06 08:00
#29 @ 3' bgs	6A17001-06	Soil	01/12/06 09:11	01/17/06 08:00
#40 @ 5' bgs	6A17001-07	Soil	01/12/06 11:30	01/17/06 08:00
#31 @ 3' bgs	6A17001-08	Soil	01/12/06 10:30	01/17/06 08:00
#1 @ 1' bgs	6A17001-09	Soil	01/13/06 10:50	01/17/06 08:00
#5 @ 1' bgs	6A17001-10	Soil	01/13/06 10:55	01/17/06 08:00
#6 @ 1' bgs	6A17001-11	Soil	01/13/06 11:00	01/17/06 08:00
#11 @ 1' bgs	6A17001-12	Soil	01/13/06 11:05	01/17/06 08:00
#18 @ 1' bgs	6A17001-13	Soil	01/13/06 13:05	01/17/06 08:00
Blend #1	6A17001-14	Soil	01/13/06 13:06	01/17/06 08:00
Blend #2	6A17001-15	Soil	01/13/06 14:10	01/17/06 08:00

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 01/18/06 11:31

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#25 @ 2' bgs (6A17001-02) Soil									
Gasoline Range Organics C6-C12	ND	10.0	mg/kg dry	1	EA61709	01/17/06	01/17/06	EPA 8015M	
Diesel Range Organics >C12-C35	ND	10.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	10.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*97.0 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*86.6 %*	*70-130*		"	"	"	"	
#29 @ 3' bgs (6A17001-06) Soil									
Gasoline Range Organics C6-C12	ND	10.0	mg/kg dry	1	EA61709	01/17/06	01/17/06	EPA 8015M	
Diesel Range Organics >C12-C35	ND	10.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	10.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*104 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*92.4 %*	*70-130*		"	"	"	"	
#40 @ 5' bgs (6A17001-07) Soil									
Gasoline Range Organics C6-C12	ND	10.0	mg/kg dry	1	EA61709	01/17/06	01/17/06	EPA 8015M	
Diesel Range Organics >C12-C35	ND	10.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	ND	10.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*99.8 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*88.4 %*	*70-130*		"	"	"	"	
#1 @ 1' bgs (6A17001-09) Soil									
Gasoline Range Organics C6-C12	ND	10.0	mg/kg dry	1	EA61709	01/17/06	01/17/06	EPA 8015M	
Diesel Range Organics >C12-C35	**192**	10.0	"	"	"	"	"	"	
Total Hydrocarbon C6-C35	**192**	10.0	"	"	"	"	"	"	
Surrogate: 1-Chlorooctane		*101 %*	*70-130*		"	"	"	"	
Surrogate: 1-Chlorooctadecane		*89.6 %*	*70-130*		"	"	"	"	

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Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/18/06 11:31

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#26 @ 2' bgs (6A17001-01) Soil									
Chloride	995	20.0	mg/kg	40	EA61708	01/17/06	01/17/06	EPA 300.0	
#25 @ 2' bgs (6A17001-02) Soil									
Chloride	1280	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
% Moisture	4.9	0.1	%	1	EA61801	01/17/06	01/18/06	% calculation	
#35 @ 1' bgs (6A17001-03) Soil									
Chloride	2130	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
#37 @ 5' bgs (6A17001-04) Soil									
Chloride	594	10.0	mg/kg	20	EA61708	01/17/06	01/17/06	EPA 300.0	
#30 @ 3' bgs (6A17001-05) Soil									
Chloride	1410	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
#29 @ 3' bgs (6A17001-06) Soil									
Chloride	1480	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
% Moisture	5.0	0.1	%	1	EA61801	01/17/06	01/18/06	% calculation	
#40 @ 5' bgs (6A17001-07) Soil									
Chloride	1440	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
% Moisture	6.2	0.1	%	1	EA61801	01/17/06	01/18/06	% calculation	
#31 @ 3' bgs (6A17001-08) Soil									
Chloride	1060	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
#1 @ 1' bgs (6A17001-09) Soil									
Chloride	214	10.0	mg/kg	20	EA61708	01/17/06	01/17/06	EPA 300.0	
% Moisture	4.2	0.1	%	1	EA61801	01/17/06	01/18/06	% calculation	

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Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 01/18/06 11:31

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#5 @ 1' bgs (6A17001-10) Soil									
Chloride	**867**	25.0	mg/kg	50	EA61708	01/17/06	01/17/06	EPA 300.0	
#6 @ 1' bgs (6A17001-11) Soil									
Chloride	**594**	20.0	mg/kg	40	EA61708	01/17/06	01/17/06	EPA 300.0	
#11 @ 1' bgs (6A17001-12) Soil									
Chloride	**688**	20.0	mg/kg	40	EA61708	01/17/06	01/17/06	EPA 300.0	
#18 @ 1' bgs (6A17001-13) Soil									
Chloride	**334**	10.0	mg/kg	20	EA61708	01/17/06	01/17/06	EPA 300.0	
Blend #1 (6A17001-14) Soil									
Chloride	**322**	10.0	mg/kg	20	EA61708	01/17/06	01/17/06	EPA 300.0	
Blend #2 (6A17001-15) Soil									
Chloride	**356**	10.0	mg/kg	20	EA61708	01/17/06	01/17/06	EPA 300.0	

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471
Reported:
01/18/06 11:31

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 EA61709 - Solvent Extraction (GC)										
Blank (EA61709-BLK1)				Prepared & Analyzed: 01/17/06						
Gasoline Range Organics C6-C12	ND	10.0	mg/kg wet							
Diesel Range Organics >C12-C35	ND	10.0	"							
Total Hydrocarbon C6-C35	ND	10.0	"							
Surrogate: 1-Chlorooctane	*53.9*		*mg/kg*	*50.0*		*108*	*70-130*			
Surrogate: 1-Chlorooctadecane	*49.7*		*"*	*50.0*		*99.4*	*70-130*			
LCS (EA61709-BS1)				Prepared & Analyzed: 01/17/06						
Gasoline Range Organics C6-C12	445	10.0	mg/kg wet	500		89.0	75-125			
Diesel Range Organics >C12-C35	534	10.0	"	500		107	75-125			
Total Hydrocarbon C6-C35	979	10.0	"	1000		97.9	75-125			
Surrogate: 1-Chlorooctane	*52.0*		*mg/kg*	*50.0*		*104*	*70-130*			
Surrogate: 1-Chlorooctadecane	*41.8*		*"*	*50.0*		*83.6*	*70-130*			
Calibration Check (EA61709-CCV1)				Prepared: 01/17/06 Analyzed: 01/18/06						
Gasoline Range Organics C6-C12	478		mg/kg	500		95.6	80-120			
Diesel Range Organics >C12-C35	594		"	500		119	80-120			
Total Hydrocarbon C6-C35	1070		"	1000		107	80-120			
Surrogate: 1-Chlorooctane	*59.0*		*"*	*50.0*		*118*	*70-130*			
Surrogate: 1-Chlorooctadecane	*47.8*		*"*	*50.0*		*95.6*	*70-130*			
Matrix Spike (EA61709-MS1)	**Source: 6A17001-02**			Prepared & Analyzed: 01/17/06						
Gasoline Range Organics C6-C12	480	10.0	mg/kg dry	526	ND	91.3	75-125			
Diesel Range Organics >C12-C35	579	10.0	"	526	ND	110	75-125			
Total Hydrocarbon C6-C35	1060	10.0	"	1050	ND	101	75-125			
Surrogate: 1-Chlorooctane	*57.6*		*mg/kg*	*50.0*		*115*	*70-130*			
Surrogate: 1-Chlorooctadecane	*46.6*		*"*	*50.0*		*93.2*	*70-130*			
Matrix Spike Dup (EA61709-MSD1)	**Source: 6A17001-02**			Prepared & Analyzed: 01/17/06						
Gasoline Range Organics C6-C12	480	10.0	mg/kg dry	526	ND	91.3	75-125	0.00	20	
Diesel Range Organics >C12-C35	583	10.0	"	526	ND	111	75-125	0.688	20	
Total Hydrocarbon C6-C35	1060	10.0	"	1050	ND	101	75-125	0.00	20	
Surrogate: 1-Chlorooctane	*57.6*		*mg/kg*	*50.0*		*115*	*70-130*			
Surrogate: 1-Chlorooctadecane	*47.1*		*"*	*50.0*		*94.2*	*70-130*			

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 01/18/06 11:31

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 EA61708 - Water Extraction										
Blank (EA61708-BLK1)				Prepared & Analyzed: 01/17/06						
Chloride	ND	0.500	mg/kg							
LCS (EA61708-BS1)				Prepared & Analyzed: 01/17/06						
Chloride	8.48		mg/L	10.0		84.8	80-120			
Calibration Check (EA61708-CCV1)				Prepared & Analyzed: 01/17/06						
Chloride	8.71		mg/L	10.0		87.1	80-120			
Duplicate (EA61708-DUP1)		**Source: 6A16008-01**		Prepared & Analyzed: 01/17/06						
Chloride	3020	50.0	mg/kg		3010			0.332	20	
Batch EA61801 - General Preparation (Prep)										
Blank (EA61801-BLK1)				Prepared: 01/17/06 Analyzed: 01/18/06						
% Solids	100		%							
Duplicate (EA61801-DUP1)		**Source: 6A17001-02**		Prepared: 01/17/06 Analyzed: 01/18/06						
% Solids	95.2		%		95.1			0.105	20	
Duplicate (EA61801-DUP2)		**Source: 6A17009-01**		Prepared: 01/17/06 Analyzed: 01/18/06						
% Moisture	13.9	0.1	%		12.1			13.8	20	

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: Celey D. Keene Date: 1/18/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
La Tasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

Pg 1 of 2

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763
Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Rice Operating
Company Address: 122 W Taylor
City/State/Zip: Hobbs, NM 88240
Telephone No: (505) 393-9174
Fax No: (505) 393-1471
Sampler Signature: Jennifer Johnson

Project Name: Abo Apache LA Lu
Project #:
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify):	TDS/CL/SAR/EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
[illegible]	26 @ 2' bgs	1/11/06	1:05pm	1	X									X		X								
[illegible]	#25 @ 2' bgs	1/11/06	1:00pm	1	X									X		X			X					X
[illegible]	#35 @ 1' bgs	1/11/06	2:10pm	1	X									X		X								
[illegible]	#37 @ 5' bgs	1/10/06	2:00pm	1	X									X		X								X
[illegible]	~~Pit Run #40~~ RRR	~~1/12/06~~	~~1:29pm~~	~~1~~	~~X~~									~~X~~		~~X~~								
[illegible]	#30 @ 3' bgs	1/12/06	9:15Am	1	X									X		X								
[illegible]	#29 @ 3' bgs	1/12/06	9:11Am	1	X									X		X			X					X
[illegible]	#40 @ 5' bgs	1/12/06	11:30Am	1	X									X		X			X					X
[illegible]	#31 @ 3' bgs	1/12/06	10:30Am	1	X									X		X								X
[illegible]	#1 @ 1' bgs	1/13/06	10:50Am	1	X									X		X			X					X

Special Instructions: PLEASE Run TPH on DESIGNATED sample if CLEAN CALL 505-631-1278 Roy, & Rush samples marked Red, Disregard samples slashed & Initialed RRR

Sample Containers Intact?
Temperature Upon Receipt:
Laboratory Comments:

Relinquished by:	Date	Time	Received by:	Date	Time
Melanie Franks	1/16/06	4:00pm	[signature]	1/16	17:30
Relinquished by: [signature]	1/17	8:03	Received by ELOT: [signature]	[illegible]	[illegible]

Pg [illegible] of 2

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Rice Operating
Company Address: 122 W Taylor
City/State/Zip: Hobbs, NM 88240
Telephone No: (505) 393-9174
Fax No: (505) 393-1471
Sampler Signature: Jennifer Johnson

Project Name: ABO Apache LA Loc
Project #:
Project Loc:
PO #:

Analyze For: TCLP: / TOTAL:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify)	TDS / CL / SAR / EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
	#5 @ 1' bgs	1/13/06	10:55Am	1	X									X		X								
	#6 @ 1' bgs	1/13/06	11:00Am	1	X									X		X								
	#11 @ 1' bgs	1/13/06	11:05Am	1	X									X		X								
	#18 @ 1' bgs	1/13/06	1:05pm	1	X									X		X								
	~~Pile from 1 4~~	~~1/13/06~~	~~2:30pm~~	~~1~~	~~X~~									~~X~~		~~X~~								
	Blend #1	1/13/06	1:06pm	1	X									X		X								
	Blend #2	1/13/06	2:10pm	1	X									X		X								

Special Instructions:

Relinquished by:	Date	Time	Received by:	Date	Time
Miriam Franko	1/16/06	4:00pm	C. R. [illegible]	1/16	17:30
Relinquished by: C. [illegible]	1/17	8:00	Received by ELOT: [illegible]	1/17/06	[illegible]

Sample Containers Intact?
Temperature Upon Receipt:
Laboratory Comments:

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

Client: Rice Operating Co.

Date/Time: 01-17-06 @0800

Order #: 6A17001

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	0.5 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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: None Given

Location: None Given

Lab Order Number: 6A23001

Report Date: 01/25/06

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/25/06 09:30

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
#35@ 2' bgs	6A23001-01	Soil	01/18/06 14:45	01/20/06 17:00
#9@ 2' bgs	6A23001-02	Soil	01/17/06 11:05	01/20/06 17:00
#63@ 5' bgs	6A23001-03	Soil	01/18/06 12:30	01/20/06 17:00
#55@ 5' bgs	6A23001-04	Soil	01/18/06 07:50	01/20/06 17:00
#32@ 2' bgs	6A23001-05	Soil	01/17/06 13:30	01/20/06 17:00
#31@ 5' bgs	6A23001-06	Soil	01/19/06 15:15	01/20/06 17:00
#3 pile	6A23001-07	Soil	01/20/06 08:20	01/20/06 17:00
#25@ 4' bgs	6A23001-08	Soil	01/19/06 15:10	01/20/06 17:00
#36@ 5' bgs	6A23001-09	Soil	01/20/06 08:18	01/20/06 17:00
#56@ 5' bgs	6A23001-10	Soil	01/19/06 12:35	01/20/06 17:00
#29@ 5' bgs	6A23001-11	Soil	01/19/06 10:40	01/20/06 17:00
#60@ 5' bgs	6A23001-12	Soil	01/18/06 08:30	01/20/06 17:00
Pile #4	6A23001-13	Soil	01/20/06 07:45	01/20/06 17:00
#33@ 2' bgs	6A23001-14	Soil	01/17/06 13:30	01/20/06 17:00
#54@ 3' bgs	6A23001-15	Soil	01/19/06 14:10	01/20/06 17:00
#30@ 5' bgs	6A23001-16	Soil	01/19/06 12:55	01/20/06 17:00
#10@ 2' bgs	6A23001-17	Soil	01/17/06 11:15	01/20/06 17:00
#61@ 5' bgs	6A23001-18	Soil	01/18/06 08:35	01/20/06 17:00

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/25/06 09:30

General Chemistry Parameters by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#35@ 2' bgs (6A23001-01) Soil									
Chloride	**1140**	25.0	mg/kg	50	EA62501	01/24/06	01/24/06	EPA 300.0	
#9@ 2' bgs (6A23001-02) Soil									
Chloride	**1040**	20.0	mg/kg	40	EA62501	01/24/06	01/24/06	EPA 300.0	
#63@ 5' bgs (6A23001-03) Soil									
Chloride	**1170**	20.0	mg/kg	40	EA62501	01/24/06	01/24/06	EPA 300.0	
#55@ 5' bgs (6A23001-04) Soil									
Chloride	**1470**	25.0	mg/kg	50	EA62501	01/24/06	01/24/06	EPA 300.0	
#32@ 2' bgs (6A23001-05) Soil									
Chloride	**1020**	25.0	mg/kg	50	EA62501	01/24/06	01/24/06	EPA 300.0	
#31@ 5' bgs (6A23001-06) Soil									
Chloride	**1380**	25.0	mg/kg	50	EA62501	01/24/06	01/24/06	EPA 300.0	
#3 pile (6A23001-07) Soil									
Chloride	**250**	10.0	mg/kg	20	EA62501	01/24/06	01/24/06	EPA 300.0	
#25@ 4' bgs (6A23001-08) Soil									
Chloride	**1170**	25.0	mg/kg	50	EA62501	01/24/06	01/24/06	EPA 300.0	
#36@ 5' bgs (6A23001-09) Soil									
Chloride	**2120**	25.0	mg/kg	50	EA62501	01/24/06	01/24/06	EPA 300.0	
#56@ 5' bgs (6A23001-10) Soil									
Chloride	**1640**	25.0	mg/kg	50	EA62501	01/24/06	01/24/06	EPA 300.0	
#29@ 5' bgs (6A23001-11) Soil									
Chloride	**933**	10.0	mg/kg	20	EA62501	01/24/06	01/24/06	EPA 300.0	

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/25/06 09:30

General Chemistry Parameters by EPA / Standard Methods
Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
#60@ 5' bgs (6A23001-12) Soil									
Chloride	**1360**	20.0	mg/kg	40	EA62501	01/24/06	01/24/06	EPA 300.0	
Pile #4 (6A23001-13) Soil									
Chloride	**261**	10.0	mg/kg	20	EA62501	01/24/06	01/24/06	EPA 300.0	
#33@ 2' bgs (6A23001-14) Soil									
Chloride	**809**	10.0	mg/kg	20	EA62501	01/24/06	01/24/06	EPA 300.0	
#54@ 3' bgs (6A23001-15) Soil									
Chloride	**962**	20.0	mg/kg	40	EA62501	01/24/06	01/24/06	EPA 300.0	
#30@ 5' bgs (6A23001-16) Soil									
Chloride	**730**	10.0	mg/kg	20	EA62501	01/24/06	01/24/06	EPA 300.0	
#10@ 2' bgs (6A23001-17) Soil									
Chloride	**1050**	20.0	mg/kg	40	EA62501	01/24/06	01/24/06	EPA 300.0	
#61@ 5' bgs (6A23001-18) Soil									
Chloride	**1380**	20.0	mg/kg	40	EA62501	01/24/06	01/24/06	EPA 300.0	

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/25/06 09:30

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 EA62501 - Water Extraction										
Blank (EA62501-BLK1)				Prepared & Analyzed: 01/24/06						
Chloride	ND	0.500	mg/kg							
LCS (EA62501-BS1)				Prepared & Analyzed: 01/24/06						
Chloride	8.29	0.500	mg/kg	10.0		82.9	80-120			
Calibration Check (EA62501-CCV1)				Prepared & Analyzed: 01/24/06						
Chloride	8.59		mg/L	10.0		85.9	80-120			
Duplicate (EA62501-DUP1)	Source: 6A23001-01			Prepared & Analyzed: 01/24/06						
Chloride	1090	25.0	mg/kg		1140			4.48	20	

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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: 1/25/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Pride Operating Co.
Company Address: 122 W. Taylor
City/State/Zip: Hobbs NM 88240
Telephone No: (505) 393-9174
Fax No:
Sampler Signature: Jennifer Johnson

Project Name: Abo Apache LA Leak
Project #:
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify)	TDS/ CL / SAR / EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030							RUSH TAT (Pre-Schedule)
[illegible]	#35 @ 2' bgs	1/18/06	2:45	1	X									X		X														X
[illegible]	#9 @ 2' bgs	1/17/06	11:05	1	X									X		X														X
[illegible]	#63 @ 5' bgs	1/18/06	12:30	1	X									X		X														
[illegible]	#55 @ 5' bgs	1/18/06	7:50	1	X									X		X														
[illegible]	#32 @ 2' bgs	1/17/06	1:30	1	X									X		X														
[illegible]	#31 @ 5' bgs	1/19/06	3:15	1	X									X		X														
[illegible]	#3 pile	1/20/06	8:20	1	X									X		X														X
[illegible]	#25 @ 4' bgs	1/19/06	3:10	1	X									X		X														X

Special Instructions: * call Roy for Rush ASAP

Relinquished by:	Date	Time	Received by:	Date	Time
Jennifer Johnson	1/20/06	2:30	[illegible]	1/20	14:15
Relinquished by: [illegible]	1/20	17:00	Received by ELOT: [illegible]	1/20/06	17:00

Sample Containers Intact? Temperature Upon Receipt: Laboratory Comments: 2.0 °C

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Rice Operating Co
Company Address: 122 W. Taylor
City/State/Zip: Hobbs NM 88240
Telephone No: (505) 393-9174
Fax No:
Sampler Signature: Jennifer A Johnson

Project Name: NOD Apache LA Leak
Project #:
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify)	Analyze For: TDS (Cl) SAR / EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
-09	#36 @ 5' bgs	1/20/06	8:18	1	X									X		X								
-10	#56 @ 5' bgs	1/19/06	12:35	1	X									X		X								
-11	#29 @ 5' bgs	1/19/06	10:40	1	X									X		X								
-12	#60 @ 5' bgs	1/18/06	8:30	1	X									X		X								
-13	Pile #4	1/20/06	7:45	1	X									X		X								
-14	#33 @ 2' bgs	1/17/06	1:30	1	X									X		X								
-15	#54 @ 3' bgs	1/19/06	2:10	1	X									X		X								
-16	#30 @ 5' bgs	1/19/06	12:55	1	X									X		X								
-17	#10 @ 2' bgs	1/17/06	11:15am	1	X									X		X								
-18	#61 @ 5' bgs	1/18/06	8:35	1	X									X		X								

TCLP:
TOTAL:

Special Instructions: * call Roy for rush   ASAP

Sample Containers Intact?
Temperature Upon Receipt:
Laboratory Comments:

Relinquished by:	Date	Time	Received by:	Date	Time
Jennifer Johnson	1/20/06	2:00pm	[signature]	1/20	14:45
Relinquished by:	**Date**	**Time**	**Received by ELOT:**	**Date**	**Time**
[signature]	1/20	17:00	[signature]	1/20/06	17:00

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

Client: Rice Op.

Date/Time: 1/20/06 17:00

Order #: 6A23001

Initials: Ck

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	2.0 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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: Remediation

Location: None Given

Lab Order Number: 6A24004

Report Date: 01/26/06

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: Remediation Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 01/26/06 15:20

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Pile #1 Blended	6A24004-01	Soil	01/23/06 12:50	01/24/06 08:00
Pile #2 Blended	6A24004-02	Soil	01/23/06 14:45	01/24/06 08:00

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: Remediation
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
01/26/06 15:20

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Pile #1 Blended (6A24004-01) Soil									
Chloride	**288**	10.0	mg/kg	20	EA62404	01/25/06	01/26/06	EPA 300.0	
Pile #2 Blended (6A24004-02) Soil									
Chloride	**244**	10.0	mg/kg	20	EA62404	01/25/06	01/26/06	EPA 300.0	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: Remediation
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
01/26/06 15:20

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 EA62404 - Water Extraction										
Blank (EA62404-BLK1)				Prepared: 01/25/06 Analyzed: 01/26/06						
Chloride	ND	0.500	mg/kg							
LCS (EA62404-BS1)				Prepared: 01/25/06 Analyzed: 01/26/06						
Chloride	8.31	0.500	mg/kg	10.0		83.1	80-120			
Calibration Check (EA62404-CCV1)				Prepared: 01/25/06 Analyzed: 01/26/06						
Chloride	8.24		mg/L	10.0		82.4	80-120			
Duplicate (EA62404-DUP1)	**Source: 6A24003-01**			Prepared: 01/25/06 Analyzed: 01/26/06						
Chloride	348	10.0	mg/kg		327			6.22	20	

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Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: Remediation	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	01/26/06 15:20

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: 1/26/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

This material is intended only for the use of the individual (s) or entity to whom it is addressed, and may contain information that is privileged and confidential.

If you have received this material in error, please notify us immediately at 432-563-1800.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763
Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name Rice Operating Company
Company Address: 122 W Taylor
City/State/Zip: Hobbs, NM 88240
Telephone No: 505-393-9174
Fax No: 505-397-1471
Sampler Signature: Roy R. Rascon

Project Name: ABO APAChe LA Leak Site Remediation
Project #:
Project Loc:
PO #:

6A24004

					Preservative							Matrix				Analyze For:															
																TCLP: / TOTAL:															
LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify):	/Cl/	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	EC, CEC, SAR, ESP	Major cations/anions, TDS					RUSH TAT (Pre-Schedule)	Standard TAT
-01	Pile #1 Blended	1-23-06	1250	1						✓				X		✓															
-02	Pile #2 Blended	1-23-06	245 P	1						✓				X		✓															

Special Instructions:

Sample Containers Intact? Y N
Temperature Upon Receipt: 1.5°C
Laboratory Comments: Labels of custody seals

Relinquished by:	Date	Time	Received by:	Date	Time
Roy R. Rascon	1-23-06	400 P ~~1:12 RRR~~	C. O. H.	1/23	16:00
Relinquished by:	**Date**	**Time**	**Received by ELOT:**	**Date**	**Time**
C. O. H.	1/24	8:00	Rolandk Juds	1-24-06	0800

462

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

Client: Rice Op.

Date/Time: 1/24/06 8:00

Order #: 6A24004

Initials: CK

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	1.5 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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: None Given

Location: None Given

Lab Order Number: 6B01009

Report Date: 02/06/06

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	02/06/06 17:06

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Pile #6	6B01009-01	Soil	01/27/06 15:00	01/31/06 19:40

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 02/06/06 17:06

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Pile #6 (6B01009-01) Soil									
Chloride	**623**	10.0	mg/kg	20	EB60608	02/03/06	02/06/06	EPA 300.0	

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471
Reported:
02/06/06 17:06

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 EB60608 - Water Extraction										
Blank (EB60608-BLK1)				Prepared: 02/03/06 Analyzed: 02/06/06						
Chloride	ND	0.500	mg/kg							
LCS (EB60608-BS1)				Prepared: 02/03/06 Analyzed: 02/06/06						
Chloride	8.98		mg/L	10.0		89.8	80-120			
Calibration Check (EB60608-CCV1)				Prepared: 02/03/06 Analyzed: 02/06/06						
Chloride	9.05		mg/L	10.0		90.5	80-120			
Duplicate (EB60608-DUP1)		**Source: 6B01006-03**		Prepared: 02/03/06 Analyzed: 02/06/06						
Chloride	200	10.0	mg/kg		200			0.00	20	

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: 2/6/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon

Company Name: Rice Operating Company

Company Address: 122 W Taylor

City/State/Zip: Hobbs, NM 88240

Telephone No: 505-393-9174

Fax No: 505-397-1471

Sampler Signature: Roy R. Rascon

Project Name: ABO Apache LA Leak Site Remd.

Project #:

Project Loc:

PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify): 4oz glass	Cl-	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	EC, CEC, SAR, ESP	Major cations/anions, TDS	RUSH TAT (Pre-Schedule)	Standard TAT
6B01009 -01	Pile #6	1-27-06	1500	1						✓				X		✓											

Analyze For: TCLP: TOTAL:

Special Instructions:

Sample Containers Intact? (Y) N
Temperature Upon Receipt: 0.5°C
Laboratory Comments: Labels w/ custody seals

Relinquished by:	Date	Time	Received by:	Date	Time
Roy R. Rascon	1-31-06	3:09 pm	[signature]	1/31	17:00
Relinquished by: [signature]	Date	Time 19:40	Received by ELOT: Rolando [signature]	1-31-06	1940

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

Client: Rice Op.

Date/Time: 1/31/06 19:40

Order #: 6B01009

Initials: CK

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	0.5 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:

ENVIRONMENTAL LAB OF TEXAS
12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:
Roy Rascon
Rice Operating Co.
122 W. Taylor
Hobbs, NM 88240

Project: ABO-Apache LA Leak Site
Project Number: None Given
Location: None Given

Lab Order Number: 6B07001

Report Date: 02/09/06

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO-Apache LA Leak Site Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 02/09/06 13:41

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Grid 18 E. Wall @ 5'	6B07001-01	Soil	02/03/06 10:00	02/07/06 08:00
Grid 18 Bttm Comp. @ 5'	6B07001-02	Soil	02/03/06 10:05	02/07/06 08:00
Grid 18 W. Wall @ 5'	6B07001-03	Soil	02/03/06 10:10	02/07/06 08:00
Grid 12 E. Wall @ 5'	6B07001-04	Soil	02/03/06 10:15	02/07/06 08:00
Grid 12 Bttm. Comp. @ 5'	6B07001-05	Soil	02/03/06 10:20	02/07/06 08:00
Grid 12 W. Wall @ 5'	6B07001-06	Soil	02/03/06 10:25	02/07/06 08:00
Grid 10 E. Wall @ 5'	6B07001-07	Soil	02/03/06 10:30	02/07/06 08:00
Grid 10 Bttm. Comp. @ 5'	6B07001-08	Soil	02/03/06 10:35	02/07/06 08:00
Grid 10 E. Wall @ 5'	6B07001-09	Soil	02/03/06 10:40	02/07/06 08:00

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	02/09/06 13:41

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Grid 18 E. Wall @ 5' (6B07001-01) Soil									
Chloride	**200**	10.0	mg/kg	20	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 18 Bttm Comp. @ 5' (6B07001-02) Soil									
Chloride	**863**	20.0	mg/kg	40	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 18 W. Wall @ 5' (6B07001-03) Soil									
Chloride	**791**	10.0	mg/kg	20	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 12 E. Wall @ 5' (6B07001-04) Soil									
Chloride	**807**	25.0	mg/kg	50	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 12 Bttm. Comp. @ 5' (6B07001-05) Soil									
Chloride	**1060**	20.0	mg/kg	40	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 12 W. Wall @ 5' (6B07001-06) Soil									
Chloride	**2250**	50.0	mg/kg	100	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 10 E. Wall @ 5' (6B07001-07) Soil									
Chloride	**1370**	20.0	mg/kg	40	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 10 Bttm. Comp. @ 5' (6B07001-08) Soil									
Chloride	**514**	10.0	mg/kg	20	EB60823	02/08/06	02/09/06	EPA 300.0	
Grid 10 E. Wall @ 5' (6B07001-09) Soil									
Chloride	**1720**	20.0	mg/kg	40	EB60823	02/08/06	02/09/06	EPA 300.0	

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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 EB60823 - Water Extraction										
Blank (EB60823-BLK1)				Prepared & Analyzed: 02/08/06						
Chloride	ND	0.500	mg/kg							
LCS (EB60823-BS1)				Prepared & Analyzed: 02/08/06						
Chloride	8.81	0.500	mg/kg	10.0		88.1	80-120			
Calibration Check (EB60823-CCV1)				Prepared & Analyzed: 02/08/06						
Chloride	9.22		mg/L	10.0		92.2	80-120			
Duplicate (EB60823-DUP1)		**Source: 6B07007-01**		Prepared & Analyzed: 02/08/06						
Chloride	66.2	5.00	mg/kg		65.3			1.37	20	

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	02/09/06 13:41

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: 2/9/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763

Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon

Company Name: Rice Operating Company

Company Address: 122 W Taylor

City/State/Zip: Hobbs, NM 88240

Telephone No: 505-393-9174

Fax No: 505-397-1471

Sampler Signature:

Project Name: ~~ABO ABO~~ Abo Apache L. A. Leak Site Remediation

Project #:

Project Loc:

PO #:

6B07001

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	Analyze For (TCLP: / TOTAL:): Cl	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	EC, CEC, SAR, ESP	Major cations/anions, TDS					RUSH TAT (Pre-Schedule)	Standard TAT
-01	Grid 18 E. Wall @5'	2-3-06	1000	1	✓									✓		✓															
-02	Grid 18 BTTM Comp. @ 5'		1005	1																											
-03	Grid 18 W. Wall @ 5		1010	1																											
-04	Grid 12 E Wall @5'	2-3-06	1015	1																											
-05	Grid 12 BTM Comp @5'		1020	1																											
-06	Grid 12 W Wall @5'		1025	1																											
-07	Grid 10 E Wall @5'	2 3 06	1030	1																											
-08	Grid 10 BtM Comp @5'		1035	1																											
-09	Grid 10 E Wall @5'		1040	1																											

Special Instructions:

Sample Containers Intact? Y N

Temperature Upon Receipt: 4.0 °C

Laboratory Comments: 4oz glass on ice w/ labels + seals. Seal on cooler

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	020606	4:00P	[signature]	2/6	1800

Relinquished by:	Date	Time	Received by ELOT:	Date	Time
[signature]	2/7	8:00	[signature]	02-07-06	0800

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

Client: Rice Operating Co.

Date/Time: 02-07-06 @0800

Order #: 6B07001

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	4.0 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:

Environmental Lab of Texas
12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:
Roy Rascon
Rice Operating Co.
122 W. Taylor
Hobbs, NM 88240

Project: ABO- Apache Leak
Project Number: None Given
Location: None Given

Lab Order Number: 6B07002

Report Date: 02/13/06

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: ABO- Apache Leak Project Number: None Given Project Manager: Roy Rascon	Fax: (505) 397-1471 **Reported:** 02/13/06 10:36

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Grid 6 E. Wall @ 5'	6B07002-01	Soil	02/03/06 10:45	02/07/06 08:00
Grid 6 Bottom Comp. @ 5'	6B07002-02	Soil	02/03/06 10:50	02/07/06 08:00
Grid 6 W. Wall @ 5'	6B07002-03	Soil	02/03/06 10:55	02/07/06 08:00

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Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO- Apache Leak
Project Number: None Given
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
02/13/06 10:36

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Grid 6 E. Wall @ 5' (6B07002-01) Soil									
Chloride	209	10.0	mg/kg	20	EB61002	02/09/06	02/10/06	EPA 300.0	
Grid 6 Bottom Comp. @ 5' (6B07002-02) Soil									
Chloride	1140	20.0	mg/kg	40	EB61002	02/09/06	02/10/06	EPA 300.0	
Grid 6 W. Wall @ 5' (6B07002-03) Soil									
Chloride	465	10.0	mg/kg	20	EB61002	02/09/06	02/10/06	EPA 300.0	

Rice Operating Co.	Project: ABO- Apache Leak	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	02/13/06 10:36

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 EB61002 - Water Extraction										
Blank (EB61002-BLK1)				Prepared: 02/09/06 Analyzed: 02/10/06						
Chloride	ND	0.500	mg/kg							
LCS (EB61002-BS1)				Prepared: 02/09/06 Analyzed: 02/10/06						
Chloride	8.93		mg/L	10.0		89.3	80-120			
Calibration Check (EB61002-CCV1)				Prepared: 02/09/06 Analyzed: 02/10/06						
Chloride	9.37		mg/L	10.0		93.7	80-120			
Duplicate (EB61002-DUP1)	**Source: 6B06018-33**			Prepared: 02/09/06 Analyzed: 02/10/06						
Chloride	12.2	5.00	mg/kg		12.2			0.00	20	

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: 2/13/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763
Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: Rice Operating Company
Company Address: 122 W Taylor
City/State/Zip: Hobbs, NM 88240
Telephone No: 505-393-9174
Fax No: 505-397-1471
Sampler Signature:

Project Name: Abo Apache Leak Site Remediation
Project #:
Project Loc:
PO #:

6807002

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Preservative: Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Matrix: Water	Sludge	Soil	Other (specify):	Analyze For: Cl	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	EC, CEC, SAR, ESP	Major cations/anions, TDS					RUSH TAT (Pre-Schedule)	Standard TAT
-01	Grid 6 E wall @ 5	020306	1045	1	✓									✓		✓															
-02	Grid 6 bottom comp @ 5	〃	1050	1	✓									✓		✓															
-03	Grid 6 W wall @ 5	〃	1055	1	✓									✓		✓															

TCLP:
TOTAL:

Special Instructions:

Sample Containers Intact? Y N
Temperature Upon Receipt: 4.0°C
Laboratory Comments: 4 oz glass on ice w/labels + seals
Seal on cooler

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	020606	4:00P	[signature]	2/6	18:00

Relinquished by:	Date	Time	Received by ELOT:	Date	Time
[signature]	2/7	8:00	[signature]	02-07-06	0800

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

Client: Rice Operating Co.

Date/Time: 02-07-06 @ 0800

Order #: 6B07002

Initials: JMM

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	4.0 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:

ENVIRONMENTAL LAB OF

12600 West I-20 East - Odessa, Texas 79765

Analytical Report

Prepared for:

Roy Rascon

Rice Operating Co.

122 W. Taylor

Hobbs, NM 88240

Project: ABO-Apache LA Leak Site

Project Number: Remediation Project

Location: None Given

Lab Order Number: 6B15003

Report Date: 02/21/06

Rice Operating Co.	Project: ABO-Apache LA Leak Site	Fax: (505) 397-1471
122 W. Taylor	Project Number: Remediation Project	**Reported:**
Hobbs NM, 88240	Project Manager: Roy Rascon	02/21/06 16:35

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Blended Backfill	6B15003-01	Soil	02/11/06 14:12	02/15/06 08:00
Sample P+A N Wall	6B15003-02	Soil	02/09/06 13:00	02/15/06 08:00
Sample P+A @ 5' Bottom Comp.	6B15003-03	Soil	02/09/06 13:05	02/15/06 08:00
Sample P+A S Wall	6B15003-04	Soil	02/09/06 13:10	02/15/06 08:00
Grid Z 2 Wall	6B15003-05	Soil	02/09/06 13:15	02/15/06 08:00
Grid Z N Wall	6B15003-06	Soil	02/09/06 13:20	02/15/06 08:00
Grid Z Bottom Comp. @ 5'	6B15003-07	Soil	02/09/06 13:25	02/15/06 08:00
Grid 3 N Wall	6B15003-08	Soil	02/09/06 13:20	02/15/06 08:00
Grid 3 BOH@ 5'	6B15003-09	Soil	02/09/06 13:40	02/15/06 08:00
Grid 3 2 Wall	6B15003-10	Soil	02/09/06 13:35	02/15/06 08:00

12600 West I-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.
122 W. Taylor
Hobbs NM, 88240

Project: ABO-Apache LA Leak Site
Project Number: Remediation Project
Project Manager: Roy Rascon

Fax: (505) 397-1471

Reported:
02/21/06 16:35

General Chemistry Parameters by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Blended Backfill (6B15003-01) Soil									
Chloride	**236**	10.0	mg/kg	20	EB61613	02/16/06	02/17/06	EPA 300.0	
Sample P+A N Wall (6B15003-02) Soil									
Chloride	**626**	10.0	mg/kg	20	EB61613	02/16/06	02/17/06	EPA 300.0	
Sample P+A @ 5' Bottom Comp. (6B15003-03) Soil									
Chloride	**1060**	25.0	mg/kg	50	EB61613	02/16/06	02/17/06	EPA 300.0	
Sample P+A S Wall (6B15003-04) Soil									
Chloride	**1150**	25.0	mg/kg	50	EB61618	02/16/06	02/20/06	EPA 300.0	
Grid Z 2 Wall (6B15003-05) Soil									
Chloride	**1370**	25.0	mg/kg	50	EB61618	02/16/06	02/20/06	EPA 300.0	
Grid Z N Wall (6B15003-06) Soil									
Chloride	**737**	10.0	mg/kg	20	EB61618	02/16/06	02/20/06	EPA 300.0	
Grid Z Bottom Comp. @ 5' (6B15003-07) Soil									
Chloride	**1110**	20.0	mg/kg	40	EB61618	02/16/06	02/20/06	EPA 300.0	
Grid 3 N Wall (6B15003-08) Soil									
Chloride	**879**	20.0	mg/kg	40	EB61618	02/16/06	02/20/06	EPA 300.0	
Grid 3 BOH@ 5' (6B15003-09) Soil									
Chloride	**1250**	25.0	mg/kg	50	EB61618	02/16/06	02/20/06	EPA 300.0	
Grid 3 2 Wall (6B15003-10) Soil									
Chloride	**1040**	20.0	mg/kg	40	EB61618	02/16/06	02/20/06	EPA 300.0	

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 EB61613 - Water Extraction										
Blank (EB61613-BLK1)				Prepared: 02/16/06 Analyzed: 02/17/06						
Chloride	ND	0.500	mg/kg							
LCS (EB61613-BS1)				Prepared: 02/16/06 Analyzed: 02/17/06						
Chloride	8.87	0.500	mg/kg	10.0		88.7	80-120			
Calibration Check (EB61613-CCV1)				Prepared: 02/16/06 Analyzed: 02/17/06						
Chloride	9.01		mg/L	10.0		90.1	80-120			
Duplicate (EB61613-DUP1)	**Source: 6B14010-05**			Prepared: 02/16/06 Analyzed: 02/17/06						
Chloride	38.5	5.00	mg/kg		38.6			0.259	20	
Batch EB61618 - Water Extraction										
Blank (EB61618-BLK1)				Prepared: 02/16/06 Analyzed: 02/20/06						
Chloride	ND	0.500	mg/kg							
LCS (EB61618-BS1)				Prepared: 02/16/06 Analyzed: 02/20/06						
Chloride	9.13	0.500	mg/kg	10.0		91.3	80-120			
Calibration Check (EB61618-CCV1)				Prepared: 02/16/06 Analyzed: 02/20/06						
Chloride	9.96		mg/L	10.0		99.6	80-120			
Duplicate (EB61618-DUP1)	**Source: 6B15003-05**			Prepared: 02/16/06 Analyzed: 02/20/06						
Chloride	1360	25.0	mg/kg		1370			0.733	20	

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: 2/21/2006

Raland K. Tuttle, Lab Manager
Celey D. Keene, Lab Director, Org. Tech Director
Peggy Allen, QA Officer

Jeanne Mc Murrey, Inorg. Tech Director
LaTasha Cornish, Chemist
Sandra Sanchez, Lab Tech.

Environmental Lab of Texas, Inc.

12600 West I-20 East
Odessa, Texas 79763
Phone: 915-563-1800
Fax: 915-563-1713

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

Project Manager: Roy Rascon
Company Name: RICE OPERATing Co.
Company Address: 122 W Taylor
City/State/Zip: Hobbs N.M. 88240
Telephone No: (505) 393-9174
Fax No:
Sampler Signature: K Wall

Project Name: Abo Apache LA Leak Site
~~Project~~ #: Remediation Project
Project Loc:
PO #:

LAB # (lab use only)	FIELD CODE	Date Sampled	Time Sampled	No. of Containers	Ice	HNO_3	HCl	NaOH	H_2SO_4	None	Other (Specify)	Water	Sludge	Soil	Other (specify)	TDS/Cl/SAR/EC	TPH 418.1	TPH TX 1005/1006	TPH 8015M GRO/DRO	Metals: As Ag Ba Cd Cr Pb Hg Se	Volatiles	Semivolatiles	BTEX 8021B/5030	RUSH TAT (Pre-Schedule)
01	Blended Backfill	021106	2:12	1	✓									✓		✓								
02	2ndpl PtA N wall	020906	1:00	1	✓									✓		✓								
03	3rd. PtA @5' Bottom Comp	020906	1:05	1	✓									✓		✓								
04	2nd PtA S wall	020906	1:10	1	✓									✓		✓								
05	Grid 2 S wall	020906	1:15	1	✓									✓		✓								
06	Grid 2 N wall	020906	1:20	1	✓									✓		✓								
07	Grid 2 Bottom Comp @5'	020906	1:25	1	✓									✓		✓								
08	Grid 3 N wall	020906	1:20	1	✓									✓		✓								
09	Grid 3 Bott @ 5'	020906	1:40	1	✓									✓		✓								
10	Grid 3 S wall	020906	1:35	1	✓									✓		✓								

Special Instructions:

Relinquished by:	Date	Time	Received by:	Date	Time
K Wall	021306	8:00	CD Hayes	2/14	17:00
CD Hayes	2/15	9:00	Received by ELOT: [illegible]	2/15/06	8:00

Sample Containers Intact? (Y) N
Temperature Upon Receipt:
Laboratory Comments:

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

Client: Rice Op.

Date/Time: 2/15/06 8:00

Order #: 6B15003

Initials: CK

Sample Receipt Checklist

Temperature of container/cooler?	Yes	No	2.0 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?	CK ~~Yes~~	No	Not Applicable

Other observations:

Variance Documentation:

Contact Person: - Date/Time: Contacted by:

Regarding:

Corrective Action Taken:

Sundance Services, Inc.

P. O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 92758

ЭR/SHIPPER/COMPANY: Rice

TBJ leak

COMPANY: RWI | TIME AM/PM

ɀo VEHICLE NO.: 600 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[✓] Contaminated Soil
[ ] C-117 No.: ______________
[ ] BS&W Content: ______________

O/d

ΓERIAL [ ] BBLS. __________ : [ ] YARD 12 : [ ] __________

N TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ЭR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ΓROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 901, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED : OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE HE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR ЗY.

DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY ΓO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S SAL.

'ERTIFY that the above Transporter loaded the material represented by this ıent at the above described location, and that it was tendered by the above described certify that no additional materials were added to this load, and that the material out incident.

Sergio Herrera
ΓURE)

ıTATIVE: ______________
(SIGNATURE)

ary - Sundance Acct #1 Pink - Sundance Acct #2 Gold - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P. O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

No 92759

)R/SHIPPER/COMPANY: Rice

HBO leak

COMPANY: RWI | TIME | AM/PM

76 VEHICLE NO.: 82 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] ~~Drilling Fluids~~ [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ________

[ ] BS&W Content: ________

6/1

TERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

N TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
OR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS
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SAL.

*'ERTIFY that the above Transporter loaded the material represented by this
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certify that no additional materials were added to this load, and that the material
out incident.*

TURE)

ITATIVE: (SIGNATURE)

ary - Sundance Acct #1 Pink - Sundance Acct #2 Gold - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P. O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

No 92760

)R/SHIPPER/COMPANY: Rice

9BD leak

COMPANY: RWI | TIME | AM/PM

06 VEHICLE NO.: 70 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[✓] Contaminated Soil
[ ] C-117 No.: ______
[ ] BS&W Content: ______

D/d

TERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

N TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS)R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS 'ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 901, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED : OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE HE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR 3Y.

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'ERTIFY that the above Transporter loaded the material represented by this ient at the above described location, and that it was tendered by the above described certify that no additional materials were added to this load, and that the material out incident.

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TURE)

ITATIVE: [signature]
(SIGNATURE)

ary - Sundance Acct #1 Pink - Sundance Acct #2 Gold - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P. O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 92765

)R/SHIPPER/COMPANY: Rice

ABO leak

COMPANY: Trenno Tek | TIME | AM/PM

x VEHICLE NO.: 103 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Contaminated Soil
[ ] BS&W Content: ____________
[ ] Completion Fluids
[ ] C-117 No.: ____________

TERIAL [ ] BBLS. ____________ : [ ] YARDS ____ : [ ] ____________

N TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
)R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS
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DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
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SAL.

*'ERTIFY that the above Transporter loaded the material represented by this
ient at the above described location, and that it was tendered by the above described
certify that no additional materials were added to this load, and that the material
out incident.*

Trenno ____________________
TURE)

ITATIVE: ____________________
(SIGNATURE)

ary - Sundance Acct #1 Pink - Sundance Acct #2 Gold - Transporter

Sundance Services, Inc.

P. O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 92763

)R/SHIPPER/COMPANY: Rice

780 Leake

COMPANY: Junior ??? | TIME | AM/PM

?? VEHICLE NO.: / DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[✓] Contaminated Soil
[ ] BS&W Content: ____________
[ ] Completion Fluids
[ ] C-117 No.: ____________

Old

TERIAL [ ] BBLS. ____________ : [ ] YARD 12 : [ ] ____________

N TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS)R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS 'ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 901, *et seq.*, THE NM HEALTH AND SAF. CODE § 361.001 *et seq.*, AND REGULATIONS RELATED : OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE HE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR ЗY.

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. M. C

ΓURE)

ITATIVE: [signature]
(SIGNATURE)

ary - Sundance Acct #1 Pink - Sundance Acct #2 Gold - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

№ 93863

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

ɔR/SHIPPER/COMPANY:

COMPANY: | TIME | AM/PM

VEHICLE NO.: 103 | DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ______

______ [ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

ɴ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ɪR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ꝚOM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME ɪ01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ꞮE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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Treviño

'URE)

TATIVE: ______
(SIGNATURE)

ary - Sundance Acct#1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93842

)R/SHIPPER/COMPANY:

COMPANY: | TIME AM/PM

VEHICLE NO.: DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[ ] Contaminated Soil
[ ] C-117 No.: ______
______ [ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ : [ ] YARD ______ : [ ] ______

ɿ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ⱢOM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME '01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ·RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY Ɔ TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

'ERTIFY that the above Transporter loaded the material represented by this ɜnt at the above described location, and that it was tendered by the above described ·rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: ______________________
(SIGNATURE)

ıry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc. № 93811

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

OR/SHIPPER/COMPANY:

COMPANY: | TIME AM/PM

VEHICLE NO.: DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ____________

____________ [ ] BS&W Content: ____________

ERIAL [ ] BBLS. ____________ : [ ] YARD ________ : [ ] ____________

N TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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URE)

TATIVE: ____________________
(SIGNATURE)

ary - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93792

ɔR/SHIPPER/COMPANY: Rice

11 ROllak

COMPANY: Reming

TIME	AM/PM

VEHICLE NO.: 12 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids

[✓] Contaminated Soil

[ ] BS&W Content: ____________

[ ] Completion Fluids

[ ] C-117 No.: ____________

Oil

ERIAL [ ] BBLS. ____________ : [ ] YARD 12 : [ ] ____________

ɴ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ·R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ꝛOM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME ·01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ːE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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'ERTIFY that the above Transporter loaded the material represented by this ɜnt at the above described location, and that it was tendered by the above described ːrtify that no additional materials were added to this load, and that the material ·ut incident.

Trevino

'URE)

TATIVE: ____________________

(SIGNATURE)

ɪry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

№ 93841

)R/SHIPPER/COMPANY: Rice

NB leak

COMPANY: Trevino | TIME AM/PM

VEHICLE NO.: 102 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Contaminated Soil
[ ] BS&W Content: ____
[ ] Completion Fluids
[ ] C-117 No.: ____

O/D

ERIAL [ ] BBLS. ____ : [ ] YARD 12 : [ ] ____

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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'ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: Cary Wingfield
(SIGNATURE)

ry - Sundance Acct #1 / Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

№ 93812

ͻR/SHIPPER/COMPANY: [illegible]

[illegible]

ͻOMPANY: [illegible] | TIME AM/PM

VEHICLE NO.: [illegible] DRIVER NO.:

[illegible]

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[~~]~~ Contaminated Soil
[ ] C-117 No.: ______________
______________ [ ] BS&W Content: ______________

______ [illegible] ______

ERIAL [ ] BBLS. ______________ : [ ] YARD [illegible] : [ ] ______________

ɿ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ɩOM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

ͻITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ɾRTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY Ↄ TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

'ERTIFY that the above Transporter loaded the material represented by this ɜnt at the above described location, and that it was tendered by the above described ɾrtify that no additional materials were added to this load, and that the material ut incident.

____
'URE)

ƮATIVE: Carl Wengfield
(SIGNATURE)

ɹry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93794

ℹR/SHIPPER/COMPANY:

COMPANY: | TIME AM/PM

VEHICLE NO.: DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ____

____ [ ] BS&W Content: ____

ERIAL [ ] BBLS. ____ : [ ] YARD ____ : [ ] ____

N TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY O TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described ertify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: Carl Wingfield

(SIGNATURE)

ary - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

№ 93864

)R/SHIPPER/COMPANY:

:OMPANY: | TIME | AM/PM

VEHICLE NO.: | DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
~~[ ] Contaminated Soil~~
[ ] C-117 No.: ______
______ [ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ : [ ] YARD ______ : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: Carl Wingfield
(SIGNATURE)

ury - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.
P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

№ 93843

)R/SHIPPER/COMPANY:

COMPANY: | TIME | AM/PM

VEHICLE NO.: | DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[ ] Contaminated Soil
[ ] C-117 No.: ____________
____________ [ ] BS&W Content: ____________

ERIAL [ ] BBLS. ____________ : [ ] YARD ______ : [ ] ____________

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME '01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

'ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described ertify that no additional materials were added to this load, and that the material ut incident.

'URE)

TATIVE: ______________________________
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

№ 93813

P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

ɔR/SHIPPER/COMPANY:

ɔOMPANY: | TIME AM/PM

VEHICLE NO.: DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids
[ ] Contaminated Soil [ ] C-117 No.: ______
______ [ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ : [ ] YARD ______ : [ ] ______

ɿ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
ʼR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS
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AL.

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ɹrtify that no additional materials were added to this load, and that the material
ʼut incident.*

______
'URE)

TATIVE: ______
(SIGNATURE)

ary - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93795

ɔR/SHIPPER/COMPANY: K...

Bolick

COMPANY: Kim | TIME AM/PM

VEHICLE NO.: 111 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ____

____ [ ] BS&W Content: ____

Oil

ERIAL [ ] BBLS. ____ : [ ] YARD 12 : [ ] ____

ɴ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ʀ/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ʀOM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME ɔ01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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____ (signature)

ʼURE)

ʇATIVE: ____

(SIGNATURE)

ʼry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93875

)R/SHIPPER/COMPANY: R.C.e

.ba Arrilh

:OMPANY: R-m | TIME AM/PM

le VEHICLE NO.: 111 DRIVER NO.:

.Ce

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[✓] Contaminated Soil [ ] C-117 No.: ____________

____________ [ ] BS&W Content: ____________

0/10

ERIAL [ ] BBLS. ____________ : [ ] YARD 12 : [ ] ____________

ı TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME '01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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'ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described ertify that no additional materials were added to this load, and that the material ut incident.

____
'URE)

TATIVE: ____________________
(SIGNATURE)

ary - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

Nº 93793

P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

ɔR/SHIPPER/COMPANY:

COMPANY: | TIME AM/PM

VEHICLE NO.: DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Contaminated Soil
[ ] BS&W Content: ______
[ ] Completion Fluids
[ ] C-117 No.: ______

Oil

ERIAL [ ] BBLS. ______ : [ ] YARD ______ : [ ] ______

ɴ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS
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DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
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D TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S
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*ERTIFY that the above Transporter loaded the material represented by this
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rtify that no additional materials were added to this load, and that the material
ut incident.*

URE)

TATIVE: ______
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93618

)R/SHIPPER/COMPANY: Rice

)Bl. 16 L

:OMPANY: Trino | TIME AM/PM

VEHICLE NO.: 103 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ____________

____________ [ ] BS&W Content: ____________

o/il

ERIAL [ ] BBLS. ____________ : [ ] YARD 12 : [ ] ____________

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this :nt at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

V Trevino

URE)

TATIVE: ____________

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

Nº 93619

)R/SHIPPER/COMPANY: Rice

BD Tank

COMPANY: Trevino TRK | TIME AM/PM

VEHICLE NO.: 22 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ______

[ ] BS&W Content: ______

Oil

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this :nt at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: Carl Wingfield

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93642

)R/SHIPPER/COMPANY:

COMPANY: | TIME | AM/PM

VEHICLE NO.: | DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Contaminated Soil
[ ] BS&W Content: ______
[ ] Completion Fluids
[ ] C-117 No.: ______

ERIAL [ ] BBLS. ______ : [ ] YARD ______ : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this :nt at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

[ATIVE: ______
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

Nº 93651

)R/SHIPPER/COMPANY: Rice

1BO leaks

:OMPANY: Tavio | TIME AM/PM

VEHICLE NO.: 102 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[ ] ~~Contaminated~~ Soil
[ ] C-117 No.: ______
[ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: Carl Winfield

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

Nº 93654

)R/SHIPPER/COMPANY: [illegible] Rice

/BO [illegible]

:OMPANY: [illegible] | TIME AM/PM

VEHICLE NO.: 103 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] ~~Contam~~inated Soil [ ] C-117 No.: ______

______ [ ] BS&W Content: ______

Oil

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this :nt at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

[illegible signature]

URE)

[ATIVE: ______

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc. № 93676

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

OR/SHIPPER/COMPANY: Rice

Bo Tank

COMPANY: Trans

TIME AM/PM

VEHICLE NO.: 122 DRIVER NO.:

Pit

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ____

[ ] BS&W Content: ____

ERIAL [ ] BBLS. ____ : [ ] YARD 12 : [ ] ____

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: Carl Littlefield
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93678

)R/SHIPPER/COMPANY: Rice

Vacuum truck

COMPANY: Trend | TIME AM/PM

VEHICLE NO.: 103 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Contaminated Soil
[ ] BS&W Content: ______
[ ] Completion Fluids
[ ] C-117 No.: ______

Old

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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[signature]

URE)

TATIVE: ______
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93728

)R/SHIPPER/COMPANY: Rice

COMPANY: Rodriguez Trk | TIME AM/PM

VEHICLE NO.: 415 DRIVER NO.:

Rice

TYPE OF MATERIAL

Unit R45

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ____________

____________ [ ] BS&W Content: ____________

ERIAL [ ] BBLS. ____________ : [ ] YARD 20 : [ ] ____________

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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Robert Rodriguez

URE)

TATIVE: ____________

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

№ 93744

P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

)R/SHIPPER/COMPANY:

COMPANY: | TIME | AM/PM

VEHICLE NO.: | DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[ ] Contaminated Soil
[ ] C-117 No.: ______
[ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ [ ] YARD ______ [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS
ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME
01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED
OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE
E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR
Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY
) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S
AL.

ERTIFY that the above Transporter loaded the material represented by this
ent at the above described location, and that it was tendered by the above described
rtify that no additional materials were added to this load, and that the material
ut incident.

URE)

TATIVE: ______
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93711

)R/SHIPPER/COMPANY: Rice

Vacuum

COMPANY: Trinity | TIME AM/PM

VEHICLE NO.: 108 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[x] Contaminated Soil [ ] C-117 No.: ______

______ [ ] BS&W Content: ______

Old

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

ı TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

Trevino

URE)

TATIVE: ______

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.
P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

№ 93722

)R/SHIPPER/COMPANY: Rice	
COMPANY:	TIME AM/PM
VEHICLE NO.: 103	DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[-] Contaminated Soil
[ ] C-117 No.: ______
[ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ : [ ] YARD ______ : [ ] ______

ɴ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ʀ/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME)01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE IE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS ɪRTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

'ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described ertify that no additional materials were added to this load, and that the material ut incident.

____
URE)

TATIVE: ______________________________
(SIGNATURE)

ıry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93736

)R/SHIPPER/COMPANY: Rice

ABO leak

:OMPANY: Trevino

VEHICLE NO.: 103

TIME AM/PM

DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids

[ ] Completion Fluids

[ ] Contaminated Soil

[ ] C-117 No.: ____________

____________ [ ] BS&W Content: ____________

Old

ERIAL [ ] BBLS. ____________ : [ ] YARD 12 : [ ] ____________

ı TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME '01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY D TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

al Trevino

URE)

TATIVE: ____________

(SIGNATURE)

ıry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

Nº 93748

)R/SHIPPER/COMPANY: Rice

-B.D Apache lent.

COMPANY: J&N Trevino | TIME | AM/PM

V VEHICLE NO.: 103 DRIVER NO.: 103

~~J&N. Trevino~~ Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ______________

______________ [ ] BS&W Content: ______________

?.D. 12 yds.

ERIAL [ ] BBLS. ______________ : [ ] YARD 12 : [ ] ______________

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

U Trevino

URE)

TATIVE: Z. Morris

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93750

)R/SHIPPER/COMPANY: R.Ce	
\Bo Apache	
:OMPANY: TNT Rivero	TIME AM/PM
6 VEHICLE NO.: # 001	DRIVER NO.:
.Ce	

TYPE OF MATERIAL

2/10 [ ] Drilling Fluids [ ] Completion Fluids

[✓] Contaminated Soil [ ] C-117 No.: ______

[ ] BS&W Content: ______

0/10

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this :nt at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE) ______

TATIVE: ______
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93712

)R/SHIPPER/COMPANY: Rice

'R Lake

COMPANY: | TIME AM/PM

'r VEHICLE NO.: 102 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] ~~Contaminated~~ Soil [ ] C-117 No.: ______

______ [ ] BS&W Content: ______

Oil

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS 'R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME '01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS 'RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

'ERTIFY that the above Transporter loaded the material represented by this :nt at the above described location; and that it was tendered by the above described :rtify that no additional materials were added to this load, and that the material ut incident.

______
URE)

TATIVE: Carl Wingfield
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93723

ɔR/SHIPPER/COMPANY: Rice

4BO leak

COMPANY: Trevino | TIME AM/PM

VEHICLE NO.: #2 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ______

______ [ ] BS&W Content: ______

Oil

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

ɿ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
ʀ/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS
ɾOM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME
'01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED
OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE
E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR
Y.

ƆITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
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AL.

*'ERTIFY that the above Transporter loaded the material represented by this
ɜnt at the above described location, and that it was tendered by the above described
'rtify that no additional materials were added to this load, and that the material
ut incident.*

URE)

ɾATIVE: Carl Wingfield
(SIGNATURE)

ɪry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

Nº 93737

)R/SHIPPER/COMPANY: Rice

'Bu Henks

COMPANY: Trevin | TIME | AM/PM

Rice VEHICLE NO.: 102 | DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
~~[ ]~~ Contaminated Soil
[ ] C-117 No.: ____________
____________ [ ] BS&W Content: ____________

ERIAL [ ] BBLS. ____________ : [ ] YARD 12 : [ ] ____________

1 TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
'R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS
ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME
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OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE
E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR
Y.

DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS
'RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY
O TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S
AL.

*'ERTIFY that the above Transporter loaded the material represented by this
ent at the above described location, and that it was tendered by the above described
ertify that no additional materials were added to this load, and that the material
ut incident.*

URE)

TATIVE: Carl Wingfield
(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

№ 93713

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

)R/SHIPPER/COMPANY: [illegible]

[illegible]

COMPANY: [illegible] | TIME AM/PM

[illegible] VEHICLE NO.: 111 DRIVER NO.:

[illegible]

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[ ] Contaminated Soil [ ] C-117 No.: ____________

____________ [ ] BS&W Content: ____________

[illegible] ____________

ERIAL [ ] BBLS. ____________ : [ ] YARD [illegible] : [ ] ____________

1 TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME '01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

DITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY D TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: Martin Carrth

(SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93726

)R/SHIPPER/COMPANY: Rice

COMPANY: RAM | TIME AM/PM

VEHICLE NO.: 111 DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids [ ] Completion Fluids

[✓] Contaminated Soil [ ] C-117 No.: ______

______ [ ] BS&W Content: ______

ERIAL [ ] BBLS. ______ : [ ] YARD 12 : [ ] ______

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

)ITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS RTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY) TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S AL.

ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: ______ (SIGNATURE)

ry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.
P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

№ 93743

)R/SHIPPER/COMPANY:

:OMPANY: | TIME AM/PM

VEHICLE NO.: | DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[ ] Contaminated Soil
[ ] C-117 No.: ____________
____________ [ ] BS&W Content: ____________

ERIAL [ ] BBLS. ____________ : [ ] YARD ______ : [ ] ____________

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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URE)

'ATIVE: ____________
(SIGNATURE)

ry - Sundance Acct # Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231

(505) 394-2511

№ 93753

)R/SHIPPER/COMPANY: Rice

ABO Leak

:OMPANY: R&M Trucking | TIME | AM/PM

?16 VEHICLE NO.: #111 DRIVER NO.:

Rice

TYPE OF MATERIAL

[ ] Drilling Fluids

[ ] Contaminated Soil

[ ] BS&W Content: ____________

[ ] Completion Fluids

[ ] C-117 No.: ____________

Oil

ERIAL [ ] BBLS. 0 : [ ] YARD 10 : [ ] ________

I TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS :OM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this :nt at the above described location, and that it was tendered by the above described :rtify that no additional materials were added to this load, and that the material ut incident.

URE)

TATIVE: ________ (SIGNATURE)

ry - Sundance Acct #1   Pink - Transporter

Superior Printing Service, Inc.

Sundance Services, Inc.

P.O. Box 1737 ★ Eunice, New Mexico 88231
(505) 394-2511

Nº 93732

)R/SHIPPER/COMPANY:

COMPANY: | TIME AM/PM

VEHICLE NO.: DRIVER NO.:

TYPE OF MATERIAL

[ ] Drilling Fluids
[ ] Completion Fluids
[ ] Contaminated Soil
[ ] C-117 No.: ________
________ [ ] BS&W Content: ________

ERIAL [ ] BBLS. ________ : [ ] YARD ________ : [ ] ________

‹ TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS R/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS ROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME 01, et seq., THE NM HEALTH AND SAF. CODE § 361.001 et seq., AND REGULATIONS RELATED OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE E EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR Y.

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ERTIFY that the above Transporter loaded the material represented by this ent at the above described location, and that it was tendered by the above described rtify that no additional materials were added to this load, and that the material ut incident.

____
URE)

TATIVE: ________
(SIGNATURE)

ıry - Sundance Acct #1 Pink - Transporter

Superior Printing Service, Inc.

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106359

Lease Operator/Shipper/ Company: RICE

Lease Name: APACHE LEAK SITO

Transporter Company: RIW Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106360

Lease Operator/Shipper/ Company: RICE

Lease Name: APACHE LEAK SITO

Transporter Company: RIW Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Saul Mojica

FACILITY REPRESENTATIVE:

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106363

Lease Operator/Shipper/ Company: RICE

Lease Name: APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/5/2005 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME. 40 U.S.C. 6901. ET SEQ., THE NM HEALTH AND SAF. CODE 361:001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET. TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL.

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106364

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LA LEAK

Transporter Company: RWI Time: __________ AM/PM

Date: 1/5/2005 Vehicle No. 82 Driver No. __________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106380

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO Time: AM/PM

Date: 1/5/2005 Vehicle No. 0 Driver No.

Charge To: TREVINO

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106383

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/5/2005 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: Kelle Reed

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106386

Lease Operator/Shipper/ Company: RICE

Lease Name: APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106387

Lease Operator/Shipper/ Company: RICE

Lease Name: APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106391

Lease Operator/Shipper/ Company: RICE

Lease Name: ABOLA A LEAKE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106394

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO TRK Time: ____ AM/PM

Date: 1/5/2005 Vehicle No. 1 Driver No. ____

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: D Bud Hunter

FACILITY REPRESENTATIVE: ____

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # **106399**

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mosica

FACILITY REPRESENTATIVE: [signature]

200

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106408

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/5/2005 Vehicle No. 16 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106409

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/5/2005 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO. BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106410

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO ~~APACHE~~ L. A. Leak

Transporter Company: RWI Time: ______ AM/PM

Date: 1/5/2005 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106417

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/5/2005 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106422

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL.

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106424

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAKE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME. 40 U.S.C. 6901. ET SEQ.. THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106424

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO ~~APACHE~~ Leake

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Genaro Hanrean

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106425

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAKE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/5/2005 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL *BBLS.* *12 YARDS*

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH *IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM* TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106435

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAKE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/6/2005 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106437

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/6/2005 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: David Hunter [illegible] # 13, 14, 1, 10, 11, 25, 476 [illegible]
[illegible] 26, 30, 24, 31, 32, 34 # 35 [illegible] 1084 540 [illegible] 67, 60 3' BGS 352,
#11 3' BGS 923 #66 3' BGS 1048 ([illegible] to 4' BGS & [illegible]), #28 1' BGS

FACILITY REPRESENTATIVE:

503, #26 1' BGS 489, #33 1' BGS 533, 59 1' BGS 1250 (Excavate to 2' BGS & [illegible])
#32 1' BGS 1216 (will Excavate to 2' BGS & Resample) #27 1' BGS 405, #22 1' BGS
574. [illegible] 275 Cl-, [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106489

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2005 Vehicle No. 80 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106530

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ.. THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________________

FACILITY REPRESENTATIVE: ________________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106496

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/6/2006 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106531

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/6/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: Rudy Long

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106463

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2005 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106464

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2005 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	
		☐ JETOUT
Description: O/D		☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106470

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAKE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2005 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106532

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/6/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL.

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: ______

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106535

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106538

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/6/2006 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: DAvid Hunter

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106568

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TKR Time: ________ AM/PM

Date: 1/6/2006 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hunter

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106571

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: AM/PM

Date: 1/6/2006 Vehicle No. 60 Driver No.

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Sergio Hernandez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106572

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2006 Vehicle No. 155 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106574

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/6/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106575

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/6/2006 Vehicle No. 62 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106620

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hunter

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106621

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 102 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesse Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106622

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 80 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Sergio Herrera

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106623

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106624

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________________

FACILITY REPRESENTATIVE: ________________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106627

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106656

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 102 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jessie Trevino

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106757

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

Description: O/D

☐ JETOUT
☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106658

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 103 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106662

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106663

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mo[illegible]

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106664

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. ~~155~~ 125 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106675

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106705

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 103 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106706

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jessie Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106712

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Sango Hennera

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106713

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106714

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mofica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106715

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106750

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901. ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ.. AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesus Trevino

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106754

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Sergio Hernandez

FACILITY REPRESENTATIVE: Kelli [illegible]

SUNDANCE SERVICES INC.

P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106755

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/9/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106756

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/9/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106782

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

☐	Produced Water	☐	Drilling Fluids	☐	Completion Fluids
☐	Tank Bottoms	☑	Contaminated Soil	☐	C-117 No.
☐	Other Materials	☐	BS&W Content:		

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106773

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106783

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

Description: O/D

- [ ] JETOUT
- [ ] CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106784

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/10/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106785

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesus Trevino

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106787

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/10/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106802

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO Time: ______ AM/PM

Date: 1/10/2006 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hunter

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106828

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL.

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DRIVER: Sergio Hernandez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106829

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	
		☐ JETOUT
Description: O/D		☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901. ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Rudy [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106830

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ____ AM/PM

Date: 1/10/2006 Vehicle No. 82 Driver No. ____

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901. ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO. BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # **106831**

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106833

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: OD ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesse Trevino

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106850

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/10/2006 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106872

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. ~~102~~ 102 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesse Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106878

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/10/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME. 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul McGee

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106879

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106880

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 ~~YARDS~~

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106881

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106899

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hower

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106909

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/10/2006 Vehicle No. 102 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesus Trevino

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106910

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106911

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL.

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Santos Herrera

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106913

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 ~~14~~ YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106914

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/10/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 17 ~~14~~ YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106944

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APECHE

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

☐	Produced Water	☐	Drilling Fluids	☐	Completion Fluids
☐	Tank Bottoms	☑	Contaminated Soil	☐	C-117 No.
☐	Other Materials	☐	BS&W Content:		

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hunter

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106950

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APECHE

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/11/2006 Vehicle No 102 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106951

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APECHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mejia

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106952

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APECHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: Rudy Lope

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106954

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APECHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

/103

Ticket # **106969**

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APECHE

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106975

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☒ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: Willie Lane

FACILITY REPRESENTATIVE: Eddie Taylor

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106991

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 102 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jessie Trevino

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106993

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☒ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106994

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☒ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: Edna Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 106995

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME. 40 U.S.C. 6901. ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107015

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107029

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jessie Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107032

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ.. THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107033

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107034

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☒ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107035

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 80 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [illegible signature]

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107046

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107061

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesus Trevino

FACILITY REPRESENTATIVE: Eddie Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107064

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/11/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107065

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: Carlos Trujillo

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107067

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ.. THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107068

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/11/2006 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107076

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: JAND N Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 103 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: CONT.SOIL

- ☐ JETOUT
- ☑ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Neal Travis

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107088

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107090

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mejia

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107091

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107092

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107093

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901. ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________________

FACILITY REPRESENTATIVE: ________________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # **107101**

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/12/2008 Vehicle No. 103 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Neal Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107132

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Molina

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107134

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hunter

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107135

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Tomaso Hernandez

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107136

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE. CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107147

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 82 Driver No. ________

Charge To: RWI

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107149

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 102 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: Neal Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107172

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: David Hunter

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107177

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mejia

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107178

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME. 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Neal Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107183

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

Description: O/D

☐ JETOUT
☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

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TRANSPORTER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107184

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/12/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107185

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107205

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. ~~170~~ 70 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mejia

FACILITY REPRESENTATIVE: Kelly Roach

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107206

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE LEAK

Transporter Company: J&N Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☒ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: Neal Treviño

FACILITY REPRESENTATIVE: Kelly Roach

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107209

Lease Operator/Shipper/ Company: RICE

Lease Name: AOB AL. LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/12/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107226

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Sergio Herrera

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107227

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107230

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107231

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME. 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107232

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

102

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107233

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 10 2 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: David Hunter

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107247

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAKE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107248

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAKE

Transporter Company: RWI Time: __________ AM/PM

Date: 1/13/2006 Vehicle No. 125 Driver No. __________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107266

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107269

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ______

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107271

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mejica

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107280

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jesus Trevino

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107296

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107297

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 125 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107304

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ____ AM/PM

Date: 1/13/2006 Vehicle No. 103 Driver No. ____

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☒ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Neal Trevino

FACILITY REPRESENTATIVE: ____

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107312

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 102 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Jessie Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107317

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107318

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107351

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107352

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO APACHE

Transporter Company: RWI Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107357

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date 1/13/2006 Vehicle No. 103 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: [signature]

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107363

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☒ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: [signature]

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107364

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/13/2006 Vehicle No. ~~60~~ 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above *Transporter* loaded the *material* represented by this *Transporter Statement* at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107373

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/13/2006 Vehicle No. 102 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: Jesus Trevino

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107536

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/16/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL.

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DRIVER: Neal Trevino

FACILITY REPRESENTATIVE:

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107537

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/16/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107538

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/16/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107539

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/16/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107540

Lease Operator/Shipper/ Company: RICE

Lease Name. ABO LEAK

Transporter Company: JUNIORS TRK Time: ________ AM/PM

Date: 1/16/2006 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107541

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE:

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107594

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: JUNIORS Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107601

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107602

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [illegible signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107603

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: __________ AM/PM

Date: 1/16/2006 Vehicle No. 125 Driver No. __________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107604

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/16/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Molina

FACILITY REPRESENTATIVE:

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107631

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: JUNIORS Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107633

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107634

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107635

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 125 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107636

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Saul Mojica

FACILITY REPRESENTATIVE: Carlie Tugle

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107644

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1-17-06 ~~1/16/2006~~ Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Noel Trevino

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107647

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1-17-06 ~~1/16/2006~~ Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ ~~Tank Bottoms~~
- ☑ ~~Contaminated Soil~~
- ☐ ~~C-117 No.~~
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Lapez

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107648

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1-17-06 ~~1/16/2006~~ Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107649

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1-17-06 ~~1/16/2006~~ Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107650

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1-17-06 ~~1/16/2006~~ Vehicle No. 2 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☒ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107665

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☒ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107672

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: JUNIORS TRK Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107694

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO Time: ______ AM/PM

Date: 1/17/2005 Vehicle No. 2 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107695

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/17/2005 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ ~~C-117 No.~~
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107696

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/17/2005 Vehicle No. 82 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: ______

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107697

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107706

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO Time: ______ AM/PM

Date: 1/17/2005 Vehicle No. 103 Driver No. ______

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107725

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: JUNIORS TRK Time: ______ AM/PM

Date: 1/17/2005 Vehicle No. 1 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107734

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/17/2005 Vehicle No. 2 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hawter

FACILITY REPRESENTATIVE:

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107736

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☒ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107744

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ____________ AM/PM

Date: 1/17/2005 Vehicle No. 60 Driver No. ____________

Charge To: RICE

Type of Material

- ☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids
- ☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.
- ☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [illegible signature]

FACILITY REPRESENTATIVE: [illegible signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107745

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107746

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107775

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: JUNIORS TRK Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL.

THIS WILL CERTIFY that the above *Transporter* loaded the material represented by this *Transporter Statement* at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107784

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ______ AM/PM

Date: 1/17/2005 Vehicle No. 103 Driver No. ______

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO. BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Neal Trevino

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107785

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 2 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☑ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	
		☐ JETOUT
Description: O/D		☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107797

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:
- [ ] JETOUT
- [ ] CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE: JR

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107798

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/17/2005 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

- [ ] Produced Water
- [ ] Drilling Fluids
- [ ] Completion Fluids
- [ ] Tank Bottoms
- [x] Contaminated Soil
- [ ] C-117 No.
- [ ] Other Materials
- [ ] BS&W Content:

Description: O/D

- [ ] JETOUT
- [ ] CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO. BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107799

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

[illegible] [illegible] [illegible] 60 [illegible]

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☒ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [illegible]

FACILITY REPRESENTATIVE: [illegible]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107830

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 2 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: David Hunter

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107832

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ____ AM/PM

Date: 1/18/2006 Vehicle No. 103 Driver No. ____

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: Neal Trevino

FACILITY REPRESENTATIVE:

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107841

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 60 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water	☐ Drilling Fluids	☐ Completion Fluids
☐ Tank Bottoms	☒ Contaminated Soil	☐ C-117 No.
☐ Other Materials	☐ BS&W Content:	

☐ JETOUT
☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107842

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ ~~Tank Bottoms~~ ☒ ~~Contaminated Soil~~ ☐ ~~C-117 No.~~

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES. INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: ________

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107843

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/16/2006 Vehicle No. 70 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: Rudy Lopez

FACILITY REPRESENTATIVE:

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107855

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: JUNIORS TRK Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:
- ☐ JETOUT
- ☐ CALLOUT

Description: O/D

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

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DRIVER: [signature]

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107889

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 103 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

ALSO AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, TRANSPORTER REPRESENTS AND WARRANTS THAT ONLY THE MATERIAL DELIVERED BY OPERATOR/SHIPPER TO TRANSPORTER IS NOW DELIVERED BY TRANSPORTER TO SUNDANCE SERVICES, INC.'S FACILITY FOR DISPOSAL

THIS WILL CERTIFY that the above Transporter loaded the material represented by this Transporter Statement at the above described location, and that it was tendered by the above described shipper. This will certify that no additional materials were added to this load, and that the material was delivered without incident.

DRIVER: Neal Trevino

FACILITY REPRESENTATIVE: ________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107890

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: TREVINO TRK Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 2 Driver No. ________

Charge To: RICE

Type of Material

- ☐ Produced Water
- ☐ Drilling Fluids
- ☐ Completion Fluids
- ☐ Tank Bottoms
- ☑ Contaminated Soil
- ☐ C-117 No.
- ☐ Other Materials
- ☐ BS&W Content:

Description: O/D

- ☐ JETOUT
- ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107903

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/16/2006 Vehicle No. 60 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Bango Hancock

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107904

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 82 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: ________________________

FACILITY REPRESENTATIVE: ________________________

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107905

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: RWI Time: ______ AM/PM

Date: 1/18/2006 Vehicle No. 70 Driver No. ______

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☒ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: Rudy Loza

FACILITY REPRESENTATIVE: ______

SUNDANCE SERVICES INC.
P.O. BOX 1737
EUNICE, NM 88231
505-394-2511

Ticket # 107927

Lease Operator/Shipper/ Company: RICE

Lease Name: ABO LEAK

Transporter Company: JUNIORS TRK Time: ________ AM/PM

Date: 1/18/2006 Vehicle No. 1 Driver No. ________

Charge To: RICE

Type of Material

☐ Produced Water ☐ Drilling Fluids ☐ Completion Fluids

☐ Tank Bottoms ☑ Contaminated Soil ☐ C-117 No.

☐ Other Materials ☐ BS&W Content:

☐ JETOUT

Description: O/D ☐ CALLOUT

VOLUME OF MATERIAL BBLS. 12 YARDS

AS A CONDITION TO SUNDANCE SERVICES, INC.'S ACCEPTANCE OF THE MATERIALS SHIPPED WITH THIS JOB TICKET, OPERATOR/SHIPPER REPRESENTS AND WARRANTS THAT THE WASTE MATERIAL SHIPPED HEREWITH IS MATERIAL EXEMPT FROM THE RESOURCE, CONSERVATION AND RECOVERY ACT OF 1976, AS AMENDED FROM TIME TO TIME, 40 U.S.C. 6901, ET SEQ., THE NM HEALTH AND SAF. CODE 361.001 ET SEQ., AND REGULATIONS RELATED THERETO, BY VIRTUE OF THE EXEMPTION AFFORDED DRILLING FLUIDS, PRODUCED WATERS, AND OTHER WASTE ASSOCIATED WITH THE EXPLORATION, DEVELOPMENT OR PRODUCTION OF CRUDE OIL OR NATURAL GAS OR GEOTHERMAL ENERGY.

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DRIVER: [signature]

FACILITY REPRESENTATIVE: [signature]

Rice Operating Company

Quality Procedure
Soil Samples for Transportation to a Laboratory

1.0 Purpose
This procedure outlines the methods to be employed when obtaining soil samples to be taken to a laboratory for analysis.

2.0 Scope
This procedure is to be used when collecting soil samples intended for ultimate transfer to a testing laboratory.

3.0 Preliminary

3.1 Obtain sterile sampling containers from the testing laboratory designated to conduct analyses of the soil. The shipment should include a Certificate of Compliance from the manufacturer of the collection bottle or vial and a Serial Number for the lot of containers. Retain this Certificate for future documentation purposes.

3.2 If collecting TPH, BTEX, RCRA 8 metals, cation /anions or O&G, the sample jar may be a clear 4 oz. container with Teflon lid. If collecting PAH's, use an amber 4 oz. container.

4.0 Chain of Custody

4.1 Prepare a Sample Plan. The plan will list the number, location and designation of each planned sample and the individual tests to be performed on the sample. The sampler will check the list against the available inventory of appropriate sample collection bottles to insure against shortage.

4.2 Transfer the data to the Laboratory Chain of Custody Form. Complete all sections of the form except those that relate to the time of delivery of the samples to the laboratory.

4.3 Pre-label the sample collection jars. Include all requested information except time of collection. (Use a fine point Sharpie to insure that the ink remains on the label.) Affix the labels to the jars.

5.0 Sampling Procedure

5.1 Do not touch the soil with your bare hands. Use new latex gloves with each sample to help minimize any cross-contamination.

5.2. Go to the sampling point with the sample container. If not analyzing for ions or metals, use a trowel to obtain the soil.

5.3. Pack the soil tightly into the container leaving the top slightly domed. Screw the lid down tightly. Enter the time of collection onto the sample collection jar label.

5.4. Place the sample directly on ice for transport to the laboratory if required.

5.5. Complete the Chain of Custody form to include the collection times for each sample. Deliver all samples to the laboratory.

6.0 Documentation

6.1 The testing laboratory shall provide the following minimum information:

a. Project and sample name.
b. Signed copy of the original Chain of Custody Form including the time the sample was received by the lab.
c. Results of the requested analyses
d. Test Methods employed
e. Quality Control methods and results

Rice Operating Company

QUALITY PROCEDURE
Chloride Titration Using
0.282 Normal Silver Nitrate Solution

1.0 Purpose

This procedure is to be used to determine the concentration of chloride in soil.

2.0 Scope

This procedure is to be used as the standard field measurement for soil chloride concentrations.

3.0 Sample Collection and Preparation

3.1 Collect at least 80 grams of soil from the sample collection point. Take care to insure that the sample is representative of the general background to include visible concentrations of hydrocarbons and soil types. If necessary, prepare a composite sample for soils obtained at several points in the sample area. Take care to insure that no loose vegetation, rocks or liquids are included in the sample(s).

3.2 The soil sample(s) shall be immediately inserted into a one-quart or larger polyethylene freezer bag. Care should be taken to insure that no cross-contamination occurs between the soil sample and the collection tools or sample processing equipment.

3.3 The sealed sample bag should be massaged to break up any clods.

4.0 Sample Preparation

4.1 Tare a clean glass vial having a minimum 40 ml capacity. Add at least 10 grams of the soil sample and record the weight.

4.2 Add at least 10 grams of reverse osmosis water to the soil sample and shake for 20 seconds.

4.3 Allow the sample to set for a period of 5 minutes or until the separation of soil and water.

4.4 Carefully pour the free liquid extract from the sample through a paper filter into a clean plastic cup if necessary.

5.0 Titration Procedure

5.1 Using a graduated pipette, remove 10 ml extract and dispense into a clean plastic cup.

5.2 Add 2-3 drops potassium chromate (K_2CrO_4) to mixture.

5.3 If the sample contains any sulfides (hydrogen or iron sulfides are common to oilfield soil samples) add 2-3 drops of hydrogen peroxide (H_2O_2) to mixture.

5.4 Using a 1 ml pipette, carefully add .282 normal silver nitrate (one drop at a time) to the sample while constantly agitating it. Stop adding silver nitrate when the solution begins to change from yellow to red. Be consistent with endpoint recognition.

5.5 Record the ml of silver nitrate used.

6.0 Calculation

To obtain the chloride concentration, insert measured data into the following formula:

$$\frac{.282 \text{ X } 35.450 \text{ X ml } AgNO_3}{\text{ml water extract}} \quad \text{X} \quad \frac{\text{grams of water in mixture}}{\text{grams of soil in mixture}}$$

Using Step 5.0, determine the chloride concentration of the RO water used to mix with the soil sample. Record this concentration and subtract it from the formula results to find the net chloride in the soil sample.

Record all results on the delineation form.

Rice Operating Company

Quality Procedure
Development of Cased Water-Monitoring Wells

1.0 Purpose

This procedure outlines the methods to be employed to develop cased monitoring wells.

2.0 Scope

This procedure shall be used for developed, cased water monitoring wells. It is not to be used for standing water samples such as ponds or streams.

3.0 Sample Collection and Preparation

3.1 Prior to development, the static water level and height of the water column within the well casing will be measured with the use of an electric D.C. probe or a steel engineer's tape and water sensitive paste.

3.2 All measurements will be recorded within a field log notebook.

3.3 All equipment used to measure the static water level will be decontaminated after each use by means of Liquinox, a phosphate free laboratory detergent, and water to reduce the possibility of cross-contamination. The volume of water in each well casing will be calculated.

4.0 Purging

4.1 Wells will be purged by using a 2" decontaminated submersible pump or dedicated one liter Teflon bailer. Wells should be purged until the pH and conductivity are stabilized and the turbidity has been reduced to the greatest extent possible.

4.2 If a submersible is used the pump will be decontaminated prior to use by scrubbing the outside surface of tubing and wiring with a Liquinox water mixture, pumping a Liquinox-water mixture through the pump, and a final flush with fresh water.

5.0 Water Disposal

5.1 All purge and decontamination water will be temporarily stored within a portable tank to be later disposed of in an appropriate manner.

6.0 Records

6.1 Rice Operating Company will record the amount of water removed from the well during development procedures. The purge volume will be reported to the appropriate regulatory authority when filing the closure report.

Rice Operating Company

Quality Procedure
Sampling of Cased Water-Monitoring Well
Using One-Liter Bailer

1.0 Purpose

This procedure outlines the methods to be employed in obtaining water samples from cased monitoring wells.

2.0 Scope

This procedure shall be used for developed, cased water monitoring wells. It is not to be used for standing water samples such as ponds or streams.

3.0 Preliminary

3.1 Obtain sterile sampling containers from the testing laboratory designated to conduct analyses of the water. The shipment should include a Certificate of Compliance from the manufacturer of the collection bottle or vial and a Serial Number for the lot of containers. Retain this Certificate for future documentation purposes.

3.2 The following table shall be used to select the appropriate sampling container, preservative method and holding times for the various elements and compounds to be analyzed.

Compound to be Analyzed	Sample Container Size	Sample Container Description	Cap Requirements	Preservative	Maximum Hold Time
BTEX	40 ml	VOA Container	Teflon Lined	HCI	7 days
TPH	1 liter	clear glass	Teflon Lined	HCI	28 days
PAH	1 liter	amber glass	Teflon Lined	Ice	7 days
Cation/Anion	1 liter	clear glass	Teflon Lined	None	48 Hrs
Metals	1 liter	HD polyethylene	Any Plastic	Ice/HNO_3	28 Days
TDS	300 ml	clear glass	Any Plastic	Ice	7 Days

4.0 Chain of Custody

4.1 Prepare a Sample Plan. The plan will list the well identification and the individual tests to be performed at that location. The sampler will check the list against the available inventory of appropriate sample collection bottles to insure against shortage.

4.2 Transfer the data to the Laboratory Chain of Custody Form. Complete all sections of the form except those that relate to the time of delivery of the samples to the laboratory.

4.3 Pre-label the sample collection jars. Include all requested information except time of collection. (Use a fine point Sharpie to insure that the ink remains on the label). Affix the labels to the jars.

5.0 Bailing Procedure

5.1 Identify the well from the sites schematics. Place pre-labeled jar(s) next to the well. Remove the plastic cap from the well bore by first lifting the metal lever and then unscrewing the entire assembly.

5.2 Using a dedicated one liter Teflon bailer, purge a minimum of three well volumes. Place the water in storage container for transport to a ROC disposal facility.

5.3 Take care to insure that the bailing device and string do not become cross-contaminated. A clean pair of rubber gloves should be used when handling either the retrieval string or bailer. The retrieval string should not be allowed to come into contact with the ground.

6.0 Sampling Procedure

6.1 Once the well has been bailed in accordance with 5.2 of this procedure, a sample may be decanted into the appropriate sample collection jar directly from the bailer. The collection jar should be filled to the brim. Once the jar is sealed, turn the jar over to detect any bubbles that may be present. Add additional water to remove all bubbles from the sample container.

6.2 Note the time of collection on the sample jar with a fine Sharpie.

6.3 Place the sample directly on ice for transport to the laboratory. The preceding table shows the maximum hold times between collection and testing for the various analyses.

6.4 Complete the Chain of Custody form to include the collection times for each sample. Deliver all samples to the laboratory.

7.0 Documentation

7.1 The testing laboratory shall provide the following minimum information:

A. Project and sample name.
B. Signed copy of the original Chain of Custody Form including the time the sample was received by the lab.
C. Results of the requested analyses
D. Test Methods employed
E. Quality Control methods and results

Calculation for Determining the Minimum Bailing Volume for Monitor Wells
Formula $V = (\pi r^2 h)$
2" well [V/231=gal] X 3 = Purge Volume

V=Volume
π=pi
r=inside radius of the well bore
h=maximum height of well bore in water table

Example:

π	r^2	h(in)	V(cu.in)	V(gal)	X 3 Volumes	Actual
3.1416	1	180	565.488	2.448	7.34 gal	>10 gal

Rice Operating Company

Quality Procedure
Composite Sampling of Excavation Sidewalls and Bottoms
For TPH and Chloride Analysis

1.0 Purpose

This procedure outlines the methods to be employed when obtaining final composite soil samples for TPH and Chloride analysis.

2.0 Scope

This procedure is to be used in conjunction with ***Quality Procedure – 02: Soil Samples for Transportation to a Laboratory*** and will be inserted at subparagraph 5.2 of Section 5.0: Sampling Procedure.

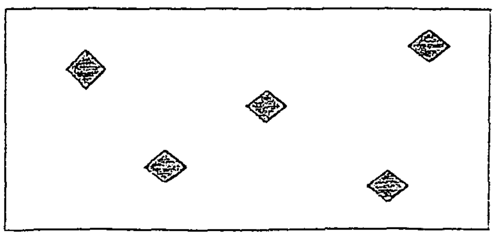
3.0 Sampling Procedure

Follow ***Quality Procedure – 02: Soil Samples for Transportation to a Laboratory*** for all Sections and subparagraphs until subparagraph 5.2 of Section 5.0: Sampling Procedure. Instead of 5.2 instructions, perform the composite sample collection procedure as follows:

3.1 Go to the excavation with a clean large blending bowl or new plastic baggie. If not analyzing for ions or metals, use a trowel to obtain the soil. If the excavation is deeper than 6' BGS, do not enter the pit, but use a backhoe to assist in procurement of the sample. (If a backhoe is used, the backhoe will obtain an amount of soil from each composite point, bring the purchase to the surface staging area where a sample-portion of soil will be extracted from the backhoe purchase. The remainder of the backhoe purchase will be staged on the surface with other staged soils.)

3.2 Sidewall samples

3.2.1 On each sidewall, procure a 5oz sample from each of five distinct points on the sidewall with distinct points resembling the "W" pattern:



3.2.2 Thoroughly blend these five samples in the blending bowl.
3.2.3 Pour blended sample into sifter and sift into labeled baggie.
3.2.4 Repeat steps 3.2.1 through 3.2.4 for each remaining sidewall, using a clean blending bowl for each sidewall.
3.2.5 From each labeled baggie, procure a 5 oz portion and pour into a baggie labeled "Sidewall Composite". Blend this soil mixture completely.
3.2.6 Obtain proper laboratory sample container for "Sidewall Composite" and continue with subparagraph 5.3 of QP – 02.

3.3 Bottom Sample
3.3.1 From bottom of excavation, procure a 5oz sample from each of five distinct points with distinct points resembling the "W" pattern as illustrated above.
3.3.2 Thoroughly blend these five samples in a clean blending bowl.
3.2.3 Pour blended sample into sifter and sift into baggie labeled "Bottom Composite".
3.2.6 Obtain proper laboratory sample container for "Bottom Composite" and continue with subparagraph 5.3 of QP – 02.

Rice Operating Company

QUALITY PROCEDURE
Sampling and Testing Protocol for VOC in Soil

1.0 Purpose

This procedure is to be used to determine the concentrations of Volatile Organic Compounds in soils.

2.0 Scope

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

3.0 Procedure

3.1 Sample Collection and Preparation

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

3.1.2 The soil sample(s) shall be immediately inserted into a one-quart or larger polyethylene freezer bag and sealed. When sealed, the bag should contain a nearly equal space between the soil sample and trapped air. Record the sample name and the time that the sample was collected on the Field Analytical Report Form.

3.1.3 The sealed samples shall be allowed to set for a minimum of five minutes at a temperature of between 10-15 Celsius, (59-77^{0}F). The sample temperatures may be adjusted by cooling the sample in ice, or by heating the sample within a generally controlled environment such as the inside of a vehicle. The samples should not be placed directly on heated surfaces or placed in direct heat sources such as lamps or heater vents.

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

3.2 Sampling Procedure

3.2.1 The instrument to be used in conducting VOC concentration testing shall be an Environmental Instruments 13471 OVM / Datalogger or a similar PID-type instrument. (Device will be identified on VOC Field Test Report Form.) Prior to use, the instrument shall be zeroed-out in accordance with the appropriate maintenance and calibration procedure outlined in the instrument operation manual. The PID device will be calibrated each day it's used.

3.2.2 Carefully open one end of the collection bag and insert the probe tip into the bag taking care that the probe tip not touch the soil sample or the sidewalls of the bag.

3.2.3 Set the instrument to retain the highest result reading value. Record the reading onto the Field Test Report Form.

3.2.4 If the instrument provides a reading exceeding 100 ppm, proceed to conduct BTEX Speciation in accordance with **QP-02 and QP-06. If the reading is 100 ppm or less, NMOCD BTEX guideline has been met and no further testing for BTEX is necessary. File the Field Test Report Form in the project file.**

4.0 Clean-up

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

Rice Operating Company

Quality Procedure
Composite Sampling of Excavation Sidewalls and Bottoms
For BTEX Analysis

1.0 Purpose

This procedure outlines the methods to be employed when obtaining final composite soil samples for BTEX analysis.

2.0 Scope

This procedure is to be used when collecting soil samples intended for ultimate transfer to a testing laboratory for BTEX analysis. This procedure is to be used only when the PID field-test results for OVM exceeds 100 ppm.

3.0 Preliminary

3.1 Obtain sterile, clear, 2 oz. glass containers with Teflon lid from a laboratory supply company or the testing laboratory designated to conduct analyses of the soil.

3.2 The container shipment should include a Certificate of Compliance from the manufacturer of the collection bottle or vial and a Serial Number for the lot of containers. Retain this Certificate for future documentation purposes.

4.0 Chain of Custody

4.1 Prepare a Sample Plan. The plan will list the number, location and designation of each planned sample and the individual tests to be performed on the sample. The sampler will check the list against the available inventory of appropriate sample collection bottles to insure against shortage.

4.2 Transfer the data to the Laboratory Chain of Custody Form. Complete all sections of the form except those that relate to the time of delivery of the samples to the laboratory.

4.3 Pre-label the sample collection jars. Include all requested information except time of collection. (Use a fine point Sharpie to insure that the ink remains on the label.) Affix the labels to the jars.

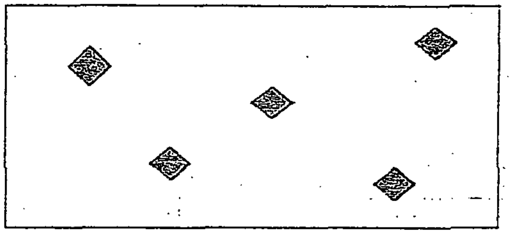
5.0 Sampling Procedure

5.1. Do not touch the soil with your bare hands. Use new latex gloves with each sample to help minimize any cross-contamination.

5.2. If safe and within OSHA regulations, go to the sampling point with the sample container. If not analyzing for ions or metals, use a trowel to obtain the soil. If the excavation is deeper than 6' BGS, do not enter the pit, but use a backhoe to assist in procurement of the sample. (If a backhoe is used, the backhoe will obtain an amount of soil from each composite point, bring the purchase to the surface staging area where a sample-portion of soil will be extracted from the backhoe purchase. The remainder of the backhoe purchase will be staged on the surface with other staged soils.)

5.3. Sidewall Samples

5.3.1. On each sidewall, procure a 2oz sample from each of five distinct points on the sidewall with distinct points resembling the "W" pattern:



5.4. Pack the soil tightly into the container leaving the top slightly domed. Screw the lid down tightly. Enter the time of collection onto the sample collection jar label. Repeat for each sampling point.

5.5. Place the samples directly on ice for transport to the laboratory if required.

5.6. Complete the Chain of Custody form to include the collection times for each sample. Deliver all samples to the laboratory.

6.0 Documentation

6.1 The testing laboratory shall provide the following minimum information:

a. Project and sample name.
b. Signed copy of the original Chain of Custody Form including the time the sample was received by the lab.
c. Results of the requested analyses
d. Test Methods employed
e. Quality Control methods and results

Tab 7 Summary

The Scanlon paper includes a table of particular interest, which is reproduced below.

Table 3. Water balance monitoring (west and east subplots) and simulation results (east subplot) (mm) for the New Mexico site.†

Subplot	Water year	*P*	PET	Irr	R_o	Net *I*	*D*	ΔS	ET	*S*	RMSE
		mm									
West (meas.)	1997‡	227	–	0	6.4	221	0.1	−23.2	244	162	
	1998	299	1772	0	22.0	277	0.4	−66.4	343	95	
	1999	280	1851	0	0.8	279	0.0	−0.9	280	95	
	2000	189	1908	0	0.2	189	0.0	35.1	153	130	
	2001	341	1786	0	0.6	341	0.0	−44.1	385	86	
	2002	181	2012	110	0.6	290	0.0	20.3	270	106	
	1997–2002	1517	9329	110	30.6	1597	0.5	−79.2	1675	674	
East (meas.)	1997‡	227	–	0	1.5	226	0.0	31.5	194	182	
	1998	299	1772	0	0.8	298	0.0	−73.6	372	108	
	1999	280	1851	0	0.6	279	0.0	−8.6	288	99	
	2000	189	1908	0	0.2	189	0.0	16.2	172	116	
	2001	341	1786	0	0.8	340	0.0	−4.3	345	111	
	2002	181	2012	0	0.4	180	0.0	3.5	177	114	
	1997–2002	1517	9329	0	4.3	1512	0.0	−35.3	1548	730	
East (simul. SF)§	1998	299	1772	0	0.0	299	0.0	−76	375	106	37
	1999	280	1851	0	0.0	280	0.0	−14	294	94	17
	2000	189	1908	0	0.0	189	0.0	−8.2	197	91	17
	2001	341	1786	0	0.0	341	0.0	−1.6	343	115	37
	2002	181	2012	0	0.0	181	0.0	13	167	124	19
	1998–2002	1290	9329	0	0.0	1290	0.0	−86.8	1376	530	
East (simul. UG)§	1998	299	1772	0	0.0	299	0.3	−76	375	106	32
	1999	280	1851	0	0.0	280	0.1	−14	294	94	17
	2000	189	1908	0	0.0	189	0.0	−8.1	197	91	17
	2001	341	1786	0	0.0	341	0.0	−1.5	343	114	37
	2002	181	2012	0	0.0	181	0.0	13	167	124	18
	1998–2002	1290	9329	0	0.0	1290	0.4	−86.6	1376	529	

† *P*, precipitation; PET, potential evapotranspiration; Irr, irrigation; R_o, runoff; net *I*, net infiltration; *D*, drainage; ΔS, water storage change; ET, evapotranspiration; *S*, water storage at end of water year; RMSE, root mean square error between simulated and measured (daily) water storage.
‡ 1 May through 30 Sept.
§ Simulation results for SF, seepage face lower boundary; and UG, unit gradient lower boundary.

The measured and simulated drainage (D) below this monolithic ET cover at the Sandia National Laboratories test site is zero after two years of operation. The authors believe that the initial drainage measured and simulated for these test areas were due to the water used in the construction of the cover and irrigation of barren soil when establishing the vegetative cap.

Similar results for ET infiltration barriers are listed on the EPA website: http://cluin.org/products/altcovers/usersearch/lf_list.cfm. This website refers to various links, including published reports such as Roesler and others (2002), which is also included in Tab 7. Table 4.1 from Roessler and others (2002) shows other arid and semi-arid sites where ET covers are performing according to design.

Table 4.1. Summary of Water Balance Data: Arid and Semi-Arid Sites.
Percentage of Precipitation in Parenthesis.

Site	Duration (Days)	Cover Type	Slope (%)	Total Precipitation (mm)	Avg. Annual Precipitation [a] (mm/yr)	Surface Runoff (mm/yr)	Lateral Flow (mm/yr)	Percolation (mm/yr)
Altamont, CA	517	Monolithic	5	486.7	358.4	18.6 (5.4%)	NA	1.0 (0.3%)
		Conventional Composite	5			10.4 (3.0%)	2.7 (0.8%)	0.0 (0.0%)
Sacramento, CA	987	Monolithic (1080-mm)	5	1142.5	434.3	44.4 (10.5%)	NA	48.4 (11.1%)
		Monolithic (2450-mm)	5			25.1 (5.9%)	NA	3.1 (0.7%)
Helena, MT	905	Capillary	5	385.3	288.8	28.4 (7.4%)	NA	0.0 (0.0%)
Polson, MT	847	Capillary	5	743.97	380.5	10.0 (3.1%)	NA	0.2 (0.1%)
		Conventional Composite	5			8.3 (2.6%)	10.9	0.2 (0.1%)
Boardman, OR	485	Monolithic (1220-mm)	25	180.8	225.3	0.0 (0.0%)	NA	0.0 (0.0%)
		Monolithic (1840-mm)	25			0.0 (0.0%)	NA	0.0 (0.0%)
		Conventional Composite	25			0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Monticello, UT	607	Capillary	5	513.8		9.3 (1.8%)	NA	0.0 (0.0%)

NA = Not Applicable

The conclusion that ET Covers are highly effective suggest that the lysimeters at the Abo-1G site may never collect any water samples. Measurements of the matric potential using tensiometers in the access tubes will not only show the direction of vadose zone flow but will allow us to estimate the moisture content of the upper vadose zone. These data will assist us in documenting that the pan lysimeters are working properly.

Evaluation of Evapotranspirative Covers for Waste Containment in Arid and Semiarid Regions in the Southwestern USA

Bridget R. Scanlon,* Robert C. Reedy, Kelley E. Keese, and Stephen F. Dwyer

ABSTRACT

Performance evaluation of evapotranspirative (ET) covers is critical for waste containment. The purpose of this study was to evaluate ET covers at sites in Texas and New Mexico representative of arid and semiarid regions in the southwestern USA using water balance monitoring during 4- and 5-yr periods and water balance simulations using short-term (1–5 yr) and long-term (25 yr) climate forcing. Estimated drainage at the Texas site was related to irrigation while measured drainage at the New Mexico site was restricted to the first 2 yr of the 5-yr monitoring period. Evapotranspirative covers work extremely well in these regions because of the dominance of summer precipitation (62–80%) that corresponds to periods of highest ET. Strong relationships between decreases in soil water storage and vegetation productivity at both sites underscore the importance of vegetation in controlling the water balance in these systems. Simulations of the Texas site indicate that drainage can occur in response to high precipitation near the end of the growing season, but such drainage can be eliminated with a capillary barrier. Inclusion of a capillary barrier increased available water storage by a factor of about 2.5 at both sites. The capillary barrier effect of drainage lysimeters can result in underestimation of drainage and overestimation of water storage relative to covers not underlain by capillary barriers. The data from this study indicate that a 1-m-thick ET cover underlain by a capillary barrier should be adequate to minimize drainage to ≤1 mm yr^{-1} in these arid and semiarid regions. Comprehensive monitoring integrated with modeling is required to assess total system performance to develop a predictive understanding of ET covers.

ENGINEERED SURFACE COVERS are widely used throughout the USA to contain radioactive, hazardous, mixed, industrial, and municipal solid wastes. There are approximately 4000 active municipal solid waste and hazardous waste landfills in the USA (EPA, 1996, 1997). In addition, surface covers are commonly used alone or in combination with other remediation technologies at contaminated sites, especially those of large areal extent. The growing realization over the past decade that total cleanup of many contaminated sites is infeasible because of cost, technical difficulties, or worker safety has resulted in a shift in emphasis from contaminant removal to containment as a remediation alternative. Engineered covers may also be used as interim covers for waste containment before remediation.

Conventional engineered covers generally consist of multilayered resistive cover systems that are relatively expensive to construct and include the prescribed Resource Conservation and Recovery Act Subtitle C design for hazardous waste and Subtitle D design for municipal solid waste recommended by the USEPA (Koerner and Daniels, 1997). Resistive barriers rely on low hydraulic conductivity to minimize water movement into the underlying waste; however, previous studies have shown that many resistive covers, particularly compacted clay layers, leak because of desiccation, which can occur even in humid settings (Melchior, 1997; Dwyer, 2001; Albrecht and Benson, 2001; Albright et al., 2003). Increasing emphasis is being placed on optimal cover design for arid and semiarid regions because they are generally considered more suitable for waste disposal than humid regions (Reith and Thompson, 1992) and many contaminated sites are located in these regions. A variety of alternative cover designs have been proposed for waste containment in arid and semiarid regions, including monolithic ET covers, capillary barrier ET covers, and anisotropic barrier ET covers, which all rely on increased water storage rather than low hydraulic conductivity to minimize water movement into waste (Albright et al., 2003; Dwyer, 2001; Hauser et al., 2001).

Evapotranspirative covers rely on vegetation to increase the water storage capacity of the cover by removing water through ET so that deep drainage is negligible or zero. In areas where winter precipitation is dominant, the thickness of the cover is designed to store the infiltrated water until vegetation can transpire it in the spring and summer. Evapotranspirative covers generally consist of a single soil type (monolithic) and may constitute the sole barrier in a system or may form a component of more complex barrier systems that include underlying capillary or resistive barriers (Wing and Gee, 1994).

Most studies evaluating the performance of ET covers have been conducted at USDOE sites (Nyhan et al., 1990; Anderson et al., 1992; Waugh et al., 1994; Anderson, 1997; Dwyer, 2001). The Alternative Landfill Cover Demonstration project was established at Kirtland Air Force Base near Albuquerque, NM, to test four alternative cover designs (monolithic ET, capillary barrier ET, anisotropic barrier ET, and geosynthetic clay liner) relative to conventional Subtitle C and D covers (Dwyer, 2001). Long-term studies of the performance of engineered covers and comparison with the natural system were conducted at the USGS Beatty site, Nevada (Andraski, 1997). In addition, the Alternative Cover Assessment Program was established by the USEPA in 1998 to evaluate the performance of various cover designs under different climatic conditions throughout the USA (Albright et al., 2003). A total of 11 field-scale test sections were established, including conventional and alternative covers.

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Abbreviations: AWS, available water storage; CB, capillary barrier; ET, evapotranspirative; GAB, geosynthetic clay layer overlying an asphalt barrier; GCL, geosynthetic clay layer; LAI, leaf area index; PET, potential evapotranspiration; TDR, time domain reflectometry.

Monitoring approaches can be subdivided into performance and process monitoring. Performance monitoring usually focuses on a performance parameter, generally drainage in the case of engineered covers. However, natural drainage is very difficult to monitor because zero pressure (pan) lysimeters used for drainage monitoring behave like capillary barriers and require overlying soils to become almost saturated before drainage will occur. Therefore, water storage is generally overestimated and drainage underestimated relative to covers without capillary barriers. The degree to which lysimeter drainage represents actual drainage beneath a cover depends on whether the interface between the cover and the underlying waste or between the final and interim cover acts as a capillary barrier. Process monitoring includes many parameters related to flow processes in a cover and provides comprehensive information on total system performance, which is considered more robust than simply relying on a single parameter. For example, increases in water storage at the base of a cover profile could provide early warning of incipient drainage.

Numerical modeling can be used to evaluate and optimize monitoring systems, assess different cover designs, and determine critical parameters through sensitivity analyses. To increase confidence in models, it is important to compare model results with detailed field monitoring data. Many previous studies have simulated the water balance of engineered covers and compared the simulation results with the monitoring data (Fayer et al., 1992; Khire et al., 1997). A detailed evaluation of the performance of different codes for simulating the water balance of engineered covers was conducted using data from sites in Texas and Idaho (Scanlon et al., 2002). Recent advances in computer technology, more computationally efficient codes, and availability of input data on climate and hydraulic properties online make long-term simulations of the near-surface water balance much more feasible. Weather generators, such as USCLIMATE and GEM (Richardson, 2000), can be used to develop long-term climate records for simulations. Pedotransfer functions are available for estimating hydraulic parameters from information on soil texture (Schaap and Leij, 1998; Schaap et al., 1998).

The purpose of this study was to evaluate ET covers in arid and semiarid sites in Texas and New Mexico on the basis of monitoring and modeling analysis. The monitoring program provides information on performance of the covers for the duration of the monitoring (4–5 yr), whereas the modeling analysis allows us to evaluate cover performance for much longer (25 yr in this study). Unique aspects of this study include detailed instrumentation of water balance parameters at these two sites, length of monitoring record (4–5 yr), integration of monitoring and modeling analysis, and detailed knowledge of unsaturated flow processes in the natural system for comparison with the ET covers.

MATERIALS AND METHODS

Site Description and Cover Designs

Texas Site

Prototype engineered covers were installed for a proposed low-level radioactive-waste disposal site in the Chihuahuan Desert in West Texas, 10 km east of Sierra Blanca, about 150 km southeast of El Paso (31°8.773′ N, 105°16.237′ W; elevation, 1337 m) (Fig. 1). The potentiometric surface is at a depth of approximately 200 m. Long-term (1962–1990) mean annual precipitation is 311 mm (Sierra Blanca). Approximately 80% of precipitation occurs in June through October (Fig. 2a). Precipitation during the monitoring period was much lower in January through May (33–65%), August (47%), and September (16%) relative to the long-term (29-yr) monthly distribution. Summer precipitation generally occurs as localized convective storms with durations of a few minutes to several hours, whereas winter precipitation is generally associated with larger frontal systems of lower intensity.

Two different engineered cover designs were installed at the site in the summer of 1997: (i) a conductive or capillary barrier (CB) of sand at the 2-m depth and (ii) a resistive or geosynthetic clay layer (GCL) overlying an asphalt barrier (GAB) at the 1.3-m depth (Fig. 1). In this study, we focus on the upper portion of both covers above the barriers because water movement was generally restricted to these zones and, both covers functioned primarily as ET covers. Each cover design was 17 by 34 m (CBET, GABET) and was divided into two 17- by 17-m subplots. Both cover designs consisted of 0.3 m of topsoil (sandy clay loam, bulk density 1.5 Mg m^{-3})

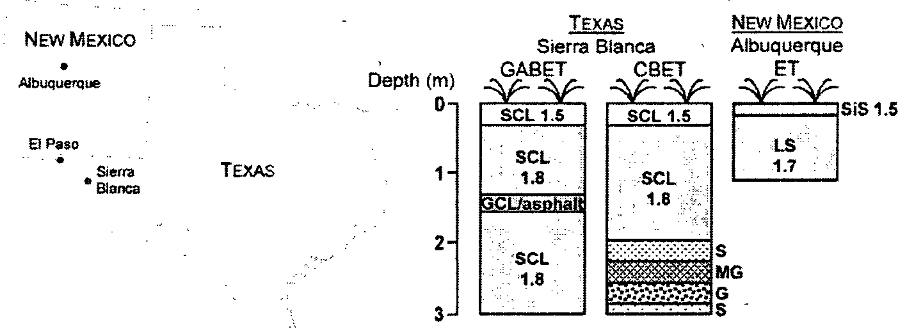

Fig. 1. Location of monitored and engineered cover sites in Texas (Sierra Blanca) and New Mexico (Albuquerque) and vertical profiles of texture and materials for the different cover designs evaluated in the study. GCL, geosynthetic clay liner; GABET, GCL/asphalt barrier ET cover; CBET, capillary barrier ET cover; SCL, sandy clay loam; S, sand; MG, muddy gravel; G, gravel; LS, loamy sand. Numbers following textures indicate soil bulk density (Mg m^{-3}). Texas site consisted of topsoil mixed with gravel (24 wt%); New Mexico site includes a 20- to 40-mm-thick gravel surface layer.

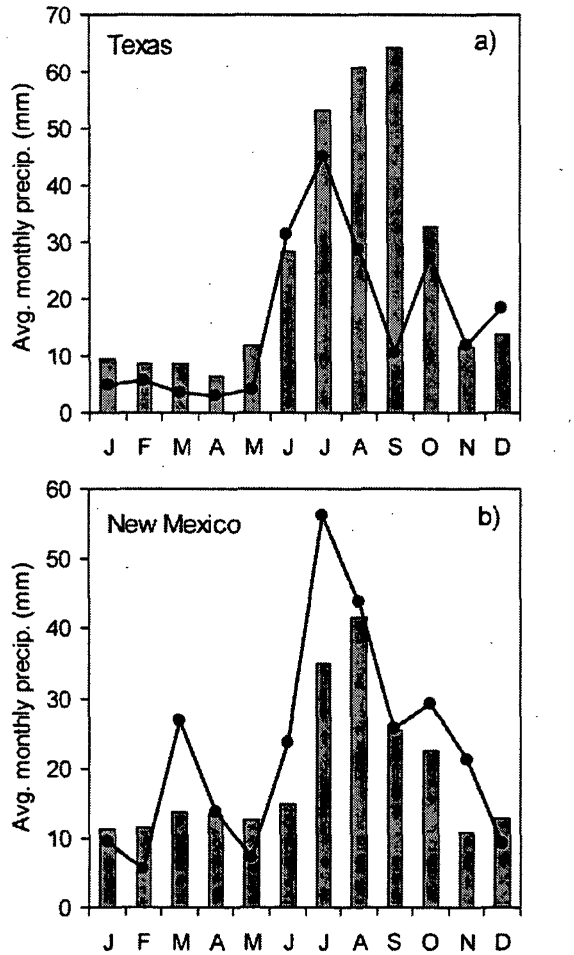

Fig. 2. Average monthly precipitation during monitoring periods (lines) and historical records (columns) for (a) Texas site (Sierra Blanca, 29-yr average annual total = 311 mm) and (b) New Mexico site (Albuquerque, 30-yr average annual total = 226 mm).

underlain by compacted soil (sandy clay loam, bulk density 1.8 Mg m^{-3}) constructed with a 2% surface slope in all layers. Gravel (24% by weight) was added to the upper 0.3 m of the topsoil to reduce erosion.

Both covers were nonvegetated during the first year. Seedlings transplanted in August 1998 consisted of five perennial warm-season bunchgrass species, including blue grama (*Bouteloua gracilis*), plains bristlegrass (*Setaria leucopila*), sand dropseed (*Sporobolus cryptandrus*), green sprangletop (*Leptochloa dubia*), and lehmann lovegrass (*Eragrostis lehmanniana*). However, opportunistic vegetation invaded the covers at different times, including tumbleweed (russian thistle; *Salsola kali*), several salt cedar (*Tamarix ramosissima*), and one mesquite tree (*Prosopsis glandulosa*). A drip irrigation system and mulch pad (20-mm-thick aspen shavings with a UV degradable mesh net) were installed before planting. The mulch pad generally degraded within 1 yr.

New Mexico Site

A monolithic ET cover was installed as part of the Alternative Landfill Cover Demonstration project established at Kirtland Air Force Base near Albuquerque, NM (34°58.473′ N, 106°32.396′ W; elevation, 1652 m) (Dwyer, 2003). Long-term (30-yr) mean annual precipitation is 226 mm, which is based on data from Albuquerque, 11 km northwest of the engineered covers. Approximately 62% of precipitation occurs in June through October (Fig. 2b). Monthly precipitation during the monitoring period differed from the long-term monthly distribution, particularly in March (196%), June (159%), July (161%), and November (196%) (Fig. 2b).

The ET cover was constructed between May and August 1996, and monitoring began in May 1997. The ET cover was divided into two 12.2- by 46-m subplots with east and west slope aspects. The engineered cover design consisted of 0.15 m of topsoil (loamy sand, bulk density 1.5 Mg m^{-3}) underlain by 0.92 m of compacted soil (loamy sand, bulk density 1.7 Mg m^{-3}) constructed with a 5% surface slope in all layers. A thin veneer of gravel (20–40 mm) was placed on the surface after the cover was seeded to enhance establishment of vegetation and minimize erosion (Reith and Thompson, 1992).

The test facility topsoil was drill seeded in fall 1996 with native rangeland vegetation that included various grasses ranging from cool-season, such as Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*), to warm-season grasses, including blue grama, galleta (*Hilaria jamesii*), and sand dropseed varieties. In addition, various opportunistic plants grew at different times, including russian thistle and fourwing saltbush (*Atriplex canescens*).

Monitoring Systems

Performance of the ET covers was evaluated by monitoring various components of the water balance:

$$ET = P + Irr - R_o - \Delta S - D \quad [1]$$

where P is precipitation, Irr is irrigation, R_o is runoff, ΔS is change in soil water storage, and D is drainage. Various instruments and measurement systems were used to monitor all of the water balance parameters except ET, which was calculated by difference. Meteorological parameters monitored at both sites included precipitation, solar radiation, air temperature, relative humidity, and wind speed and direction.

Texas Site Monitoring Systems

The covers were irrigated in August and September 1998 to establish vegetation. Vegetation was removed in June 2001 from one of the CBET subplots using herbicide. The CBET subplots were also irrigated in late June through early August 2001. Vegetation coverage was evaluated by making notes during each site visit (approximately monthly) and by photographing the vegetation. In addition, relative variations in leaf area index (LAI, one sided green leaf area per unit ground area) were estimated from surveyed transects at selected times from October 2000 through September 2001 using an AccuPar Ceptometer (Model PAR-80, Decagon Devices, Inc., Pullman, WA).

Surface runoff was collected in trench drains at the base of each subplot and measured to ±0.004 to ±0.06 mm for runoff events ≤2 and ≤400 mm, respectively. Deep drainage was collected by 12- by 12-m pan lysimeters (1.5-mm [60-mil] very flexible polyethylene geomembrane) buried at a depth of 3 m and centered beneath the subplots. Lateral drainage was collected from two 15- by 15-m areas of the asphalt layer. All drainage was collected in subsurface drains located along the down-slope lysimeter edges and measured with infrared drop sensors, tipping bucket rain gauges, and a graduated cylinder in 114-L collection drums. Cumulative measurement errors per event were ≤0.5%.

Soil water storage was monitored on a monthly basis using a neutron probe (Model 503DR Hydroprobe, CPN, Martinez, CA) at 0.15-m depth intervals in 20 vertical neutron probe access tubes (51-mm i.d. PVC) installed in June 1998. Water content in the upper 0.15 m was calculated using an empirical correction factor to adjust for the loss of neutrons at the soil surface (Greacen et al., 1981, after Grant, 1975). The neutron probe was calibrated with water content data from core samples ($r^2 = 0.96$; $\sigma = 0.011$ m^3 m^{-3}). Water content before June 1998 was estimated for the upper 0.3 m from matric potential measurements using heat dissipation sensors and laboratory-measured water retention functions. Electromagnetic induction was also used to monitor water storage (Reedy and Scanlon, 2003) but is not discussed in this paper.

Heat dissipation sensors (model 229, Campbell Scientific Inc., Logan, UT) were installed during site construction to monitor matric potentials that can be used to determine flow direction. These instruments were calibrated individually using pressure plate extractors (−0.1 to −50 m) and by equilibrating the sensors over saturated salt solutions (−450 to −2500 m). Temperature corrections were applied according to procedures outlined in Flint et al. (2002).

A cylindrical instrument silo (3.7-m diameter, 6.1 m high) constructed of welded steel panels was installed in the center of the installation to house data loggers and computers. Eight PVC instrument trees (0.3-m diameter) were installed 12 m from the silo to accommodate heat dissipation sensor installation. A 0.6-m-diameter, 10-mm-thick disk-shaped baffle was installed 0.45 m below the ground surface to inhibit preferential flow along the perimeter of the instrument trees. Instrument cable bundles passed through watertight fittings in the walls of the instrument trees at selected depths and were connected to data loggers in the silo. Instruments were installed in the soil during site construction at 1.0- to 1.5-m offset distances from the trees.

New Mexico Site Monitoring Systems

The west subplot was irrigated in January and February 2002. Vegetation parameters, including plant cover percentage and species count, were measured approximately annually (fall 1997 through 2000 and spring 1998) using point frames (Dwyer, 2003). Surface runoff was collected in a gutter system located along the base of each subplot slope and routed through pipes to tanks with flow meters that quantified runoff with cumulative errors per event ≤0.2%. Deep drainage was measured using pan lysimeters that consisted of a geotextile underlain by a geonet, and then a geomembrane and water was routed to an underdrain collection system that included tipping buckets and measured with cumulative errors per event ≤0.2%.

Changes in water storage were monitored using time domain reflectometry (0.3 m long, three-wire probes; Campbell Scientific Inc. Model 610). Vertical profiles of time domain reflectometry (TDR) probes were installed in 10 locations equally spaced along the center of the plot. Time domain reflectometry probes were installed horizontally at the 0.15-m depth (base of topsoil) and 0.45- and 0.9-m depths within the compacted soil. Water content monitoring with TDR began in May 1997 and continued through September 2002.

Numerical Modeling

The computer code UNSAT-H (Fayer, 2000) was used to simulate water balance of the engineered covers. In this study, we conducted short-term simulations (1–5 yr) of the covers at both sites for comparison with measured water balance parameters. We also conducted long-term simulations on the basis of meteorological data from 1961 through 1990, which were obtained from the GEM database for El Paso and Albuquerque (Hanson et al., 1994). Model results are reported for the last 25 yr of the 30 yr simulated to avoid the impact of initial conditions; therefore, these simulations are termed 25-yr simulations. Nodal spacing ranged from 2 mm at the top and base of the profile and increased by a factor of 1.2 to a maximum of 150 mm within the profile. This grid design resulted in negligible mass balance errors (two to three orders of magnitude less than simulated drainage).

Table 1. Model input parameter values.†

Layer	Z	G, S, Si, C	K_s	θ_s	θ_r	α	n
	m	— wt % —	mm d^{-1}	- m^3 m^{-3} -		mm^{-1}	
			Texas				
1	0.30	24, 43, 17, 16	410	0.45	0.00	0.0027	1.276
2	1.7	0, 55, 18, 27	199	0.35	0.00	0.0010	1.167
3	0.30	0, 89, 3, 8	6390	0.40	0.00	0.0020	1.464
			New Mexico				
1	0.15	0, 83, 10, 7	873	0.40	0.00	0.0035	1.378
2	0.90	0, 83, 10, 7	38	0.36	0.00	0.0020	1.280
3	0.10	100, 0, 0, 0	302, 400	0.42	0.00	49.30	2.190

† Z, layer thickness; G, gravel; S, sand; Si, silt; C, clay; wt%, weight percent; K_s: saturated hydraulic conductivity; θ_s, saturated water content; θ_r, residual water content; α and n, van Genuchten water retention function parameters.

The upper boundary for UNSAT-H was based on meteorological forcing and included daily precipitation, minimum and maximum air temperature, dew-point temperature, solar radiation, average wind speed, and average cloud cover. Daily precipitation was input to the simulations, and actual intensities were approximated by a default value of 10 mm h^{-1} (Fayer, 2000). Examination of the precipitation records during the monitoring period indicates that this intensity generally represents the median intensity of the precipitation. Plant transpiration is simulated as a sink term in UNSAT-H (Fayer, 2000). The lower boundary was simulated as a seepage face by including a 0.1-m-thick gravel layer at the base of the profile (Scanlon et al., 2002). A seepage face approximates the capillary barrier present beneath the ET cover at the Texas site and approximates the capillary barrier effect of the pan lysimeter at the base of the New Mexico cover. In additional simulations, a unit gradient lower boundary condition was used that allows free drainage at the base. Vegetation was represented using ecosystem LAI where measured transects included vegetated and bare areas, and percentage bare area was set to zero in the model. The growing season was based on visual observations of plant growth and water content and matric potential data over the monitoring period. Maximum root depths were not measured at either site, and estimates used in the models were evaluated using sensitivity analyses. Root length densities for bunchgrass were used (Rockhold et al., 1995).

Texas Site Model Input

Most input data for the Texas site are described in Scanlon et al. (2002). Simulations were conducted of the upper 1.1 m for comparison with the New Mexico profile and of the upper 2 m to represent the CBET system. Hydraulic parameters used in the model are described in Scanlon et al. (2002) and given in Table 1. In this study, simulations were conducted through the vegetated cover for water year 2000 (October 1999–September 2000; WY00) that is generally representative of long-term conditions and provided guidance on vegetation parameters for the 25-yr simulations (Table 2). Drying that occurred in WY99 was not considered representative of long-term conditions.

Long-term (25-yr) simulations were also conducted. The short-term (1-yr) and long-term (25-yr) models were identical

Table 2. Water balance monitoring results (mm) for the GCL/Asphalt evapotranspirative system (GABET) and capillary barrier evapotranspirative (CBET) systems and simulation results for the CBET system at the Texas site.†

Cover	Water year	P	PET	Irr	R_o	Net I	0–1.1 m depth D	ΔS	ET	S	RMSE	0–2.0 m depth D	ΔS	ET	S	RMSE
		mm										mm				
GABET																
(measured)	1998	202	1644	221	56	367	0.0	59	308	246						
	1999	247	1588	0	5.5	241	0.0	−75	317	171						
	2000	130	1484	0	9.3	121	0.0	−8.7	129	163						
	2001	199	1346	0	12	187	0.0	−4.6	191	158						
	98–01	778	6062	221	83	916	0.0	−29	945	738						
CBET																
(measured)	1998	202	1644	226	60	368	0.9	59	309	246		0.0	61	307	448	
	1999	247	1588	0	5.7	241	0.8	−71	311	174		0.0	−73	314	374	
	2000	130	1484	0	8.2	122	0.0	−9.5	131	164		0.0	−13	135	361	
	2001	199	1346	2340	1866	673	5.0	34	630	198		0.0	43	631	404	
	98–01	778	6062	2566	1940	1404	6.7	12.5	1381	782		0.0	18	1387	1587	
SF‡	2000	130	1484	0	8.1	122	0.0	−8.5	130	165	8.4	0.0	−15	136	357	8.6
UG‡				0	8.1	122	0.2	−8.6	130	165	7.5	2.4	−17	136	359	8.6

† P, precipitation; PET, potential evapotranspiration; Irr, irrigation; R_o, runoff; net I, net infiltration; D, drainage; ΔS, water storage change; ET, evapotranspiration; S, water storage at end of water year; RMSE, root mean square error between simulated and measured (monthly) water storage.
‡ Simulation results for SF, seepage face lower boundary for CBET; and UG, unit gradient lower boundary for CBET.

with the exception of meteorological forcing and a slight increase in ecosystem level LAI from 0.1 to 0.15 because WY00 was a dry year. The long-term simulations were based on daily meteorological data (1961–1990) from El Paso rather than Sierra Blanca because Sierra Blanca had only precipitation data and El Paso included all required meteorological parameters. During the 4-yr monitoring period (1997–2001), precipitation at El Paso was ±25% of annual precipitation at Sierra Blanca and averaged within 5% during the 4 yr. The long-term monthly distributions of precipitation in El Paso and Sierra Blanca are also similar. Initial conditions for the 25-yr simulations were based on linear interpolation of water content on 1 Oct. 1999, which generally represents average conditions for the cover during the monitoring period.

New Mexico Site Model Input

Input data for the New Mexico site are described in Dwyer (2003). Simulations were conducted for 1997 through 2002 for comparison with the measured water balance. Meteorological data for the simulations were based on daily values from the onsite meteorological station. Water retention was measured on disturbed soil samples using hanging water columns and pressure plates. The van Genuchten water retention function was fitted to the laboratory-measured water retention data (Table 1). Saturated hydraulic conductivity of the different materials was measured in the laboratory on disturbed soil samples collected from a borrow pit in the field (Dwyer, 2003). The samples (100-mm diam, 120-mm height) were recompacted to bulk densities ranging from 1.5 to 1.7 Mg m^{-3}. A falling head approach was used with a compaction mold permeameter (ASTM D5856, ASTM, 1995). Initial conditions for the simulations were based on linear interpolation of water contents monitored by TDR on 1 Oct. 1997 converted to matric potentials using water retention functions for the different materials. Long-term (25-yr) simulations were based on the monitoring period and used daily meteorological data from Albuquerque (1961–1990).

RESULTS AND DISCUSSION

Texas Site Monitoring

Precipitation, Irrigation, and Runoff

The 4-yr monitoring period was generally not representative, and precipitation ranged from 42% (WY00) to 79% (WY99) of the long-term (29-yr) average precipitation at Sierra Blanca (311 mm yr^{-1}) (Fig. 3, Table 2). Irrigation in August and September 1998 (221–226 mm) combined with precipitation in that year represented 140% of the long-term average precipitation. Both CBET subplots were also irrigated in summer 2001. A total of 459 mm of water was applied from 18 June through 8 Aug. 2001. Malfunction of the irrigation system in the vegetated CBET subplot resulted in continuous irrigation (1881 mm) during 9 through 11 August.

Total annual runoff ranged from 6 to 1866 mm yr^{-1}, which represented 2 to 73% of annual precipitation + irrigation for WY98 through WY01 (Fig. 3, Table 2). Runoff was highest (1866 mm) in the CBET subplot that was irrigated with 2340 mm of water in summer 2001. Runoff was also high during WY98 (13–14% of P + Irr) because the covers were irrigated and not vegetated. Runoff during the remaining years (WY99 and WY00) ranged from 2 to 7% of precipitation.

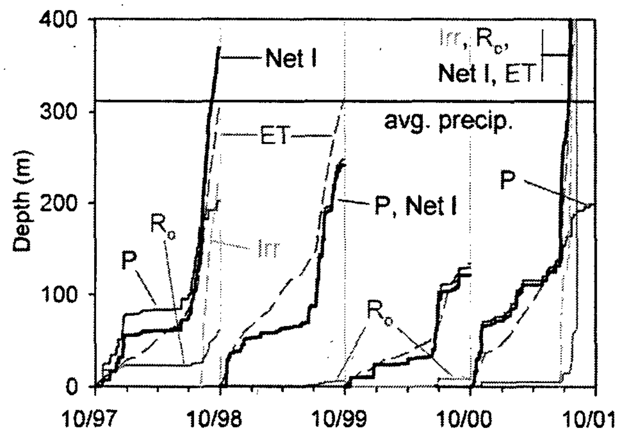

Fig. 3. Measured cumulative precipitation (P), irrigation (Irr), runoff (R_o), and net infiltration (Net I = P + Irr − R_o) and calculated cumulative ET for the CBET cover system for 1998 through 2001 water years at the Texas site. The long-term (1962–1990) average annual precipitation of 311 mm is shown (± 102 mm 1σ). Water year 2001 cumulative values are Irr: 2340 mm, R_o: 1866 mm, net I: 673 mm, and ET: 630 mm.

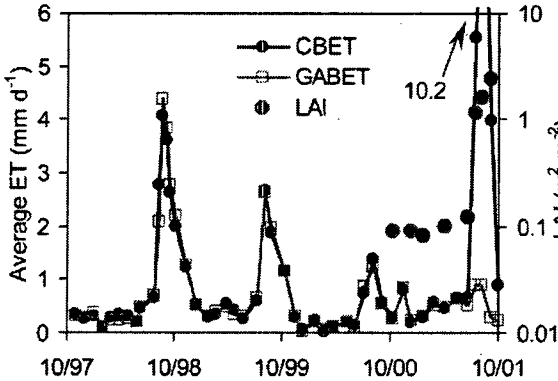

Fig. 4. Daily ET rates to the 1.1-m depth calculated from monthly average values for the GABET and CBET systems and measured leaf area index (LAI) for the CBET system at the Texas site.

Evapotranspiration, Water Storage, and Matric Potential

The main components of the monitored water budget were ET and water storage change. Cumulative ET was less than net infiltration (P + Irr − R_o) of water to the system in WY98 when the subplots were irrigated to establish vegetation (Fig. 3). During the following year cumulative ET exceeded net infiltration as the cover dried out. Potential evapotranspiration (PET) exceeded actual ET by factors ranging from 5 (WY 98, WY 99) to 11 (WY 00). Average daily ET rates for approximately monthly periods between water content monitoring were initially generally uniform (0.2–0.6 mm d^{-1}; Oct. 1997–Aug. 1998) when the covers were nonvegetated and peaked (≤4.4 mm d^{-1}) after irrigation in September 1998 (Fig. 4). High ET rates during and after irrigation are attributed primarily to evaporation with limited transpiration from opportunistic weeds that grew on the cover. Evapotranspiration rates decreased during the 1998–1999 winter to values of 0.1 to 0.4 mm d^{-1} and increased again in summer 1999 (≤2.6 mm d^{-1}), corresponding to expansion of tumbleweed growth. Highest ET rates (≤10.2 mm d^{-1}) were recorded in summer 2001 after irrigation of the CBET subplots. Periods of high ET generally corresponded to periods of increased water availability and vegetation productivity (Fig. 4, 5). Ecosystem level LAI measurements were low (≈0.1 m^2 m^{-2}) from October 2000 through June 2001 and increased to a maximum value of 2.4 m^2 m^{-2} after irrigation in summer 2001.

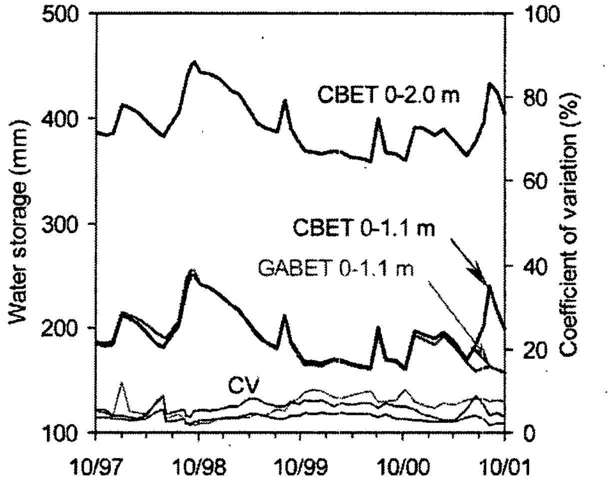

Fig. 6. Average water storage (thick lines) to the 1.1-m depth in the GABET and CBET systems and to the 2.0-m depth in the CBET system at the Texas site. Thin lines represent the coefficient of variation (CV = 100 σ/μ) of water storage from 10 neutron probe access tube measurement locations in each design.

The importance of vegetation in controlling water balance is shown by strong relationships between vegetation productivity and soil water storage changes (Fig. 4, 6). Temporal patterns of water storage are similar for the different depth intervals considered, 0 to 1.1 m for the CBET and GABET and 0 to 2 m for the CBET. Water storage was highest after irrigation in September 1998. The large decrease in water storage from October 1998 through June 1999 can be attributed primarily to evaporation and limited transpiration related to weeds and grasses. Sharp increases in water storage (24–40 mm) during July 1999 and 2000 in response to summer monsoon precipitation were reduced rapidly in 1 to 2 mo as a result of increased ET (Fig. 4, 6). Large increases in tumbleweed occurred after high precipitation in July 1999. Monsoonal precipitation results in desert blooms as vegetation quickly responds to increased water availability. In contrast to rapid decreases in water storage in the summer, water storage in winter (e.g., October–November 2000) remained high

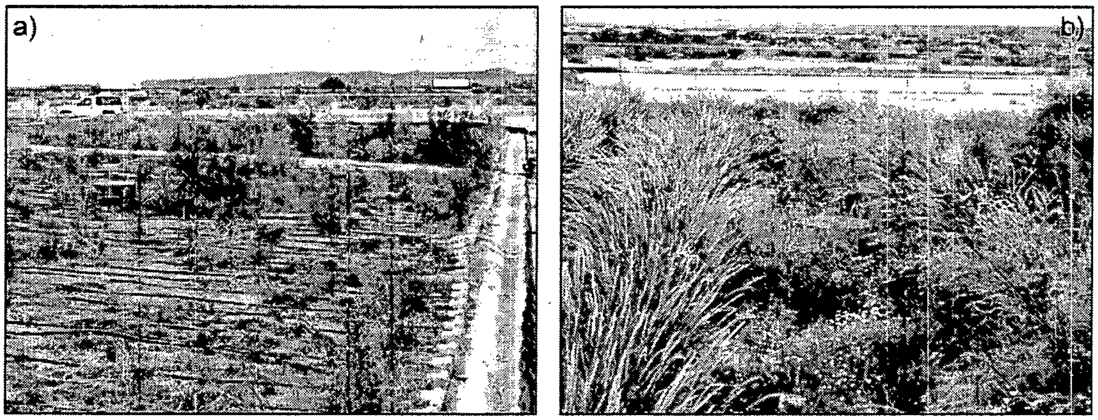

Fig. 5. Texas site vegetation response to (a) natural summer precipitation (Aug. 2000) and (b) irrigation (Aug. 2001).

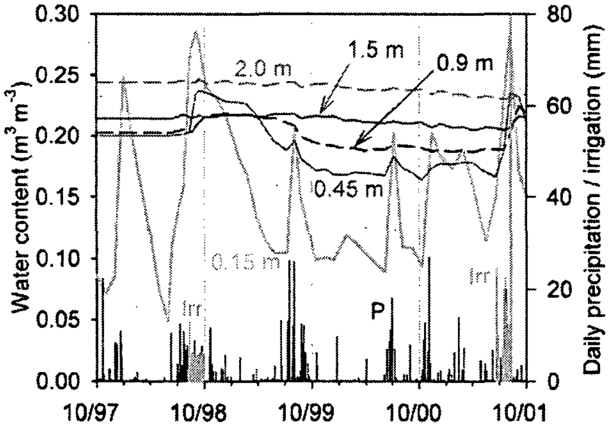

Fig. 7. Average water content based on data from 10 neutron probe access tubes at selected depths in the CBET system and daily precipitation and irrigation at the Texas site.

for several months when vegetation was dormant because evaporation was insufficient to remove the infiltrated water. Water storage was reduced in the following spring 2001 when vegetation began actively transpiring. The opportunistic response of vegetation to soil water storage is shown by the large increase in vegetation after irrigation of 422 mm (July and August 2001) and resulted in monthly ET values of 144 to 214 mm, which equaled PET in July and exceeded PET by a factor of 2 in August 2001.

Measured water content was highly variable with time at different depths in the CBET system (Fig. 7); similar patterns were seen in the GABET system (data not shown). Temporal variability in water content was greatest near the surface (0.15-m depth) and decreased with depth. Water content ranged from 0.05 m^3 m^{-3} (May 1998) to a maximum value of 0.28 m^3 m^{-3} (September 1998) after the plot had been irrigated to establish vegetation. Minimum water content during the remaining time was about 0.1 m^3 m^{-3} and increased in July and August 1999 and 2000 to a maximum value of 0.2 m^3 m^{-3}. Progressively smaller water content changes occurred with increasing depth (0.23 m^3 m^{-3}, 0.15 m; 0.08 m^3 m^{-3}, 0.45 m; 0.03 m^3 m^{-3}, 0.9 m; 0.02 m^3 m^{-3}, 1.5 m). Increases in average water content following the 1998 irrigation penetrated to depths between 0.9 and 1.5 m, whereas the 2001 irrigation penetrated to the 1.5-m depth. Successive increases in water content with depth, as seen after the 1998 irrigation, indicate predominantly piston-type flow, as the wetting front moved progressively deeper with time. Water content generally increased with depth from a low value ($\approx$0.10 m^3 m^{-3}) at the 0.15-m depth when the soils were dry to a high value of 0.24 m^3 m^{-3} at the 2-m depth. The high water content at depth is attributed to heavy precipitation during construction of the deeper parts of the cover. There was no uniform trend in average water content for the top of slope vs. the base of slope, which may reflect in part the low slope of the cover (2%). Initially, water contents were higher at the base of the slope relative to the top; however, vegetation concentrated in this region and resulted in lower water contents at the base relative to the top of the slope.

Representative time series of monitored matric potentials indicate predominantly upward water movement, except after infiltration events, as shown by low matric potentials near the surface (0.3-m depth) and increasing with depth (Fig. 8b, 8c). Information on flow processes derived from matric potential data was similar to that from water content data: piston-type flow following irrigation, matric potential spikes to 0.3-m depth in the summer in response to monsoon precipitation followed by high ET, and persistent high matric potential in response to winter precipitation (2000–2001). Two time series representing different types of vegetation after October 1999, grasses and salt cedar (Fig. 8b) and grasses only (Fig. 8c), indicate that salt cedar was more effective in drying out the soil, as shown by lower matric potentials from summer 2000 through mid summer 2001. The matric potential data during fall 2001 following irrigation recorded progressive downward movement of a drying front. Matric potentials stopped decreasing in mid November 2001 because vegetation was dormant and started decreasing again in April and May 2002 when vegetation became active. Matric potentials at all depths started decreasing at the same time, indicating that roots at different depths were active in the spring. These data provide very valuable information on the time scales at which vegetation actively dries out the cover. The matric potential data suggest generally deeper water penetration at the locations of the heat dissipation sensors relative to the neutron probe access tubes, which showed penetration to 1.4 to 2 m at different locations. Focused flow may have occurred because of less compaction around the instrument trees where heat dissipation sensors were installed.

Drainage

Measured drainage was zero at the base of the capillary barrier (3-m depth) (Table 2). Even after addition of 1883 mm of irrigation in August 2001, there was no measured drainage at the base of the profile in 2001 through 2002. Ideally, evaluation of the performance of the ET portion of the cover would require drainage measurements at the 2-m depth. However, the capillary break at the 2-m depth precludes drainage until the overlying material becomes almost saturated. Calculated drainage at the 1.1-m depth in the CBET profile for comparison with the New Mexico profile was based on increases in water content over time below this depth and ranged from 0.00 (WY00) to 5.0 mm yr^{-1} (WY01). Calculated drainage at the 1.1-m depth in the CBET subplots followed 1998 and 2001 irrigations.

Measured lateral drainage from the GCL/asphalt layer in the GABET cover ranged from 0.00 mm yr^{-1} in one subplot to 0.14 mm yr^{-1} in the other for WY98 through WY01. The measured lateral drainage from one subplot may be attributed to localized fluxes because there was no evidence of increased water contents or matric potentials in any of the instrument locations.

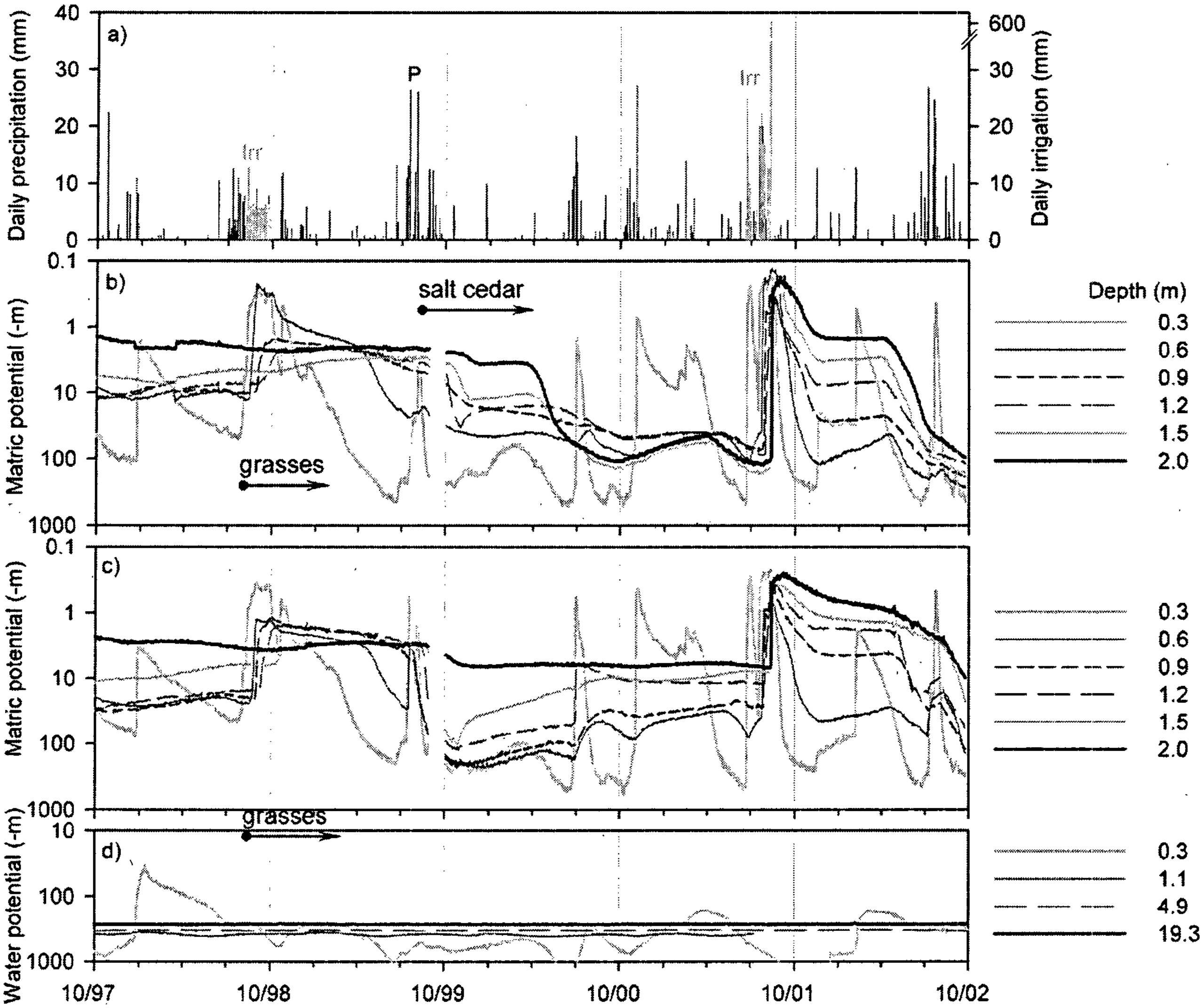

Fig. 8. (a) Daily precipitation (*P*) and irrigation (Irr) depths, (b) and (c) matric potential at selected depths at two locations in the CBET cover system at the Texas site, and (d) water potential monitored with thermocouple psychrometers in the adjacent natural setting at the Texas site.

New Mexico Site Monitoring

Precipitation, Irrigation, and Runoff

The monitored period was representative and precipitation ranged from 80% (WY02) to 151% (WY01) of the long-term (30-yr) average precipitation at Albuquerque (226 mm yr^{-1}) (Table 3, Fig. 9). The west subplot was irrigated in late January through early February 2002, with a total of 110 mm of water. Total annual runoff ranged from 0.2 to 22.0 mm. The highest runoff (14 mm on 26 July 1998) occurred in response to heavy precipitation (24.2 mm) the previous day. Runoff was also relatively high in WY97 in the west subplot (6.4 mm yr^{-1}). Annual runoff was generally low during the remaining time (0.2–0.8 mm yr^{-1}).

Evapotranspiration, Water Storage, and Drainage

Cumulative ET was greater than net infiltration to the cover in WY98 and similar to net infiltration on an annual basis during the remaining time (Fig. 9). Net infiltration generally exceeded ET during November through June in WY01. Potential evapotranspiration exceeded actual ET by factors ranging from 5 (WY01) to 11 (WY02) (Table 3).

Trends in water storage were similar in the west and east subplots; however, water storage was generally lower in the west subplot, except after irrigation in WY02 (Fig. 10). Mean water storage showed large seasonal and interannual variability. High initial water storage may be attributed to precipitation exceeding the long-term average by 70% in summer 1997 (April–September) and by 57% in winter 1997-1998 (October–March), corresponding to the strong 1997-1998 El Niño period. Large decreases in water storage in spring and summer 1998 corresponded to substantial increases in plant cover from about 1% in fall 1997 to between 30 and 60% in 1998 (Fig. 10). Interannual variability in water storage generally reflected variability in precipitation: low water

Table 3. Water balance monitoring (west and east subplots) and simulation results (east subplot) (mm) for the New Mexico site.†

Subplot	Water year	P	PET	Irr	R_o	Net I	D	ΔS	ET	S	RMSE
		mm									
West (meas.)	1997‡	227	–	0	6.4	221	0.1	−23.2	244	162	
	1998	299	1772	0	22.0	277	0.4	−66.4	343	95	
	1999	280	1851	0	0.8	279	0.0	−0.9	280	95	
	2000	189	1908	0	0.2	189	0.0	35.1	153	130	
	2001	341	1786	0	0.6	341	0.0	−44.1	385	86	
	2002	181	2012	110	0.6	290	0.0	20.3	270	106	
	1997–2002	1517	9329	110	30.6	1597	0.5	−79.2	1675	674	
East (meas.)	1997‡	227	–	0	1.5	226	0.0	31.5	194	182	
	1998	299	1772	0	0.8	298	0.0	−73.6	372	108	
	1999	280	1851	0	0.6	279	0.0	−8.6	288	99	
	2000	189	1908	0	0.2	189	0.0	16.2	172	116	
	2001	341	1786	0	0.8	340	0.0	−4.3	345	111	
	2002	181	2012	0	0.4	180	0.0	3.5	177	114	
	1997–2002	1517	9329	0	4.3	1512	0.0	−35.3	1548	730	
East (simul. SF)§	1998	299	1772	0	0.0	299	0.0	−76	375	106	37
	1999	280	1851	0	0.0	280	0.0	−14	294	94	17
	2000	189	1908	0	0.0	189	0.0	−8.2	197	91	17
	2001	341	1786	0	0.0	341	0.0	−1.6	343	115	37
	2002	181	2012	0	0.0	181	0.0	13	167	124	19
	1998–2002	1290	9329	0	0.0	1290	0.0	−86.8	1376	530	
East (simul. UG)§	1998	299	1772	0	0.0	299	0.3	−76	375	106	32
	1999	280	1851	0	0.0	280	0.1	−14	294	94	17
	2000	189	1908	0	0.0	189	0.0	−8.1	197	91	17
	2001	341	1786	0	0.0	341	0.0	−1.5	343	114	37
	2002	181	2012	0	0.0	181	0.0	13	167	124	18
	1998–2002	1290	9329	0	0.0	1290	0.4	−86.6	1376	529	

† P, precipitation; PET, potential evapotranspiration; Irr, irrigation; R_o, runoff; net I, net infiltration; D, drainage; ΔS, water storage change; ET, evapotranspiration; S, water storage at end of water year; RMSE, root mean square error between simulated and measured (daily) water storage.

‡ 1 May through 30 Sept.

§ Simulation results for SF, seepage face lower boundary; and UG, unit gradient lower boundary.

storage in WY99 and WY00 when precipitation was low and higher water storage in WY01 when precipitation was higher. Temporal variability in water storage at shorter time scales generally reflected variability in precipitation and plant growth. Large increases in water storage occurred on 15 Mar. 1998, in response to high precipitation (48 mm in 2 d). Summer precipitation in 1999 was effective in increasing water storage. The large increase in water storage recorded in summer 2000 through spring 2001 was attributed to high precipitation during this time. Decreases in water storage in some years (1998 and 2002) can be related to vegetation growth and ET in the spring and summer. However, there was no definite seasonal variability in water storage because water storage increases and decreases occurred in both winter and summer. The much larger coefficient of variation (100 σ/μ) in measured water storage (≤ about 35%) relative to that for the Texas data (≤ about 10%) may reflect the smaller sampling volume of the TDR probes relative to the neutron probe and lower number of sample points in each average (15 in New Mexico vs. 70 in Texas data). The CV in water storage also reflects spatial variability in measured water content: lower water contents in the upland areas and higher water contents toward the base of the slopes (Fig. 11a).

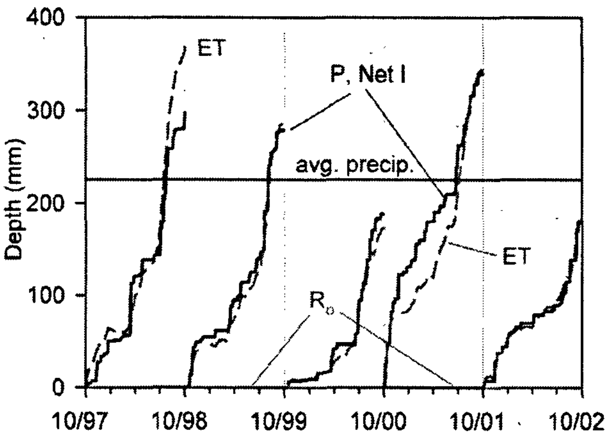

Fig. 9. Measured cumulative precipitation (P), runoff (R_o), and net infiltration (net $I = P - R_o$) and calculated cumulative evapotranspiration (ET) for the ET engineered cover to the 1.1-m depth for water years 1998 through 2002 at the New Mexico site. The long-term (1961–1990) average annual precipitation of 226 mm is shown (±55 mm 1 σ).

Temporal variability in water content measured at different depths was greatest near the surface and decreased with depth (Fig. 11b). Water content was generally high at 0.15 m during winter periods, with the exception of 1999, and generally decreased in March and April of each year when vegetation became active. Water redistributed to depths of 0.45 and 0.90 m after infiltration in winter 1997–1998 and winter and spring 2000–2001. Drying also propagated with depth (e.g., for 1998: 0.15 m in March, 0.45 m in June, 0.9 m in August).

Measured drainage at the base of the ET cover was 0.0 mm yr^{-1} in the east subplot and ranged from 0.0 to 0.4 mm yr^{-1} in the west subplot. Drainage occurred during the first 2 yr of the 5-yr monitoring period. Low drainage during 1997 extended over several months and was attributed to wet initial conditions (average water content 0.18 m^3 m^{-3}) from construction water in the profile and summer precipitation events (10 July 1997, 24.4 mm; 18 July 1997, 20.6 mm; 22 Aug. 1997, 23.6 mm; 21 Sept. 1997, 50.8 mm). Drainage in 1998 generally occurred during a short time period (0.39 mm; 18 July 1998 to 20 Sept. 1998) and was attributed to a sequence

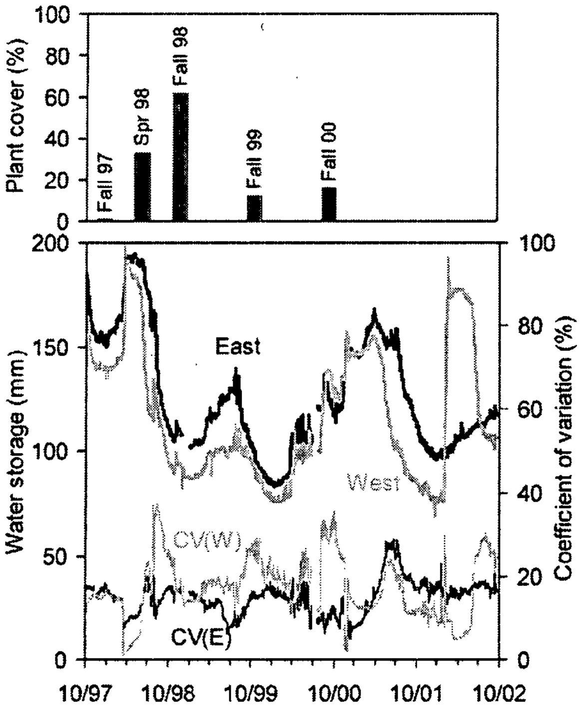

Fig. 10. Average plant cover (columns) and average water storage (thick lines) to the 1.1-m depth in the west and east subplots at the New Mexico site. Thin lines represent the coefficients of variation of five TDR measurement locations for both the west and east subplots.

of large discrete precipitation events (16 July 1998, 24.6 mm; 25 July 1998, 24.4 mm; and 1 Aug. 1998, 18.5 mm). Drainage may have been spatially focused also, as shown by lack of drainage in the east subplot.

Comparison with the Natural System

The natural system surrounding the ET covers in West Texas was characterized for a proposed low-level radioactive waste disposal facility (Scanlon et al., 1999). Water content monitored with a neutron probe in an access tube installed 20 m from the covers did not change below 0.6 m during the 4-yr monitoring period. Long-term water potential monitoring using thermocouple psychrometers 30 m from the covers showed that maximum depth of the wetting front was <0.3 m (Fig. 8d; Scanlon et al., 2003). Water potential includes matric and osmotic potentials; however, estimated osmotic potentials from pore water Cl^- data are generally ≤10% of measured water potentials (Scanlon et al., 2003); therefore, water potential and matric potential can be considered approximately equivalent. Matric potentials in the engineered cover were much higher than water potentials monitored in the natural system (Fig. 8d). Wetter conditions in the engineered covers can be attributed partly to precipitation, addition of water for compaction during construction, and irrigation of the subplots to establish vegetation. Measurement and modeling of matric potential and Cl^- profiles in the natural system indicate that it has been in a long-term drying trend since the Pleistocene (≈10 000–15 000 yr ago) and that water has been moving upward since that time (Scanlon et al., 2003). Chloride moves into the subsurface with infiltrating precipitation and builds up in the subsurface as water is evapotranspired because Cl^- is not volatile and plant uptake is negligible. This comparison of engineered covers and the surrounding natural system indicates that the two are not directly comparable. Soils in the natural system have been developing for very long times and are characterized by thick caliche development. It is questionable whether the water balance of the covers will approach that of the natural system in the near future.

Numerical Simulation Results

Texas Site Water Balance Simulations

Previous studies indicate that simulated and measured water balance generally compare favorably for the first year of monitoring (WY98) when the system was nonvegetated; however, simulated runoff was underestimated (Scanlon et al., 2002). Simulated water balance of the vegetated cover for WY00 was similar to the

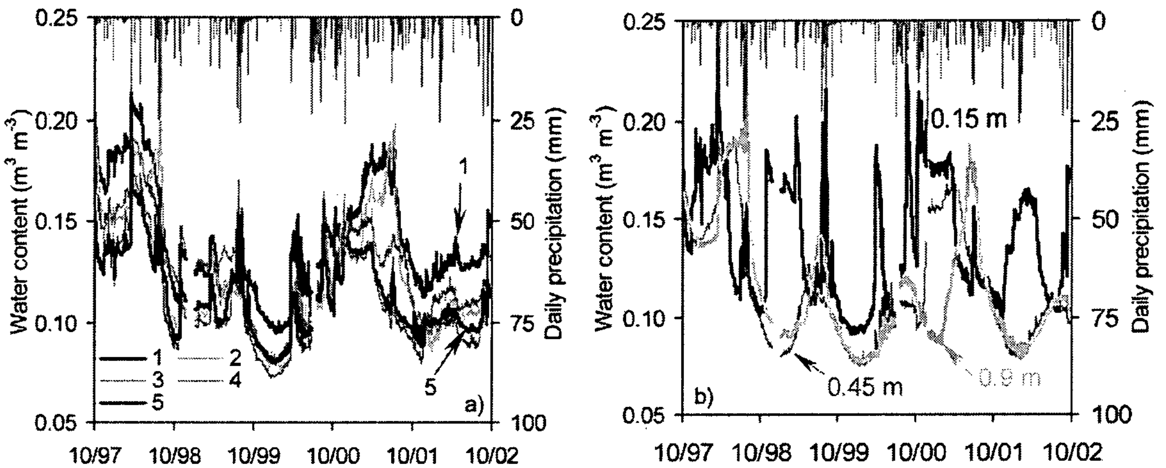

Fig. 11. Average measured water content for (a) all monitored depths within a given slope position (1: base of slope, 5: top of slope) and (b) all slope positions at a given monitored depth in the east subplot at the New Mexico site.

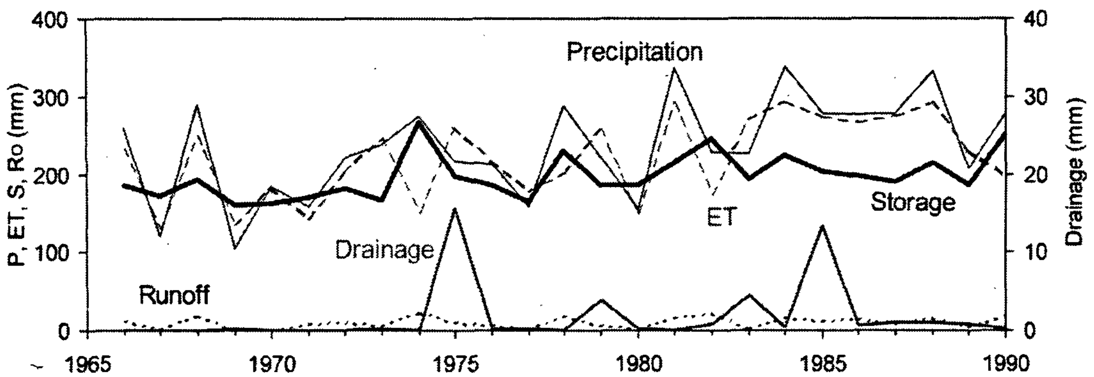

Fig. 12. Simulated annual water balance results for the 1.1-m Texas profile with a unit gradient lower boundary condition.

measured water balance also (Table 2). Vegetation parameters included maximum ecosystem level LAI of 0.1 m^2 m^{-2}. The growing season extended from mid March to the end of September, with maximum LAI from late May through mid-August. The maximum rooting depth was set at 0.75 m and was evaluated using sensitivity analyses. To better simulate runoff, a 50-mm crust with 44% lower hydraulic conductivity was included in the simulation profile. Crusts often form in these regions. The saturated hydraulic conductivity of the crust can be considered a calibration parameter to better simulate runoff. Simulated drainage was 0.0 mm for the 2-m profile using a seepage face lower boundary condition that reflects the underlying capillary barrier. In contrast, simulations using a unit gradient lower boundary condition, which allows free drainage, resulted in 0.2 mm of drainage at the 1.1-m depth and 2.4 mm of drainage at the 2-m depth. The higher drainage at the 2-m depth reflects the wetter initial conditions between 1 and 2 m because of heavy rain during construction (Fig. 7). Simulated drainage at the 1.1-m depth is similar to zero drainage estimated at this depth.

The main components of the water balance were ET and water storage change because runoff and drainage were low. Simulated and measured annual ET values were within 1%, and water storage changes were within 12%. Calculated root mean square errors based on measured and simulated water storage were low ($\leq$10 mm), indicating that the simulations generally reproduced the temporal variability in water storage.

Although there are no measured data for comparison with the 25-yr simulations, these simulations provide information on how the cover might perform in response to long-term climate forcing (Fig. 12). The results for the 1.1-m profile are described and are similar to those for the 2-m profile. Simulated runoff ranged from 0.0 to 22.7 mm yr^{-1} and averaged 9.5 mm yr^{-1}, which is similar to measured values during the monitoring period (Table 2). Simulated drainage was 0.0 mm yr^{-1} for the 1.1- and 2-m profiles using a seepage face lower boundary condition. In contrast, a unit gradient lower boundary resulted in simulated drainage ranging from 0.0 to 1.0 mm yr^{-1}, with the exception of 4 yr when drainage was higher: 1975 (16.7 mm yr^{-1}), 1979 (4.5 mm yr^{-1}), 1983 (4.9 mm yr^{-1}), and 1985 (14.1 mm yr^{-1}) (Fig. 12). The highest drainage occurred in 1975 after above-normal precipitation in September 1974. A total of 163 mm of precipitation occurred in 9 d in September, with daily precipitation up to 57 mm. Precipitation during 1974 before September was low (112 mm), and low simulated ET is consistent with the low precipitation before September. High precipitation near the end of the growing season resulted in insufficient time for the vegetation to remove the infiltrated water and resulted in a large increase in water storage (100 mm) in 1974 followed by drainage in 1975 (16.7 mm) (Fig. 12). Similar processes occurred in 1984 (131 mm precipitation 4–13 Aug.; 68 mm, 23–26 Oct.) that resulted in 14.1 mm of drainage in 1985. Dominant parameters in the water balance were ET and water storage changes. Temporal variability in water storage was low. The highest water storage increase (100 mm) was recorded in 1974, which corresponded to above-normal precipitation in September. These simulations indicate that cover performance in response to long-term climatic forcing should be similar to that shown by the shorter term monitoring record; however, drainage may occur in response to intense precipitation toward the end of the growing season that can be eliminated with a capillary barrier.

New Mexico Site Water Balance Simulations

The 5-yr water balance of the east subplot was simulated to determine how well simulations would match measured values. The vegetation parameters included maximum ecosystem level LAI of 0.3 m^2 m^{-2} (Dwyer, 2003). The growing season extended from mid-March to the end of September, with maximum LAI from mid-May through early September. Maximum rooting depth was set at 0.75 m, and sensitivity of model results to this parameter was tested. Zero runoff was simulated, which is generally consistent with very low measured runoff values (Table 3). Simulated drainage of zero for the seepage face lower boundary condition is consistent with zero measured drainage. Replacement of the seepage face with a unit gradient resulted in small amounts of drainage that decreased with time (0.1–0.3 mm yr^{-1}; Table 3). Interannual trends and variability in both ET and water storage were generally reproduced by the simulations; however, magnitudes differed. Simulated and measured annual ET values were within 15%. The greatest discrepancy in simulated and measured water

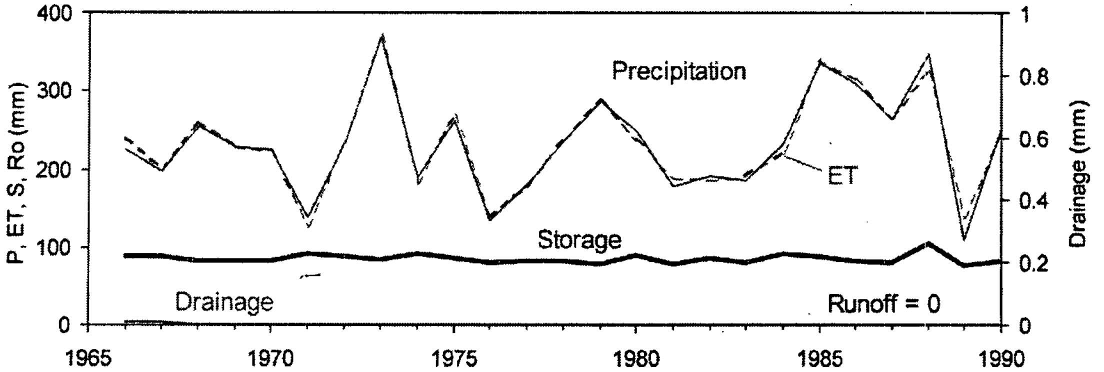

Fig. 13. Simulated annual water balance results for the 1.1-m New Mexico profile with a unit gradient lower boundary condition.

storage was for WY00, when measured storage increased and simulated storage decreased.

The 25-yr simulations resulted in zero runoff and drainage, which is consistent with the monitoring data (Fig. 13). The largest increase in water storage occurred in 1988 (24 mm) and may be attributed to precipitation being about 60 to 70% above average in April through September 1987 and October through March 1997-1998 related to El Nino. Increases in water storage of about 10 mm also occurred in 1964, 1965, 1971, 1974, 1980, and 1984. Annual precipitation and ET were highly correlated ($r = 0.99$). Similar results were obtained for seepage face and unit gradient lower boundary conditions.

Sensitivity Analysis

The simulations provide information on the sensitivity of the simulated water balance to variations in meteorological forcing, profile thickness, and lower-boundary condition. Additional simulations were conducted to assess sensitivity of simulations to variations in PET, vegetation parameters (including root depth, root-length density, vegetation type, and LAI), and hydraulic parameters (Fig. 14, Table 4). Parameters were generally varied from a factor of 0.5 to 1.5 times the values used in the base case. The sensitivity analyses were conducted on the 25-yr simulations.

Results of sensitivity analyses for the Texas site are described for the 1.1-m-deep profiles because results from the 2-m profiles were similar (Fig. 14; Table 4). Simulations were based on a unit gradient lower boundary condition. Simulated water balance was most sensitive to the presence or absence of vegetation. Simulating the extreme case of no vegetation resulted in increased drainage by 27.7 mm yr^{-1} and was balanced by reduced ET. The model was not very sensitive to variations in individual vegetation parameters, such as LAI, root depth, or root-length density. Varying root distribution from bunchgrass (base case) to cheat grass (higher root density at shallower depths; Rockhold et al., 1995) increased drainage by 3.6 mm yr^{-1} and was generally balanced by reduced ET. Decreasing PET by a factor of 2 increased drainage by 7.7 mm yr^{-1} and was generally balanced by reduced ET, whereas increasing PET by a factor of 1.5 decreased drainage and increased ET. However, temporal variability in annual PET is low (CV 0.06–0.08), and PET is generally not highly uncertain. Simulated water balance was more sensitive to variations in hydraulic parameters than in vegetation parameters. Previous studies at the Texas site showed that laboratory and field measured K_s values underestimated the effective K_s of the cover as shown by the monitoring data (Scanlon et al., 2002). Simulations are sensitive to variations in K_s. Increasing K_s by an order of magnitude increased drainage by 7.5 mm yr^{-1} that was balanced by reduced ET, whereas

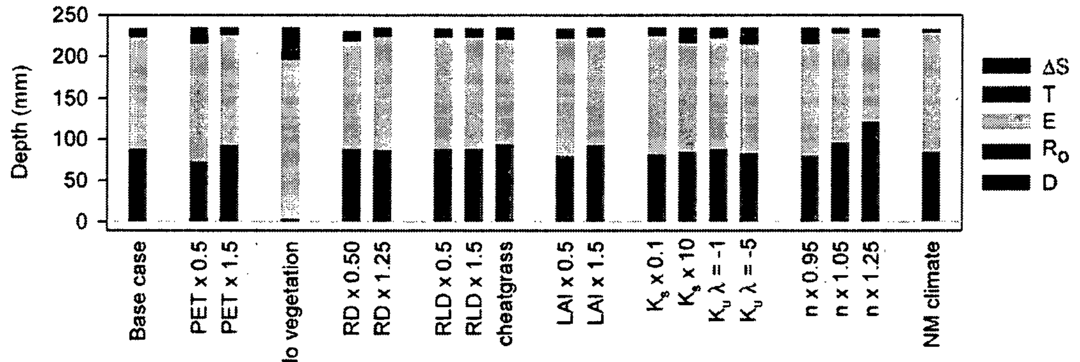

Fig. 14. Sensitivity analysis for the Texas site simulation: 25-yr average annual values are shown for the base case simulation and for simulations with a single parameter altered as indicated. PET, potential evapotranspiration; RD, root depth; RLD, root length density; LAI, leaf area index; K_s, saturated hydraulic conductivity; K_u λ, unsaturated hydraulic conductivity function parameter; *n*, van Genuchten soil water retention function parameter; NM climate, simulation using New Mexico site climate forcing. Water balance parameters are ΔS, water storage change; *T*, transpiration; *E*, evaporation; R_o, runoff; *D*, drainage.

Table 4. Sensitivity analysis results for 25-yr simulations using a unit-gradient lower boundary condition. Base case represents the model average annual total values. All other values represent *changes* relative to the base case in average annual total values resulting from the indicated parameter modification.†

	Texas site 1.1-m profile						New Mexico site 1.1-m profile					
Parameter	T	E	ET	R_o	D	ΔS	T	E	ET	R_o	D	ΔS
						mm						
Base case	85.8	134.9	220.7	9.5	1.9	3.2	93.6	139.8	233.4	0.0	0.0	−0.8
PET × 0.5	−16.7	7.7	−9.0	0.8	7.7	0.9	−11.2	13.6	2.5	0.0	0.0	0.3
PET × 1.5	5.1	−2.7	2.3	−0.3	−1.1	−0.5	9.0	−6.7	2.3	0.0	0.0	0.5
No vegetation	−85.8	57.4	−28.4	1.0	27.7	−0.3	−93.6	90.8	−2.8	0.0	1.8	1.0
RD × 0.5	1.9	−4.3	−2.4	−0.1	2.6	0.0	16.0	−17.2	−0.3	0.0	0.1	0.2
RD × 1.25	−1.2	1.5	0.3	0.1	−0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RLD × 0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.4	−1.3	0.0	0.0	0.0	−0.1
RLD × 1.5	−0.3	0.2	−0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cheat grass	4.8	−8.5	−3.8	−0.2	3.6	0.3	21.0	−20.9	0.2	0.0	0.0	−0.2
LAI × 0.5	−9.3	7.4	−1.9	0.1	1.5	0.3	−9.6	9.3	−0.3	0.0	0.0	0.3
LAI × 1.5	4.9	−4.1	0.8	−0.1	−0.5	−0.2	6.3	−6.3	0.0	0.0	0.0	0.0
K_s × 0.1	−6.6	8.6	2.0	0.2	−1.9	−0.3	−11.5	11.4	−0.1	0.0	0.0	0.1
K_s × 10	−4.1	−3.2	−7.4	−0.1	7.5	0.0	14.6	−14.7	−0.1	0.0	0.0	0.1
K_u λ = −1	−0.1	−1.1	−1.2	0.0	1.2	0.0	7.3	−7.4	−0.1	0.0	0.0	0.1
K_u λ = −5	−6.0	−3.0	−8.9	0.1	8.9	0.0	20.6	−24.0	−3.5	0.0	3.3	0.1
n × 0.95	−8.5	0.3	−8.2	9.6	−0.9	−0.5	−7.5	7.5	0.0	0.0	0.0	0.0
n × 1.05	7.3	−3.4	3.9	−5.5	1.2	0.4	7.5	−7.5	0.0	0.0	0.0	0.0
n × 1.25	32.1	−34.2	−2.1	−9.5	10.7	1.0	41.3	−41.2	0.1	0.0	0.0	−0.1
Climate	−0.8	9.2	8.4	−5.7	−1.7	−3.8	0.6	−2.8	−2.2	2.1	0.0	2.9

† T, transpiration; E, evaporation; ET, evapotranspiration; R_o, runoff; D, drainage; ΔS, water storage change; PET, potential evapotranspiration; RD, root depth; RLD, root length density; LAI, leaf area index; K_s, saturated hydraulic conductivity; K_u λ, unsaturated hydraulic conductivity function parameter; n, van Genuchten water retention function parameter; Climate, climate forcing exchanged between the Texas and New Mexico sites.

decreasing K_s by an order of magnitude decreased drainage by 1.9 mm yr^{-1}. The unsaturated hydraulic conductivity (K_u) can also be varied by changing the λ parameter in the van Genuchten–Mualem K_u function. Mualem (1976) suggested a value of 0.5 for λ. Decreasing λ to values of −1 to −5 increased the K_u and increased drainage by 1.2 and 8.9 mm yr^{-1}, respectively, balanced by reduced ET. The van Genuchten n parameter in the water retention function represents the range in pore sizes in the soil: high n indicates low pore-size distribution, typical of coarser material, and low n indicates high pore-size distribution, typical of finer material. The typical range in parameters (factor of 0.5–1.5) could not be considered for n because it resulted in unrealistic values ($n \leq 1.0$). Increasing n by a factor of 1.25 increased drainage by 10.7 mm yr^{-1} and was balanced by reduced runoff. Decreasing n by a factor of 0.95 generally reduced drainage slightly. Replacing the unit gradient lower boundary condition with a seepage face to simulate a capillary barrier resulted in zero drainage for all sensitivity cases.

Simulated water balance of the New Mexico site was much less sensitive to the parameter variations considered in the sensitivity analyses than that of the Texas site (Fig. 15, Table 4). The following results are based on a unit gradient lower boundary condition. Varying PET by factors of 0.5 and 2 changed ET by only 1%. Simulating nonvegetated conditions increased water storage by 1.0 mm yr^{-1} and increased drainage by 1.8 mm yr^{-1} and was balanced by reduced ET. Simulation results were insensitive to variations in vegetation parameters. Varying hydraulic parameters, such as K_s and van Genuchten n, had little impact on the simulated water balance. Reducing the Mualem λ parameter to −5 increased drainage by 3.3 mm yr^{-1} balanced by reduced ET. Results for a seepage face lower boundary condition were similar to those for unit gradient condition, except that simulated drainage was zero for all sensitivity cases with a seepage face. The general insensitivity of simulated water balance to many of the parameters evaluated suggests that it may be difficult to estimate parameters using inverse modeling.

To evaluate causes of differences in simulated long-term water balances between Texas and New Mexico, we interchanged climate forcing between sites. Simulating Texas soils with New Mexico climate forcing resulted in reduced drainage, runoff, and water storage change, balanced by increased ET relative to the Texas base case simulation. These changes may be attributed to the lack of large precipitation events occurring near the end of the growing season (August–October) that are present in the Texas climate forcing. Simulating New Mexico soils with Texas climate forcing resulted in zero drainage (i.e., no change) and increased runoff and water storage change balanced by decreased ET relative to the New Mexico base case simulation. The changes may be attributed the 80% lower K_s in New Mexico subsoil relative to Texas subsoil, which reduced the impact of the late growing season precipitation events present in the Texas climate forcing. These comparisons indicate that low K_s in New Mexico subsoil plays an important role in minimizing drainage; however, as with traditional resistive covers, it may be difficult to determine the optimal K_s that can be achieved without developing cracks and preferential pathways. The above comparisons indicate that both climate forcing and hydraulic properties contribute to differences in simulated water balances between the sites.

Implications for Future Studies

Monitoring and modeling results from these studies have important implications for future studies of engineered covers. Major implications for the monitoring program include (i) limitations of relying on a single param-

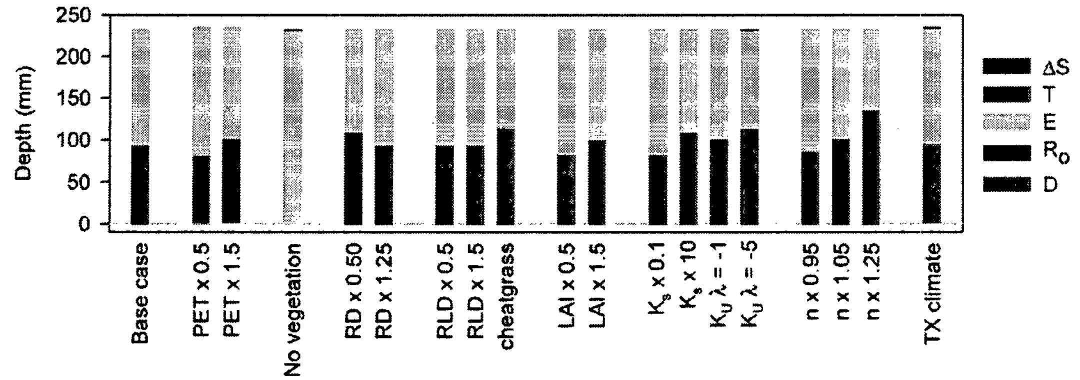

Fig. 15. Sensitivity analysis for the New Mexico site simulation: 25-yr average annual values are shown for the base case simulation and for simulations with a single parameter altered as indicated. PET, potential evapotranspiration; RD, root depth; RLD, root length density; LAI, leaf area index; K_s, saturated hydraulic conductivity; K_u λ, unsaturated hydraulic conductivity function parameter; *n*, van Genuchten soil water retention function parameter; TX climate, simulation using Texas site climate forcing. Water balance parameters are ΔS, water storage change; *T*, transpiration; *E*, evaporation; R_o, runoff; *D*, drainage.

eter such as drainage, (ii) length of the monitoring record, and (iii) spatial variability in water balance parameters.

Drainage is the most critical water balance parameter for performance of engineered covers; however, it is difficult to measure natural drainage in these systems because most pan lysimeters create a capillary barrier effect. The applicability of the lysimeter drainage measurements to actual cover system performance depends on whether the interface between the cover and the underlying waste also acts as a capillary barrier. Although the measurement systems used with pan lysimeters (e.g., tipping bucket rain gauges) can precisely measure drainage, the problem is that water cannot reach these measurement devices and builds up above the lysimeter. Therefore, these systems can underestimate drainage and overestimate soil water storage relative to systems that do not contain a capillary barrier. The impact of the lower-boundary condition was shown by monitoring and modeling at the Texas site. The lack of drainage in the CBET subplot that was irrigated with 2340 mm of water in summer 2001 is attributed to the capillary barrier. In addition, simulated drainage at the Texas site was higher for the unit gradient vs. the seepage face boundary condition, indicating that measured drainage using lysimeters underestimates natural drainage and overestimates water storage for systems without a capillary barrier at this site. The low K_s subsoil in the New Mexico profile resulted in zero drainage for both seepage face and unit gradient conditions. The studies described here emphasize the importance of monitoring multiple parameters to understand total system performance, including water storage, matric potential, and plant parameters.

Engineered covers should be monitored for at least 10 to 20 yr because short-term monitoring may be dominated by construction effects and by disequilibrium between cover parameters and climate forcing. The representativeness of climate forcing during the monitoring period is also very important.

Spatial variability in water balance parameters is important in assessing cover performance. Spatial variability in water content was particularly evident in the New Mexico site (slope 5%) with lower water content in upland areas and higher water content at the base of the slope (Fig. 11a). Monitoring of future covers, particularly those with steeper slopes, should not rely on a single vertical profile for monitoring water storage.

Many limitations associated with modeling are described in an intercode comparison study (Scanlon et al., 2003), such as difficulties in simulating runoff, accurate representation of precipitation intensity, upper boundary condition during precipitation, and variations in simulated water balance related to hydraulic parameterization. One of the most critical parameters in ET covers is vegetation and how it controls water balance. Most models simulate vegetation by externally prescribing time series in vegetation parameters such as LAI and root depth (Simunek et al., 1998; Fayer, 2000). However, this approach precludes any feedback between soil water storage changes and vegetation and fails to simulate the dynamic two-way interaction between vegetation and water balance. The opportunistic behavior of vegetation is clearly shown in the monitoring data. Vegetative response to water storage changes should be simulated internally rather than prescribed in the input data set. All available data, including monitoring and modeling, should be combined to develop a comprehensive conceptual model of total system performance.

Implications for Cover Design

The monitoring and modeling studies described in this work provide valuable information that can be used to optimize the design of ET covers in arid and semiarid regions. One of the basic design issues is cover thickness. A variety of approaches can be used to estimate cover thickness. Traditional approaches estimate available water storage (AWS) from water content at field capacity and wilting point. However, Meyer and Gee (1999) showed that a head-based approach for estimating AWS may not be valid because field capacity may correspond to unacceptably large water fluxes; they proposed a flux-based approach to estimate AWS. Using the Texas profile as an example, field capacity (h = −3.3 m) corresponds to a flux of 67 mm yr^{-1} under unit gradient

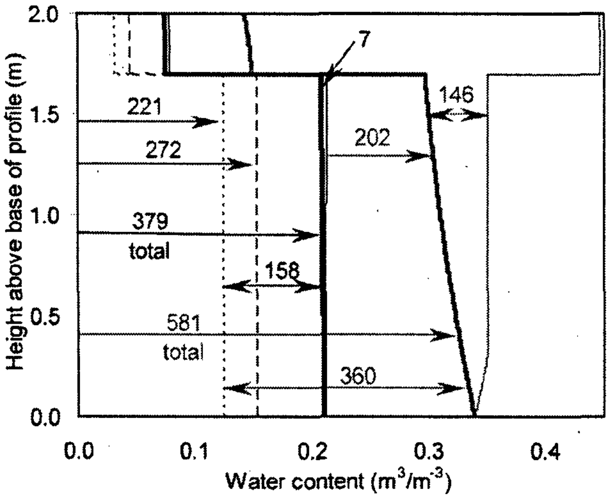

Fig. 16. Calculated water content profiles for the Texas CBET system. All values shown are in millimeters and represent total water storage values over the intervals indicated by associated arrows. Heavy and thin solid line pairs converging at the zero height represent water content profiles for zero and unit downward total head gradient conditions, respectively. The pair of lines converging at 0.34 m^3 m^{-3} water content represent profiles with a capillary barrier located at the zero height having a breakthrough water content equating to −0.3-m head. The two lines converging at 0.21 m^3 m^{-3} water content represent profiles without a capillary barrier and water content at the zero height equating to a prescribed flux of 1 mm yr^{-1}. Dashed lines represent wilting point water content profiles for uniform head conditions ranging from −150 m (long dash) to −500 m (short dash). Abrupt shift in water content near the top of each profile indicates transition from topsoil to subsoil.

conditions (free drainage, no capillary barrier). A flux of 67 mm yr^{-1} is considered excessive. A reasonable performance goal for covers in arid and semiarid regions would be a flux of 1 mm yr^{-1} which corresponds to a head at the base of the profile of −21 m. The maximum water that can be stored in the profile before drainage occurs corresponds to equilibrium or no flow conditions, which corresponds to a total head (H) gradient of zero (i.e., $H = h + z$, unit downward gravitational potential head, z, gradient balanced by unit upward matric potential head, h, gradient). Under equilibrium conditions, a head of −21 m corresponds to 379 mm total water storage in a 2-m profile (Fig. 16) and 191 mm in a 1.1-m profile (Table 5). Under drainage conditions, a unit downward total head gradient is more appropriate, which corresponds to a zero matric potential head gradient and unit downward gravitational potential head gradient. However, the difference in water storage between equilibrium and a downward gradient is small (7 mm) (Fig. 16). To calculate the AWS, water storage associated with the wilting point should be subtracted from storage calculated for the 1 mm yr^{-1} flux. The AWS ranges from 158 mm for a 2-m profile to 82 mm for a 1.1-m profile using a wilting point head of −500 m, which is typical of arid and semiarid conditions (Table 5). The choice of wilting point head impacts the AWS estimate. Use of a wilting point head of −500 vs. −150 m (typical of more humid settings) results in 1.5 times greater AWS.

Stormont and Morris (1998) and Khire et al. (2000) assessed increased storage provided by an underlying capillary barrier. A similar approach was used in this study to evaluate the impact of a capillary barrier. The Texas profile was used as an example. Similar results were found for the New Mexico profile (Table 5). A water entry pressure of −0.3 m was used for the capillary barrier. This analysis indicated that addition of a capillary barrier increases the AWS by 202 mm (2 m profile) and 121 mm (1.1 m profile) for zero total head gradient (equilibrium) and by 348 mm (2 m profile) and 221 mm (1.1 m profile) for unit downward total head gradient (drainage). Stormont and Morris (1998) indicated that unit downward gradients are generally observed during capillary breakthrough conditions. The calculated AWS was not very sensitive to variations in water entry pressure of the capillary break material. Varying water entry pressure from −1.0 m to −3.0 mm only changed the AWS in the 2-m profile by 45 mm. Average water storage at the Texas site exceeded water storage corresponding to the calculated 1 mm yr^{-1} downward water flux 70% of the time; therefore, a capillary barrier was required to minimize drainage in this system (Fig. 17).

The required AWS of a cover is difficult to determine. The dominance of summer precipitation in the Texas and New Mexico regions studied, which corresponds to periods of high ET, reduces the required AWS. However, critical events may result from periods of above-normal summer precipitation followed by high winter precipitation, as in the 1997–1998 El Niño period in New Mexico. Examining the long-term simulations of the Texas site using a unit gradient lower boundary condition (free drainage), total water storage increased from 167 to 282 mm for a 1.1-m profile, and drainage

Table 5. Total water storage (WS_T) and available water storage (AWS) estimates for the Texas and New Mexico cover systems. Both unit gradient (UG) (equivalent to free drainage) and seepage face (SF) (equivalent to capillary barrier) lower boundary conditions are shown using water content profiles corresponding to both zero total head (Equil. = equilibrium conditions) and downward (↓) UG total head conditions within the cover system profiles. AWS was estimated as the difference between WS_T and the water storage corresponding to a uniform −500 m wilting point matric potential. Also shown is the benefit related to a capillary barrier (SF lower boundary condition) expressed as the ratio of SF to UG water storage capacity.

	UG lower boundary condition				SF lower boundary condition				SF/UG ratio			
	Equil. profile		↓ UG profile		Equil. profile		↓ UG profile		WS_T		AWS	
Profile	WS_T	AWS	WS_T	AWS	WS_T	AWS	WST	AWS	Equil	↓	Equil	↓
	mm											
TX 2.0 m	379	158	386	165	581	360	727	506	1.5	1.9	2.3	3.1
TX 1.1 m	191	82	193	84	312	203	412	303	1.6	2.1	2.5	3.6
NM 1.1 m	181	130	194	143	303	252	390	339	1.7	2.0	1.9	2.4

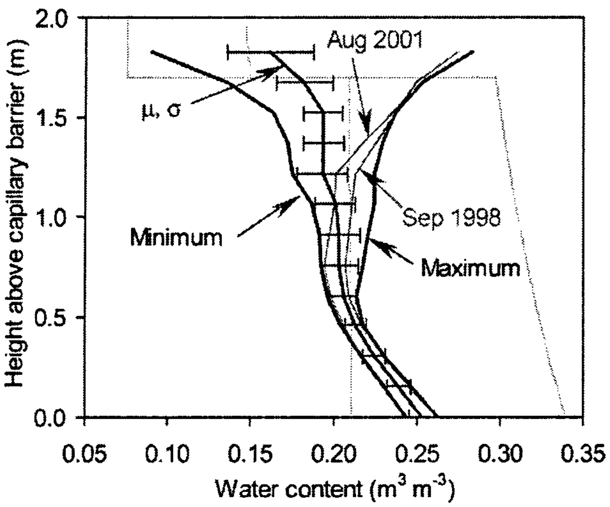

Fig. 17. Temporal variability of measured water content with depth in the Texas site CBET system. Calculated water content profiles for zero total head gradient conditions from Fig. 16 are shown in the background for reference. Average water content throughout the monitored period (μ) is shown with error bars, indicating the temporal standard deviation (σ) at the monitored depths. Also shown are water content temporal minimum and maximum values at each depth. The two wettest measured water content profiles are shown (Sept. 1998 and Aug. 2001).

later occurred following a large precipitation event in September 1974 (Fig. 12). Simulated total water storage increased above the total water storage corresponding to 1 mm yr^{-1} flux without a capillary barrier (191 mm) but remained below that corresponding to a capillary barrier (zero total head gradient, 312 mm; unit downward total head gradient, 412 mm). Monitoring and modeling analyses indicate that a 1-m-thick ET cover underlain by a capillary barrier should be adequate to minimize drainage to ≤1 mm yr^{-1} in these arid and semiarid settings.

CONCLUSIONS

- Estimated drainage from water content data at the Texas site (0.4–5.0 mm yr^{-1}) corresponded to irrigation (226–2340 mm). Low drainage at the New Mexico site (0.1–0.4 mm yr^{-1}) was restricted to the first 2 yr of the 5-yr monitoring period.
- Vegetation plays a critical role in controlling the water balance of ET covers, as shown by the correspondence between rapid water storage decreases and enhanced vegetation productivity at both sites.
- Climate at the Texas and New Mexico sites is particularly suitable for ET covers because of the dominance of monsoonal precipitation in June through October (62–80% of annual precipitation) when ET rates are highest.
- Modeling analysis indicates that the measured water balance can generally be reproduced with the models. Simulating runoff is difficult and required calibration of surface saturated hydraulic conductivity at the Texas site.
- Extension of these models to 25-yr periods indicates that there were critical precipitation events toward the end of the growing season in 1974 and 1984 at the Texas site that resulted in simulated drainage.
- Differences in long-term simulations between the Texas and New Mexico sites indicate that both climate forcing and hydraulic conductivity impact the simulated water balance. Low K_s in New Mexico subsoil was important in resulting in zero simulated drainage at this site.
- Sensitivity analyses indicated that simulated water balance was most sensitive to the presence or absence of vegetation and variations in hydraulic parameters at the Texas site but was much less sensitive to all parameters considered at the New Mexico site.
- Much wetter conditions in the ET covers relative to the natural system at the Texas site are attributed to addition of water for compaction and precipitation during construction of the covers.
- Monitoring and modeling analyses indicate that capillary barrier effects of the drainage lysimeters underestimate free drainage and overestimate water storage in the covers at the Texas site relative to systems that do not contain a capillary barrier. The reliability of the drainage estimates depends on how well the lysimeter capillary barrier replicates the actual system over the waste.
- Capillary barriers increased AWS at both sites by a factor of approximately 2.5 and precluded drainage for all simulated conditions, suggesting that a capillary barrier can provide a significant safety factor and should be considered in cover designs where technically and economically feasible.
- Limitations associated with monitoring drainage in systems without a capillary barrier underscore the need to monitor multiple parameters and integrate modeling to develop a predictive understanding of total system performance.
- Various limitations associated with monitoring and modeling, particularly drainage monitoring and vegetation modeling, should be addressed in future studies. The opportunistic behavior of vegetation would be simulated more realistically using two-way feedback between soil water storage and vegetation.

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FIELD HYDROLOGY AND MODEL PREDICTIONS FOR FINAL COVERS IN THE ALTERNATIVE ASSESSMENT PROGRAM - 2002

by

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EXECUTIVE SUMMARY

The water balance of twenty-one landfill final cover test sections has been evaluated in this study. Each of the test sections is being monitored as part of the United States Environmental Protection Agency's Alternative Cover Assessment Program. The test sections are located at ten sites across the United States in climates ranging from arid to humid. Water balance predictions for seventeen of the test sections have been made using the models HELP and UNSAT-H, which are commonly used for evaluating the hydrology of final covers. Most of the climatic, soil, and vegetative inputs to the models were measured in the field or laboratory. For those inputs where measurements did not exist, estimates were made based on information in the literature.

The alternative covers in arid and semi-arid climates generally are transmitting significantly less percolation than the alternative covers in humid climates. Percolation rates for the alternative covers in arid and semi-arid climates typically are less than 1 mm/yr. The exception is the thin monolithic barrier in Sacramento, which has transmitted percolation at an average rate of 48 mm/yr. For the humid sites, percolation from the alternative covers typically is between 37 and 144 mm/yr. Percolation rates for the alternative covers in humid climates should decrease over time as the vegetation matures, and is capable of removing more soil water. For example, 170 mm of percolation was measured during the first nine months following construction of the alternative cover at Albany, GA. The percolation rate then decreased to less than 6 mm/yr as the poplar trees on the cover matured.

Data from the test sections simulating a composite cover (i.e., a geosynthetic clay liner or compacted clay barrier overlain by a geomembrane) indicate that these covers are very effective when constructed properly. Percolation rates for the composite covers are generally less than 1 mm/yr in semi-arid and arid regions, and 5 mm/yr in humid regions. Data from the test sections simulating compacted clay covers show that clay barriers are highly susceptible to desiccation cracking and can transmit percolation at large rates (several hundred mm/yr).

Predictions of the water balance made with HELP and UNSAT-H generally were not accurate even though the parameters used as input were well-defined. Discrepancies between field conditions and model predictions were related to the prediction of surface runoff, frozen ground conditions, preferential flow, and uncertainty in vegetation characteristics. Initial simulations that were conducted with "as constructed" input parameters (i.e. saturated hydraulic conductivity, runoff curve number) greatly over-predicted surface runoff, which resulted in the subsequent flow processes being incorrect. Hydraulic conductivity of the surface layer was measured on specimens collected immediately after construction that probably did not include macroscopic features (desiccation and freeze-thaw cracks, root holes, worm holes, etc.) that affect the saturated hydraulic conductivity at field scale. Therefore, additional simulations were conducted using an "adjusted" saturated hydraulic conductivity and runoff curve number for the surface layer. Model predictions improved when the surface layer was more permeable, but the predictions were still inconsistent over time. Also, modeling of frozen ground conditions appears to be significant at sites in cooler climates if surface runoff due to melt water is to be predicted accurately.

Modeling of the long-term performance of compacted clay covers does not appear to be possible without significantly increasing the saturated hydraulic conductivity of the barrier layer to account for preferential flow through desiccation cracks. For composite covers, HELP predicted little percolation would occur, which is expected in arid and semi-arid climates. However, HELP under-predicted percolation from composite covers at sites in humid climates, even when placement conditions were degraded, and the defect frequency was increased. Also, HELP typically over-predicted lateral flow for covers that incorporated a drainage composite, and under-predicted lateral flow for covers that did not incorporate a drainage composite.

ACKNOWLEDGMENTS

Financial support for this study was provided by the United States Environmental Protection Agency (USEPA) through a subcontract with the Bureau of Economic Geology of the State of Texas. Dr. Bridget Scanlon was the project director for the Bureau of Economic Geology of the State of Texas. Mr. David Carson was the program manager for USEPA. The field data were provided by USEPA's Alternative Cover Assessment Program, which is managed at USEPA by Mr. Steven Rock. This report has not been subjected to USEPA's review. Endorsement by USEPA is not implied, and should not be assumed. Each of the sites in ACAP has made considerable contributions to this effort. Assistance that has been provided by the site owners and managers is greatly appreciated.

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SECTION ONE
INTRODUCTION

The U.S. Environmental Protection Agency (USEPA) has developed guidance for design, construction, operation, and maintenance of final covers for landfills. Final covers constructed based on these guidelines (typically referred to as "conventional covers") have traditionally relied on hydraulic barrier layers having low saturated hydraulic conductivity to reduce the amount of water percolating into the underlying waste. Due to the higher cost associated with prescriptive final covers, as well as their questionable performance in certain climates, alternative landfill cover designs are being explored.

Alternative covers typically rely on a combination of soil and vegetation to restrict percolation rather than relying on hydraulic barrier layers. For an alternative cover to perform as well as a prescriptive cover, the soil must be able to store water long enough to allow the atmosphere and vegetation to remove the water via evaporation and transpiration. Because evaporation and transpiration are important processes affecting their performance, alternative covers are often referred to as evapotranspiration (ET) covers. They are also referred to as "vegetative covers" or "store-and-release" covers.

This study relied on field data from USEPA's Alternative Cover Assessment Program (ACAP), which is evaluating twenty-one cover designs throughout the United States in climates ranging from arid to humid. Each cover is being evaluated for 5 years. The purpose of ACAP is to collect field-scale data regarding the hydrology of prescriptive and alternative covers that can be used for model evaluations, development of design guidance, and improvement of regulations (Bolen et al. 2001). This study had three objectives: (1) to analyze the ACAP field data and to make preliminary assessments, (2) to compare predictions made with two water balance models (UNSAT-H and HELP) to the field data for each cover, and (3) to perform a parametric study using the two water balance models to determine which parameters have a significant effect on water balance predictions. This report describes the findings of this study.

SECTION TWO
TYPES OF FINAL COVERS

Minimum standards for landfill liners and covers are listed in the United States Code of Federal Regulations (CFR), and are broken into two categories depending on the type of landfill. Subtitle D of the Resource Conservation and Recovery Act (RCRA) is for municipal solid waste (MSW) landfills, and Subtitle C is for hazardous waste landfills. The United States Environmental Protection Agency (USEPA) has also issued guidance on the design of landfills. The guidance is intended to clarify the regulations, and to assist the designer.

The cover designs described in RCRA depend on the design of the bottom liner, with the intention of preventing the "bath-tub" effect. The cover must have a hydraulic conductivity less than or equal to the hydraulic conductivity of any bottom liner or natural subsoils. Clarifications to the requirements of Subtitle D that were issued by USEPA match cover designs with liner designs (USEPA 1992). These cover designs are summarized in Table 2.1.

Subtitle D permits alternative covers if the alternative cover can be shown to be equally effective in reducing the rate of percolation into the underlying waste, as well as having equivalent resistance to erosion. Typical alternatives designs do not rely on a hydraulic barrier with a specific hydraulic conductivity, but rather on a combination of soil and vegetation to prevent water from percolating into the waste. This type of cover is also referred to as an evapotranspiration cover (or "ET" cover), a vegetative cover, or a store-and-release cover.

Table 2.1. Landfill Cover Designs Required by RCRA Subtitle D.

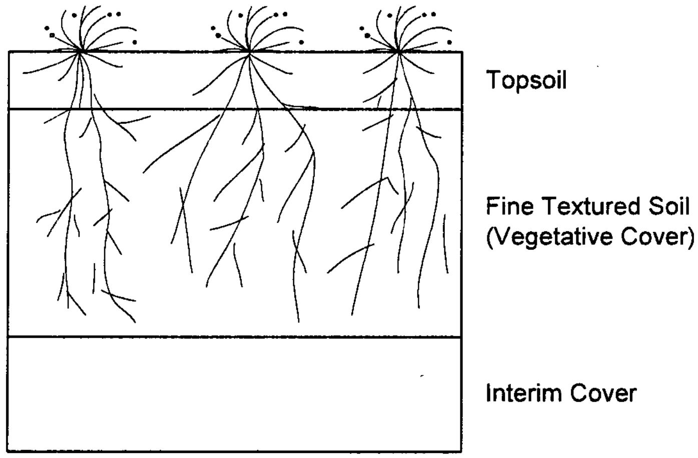
Category	Liner	Cover Requirement
A	No Liner.	150 mm erosion layer; 460 mm barrier layer with $K_s^a < 10^{-5}$ cm/s or K_s of underlying soils, whichever is smaller.
B	Soil Liner with $K_s < 10^{-6}$ cm/s.	150 mm erosion layer; 460 mm barrier layer with $K_s < 10^{-6}$ cm/s.
C	Soil Liner with $K_s < 10^{-7}$ cm/s.	150 mm erosion layer; 460 mm barrier layer with $K_s < 10^{-7}$ cm/s.
D	Composite liner (soil layer having a $K_s < 10^{-7}$ cm/s overlain by geomembrane.	150 mm erosion layer; geomembrane; 460 mm barrier layer with $K_s < 10^{-5}$ cm/s.

$^a K_s$ = saturated hydraulic conductivity

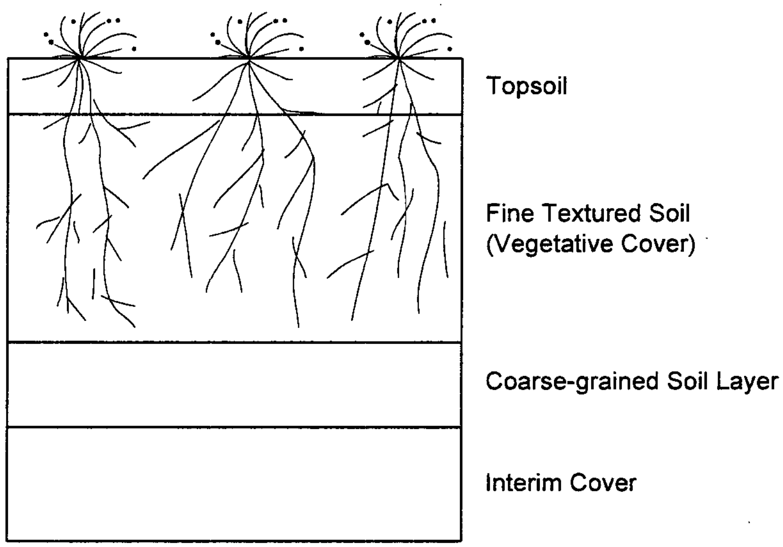
Alternative covers balance the hydrological processes (e.g., precipitation, surface runoff, soil water storage, evaporation, and transpiration) so as to limit percolation to an acceptable amount (Khire et al. 2000). Fine textured soils are used to store the infiltrating water, which is later removed by evaporation from the soil surface or by transpiration by plants. An effective alternative cover provides balance between the storage capacity of the soil and the water removal capabilities provided by the local climate and the vegetation. A mixture of native grasses, shrubs, and/or trees is used to take advantage of the varying growing seasons so that the number of days during which transpiration occurs is maximized.

In arid to semi-arid regions of the country, where potential ET typically exceeds precipitation, plants often are capable of using all the available moisture in the soil profile (Anderson et al. 1987, Hauser et al. 1994). As a result, the soil is rendered an empty reservoir to store infiltrating water in the cooler and wetter months. The type of soil plays an important role. Finer textured soils are generally suitable, because they can have substantial soil water storage capacity. In contrast, even under the most ideal plant and climatic scenario, soils with a low water storage capacity (e.g. coarse textured soils with little fines) are unlikely to be effective as a storage medium in an ET cover.

Several types of alternative cover designs have been evaluated. Two common designs (Fig. 2.1) are monolithic and capillary barriers. A monolithic barrier consists of a single layer of finer textured soil. A capillary barrier consists of finer textured layer overlying a coarse-grained soil. The contrast in unsaturated hydraulic properties between the two layers in a capillary barrier forms a capillary break that limits downward water movement in a capillary barrier (Khire et al. 2000).



(a)



(b)

Fig. 2.1. Typical Alternative Cover Designs: (a) Monolithic Barrier, (b) Capillary Barrier .

SECTION THREE
ALTERNATIVE COVER ASSESSMENT PROGRAM

USEPA's Alternative Cover Assessment Program (ACAP) was created to (i) provide data to support the development of an effective cover for each individual test site, (ii) provide data to support the development of guidelines for alternative cover designs throughout the country, and (iii) provide data to support the development of improved models for designers and regulators (Bolen et al. 2001).

During the initial phase of ACAP, twenty-one test sections were constructed at ten sites throughout the United States to evaluate similar cover designs in differing climates. Each site is proposing to use an alternative earthen final cover (AEFC). At least one AEFC test section was constructed at each site. The AEFC was designed by the owner, or an engineering consultant working for the owner, with input from the ACAP investigators. At eight of the sites, alternative and conventional cover designs are being compared side by side. Design of the conventional covers was based on regulations stipulated by the regulatory agencies having jurisdiction at each site. Each test section is to be monitored for a period of at least 5 years.

Performance of each cover is being evaluated by measuring the percolation rate. Other hydrological processes are also being measured, such as precipitation, surface runoff, lateral flow, and soil water content to calculate the water balance of each test section. Disturbed and undisturbed soil samples were collected during construction to determine the physical and hydraulic properties of the soils. A description of the testing that was conducted can be found in Bolen et al. (2001) and Gurdal (2002).

3.1 ACAP LYSIMETER

To evaluate each cover design, a large-scale lysimeter was constructed using linear-low density polyethylene (LLDPE) geomembrane and a geocomposite drain (Benson et al. 2001). Each lysimeter had an areal extent of 10 m by 20 m (Fig. 3.1). The slope varied from site to site, and was between 5 and 25%. The lysimeter was constructed from several geomembrane panels that were welded together to form a "box" (Fig. 3.2).

Non-destructive testing was performed on each geomembrane seam to ensure the lysimeter was leak tight. A geocomposite drain was then placed above the base of the lysimeter on top of the geomembrane to direct any percolation through the cover to the sump. To ensure the drainage sump and associated plumbing was leak free, a leak test was performed by ponding water on the downstream end of the lysimeter, creating a small head on the drainage sump. The elevation of the water was monitored for any leaks for approximately one hour using a standpipe attached to the end of the drainage pipe. A description of the installation methods can be found in Benson et al. (1999).

3.1.1 Cover Placement

Soil was placed inside the test section using typical construction equipment (Fig. 3.3) following specifications described in Benson et al. (1999). A nuclear gauge was used to check compaction of each soil lift. Alternative cover soils typically were placed at 85% of maximum dry unit weight per standard Proctor, while compacted soil barriers were compacted as specified by the designer. To ensure uniform and adequate compaction, the maximum lift thickness was 460 mm, although thinner lifts were used for the conventional covers. Also, the surface elevation of each lift was surveyed to

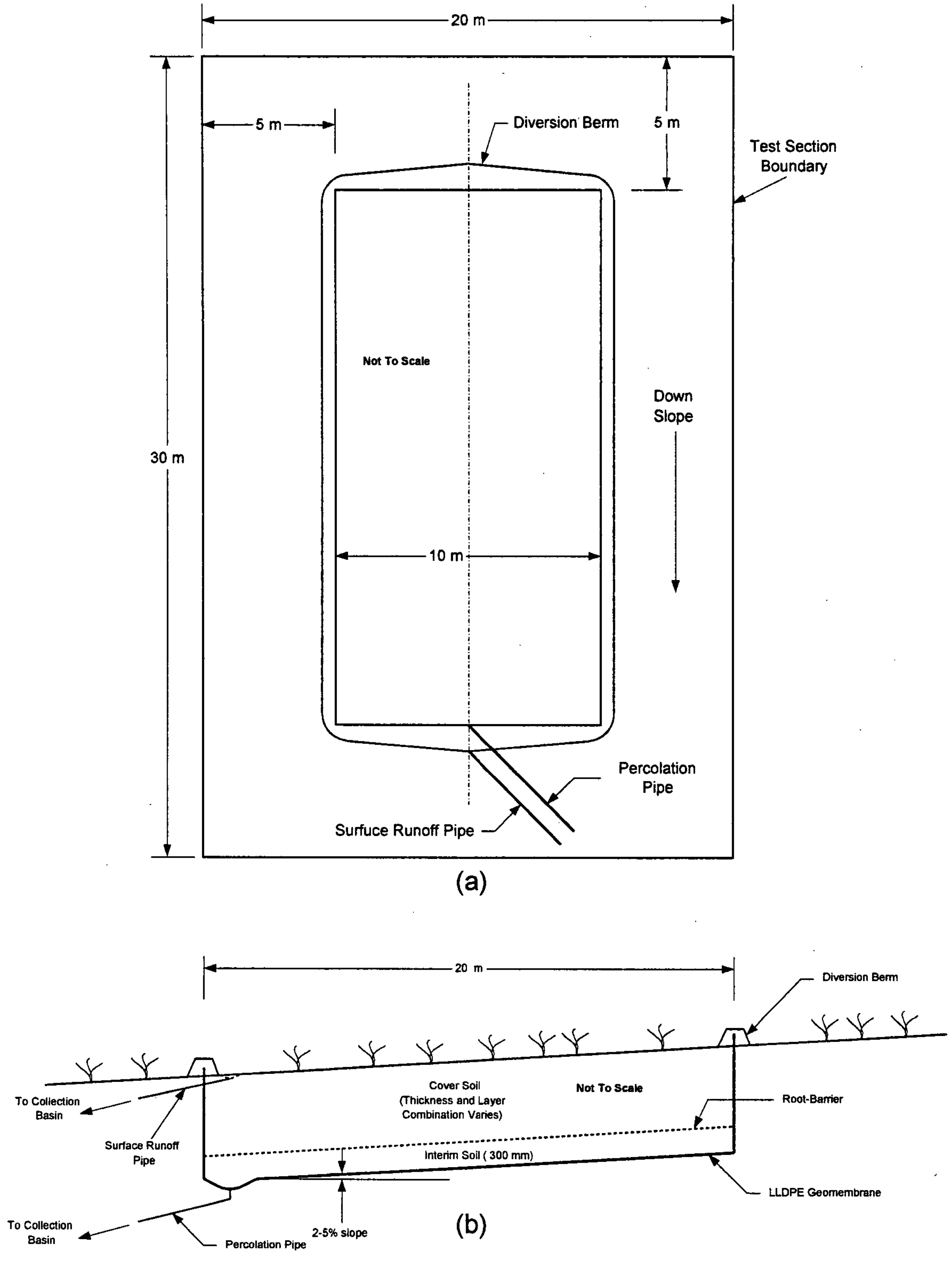


Fig. 3.1. Schematic of ACAP Test Section and Lysimeter: (a) Plan View and (b) Cross-Section.

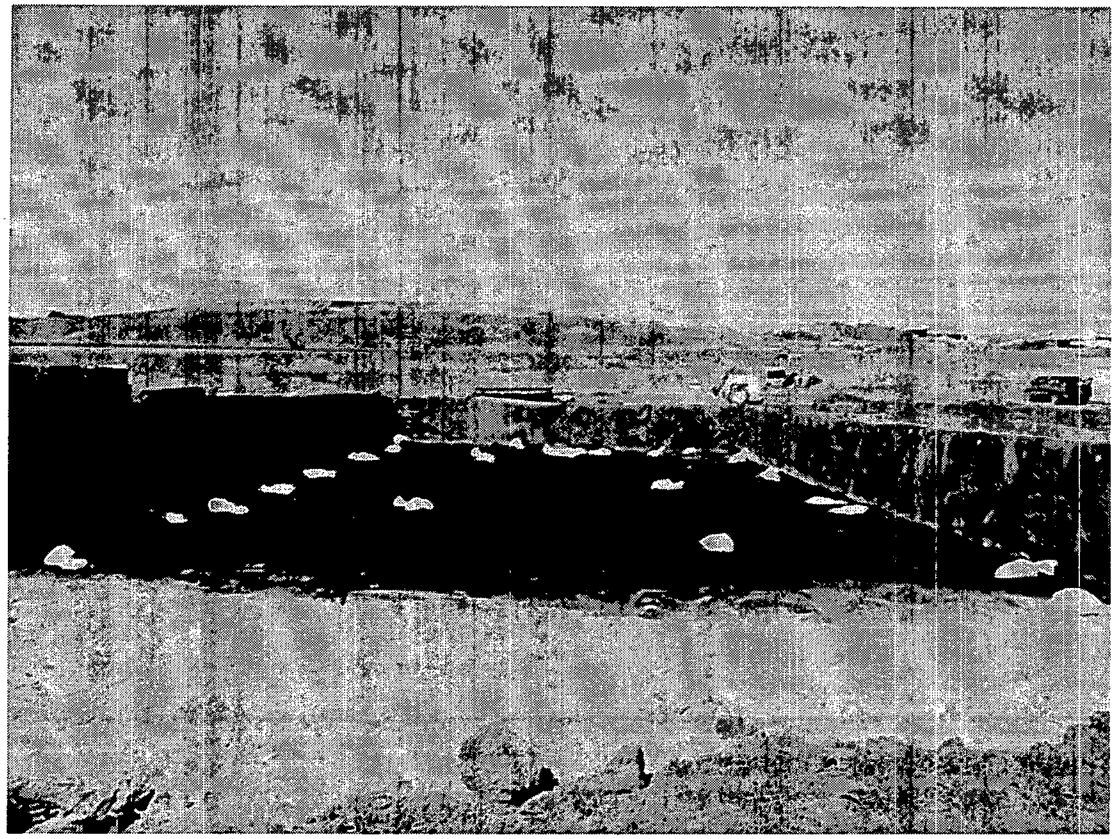


Fig. 3.2. Photograph of Lysimeter "Box" Constructed with LLDPE Geomembrane at Cedar Rapids Site. Base is Covered with Geocomposite Drain.

replicate the level of control likely to exist during full-scale construction of final covers.

The first soil layer placed inside the lysimeter was an interim cover layer simulating the soil likely to exist over the waste prior to construction of the cover. A geosynthetic root barrier was placed on top of the interim cover soil (Fig. 3.5). The root barrier is a non-woven geotextile containing nodules impregnated with the root inhibitor trifluralin, which prevents penetration of roots into the geocomposite drain and other elements of the system used to collect percolation (Burton et al. 1986). Water in these elements would not normally be available for uptake by plants. The root barrier also provides a well-defined lower boundary for root penetration, since the root-barrier controls the rooting depth for all vegetation types (i.e. shrubs, trees, or grasses). The cover profile was constructed on top of the root barrier.

To achieve the necessary saturated hydraulic for barrier layers in the test sections simulating conventional covers, additional compactive effort and moisture conditioning generally were performed. To increase the compactive effort, a heavy tamping foot compactor was typically used (Fig. 3.4). Compaction was controlled using a compaction specification defined by the site owner. If a geomembrane was to be placed on top of a clay barrier layer, a smooth-drum roller was used to provide good contact between the soil layer and geomembrane. Once the cover geomembrane was installed, a single circular hole with a diameter of 11 mm (100 m^2 area) was placed in the center of the geomembrane to simulate an installation defect.

To prevent preferential flow along the sidewalls of the lysimeter, dry bentonite was placed along the geomembrane-soil interface during soil placement. A jumping-jack or vibrating plate compactor was also run along the inside of the sidewalls to ensure good compaction along the sidewall of the lysimeter.

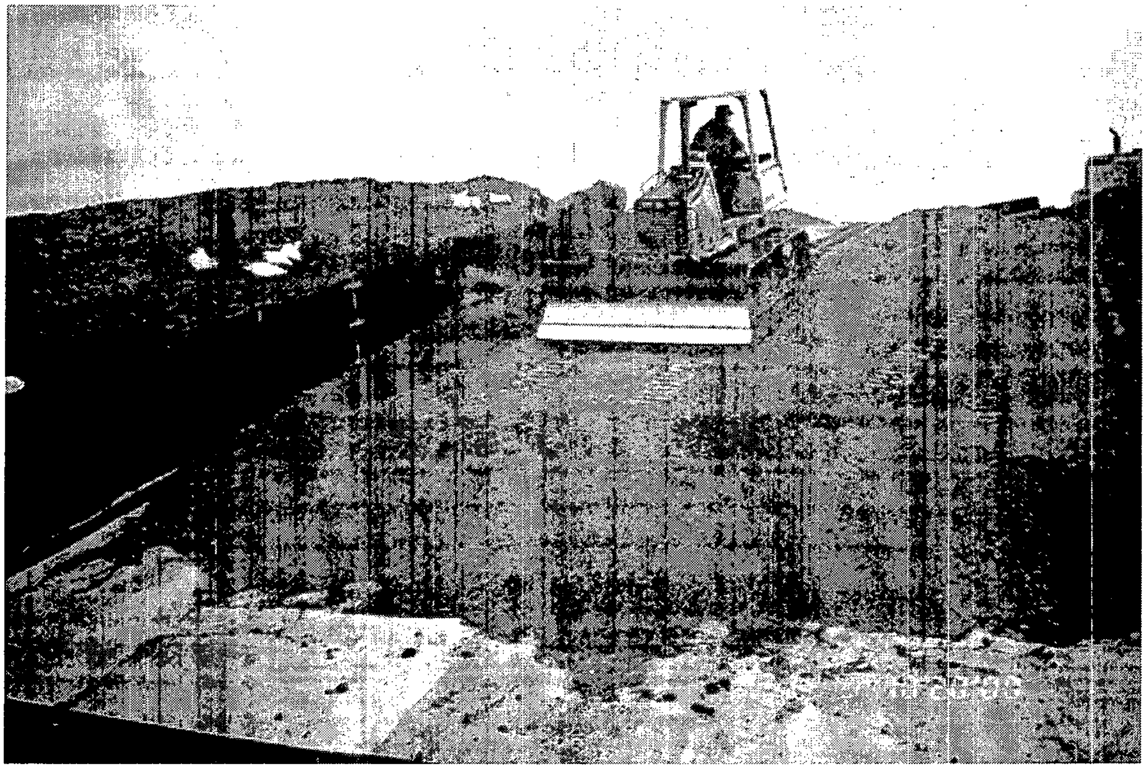


Fig. 3.3. Placement of Soil on Top of Geocomposite Drainage Layer at the Boardman Site.

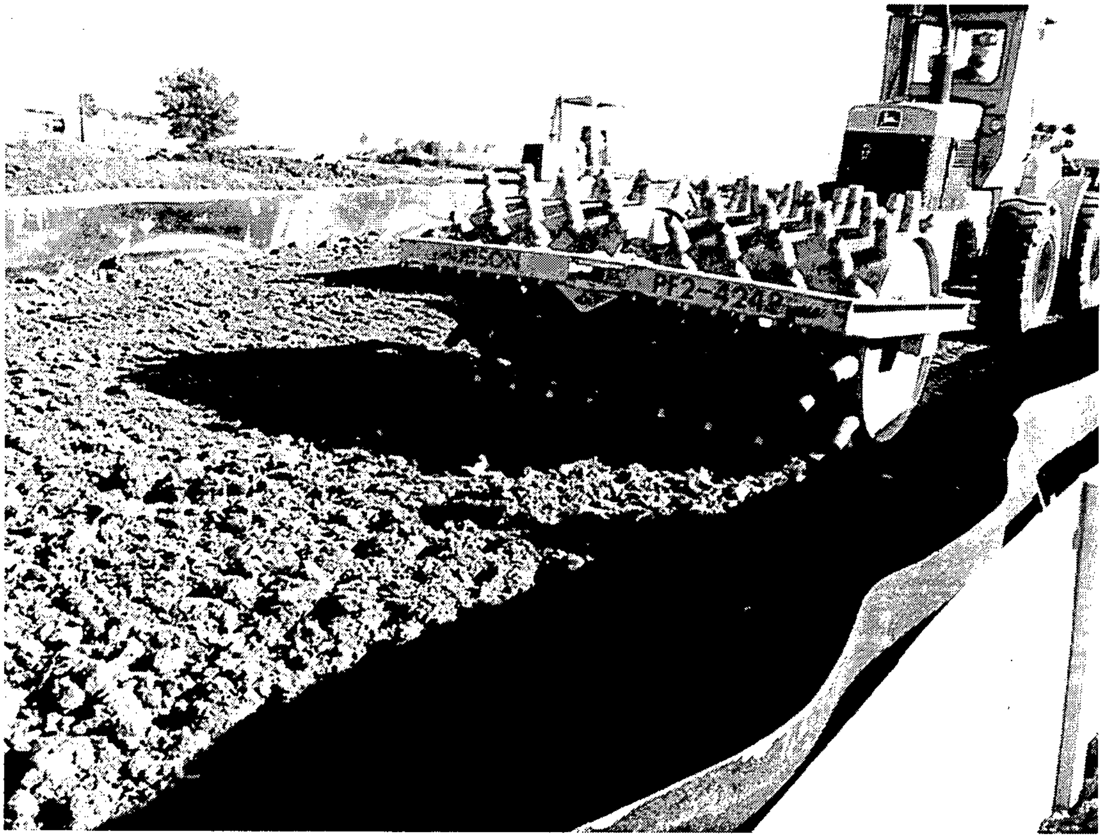


Fig. 3.4. Tow-Behind Tamping Foot Compactor Used to Compact a Clay Barrier Layer at the Cedar Rapids Site.

3.1.2 Soil Monitoring Instrumentation

Water content of the soils is measured using CS615 water content reflectometers (WCR) manufactured by Campbell Scientific Inc. (CSI). A WCR consists of two parallel rods (300 mm long, 32 mm spacing) attached to an electronic signal generator. The water content of material surrounding the conductors influences the speed of an electromagnetic wave displaced along the rods. As the dielectric constant of the soil increases, the wave propagates more slowly. Because the dielectric constant of water is much higher than that of most other materials, an electromagnetic wave propagates slower in a wet or moist soil than in the same soil when dry. A WCR measures the round-trip travel time of the electromagnetic wave, which is calibrated against water content (Campbell and Anderson 1998). Calibrations for the WCRs can be found in Kim (2002). Kim (2002) also found that the WCR measurements are sensitive to temperature, and that calibration equations should require a temperature correction. Temperature corrections were not incorporated in this study, will be in future work.

Soil matric suction is measured with heat dissipation units (HDU) manufactured by CSI. HDUs consist of a heat source and a temperature sensor contained within a porous ceramic housing (Phene et al. 1971). A thermocouple monitors dissipation of a heat pulse generated by a resistive heating element, and reports a temperature differential (ΔT) over a 29 s period. Heat dissipation is a function of the water content of the ceramic housing, which is assumed to be in equilibrium with the matric suction of the surrounding soil. A calibration relating soil matric suction and ΔT was determined for each sensor by the Desert Research Institute. The initial temperature reading of the HDU was taken as ambient temperature of the soil.

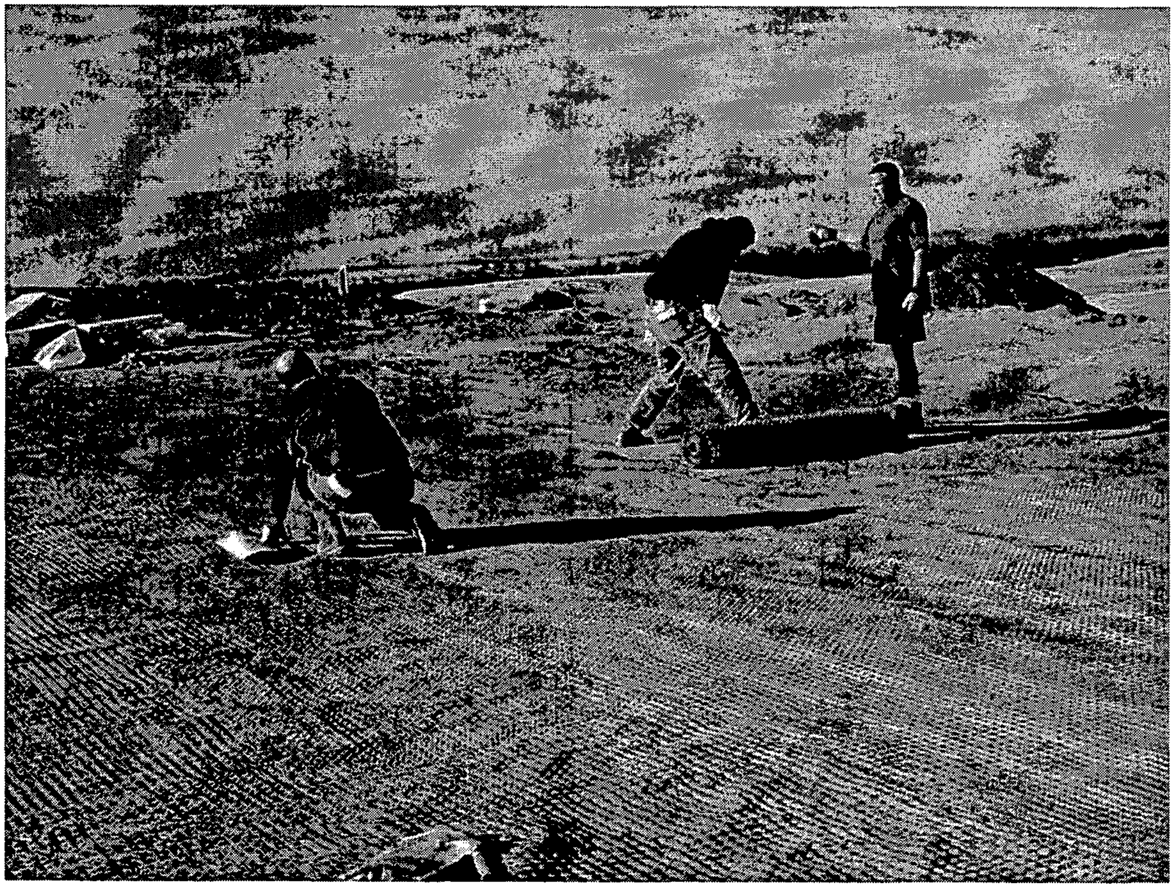


Fig. 3.5. Placing Root Barrier on Top of Interim Cover Soil at the Sacramento Site.

3.1.3 Water Flow Monitoring System

The bottom of each test section is sloped (≥ 2%) toward the centerline. The primary axis of the lysimeter is aligned with the natural slope of the setting to allow percolation to collect in a sump. Collected water is conveyed through a boot in the geomembrane to a collection basin containing a redundant system with three devices to measure flow. Volume of percolation is measured by a tipping bucket, a pressure transducer, and a float switch. The float switch is used to identify when a collection basin is flushed. Each flush corresponds to the same volume of water (~90 L). A dosing siphon is used to flush the basin.

The primary means of measuring flow is with the float switch, because the tipping bucket is only able to measure low flows accurately. A pressure transducer located at the bottom of the collection basin measures the elevation (or stage) of the water (Fig. 3.6), and is used to confirm that a flush of the dosing siphon has occurred. The precision of the percolation measurements made with each instrument is described in Benson et al. (2001).

Surface runoff berms were constructed around the perimeter of each test section to prevent run-on, as well as to facilitate the collection of run-off (Fig. 3.7). Runoff is routed to a collection basin with a similar measurement system as the percolation basin, except that a tipping bucket is not used. For test sections with a drainage layer and/or a cover geomembrane, interflow is collected and measured using a system similar to that used for measuring runoff.

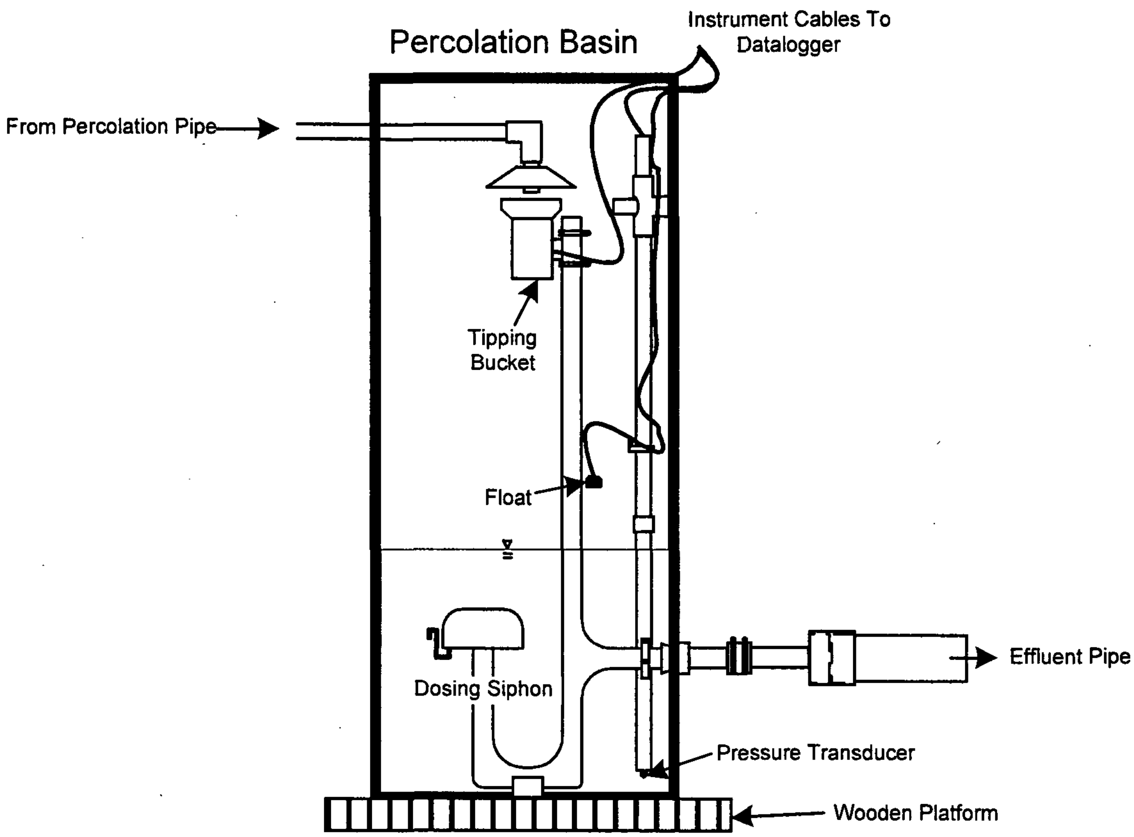


Fig. 3.6. Schematic of Collection Basin with Dosing Siphon Used to Monitor Flows.

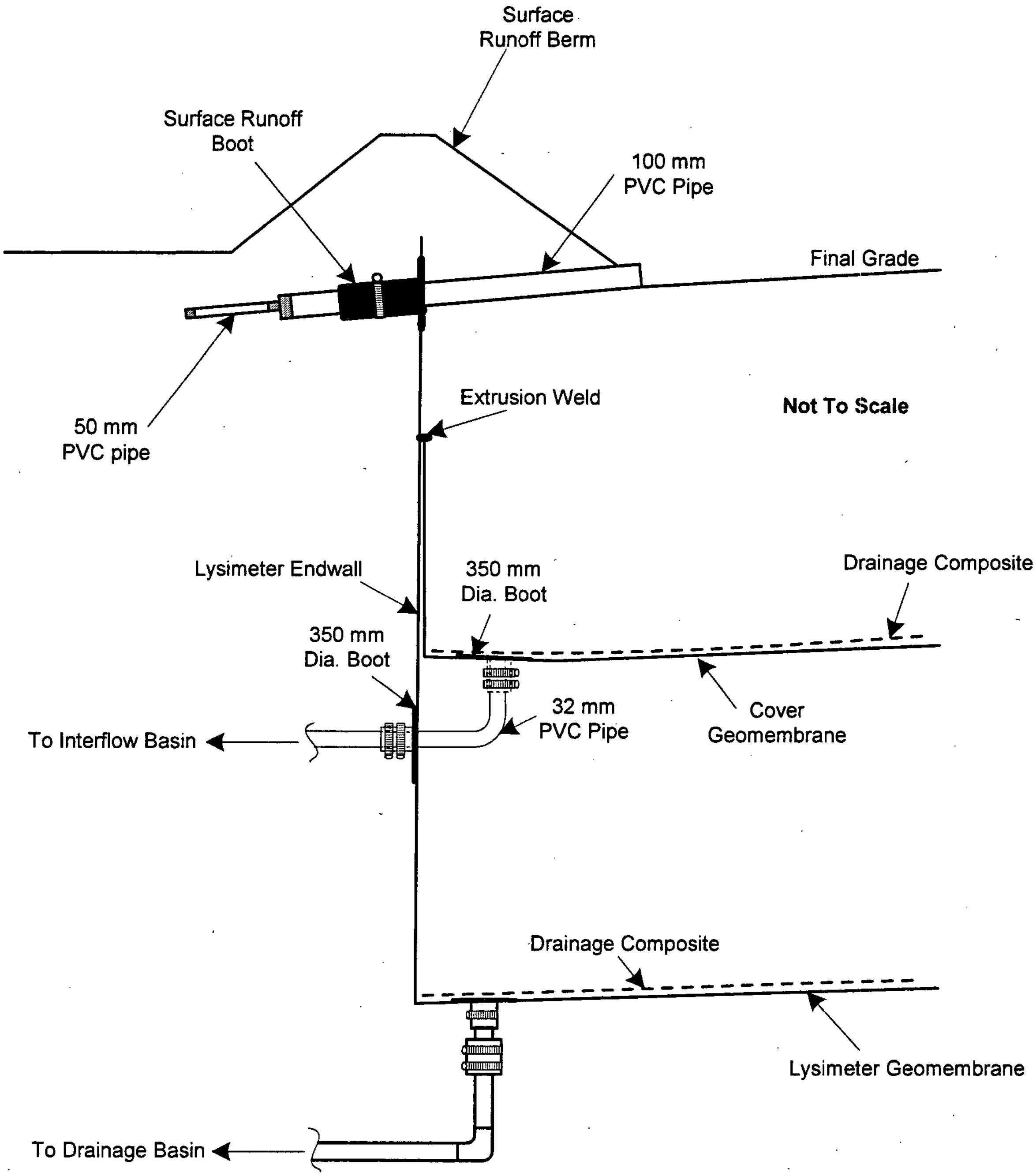


Fig. 3.7. Typical Cross-Section of Sumps Used to Collect Percolation, Interflow, and Surface Runoff.

3.1.4 Meteorological Measurements

A CSI weather station (Fig. 3.8) was installed at each site to monitor local meteorological conditions. Wind speed and direction, air temperature, relative humidity, solar radiation, and precipitation are being measured.

3.2 TEST FACILTIES

Twenty-one test sections were constructed at ten sites (Fig. 3.9) across the United States. At five of the sites, two test sections were constructed to compare a conventional cover and an alternative cover. At three of the sites, three test sections were constructed to compare multiple conventional and/or alternative covers. At two of the sites, only one test section (an alternative cover) was constructed.

The majority of the cover soils came from on-site borrow areas. The vegetation generally was chosen to be representative of native vegetation at the site. A detailed summary of all sites can be found in Bolen et al. (2001). An illustration of the cover profiles for each site is shown in Figures 3.10 and 3.11. A description of the profile of each test section is in Table 3.1. The seed mixtures for each site is in Table 3.1.

3.2.1 Altamont Site

The Altamont site is located in the Altamont Hills near the City of Livermore, CA approximately 64 km east of the San Francisco Bay. The conventional final cover design, as dictated by Title 27 of the California Code of Regulations, is a composite barrier.

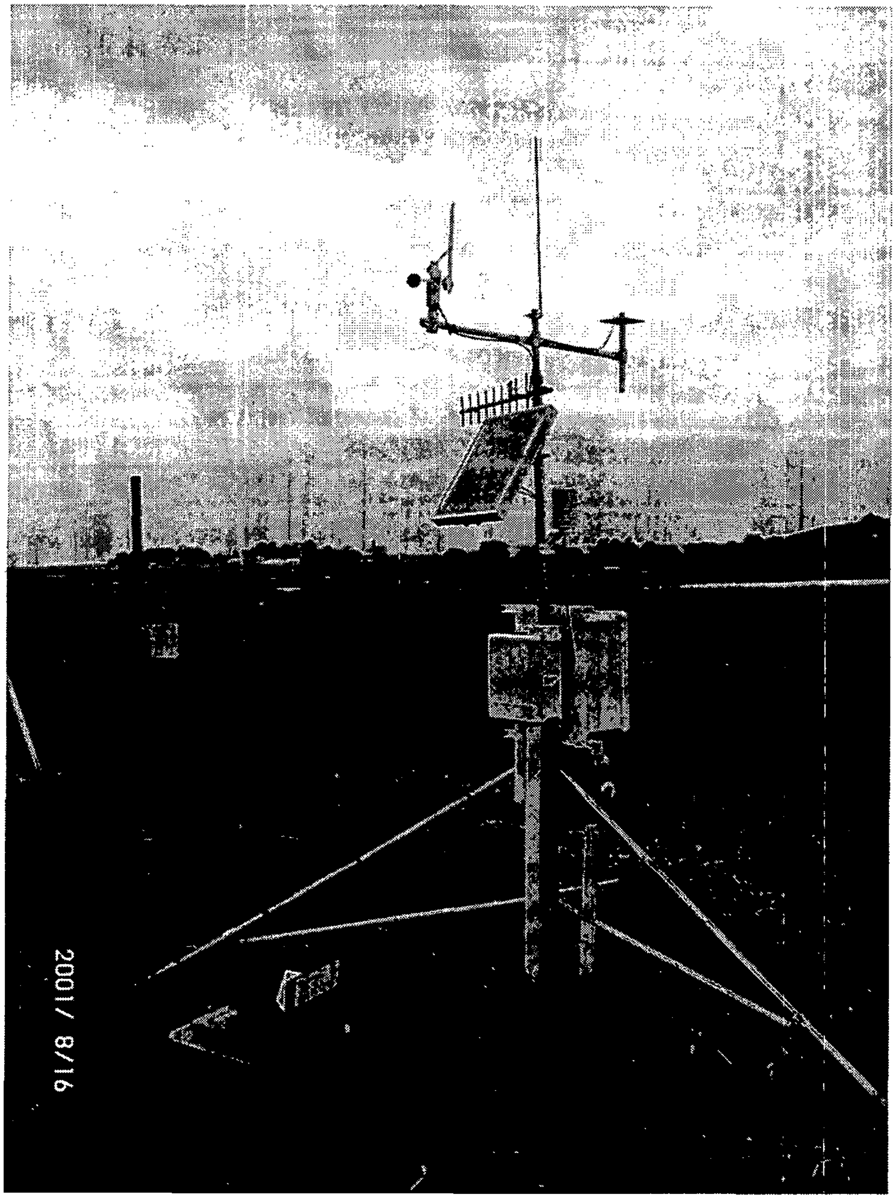


Fig. 3.8. Weather Station Installed at the Cedar Rapids Site.

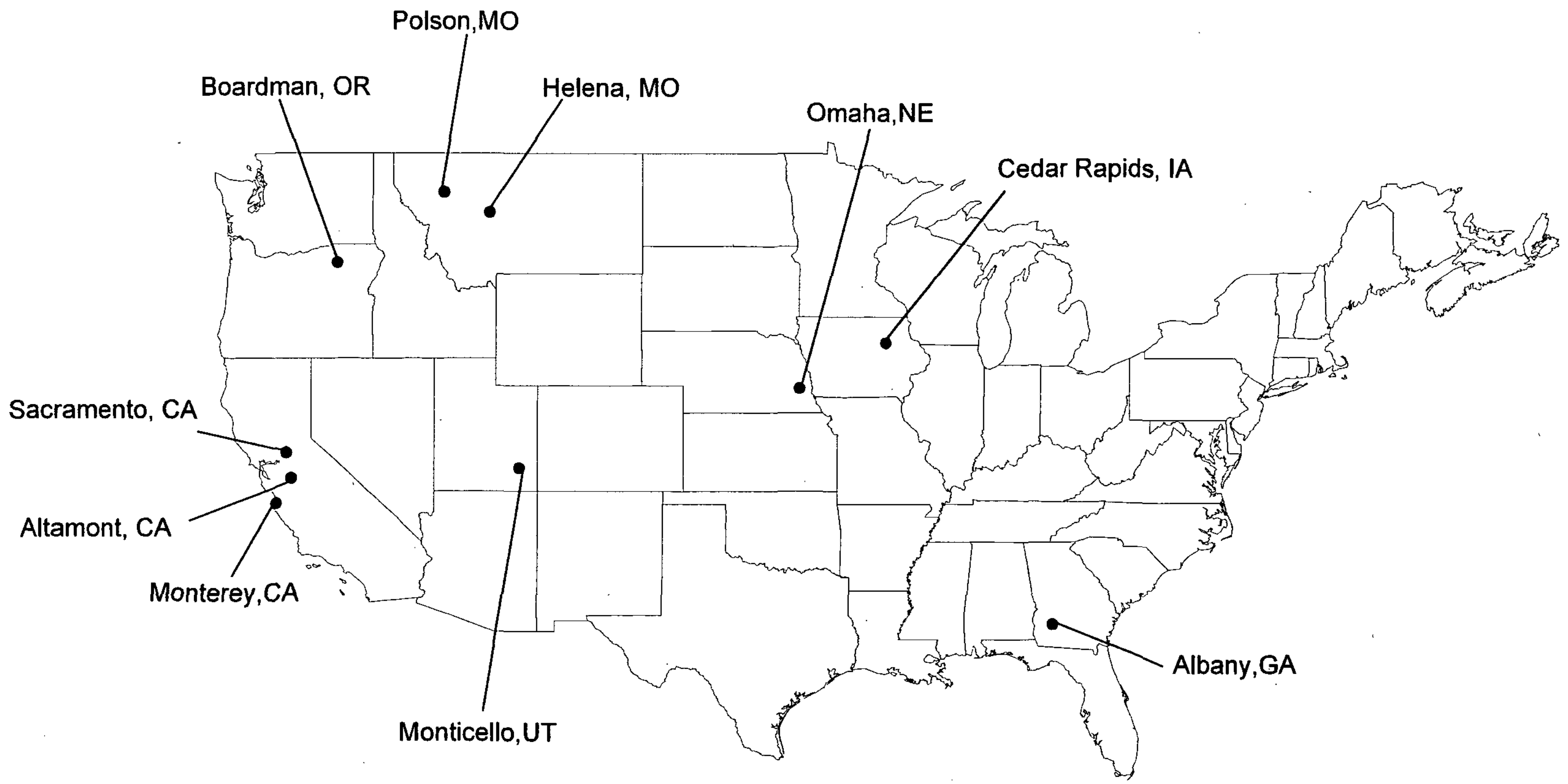


Fig. 3.9. Locations of ACAP Test Sections.

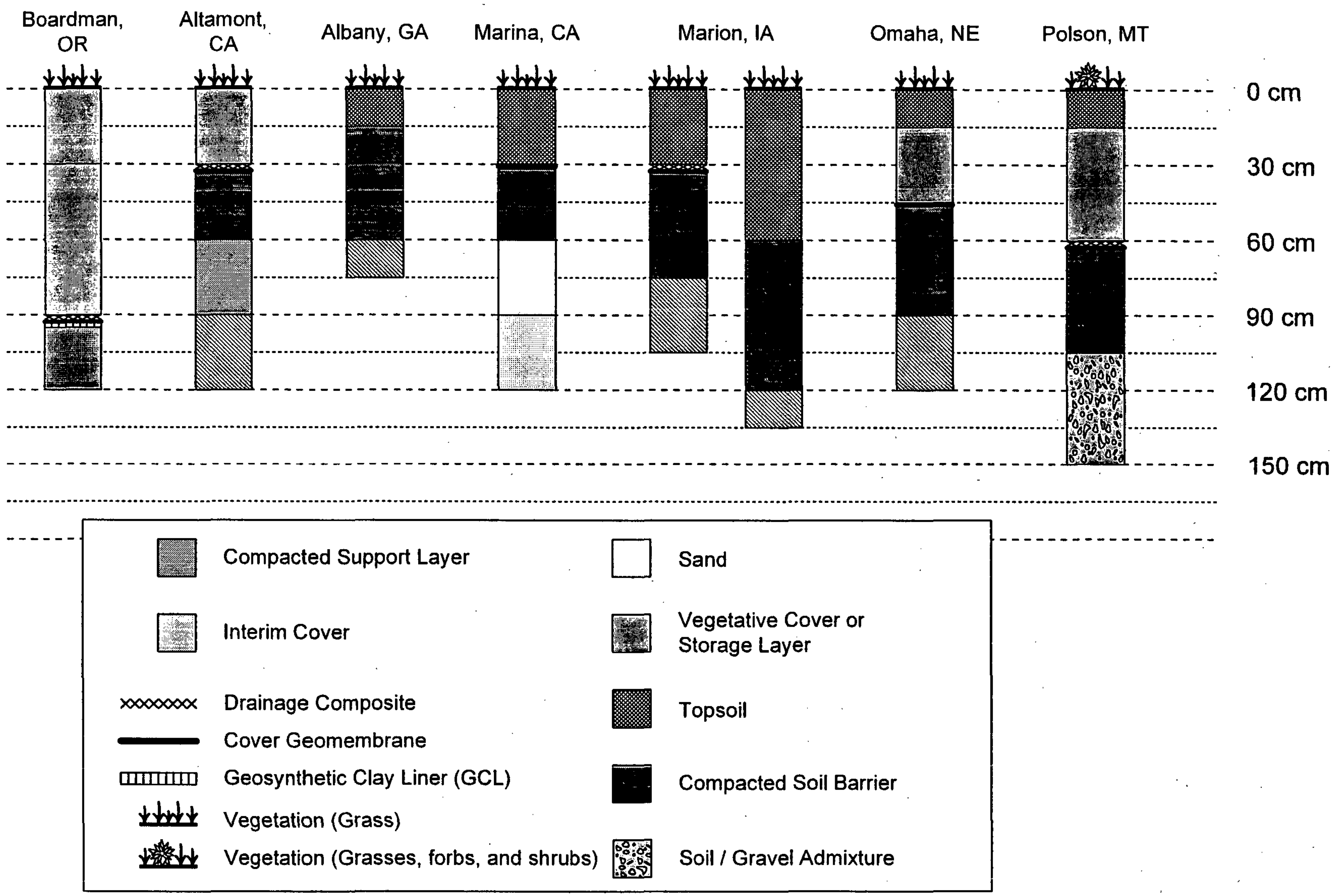


Fig. 3.10. Cover Profiles of Conventional Covers Being Evaluated by ACAP.

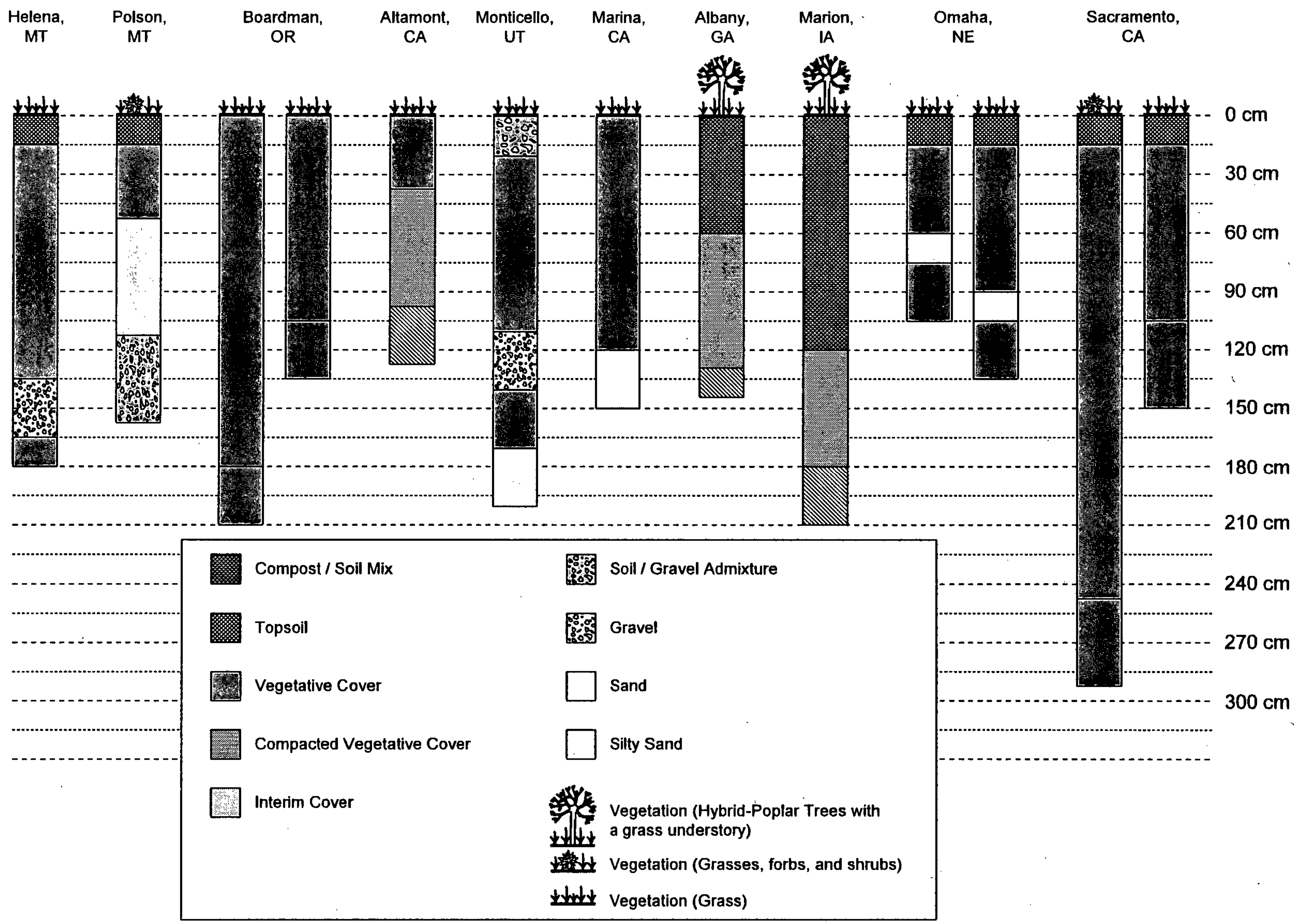


Fig. 3.11. Cover Profiles of Alternative Covers Being Evaluated by ACAP.

Table 3.1. Profile of Each Cover Being Evaluated by ACAP.

Site	Test Section	Layer	Description	Material[a]
Omaha Site	Capillary Barriers	Topsoil	Lean clay with organics	CL
		Storage Layer	Lean clay	CL
		Sand	Clean sand (Poorly graded)	SP
		Interim Cover	Lean clay	CL
	Composite Barrier	Topsoil	Lean Clay with organics	CL
		Vegetative Layer	Lean clay	CL
		Geomembrane	-	1.0 mm HDPE
		Compacted Soil Barrier	Lean clay	CL
		Interim Cover	Lean clay	CL
Albany Site	Compacted Clay Barrier	Topsoil	Clayey sand	SC
		Compacted Soil Barrier	Clayey sand	SC
		Interim Cover	Clayey sand	SC
	Monolithic Barrier	Soil / Compost Mix	Clayey sand	SC
		Support Layer	Clayey sand	SC
		Interim Cover	Clayey sand	SC
Altamont Site	Composite Barrier	Topsoil	Lean clay	CL
		Drainage Composite	-	GT/GN/GT[b]
		Geomembrane	-	1.5 mm HDPE
		Compacted Soil Barrier	Lean clay	CL
		Foundation Layer	Lean clay	CL
		Interim Cover	Lean clay	CL
	Monolithic Barrier	Storage Layer	Lean clay	CL
		Support Layer	Lean clay	CL
		Interim Cover	Lean clay	CL
Cedar Rapids Site	Composite Barrier	Topsoil	Lean clay with sand	CL w/ organic matter
		Drainage Composite	-	GT/GN/GT
		Geomembrane	-	1.0 mm LLDPE
		Compacted Soil Barrier	Sandy lean clay	CL
		Interim Cover	Sandy lean clay	CL
	Compacted Clay Barrier	Topsoil	Lean clay with sand	CL w/ organics matter
		Compacted Soil Barrier	Fat clay with sand	CH
		Interim Cover	Sandy lean clay	CL
	Monolithic Barrier	Soil / Compost Mix	Clayey sand	SC-CL w/ organic matter
		Support Layer	Sandy lean clay	CL
		Interim Cover	Sandy lean clay	CL

[a]Unified Soil Classification System, [b]GT/GN/GT corresponds to a geocomposite drainage layer consisting of a geonet between two non-woven geotextiles.

Table 3.1. Profile of Each Cover Being Evaluated by ACAP *(continued)*.

Site	Test Section	Layer	Description	Material[a]
Boardman Site	Monolithic Barriers	Storage Layer	Silt with sand	ML
		Interim Cover	Silt with sand	ML
	Composite Barrier	Vegetative Layer	Silt with sand	ML
		Drainage Composite	-	GT/GN/GT
		Geomembrane	-	1.5 mm LLDPE
		Geosynthetic Clay Liner	-	Bentomat
		Interim Cover	Silt with sand	ML
Helena Site	Monolithic Barrier	Topsoil	Clayey sand with gravel	SC w/ organic matter
		Storage Layer	Clayey sand - Sandy fat clay	SC-CH
		Gas Vent Layer	Poorly graded gravel with silty clay	GP-GC
		Interim Cover	Clayey sand - Sandy fat clay	SC-CH
Sacramento Site	Monolithic Barriers	Topsoil	Sandy lean clay with gravel	SC-SM
		Storage Layer	Clayey sand, silty sand	CL, SC
		Interim Cover	Clayey sand	SC-CL
Marina Site	Composite Barrier	Vegetative Soil	Clayey sand	SC
		Geomembrane	-	1.5 mm LLDPE
		Compacted Soil Barrier	Fat clay	CH
		Interim Cover	Poorly graded sand w/ silt	SP-SM
	Monolithic Barrier	Storage Layer	Clayey sand	SC
		Interim Cover	Poorly graded sand w/ silt	SP-SM
Polson Site	Composite Barrier	Topsoil	Silty sand	SM
		Vegetative Layer	Silty sand	SM
		Drainage Composite	-	GT/GN/GT
		Geomembrane	-	1.5 mm LLDPE
		Compacted Soil Barrier	silty clay	CL-ML
		Interim Cover	Poorly graded gravel with sand	GP
	Capillary Barrier	Topsoil	Silty sand	SM
		Storage Layer	Silty clay	CL-ML
		Coarse-Grained Layer	Silty sand	SM
		Interim Cover	Poorly graded gravel with sand	GP
Monticello Site	Alternative	Soil / Gravel Admixture	Clayey gravel with sand	GC
		Storage Layer	Lean clay with sand	CL
		Bio-Intrusion Layer	Gravel	GC
		Fine-Grained Layer	Lean clay with sand	CL
		Coarse-Grained Layer	Clean sand (Poorly graded)	SP

[a]Unified Soil Classification System, [b]GT/GN/GT corresponds to a geocomposite drainage layer consisting of a geonet between two non-woven geotextiles.

Table 3.2. Vegetation Mixture Used at Each Site.

Site	Seed Mixture
Omaha	Cool Season Grasses: Brome and Switchgrasses
Albany	Bermuda Grass, Perennial Rye, and Eastern Cottonwood and Black Poplar, Imperial Carolina DN-34 (ECap only)
Altamont	Soft chess, slender oats, foxtail chess, Italian ryegrass, red-stemmed filaree, black mustard, yellow star-thistle, prickly lettuce, bull thistle, prickly sow-thistle, blue dicks, California poppy, purple owl's-clover, and miniature lupine
Cedar Rapids	Indian Grass, Little Bluestem, Big Bluestem, Side Oats, and Switch Grass, Tall Fescue Lawn Mix, and Crown Vetch
Boardman	Siberian, Bluebunch, and Thickspike Wheatgrasses, Alfalfa, and Yellow Blossom Sweetclover
Helena	Bluebunch, Slender, and West Wheatgrasses, Sandburg Bluegrass, Sheep Fescue, Blue Gamma, Green Needlegrass, and Needle-and-Thread
Sacramento	California Brome, Purple Needlegrass, Zorro Fescue, Arroyo Lupin, and Oleander bushes.
Marina	Blue Wild Rye, California Brome, Creeping Wild Rye, and Pacific Hairgrass
Polson	Thickspike, Bluebunch, Slender, and Crested Wheatgrasses, Mountain Brome, Idaho Fescue, Prarie Junegrass, Needle-and-Thread, Meadow Brome, Canada and Kentucky Bluegrasses, Yarrow, Fringed Sagewort, Alfalfa, Rubber Rabbitbrush, Prickly Rose, Arrowleaf Balsamroot, and Dolted Gayfeather, Lewis Flax, and Silky Lupine, and Cicer Milkvetch
Monticello	Western and Crested Wheatgrasses, Gray Rabittbrush, Sagebrush, Pinyon, and Juniper

The conventional cover was constructed with a 300 mm foundation layer and a 300 mm barrier layer (saturated hydraulic conductivity, K_s, less than $1x10^{-6}$ cm/s) underlying a 1.5 mm thick smooth HDPE geomembrane, drainage composite, and a 300 mm vegetative layer. The alternative cover was constructed with a 600-mm compacted "support layer" and a 460 mm "storage layer," which effectively act together as a 1060 mm storage layer. Both covers overlay 300 mm of soil simulating interim cover.

All soil layers were constructed with crushed Panoche claystone from a nearby borrow area. To promote root growth, the storage, storage, and interim cover layers were compacted to 85% of maximum dry unit weight per standard Proctor. The support layer in the alternative cover was compacted between 90 and 95% of maximum dry unit weight per standard Proctor. The top layers of both test sections were seeded with grasses that currently exist on-site (see Table 3.2).

3.2.2 Cedar Rapids Site

The Cedar Rapids site is located in Marion, IA, outside of Cedar Rapids. The bottom liner of the existing landfill consists of a compacted clay barrier, whereas the bottom liner of an expansion of the landfill will consist of a RCRA Subtitle D composite barrier. Therefore, two conventional covers that meet the RCRA Subtitle D criteria (as interpreted by the Iowa Department of Natural Resources) for the existing and expansion portions of the landfill were constructed, along with an alternative cover.

The composite cover consists of a 600 mm compacted clay layer ($K_s \leq 1x10^{-7}$ cm/s) overlain by a 1.0 mm thick textured LLDPE geomembrane, a drainage composite, and a 150 mm layer of topsoil. The compacted clay cover consists of 600 mm of compacted clay ($K_s \leq 1 \times 10^{-7}$ cm/s) and a 600 mm layer of topsoil. The alternative cover, also known as an ECap, consists of a 600 mm support layer and a 920 mm storage layer. All test sections overlay 300 mm of soil simulating interim cover.

All soil layers were constructed with soil (sandy lean clay) from a nearby borrow area. The soil used for the storage layer in the alternative cover is mixture of borrow soil (95%) and compost (5%). The compost consists of composted paper mill sludge, leaves, grass clippings, and corn hulls. The topsoil layers were stripped from the same borrow area as the clay, and had higher organic content.

Both covers were seeded with a mixture of native grasses (see Table 3.2). The alternative cover was also vegetated with two-year old hybrid poplar trees. The hybrid poplar trees were 4.5 m tall prior to planting, and were placed in 600 mm deep trenches. Additional rows of hybrid poplars were planted around the alternative test section as a perimeter buffer to minimize 'edge effects' caused by wind, humidity, and light, which makes the alternative test section more representative of a large-scale ECap.

3.2.3 Omaha Site

The Omaha site is located in Bennington, NE, just outside of Omaha. The existing landfill employs two types of bottom liners that consist of a RCRA Subtitle D compacted clay barrier and a composite barrier. The final cover for the expansion of the Omaha site is a RCRA Subtitle D cover with a composite barrier. Therefore, a conventional cover with a composite barrier is being tested along side two alternative covers. The two alternative covers contain a capillary break to enhance soil water storage in the storage layer.

The conventional cover consists of a 460 mm barrier layer ($K_s \leq 1x10^{-5}$ cm/s), a 1.0 mm thick smooth HDPE geomembrane, a 460 mm vegetative layer, and a 150 mm layer of topsoil. The two alternative covers were constructed with a 150 mm layer of clean sand, a storage layer (460 mm and 760 mm thick), and a 150-mm-thick layer of topsoil. All of the covers overlay 300 mm of soil simulating an interim cover.

The interim covers, storage layers, and compacted barrier layers were constructed from lean clay (Peorian Loess) from a nearby borrow area. The clean sand was delivered to the site from a local quarry. The topsoil layers were stripped from the same borrow area as the clay, and had higher organic content. Vegetation established on each test cover consisted of a mixture of native warm and cool season grasses (see Table 3.2).

3.2.4 Boardman Site

The Boardman site is located 16 km south of Boardman, OR, in the vicinity of Finley Buttes. The existing landfill is lined with a RCRA Subtitle D conventional design consisting of a composite barrier. The soil component of the liner is a geosynthetic clay liner (GCL). The covers being tested at the Boardman site are a conventional cover (consisting of a composite barrier with a GCL), and two alternative covers.

The conventional cover consists of a GCL, 1.0 mm thick textured geomembrane, drainage composite, 600 mm of vegetative cover, and 300 mm of topsoil. The alternative covers tested at Boardman are monolithic barriers, consisting of a single storage layer (1220 mm or 1840 mm). All cover profiles overlay a 300 mm soil layer simulating an interim cover.

All soil layers were constructed with Sagehill sandy silt from a nearby borrow area. All covers were seeded with indigenous grasses that are common in the non-irrigated rangelands in the area (see Table 3.2).

3.2.5 Sacramento Site

The Sacramento site is located in eastern Sacramento County, approximately 24 km southeast of the Sacramento, CA metropolitan area. Older portions of the existing landfill are unlined, whereas newer portions are lined with a RCRA Subtitle D composite barrier.

The two covers being evaluated at the Sacramento site are alternative covers (monolithic barriers), and differ only in thickness (1.2 m and 2.4 m). Both covers were constructed using soil (interbedded sandy silts, clays, and fine sands) from a nearby borrow area, and are underlain by an interim cover layer 300 mm thick. A mixture of native grasses was used as the vegetation for both covers (see Table 3.2).

3.2.6 Polson Site

The Polson site is located approximately 4.8 km southwest of Polson, MT, within the boundaries of the Flathead Indian Reservation. The existing landfill is unlined. Plans for an expansion included a liner system with a RCRA Subtitle D composite barrier using a GCL. Two covers are being tested at the Polson site, a conventional cover with a composite cover and an alternative cover containing a capillary barrier.

The conventional cover consists of 460 mm of compacted fine-grained soil ($K_s \leq 10^{-5}$ cm/s), a 1.5 mm thick textured LLDPE textured geomembrane, a drainage composite, a 460 mm vegetative layer, and 150 mm of topsoil. The alternative cover consists of 600 mm of silty sand, 460 mm of silt, and 150 mm of topsoil. Both covers overlay 460 mm of sandy gravel that serves as interim cover and as a gas vent.

The vegetative layer for the conventional cover and the coarse-grained layer in the alternative cover were constructed with fine sand from a borrow area on-site. The compacted soil barrier and the storage layer (alternative cover) were constructed with non-plastic silt from a local source off-site. Both covers were seeded with a mixture of native and introduced grasses, forbs, and shrubs (see Table 3.2).

3.2.7 Helena Site

The Helena site is located in southeastern Lewis and Clark County, approximately 16 km northeast of Helena, MT. The existing landfill is lined with a RCRA Subtitle D composite barrier. The alternative cover being tested at the Helena site is an alternative cover containing a capillary barrier. The cover consists of a 300 mm gravel gas-venting layer, 1200 mm of native soil, and 150 mm of topsoil. To simulate an interim cover, the final cover overlays 150 mm of native sandy clay from a nearby borrow area. The gravel was delivered to the site from a local quarry. The cover was seeded with a mixture of native grasses (see Table 3.2).

3.2.8 Albany Site

The Albany site is located about 850 m west of the western edge of the Indian Lake Refuge Area, in Albany, GA. There is no liner underlying the waste at the site. Approximately 700 mm of intermediate cover currently exists on top of the waste. The two covers being tested are a RCRA Subtitle D compacted clay barrier and an alternative cover. The compacted clay cover is the prescriptive remedy for the site, as required by the Georgia Environmental Protection Agency.

The conventional cover consists of a 460 mm barrier layer of compacted clay and a 150 mm topsoil layer. The clay was compacted to achieve $K_s \leq 1 \times 10^{-7}$ cm/s. The alternative cover, also known as an ECap, consists of 700 mm of soil to simulate the interim cover and a 600 mm storage layer comprised of soil blended with organic amendments. Both covers overlay 150 mm of interim cover soil.

All soil layers were constructed with sandy clay that was stockpiled on-site during previous construction efforts. The storage layer in the alternative cover consists of a 4:1 ratio of soil and organic amendments, the latter being comprised of 75% peanut hulls and 25% composted municipal wastewater biosolids.

Both test covers were vegetated with Bermuda grass. The alternative cover was also vegetated with two-year old hybrid poplar trees. The hybrid poplar trees were 4.5 m tall prior to planting and were placed in 600 mm deep trenches. Tree rows were spaced 3 m apart with an in-row spacing of 1.2 m. Two rows of trees were also planted around the alternative test section as a perimeter buffer to minimize 'edge effects' caused by wind, humidity, and light, which makes the alternative test section more representative of a large-scale ECap.

3.2.9 Marina Site

The Marina site is located approximately 3.2 km north of Marina, CA. Portions of the existing landfill are unlined, while other portions have a composite barrier. Two covers are being tested at the Marina site, a conventional cover with a composite barrier and an alternative cover.

The conventional cover consists of 600 mm of sand that serves as interim cover and as a gas vent, 300 mm of imported clay compacted to achieve a $K_s \leq 1x10^{-5}$ cm/s, a 1.5 mm thick textured LLDPE textured geomembrane, and a 300 mm vegetative layer. The alternative cover consists of a 300 mm intermediate cover and a 1220 mm storage layer.

The vegetative layer and the storage layer consist of heterogeneous clayey sand stockpiled on site as waste soil from nearby construction projects. The clay used for the compacted soil barrier was imported for a previous liner installation. The interim cover used for both covers is sand from a borrow area on site. Both covers were seeded with a mixture of native grasses (See Table 3.2). To improve vegetative growth in the alternative cover, compost was tilled into the top 75 mm of the storage layer November 2000, approximately five months after construction.

3.2.10 Monticello Site

The Monticello site is a uranium mill tailings disposal cell located in Monticello, UT. A RCRA Subtitle C cover was installed at the site in 1999. A 3.0 ha portion of the cover was hydraulically isolated from the rest of the 32.4 ha cover to test an alternative cover design. The alternative cover being tested is a capillary barrier that consists of

300 mm of clean sand, a geotextile filter, 300 mm of fine-grained soil, a 300 mm bio-intrusion layer (gravel), a 920 mm storage layer (fine-grained soil), and a 200 mm soil/gravel admixture. The vegetative cover consists of a mixture of grasses, forbs, and shrubs (See Table 3.2).

SECTION FOUR
ACAP WATER BALANCE DATA

This section presents data collected from the ACAP test sections. The monitoring period presented in this study varies from site to site, depending on when the test sections were constructed. The monitoring period reported here ended on approximately April 10, 2002. The water balance parameters that are discussed are surface runoff, soil water storage, lateral flow (if applicable), and percolation. Evapotranspiration is not discussed because it is not a direct measurement, but rather is determined indirectly from the water balance equation (Section 5.1). A summary of the water balance quantities for each cover is in Tables 4.1 and 4.2. A summary of factors affecting surface runoff is in Appendix 3.

A summary of soil properties measured during construction is discussed along with the modeling in Section 5, with the exception of those the soil properties for the Cedar Rapids and Monticello sites. Model simulations were not conducted for Cedar Rapids and Monticello. Therefore, hydraulic properties of soils at these sites are presented in this section. A more detailed report on the soil properties can be found in Gurdal (2002).

In this section, soil water storage records from each site are compared to the soil water storage capacity of each cover. Soil water characteristic curves were measured for each soil (Gurdal 2002), and were used to calculate the field capacity and wilting points of each soil. The soil water storage (SWS) capacity for each test section was then calculated based on the field capacity of each layer, with the field capacity defined as the water content at a matric suction of 33 kPa. The total SWS capacity includes the cover profile and the interim cover.

Table 4.1. Summary of Water Balance Data: Arid and Semi-Arid Sites. Percentage of Precipitation in Parenthesis.

Site	Duration (Days)	Cover Type	Slope (%)	Total Precipitation (mm)	Avg. Annual Precipitation [a] (mm/yr)	Surface Runoff (mm/yr)	Lateral Flow (mm/yr)	Percolation (mm/yr)
Altamont, CA	517	Monolithic	5	486.7	358.4	18.6 (5.4%)	NA	1.0 (0.3%)
		Conventional Composite	5			10.4 (3.0%)	2.7 (0.8%)	0.0 (0.0%)
Sacramento, CA	987	Monolithic (1080-mm)	5	1142.5	434.3	44.4 (10.5%)	NA	48.4 (11.1%)
		Monolithic (2450-mm)	5			25.1 (5.9%)	NA	3.1 (0.7%)
Helena, MT	905	Capillary	5	385.3	288.8	28.4 (7.4%)	NA	0.0 (0.0%)
Polson, MT	847	Capillary	5	743.97	380.5	10.0 (3.1%)	NA	0.2 (0.1%)
		Conventional Composite	5			8.3 (2.6%)	10.9	0.2 (0.1%)
Boardman, OR	485	Monolithic (1220-mm)	25	180.8	225.3	0.0 (0.0%)	NA	0.0 (0.0%)
		Monolithic (1840-mm)	25			0.0 (0.0%)	NA	0.0 (0.0%)
		Conventional Composite	25			0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Monticello, UT	607	Capillary	5	513.8		9.3 (1.8%)	NA	0.0 (0.0%)

NA = Not Applicable

Table 4.2. Summary of Water Balance Data: Humid Sites. Percentage of Precipitation in Parenthesis.

Site	Duration (Days)	Cover Type	Slope (%)	Total Precipitation (mm)	Avg. Annual Precipitation (mm/yr)	Surface Runoff (mm/yr)	Lateral Flow (mm/yr)	Percolation (mm/yr)
Marina, CA	684	Monolithic	25	605.0	466.1	0.0 (0%)	NA	61.8 (13.3%)
		Conventional Composite	25			45.7 (14.2%)	7.8 (1.7%)	18.1 (3.9%)
Albany, GA	722	Monolithic	5	1614.9 (1982.7) [b]	1263.4	7.8 (0.1%)	NA	91.3 (7.2%)
		Conventional Compacted Clay	5	1614.9 (1660.5) [b]		85.2 (10.4%)	NA	280.4 (22.2%)
Cedar Rapids, IA	381	Monolithic	5	772.1	914.7	25.7 (3.5%)	NA	143.1 (15.6%)
		Conventional Compacted Clay	5			14.2 (1.9%)	1.4 (0.2%)	15.5 (1.7%)
		Conventional Composite	5			21.0 (2.8%)	1.4 (0.2%)	0.9 (0.1%)
Omaha, NE	552	Capillary (760-mm)	25	719.1[c]	760.2	47.8 (6.6%)	NA	62.9 (8.3%)
		Capillary (1060-mm)	25			36.0 (5.0%)	NA	36.8 (4.8%)
		Conventional Composite	25			45.5 (6.3%)	18.1 (2.4%)	3.7 (0.5%)

[a] Average Annual Precipitation from historical data.
[b] Total precipitation for Albany includes irrigation applied to each test section.
[c] Precipitation record at Omaha is from October 5, 2000 to mid December 2001.
NA = Not Applicable

4.1 ALTAMONT SITE

Construction of two test sections at the Altamont site was completed on August 30, 2000. Data collection began on November 10, 2000. The total precipitation during the monitoring period is 487 mm. The majority of the precipitation occurred during the fall and winter.

The water balance for each test section is shown in Fig. 4.1. A datalogger error resulted in a large data gap between January 10, 2001 and March 29, 2001. However, meteorological data during this gap were obtained from a nearby weather station operated by the National Weather Service (Livermore, CA: station number 44997).

4.1.1 Surface Runoff

Surface runoff during the monitoring period is shown in Fig. 4.1. Surface runoff was 14.8 mm from the conventional cover and 26.4 mm from the alternative cover, which corresponds to 3.5% and 6.1% of precipitation. Surface runoff was only recorded during two rain events. The majority of the runoff (14.3 mm for the conventional cover and 22.4 mm for the alternative cover) occurred between December 2, 2001 and January 2, 2001, when 128 mm of precipitation was recorded. The amount of surface runoff may be underestimated due to the data gap occurring during the winter, when most of the precipitation occurs.

The type of vegetation and the soil used for each cover are similar; therefore, the surface runoff from both covers should be similar. The difference in surface runoff that was measured is likely due to the conventional cover having a more permeable topsoil layer (2.0×10^{-5} cm/s) than the alternative cover (2.8×10^{-6} cm/s).

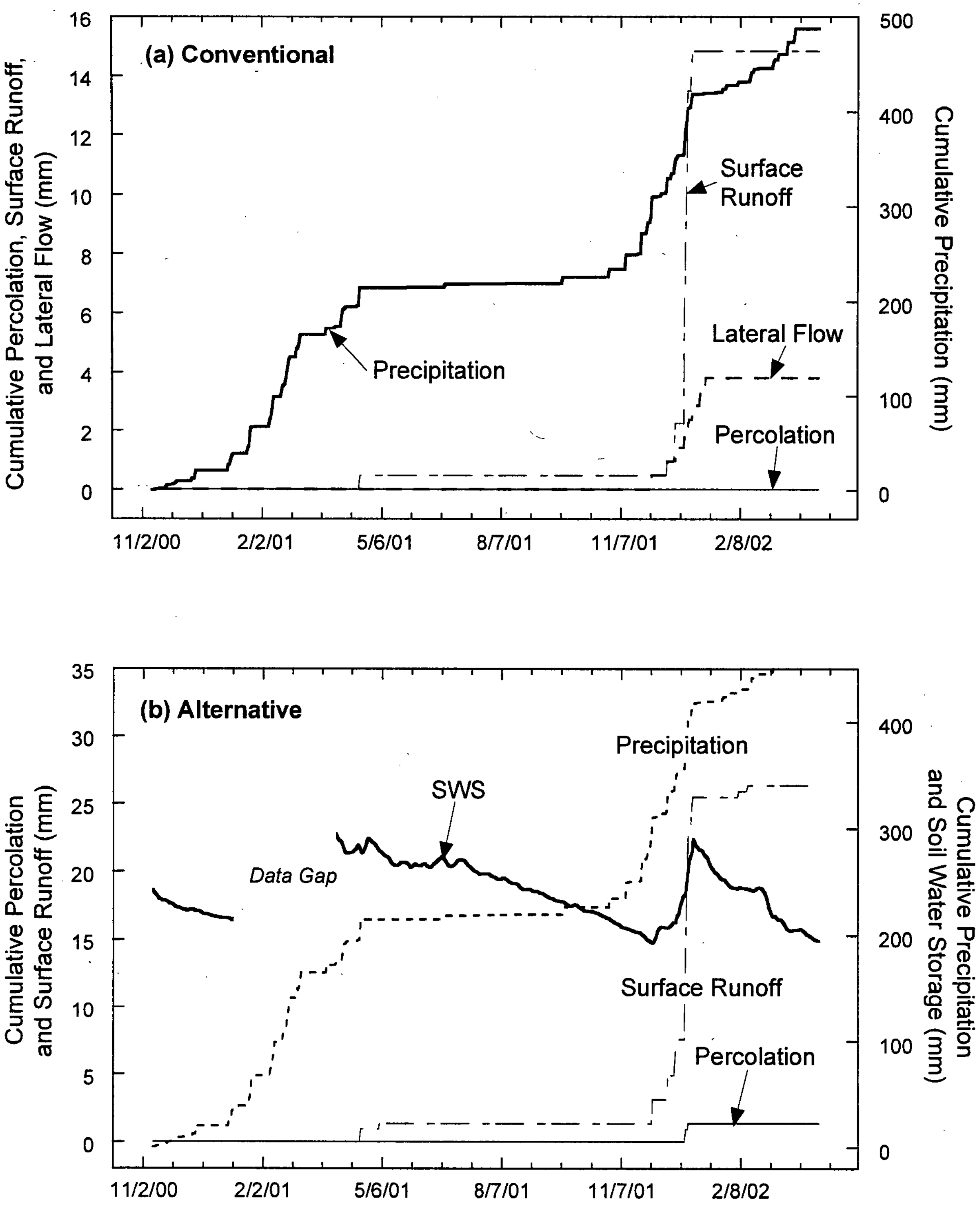


Fig. 4.1. Cumulative Water Balance for the Altamont Site: (a) Conventional Cover and (b) Alternative Cover.

4.1.2 Lateral Flow from Conventional Cover

Lateral flow was only recorded (3.8 mm) during the large rain event in December 2001. Lateral flow began on December 2, 2001, and ended on January 13, 2002. Approximately 18 mm of precipitation was measured during the four days prior to December 2, which slowly soaked into upper soil layer. On December 2, 20 mm of precipitation infiltrated the conventional cover and created lateral flow, even though surface runoff had not yet been recorded. This is likely due to the topsoil layer of the conventional cover being permeable, allowing for more infiltration than runoff.

4.1.3 Soil Water Storage

Soil water storage (Fig. 4.2) in the conventional and alternative covers increases during the winter due to the increase in precipitation, and then decreases due to evapotranspiration. During the winter, the soil water storage capacity was exceeded in the upper soil layers for short durations, but not in the lower soil layers (Fig. 4.3).

For the alternative cover, there is a delay in the increase in soil water storage (Fig. 4.3b) of the support layer and interim cover from the winter rains, which reflects the downward flow of water. Soil water storage initially peaked in the storage layer, which is followed by a peak in the support layer, and then the interim cover. The changes also occur more gradually with depth. During the first year, the soil water storage of the support layer rises sharply in Spring 2001, and slowly decreases during the following summer and fall. Water is primarily removed from the support layer by the vegetation.

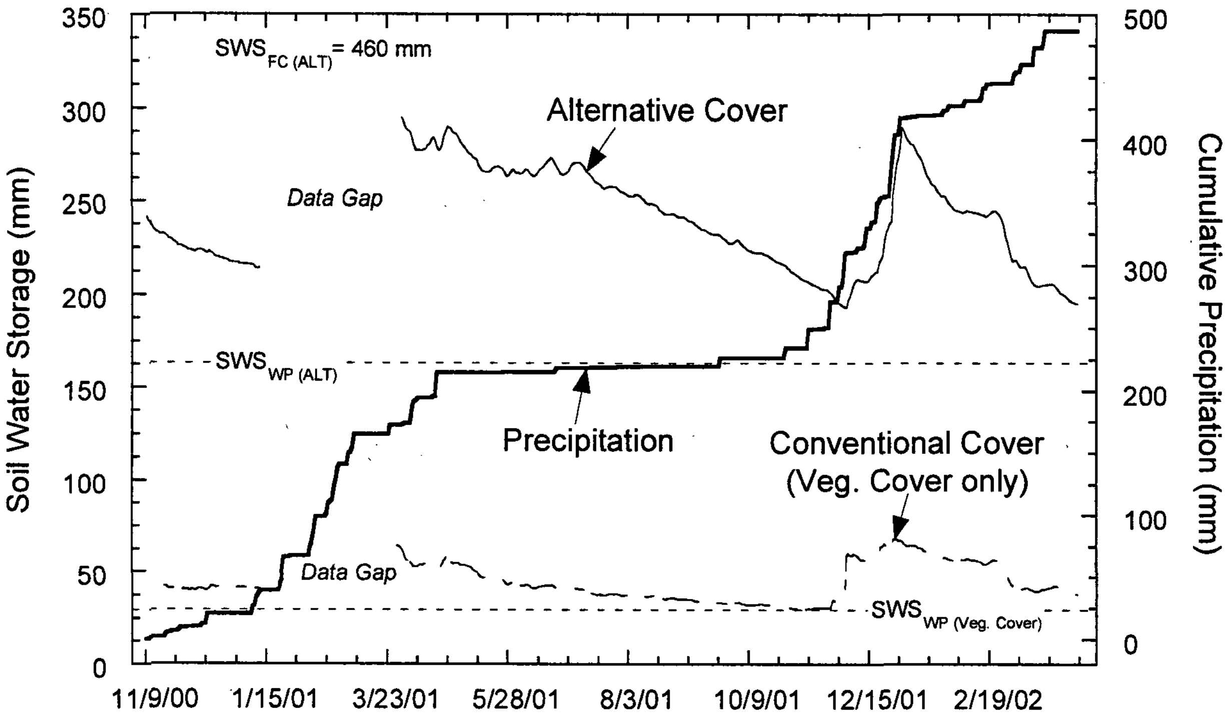


Fig. 4.2. Soil Water Storage in Test Sections at the Altamont Site.

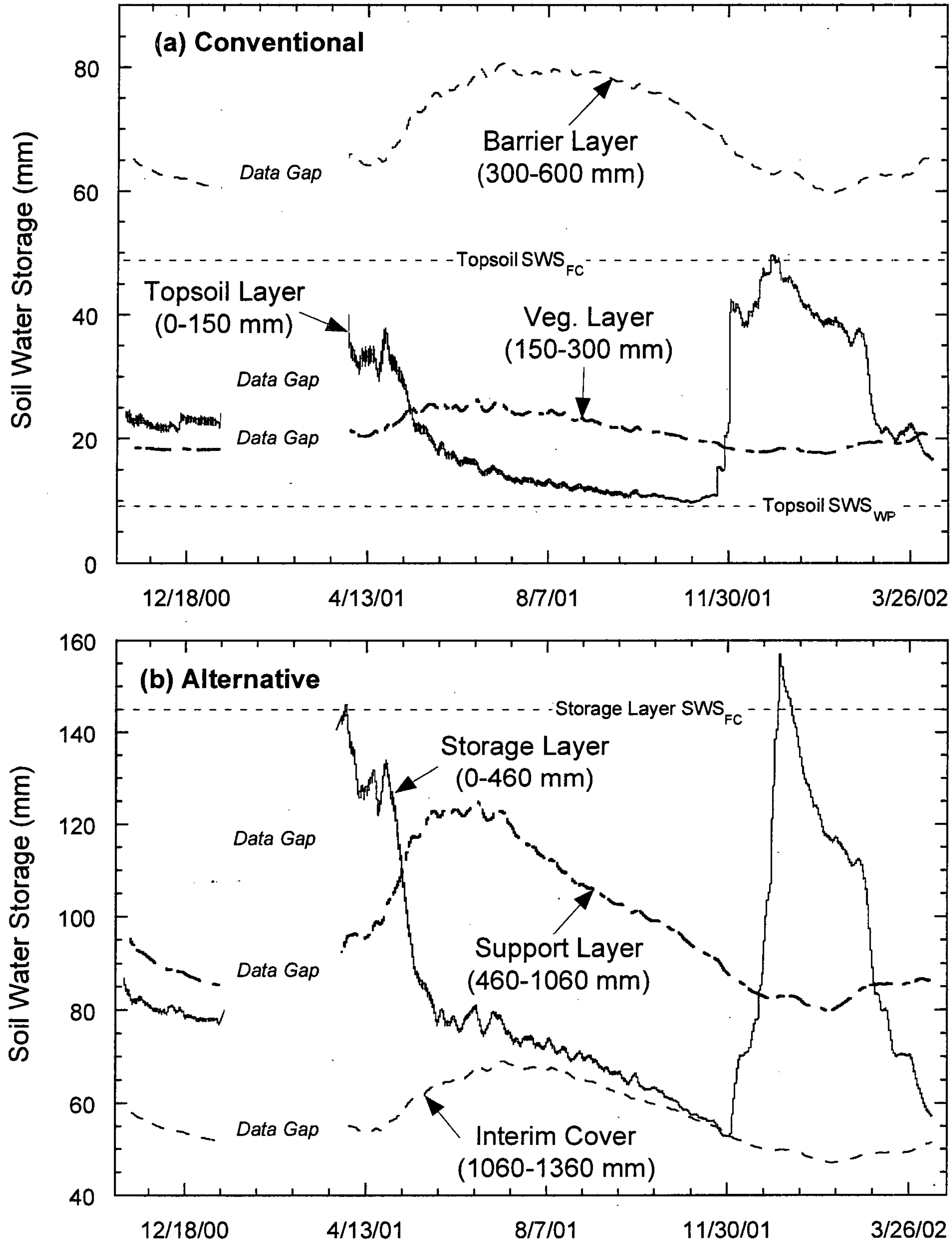


Fig. 4.3. Soil Water Storage of Individual Layers at the Altamont Site for the (a) Conventional Cover and (b) Alternative Cover.

The fluctuation of soil water storage in the interim cover of the alternative cover and the barrier layer of the conventional cover is likely due to either (1) water flux from a warmer to a cooler region caused by thermal gradients, or (2) is related to temperature effects on the WCR probes. Negative thermal gradients (upward water flow) were measured from mid August 2001 to end of March 2002.

4.1.4 Percolation

Percolation during the monitoring period is shown in Fig. 4.1. No percolation was recorded from the conventional cover. For the alternative cover, percolation was not recorded until December 28, 2001, which corresponds to the large rain event in December 2001. During this event, 1.4 mm of percolation was recorded. Soil water storage of the storage layer increased sharply during this rainy period (Fig. 4.3). However, the soil water storage of the support layer and interim cover did not increase at all. Thus, the percolation recorded between December 28-30 may be the result of preferential flow.

4.2 SACRAMENTO SITE

Construction of two monolithic barrier covers (1070 and 2450 mm) at the Sacramento site was completed on July 25, 1999. Data collection also began on July 29 1999. The covers are referred to as “thick” (2450 mm) and “thin” (1070 mm) monolithic barriers throughout this section. Total precipitation during the monitoring period was 1143 mm.

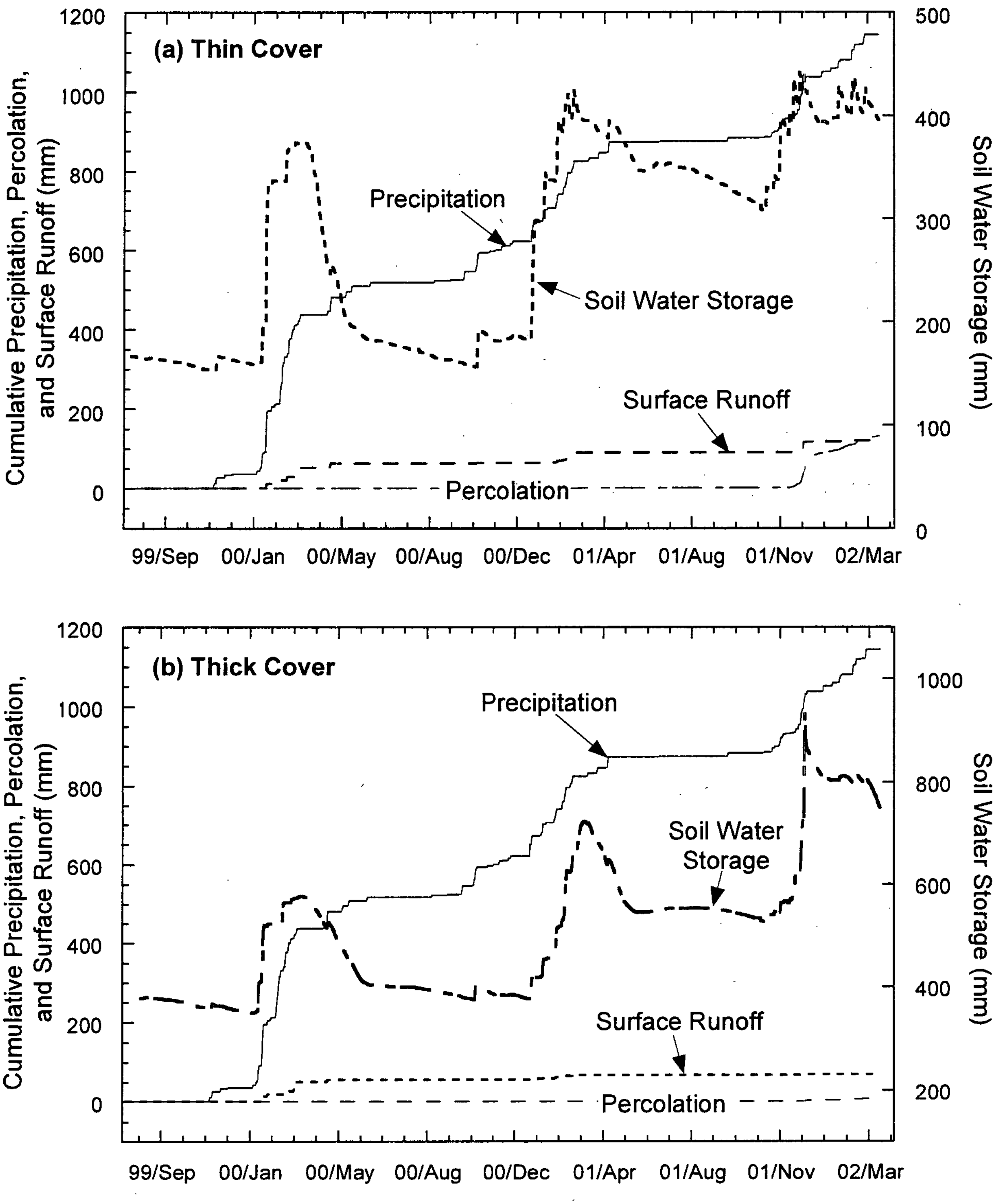


Fig. 4.4. Cumulative Water Balance at the Sacramento Site: (a) "Thin" Monolithic Barrier and (b) "Thick" Monolithic Barrier.

4.2.1 Surface Runoff

Surface runoff during the monitoring period is shown in Fig. 4.4. Surface runoff measured from the "thick" monolithic barrier was 68 mm and from the "thin" monolithic barriers was 120 mm. These volumes correspond to 5.9 and 10.5% of precipitation.

Surface runoff only occurred during large rain events, at which time the volumetric water content of the topsoil layer exceeded the field capacity (Fig. 4.5). The topsoil layer needs to become nearly saturated before runoff begins because the vegetation on both covers is well established, trapping the water.

4.2.2 Soil Water Storage

The rainy season at the Sacramento site occurs during the winter and spring, which is reflected in the trends in soil water storage. The water balance for each test section is shown in Fig. 4.4. Soil water storage increases during the rainy season (winter) and decreases during the summer. The soil water storage capacity for the "thin" monolithic barrier is exceeded twice during the monitoring period (February 5, 2001 and December 15, 2002). The soil water storage capacity for the "thick" monolithic barrier is exceeded once, which is towards the end of the monitoring period (January 1, 2002), as shown in Fig. 4.6.

During Summer 2000, the soil water "reservoir" for both covers was emptied by evapotranspiration, and the soil water storage reached the wilting point for both the "thin" monolithic barrier (θ_{WP}=150 mm) and the thick" monolithic barrier (θ_{WP}= 351 mm). However, during Summer 2001, the soil water storage of both covers only dropped approximately 100 mm.

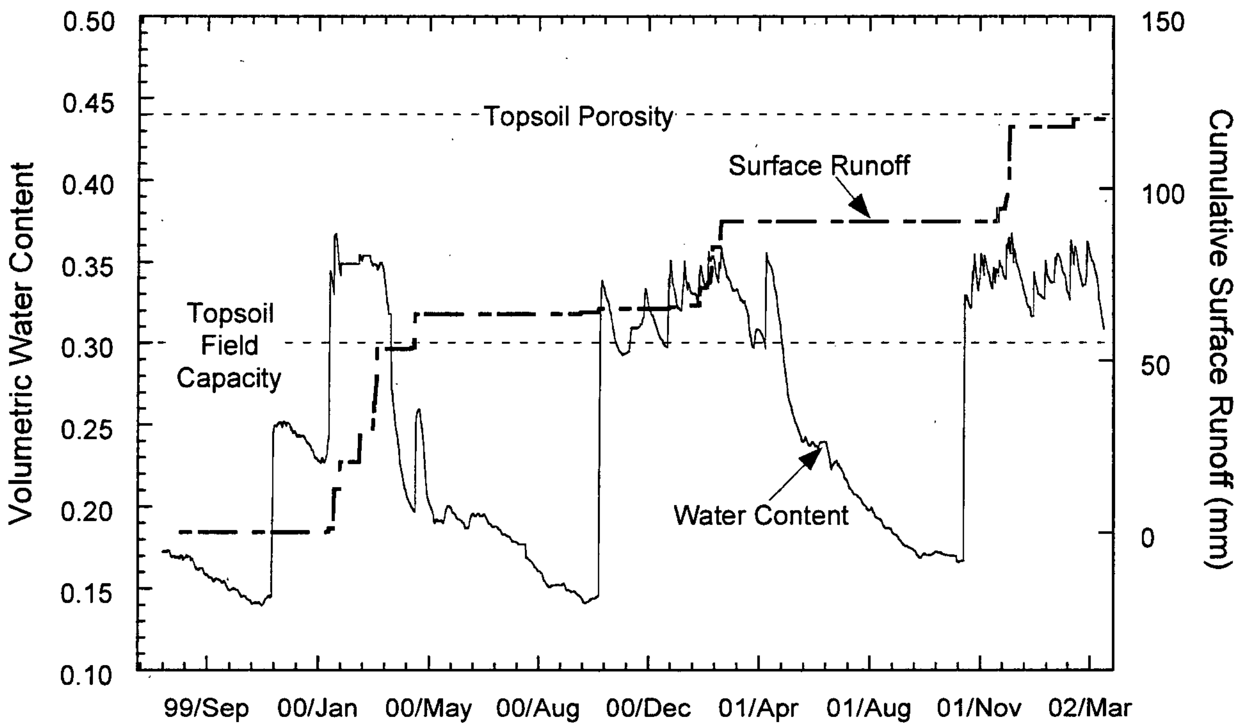


Fig. 4.5. Surface Runoff Occurring in Response to Topsoil Water Content: “Thin” Monolithic Barrier at the Sacramento Site.

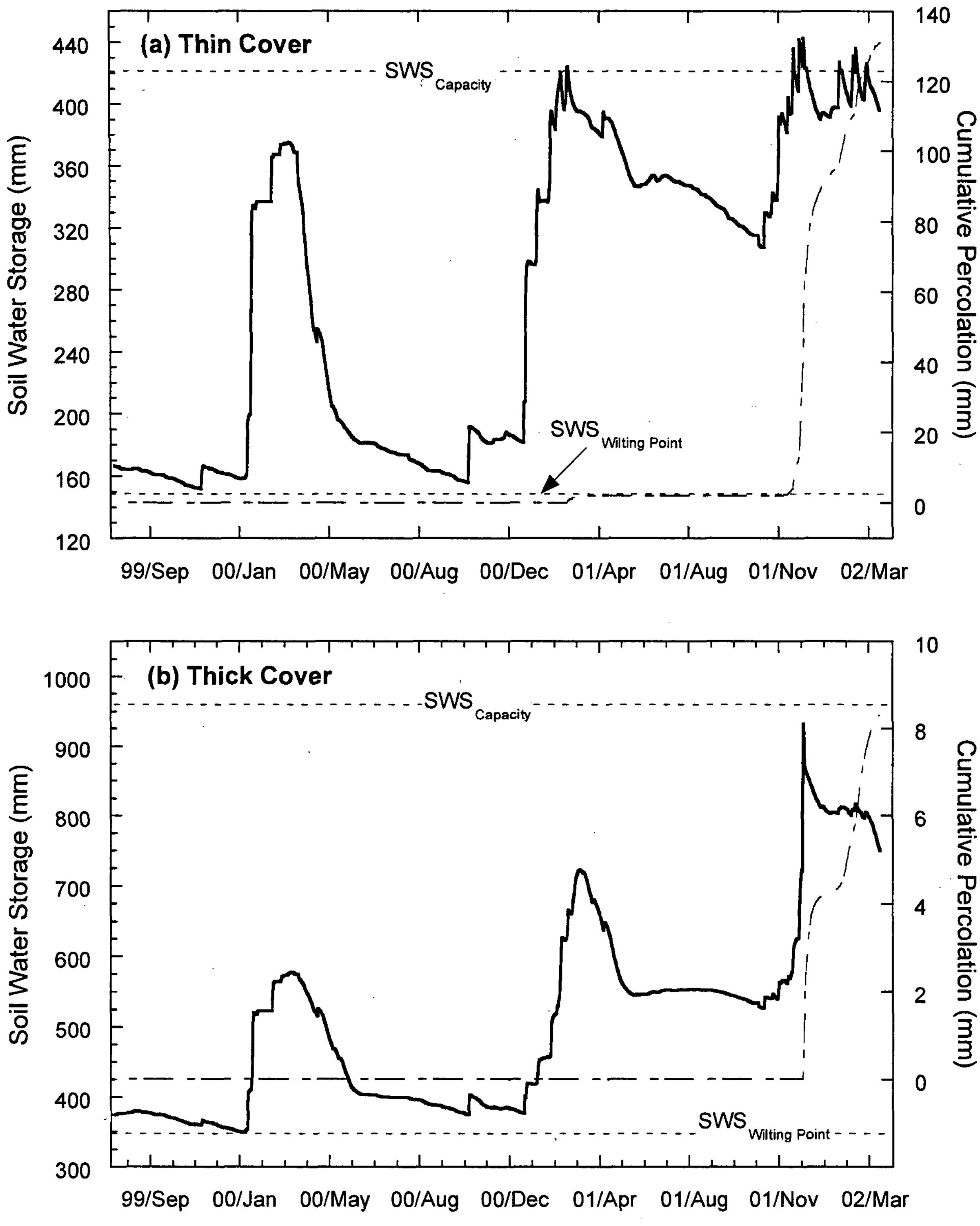


Fig. 4.6. Soil Water Storage for the Monolithic Barriers at the Sacramento Site: (a) "Thin" Cover and (b) "Thick" Cover.

4.2.3 Percolation

Percolation during the monitoring period is shown in Fig. 4.5. Percolation was transmitted from both the "thick" (3.7 mm) and "thin" (79.9 mm) monolithic barriers. The "thick" monolithic barrier did not transmit percolation until Winter 2001. A small amount of percolation (2 mm) was transmitted by the "thin" monolithic barrier during Winter 2000, when the soil water storage capacity was exceeded. During Winter 2001, percolation transmitted by the "thin" monolithic barrier increased dramatically, resulting in an additional 129 mm of percolation. Percolation was transmitted by both covers during Winter 2001 because the soil water storage did not decrease sufficiently during Summer 2001.

The most likely cause for the inadequate depletion of soil water storage is the vegetation ceases to transpire during the summer. The typical harvest date for the vegetation at the Sacramento site is July 1, but the soil water storage for the "thick" monolithic barrier appears to stop decreasing at the end of May.

4.3 HELENA SITE

Construction of the test section at the Helena site was completed on October 10, 1999. Data collection also began on October 10, 1999. Total precipitation during the monitoring period was 385 mm, 14.1% of which was frozen. Helena can be described as having wet summers and dry winters. The water balance for the test section is shown in Fig. 4.7.

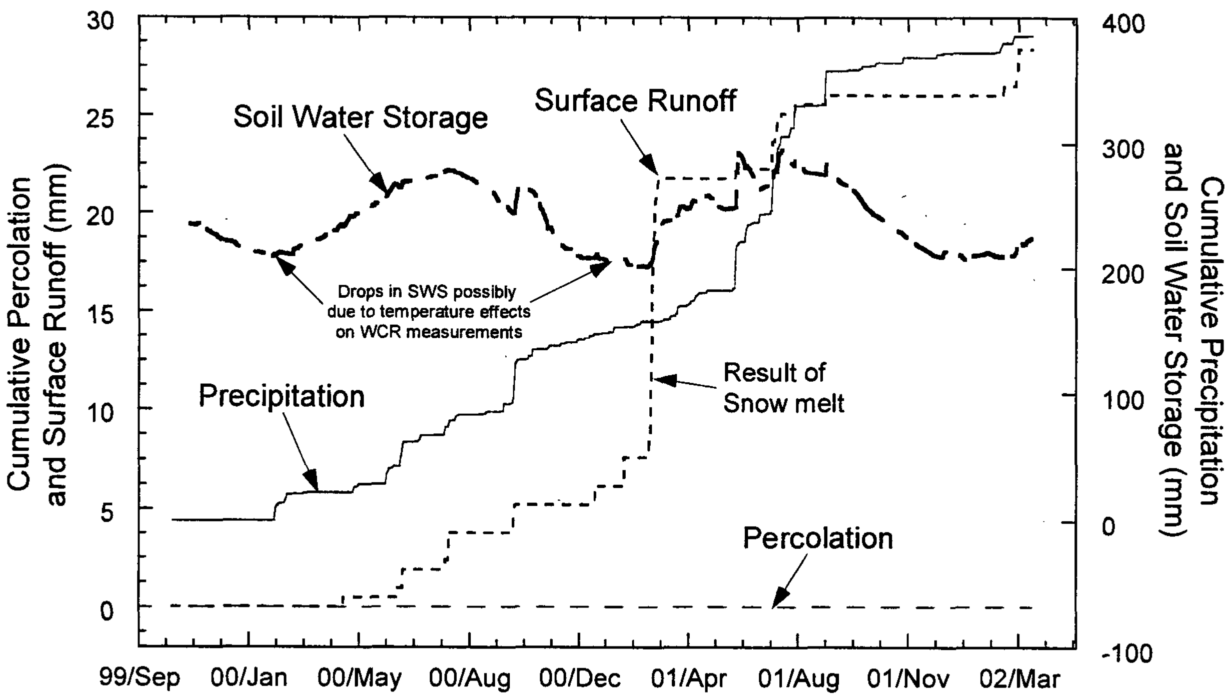


Fig. 4.7. Cumulative Water Balance at the Helena Site.

4.3.1 Surface Runoff

Surface runoff during the monitoring period is shown in Fig. 4.7. The total amount of surface runoff was 28.4 mm, or 7.4% of precipitation. The majority of surface runoff occurred during large rain events (9.5 mm) and snow melt events (18.9 mm), with the largest (14.2 mm) occurring in Spring 2001 as a result of a single snow melt event. The ground surface was frozen during both snowmelt events that occurred during the monitoring period (Fig. 4.8).

4.3.2 Soil Water Storage

The soil water storage capacity of the monolithic barrier (475 mm) was never close to being exceeded during the monitoring period (Fig. 4.7). The largest fluctuations of soil water storage occurred in the upper 460 mm (Fig. 4.9), whereas smaller fluctuations occurred in the lower soil layers. During the winter (November to February), the soil water storage appears to drop. However, this drop is the result of the WCR readings being affected by frozen ground. The WCRs record only the unfrozen water content, and thus do not reflect the actual volume of water in the soil during frozen conditions.

4.3.3 Percolation

No percolation was recorded during the monitoring period. Water reaches deeper depths of the cover profile, but is removed before percolation occurs.

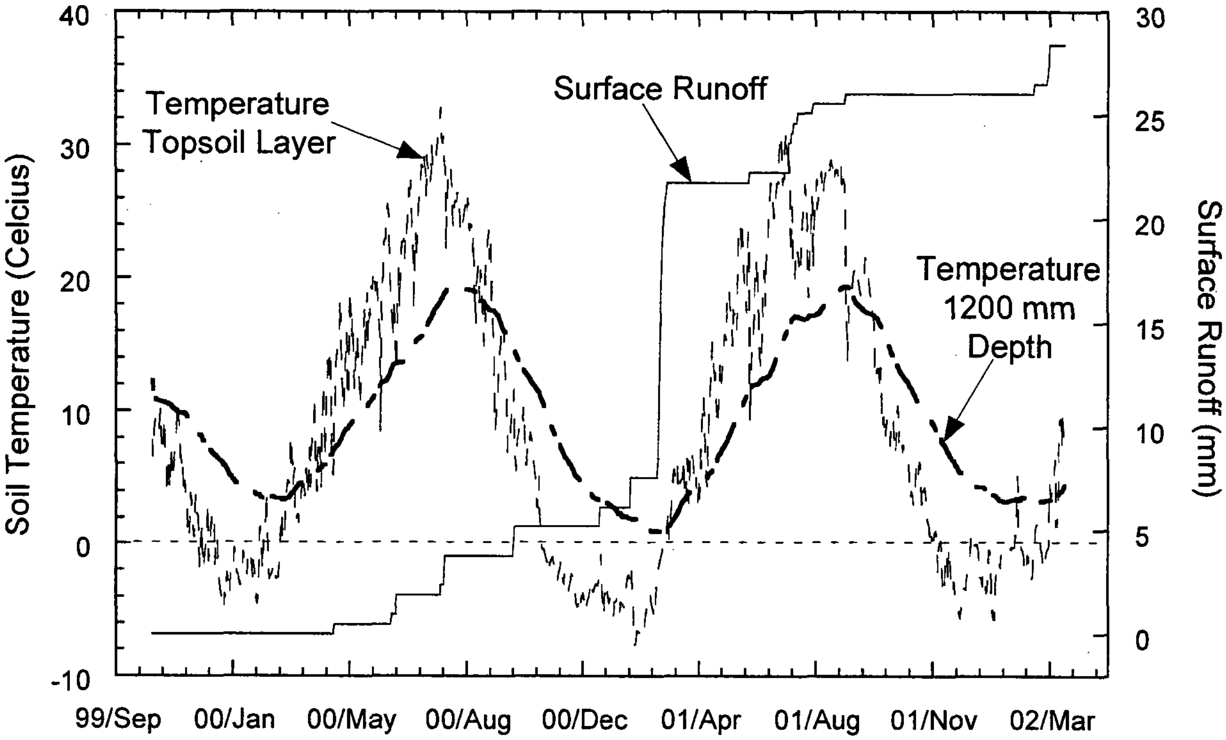


Fig. 4.8. Soil Temperatures and Surface Runoff for Alternative Cover at the Helena Site.

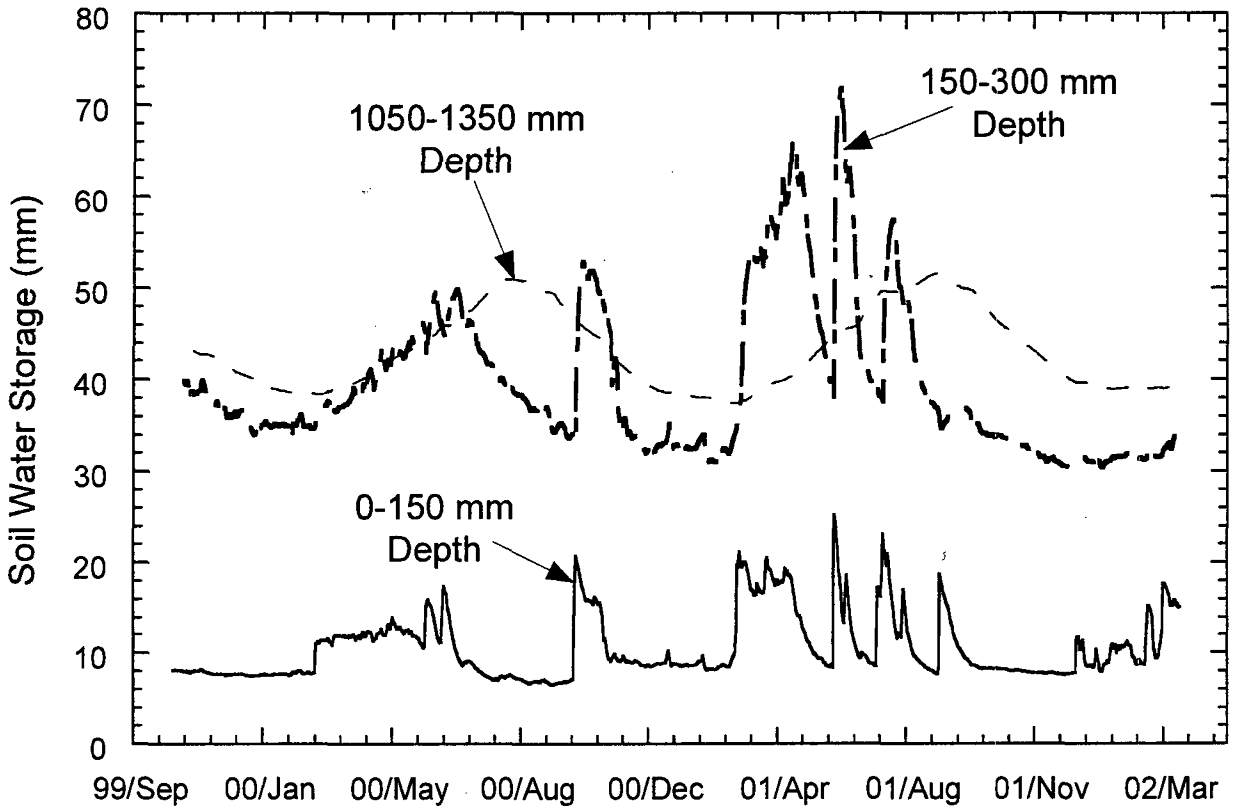


Fig. 4.9. Soil Water Storage for the Alternative Cover at the Helena Site.

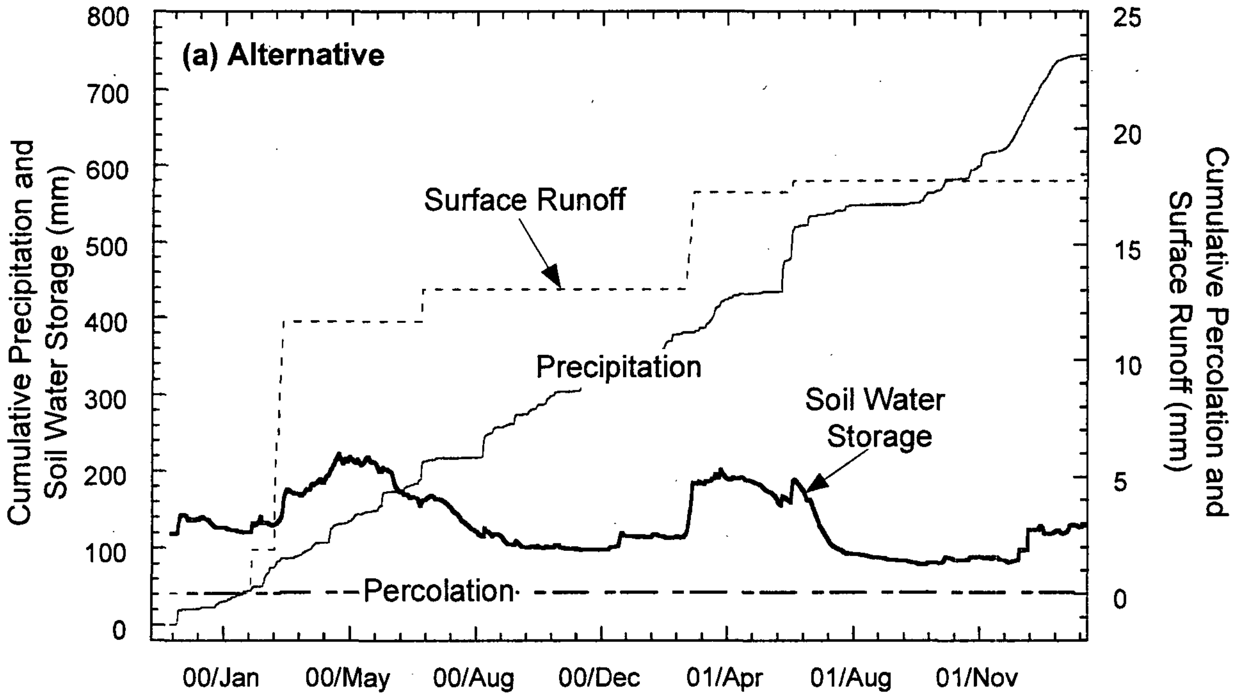
4.4 POLSON SITE

Construction of two test sections at the Polson site was completed on October 19, 1999. Data collection also began on November 19, 1999. Total precipitation during the monitoring period was 744 mm, of which 27% was frozen. The water balance for each test section is shown in Fig. 4.10.

4.4.1 Surface Runoff

Surface runoff during the monitoring period is shown Fig. 4.10. Surface runoff from the alternative cover was 23.3 mm, and from the conventional cover it was 19.2 mm, which is 3.1% and 2.6% of precipitation. The small volume of surface runoff is attributed to the shallow slope (5%) of the test sections, the higher hydraulic conductivity (5×10^{-5} cm/s) of the topsoil layer, and the well-established vegetation.

Most of the surface runoff occurred as a result of large snowmelt events at the end of winter and the beginning of spring. During this period, the ground is frozen, which enhances surface runoff. The snowmelt event during February 23-29, 2000 resulted in surface runoff (9.8 mm for the alternative cover and 9.3 mm for the conventional cover), more than double that occurring during snow melt events in subsequent years. For example, on March 6-14, 2001, surface runoff was 4.2 mm for the alternative cover and 2.8 mm for the conventional cover. During the next winter and spring (January 4, 2002 to March 4, 2002), 71.7 mm of melt water was generated, but no surface runoff occurred. During all of the snowmelt events, the ground surface was frozen. The decreasing trend of surface runoff is most likely because of dense vegetation, trapping the water.



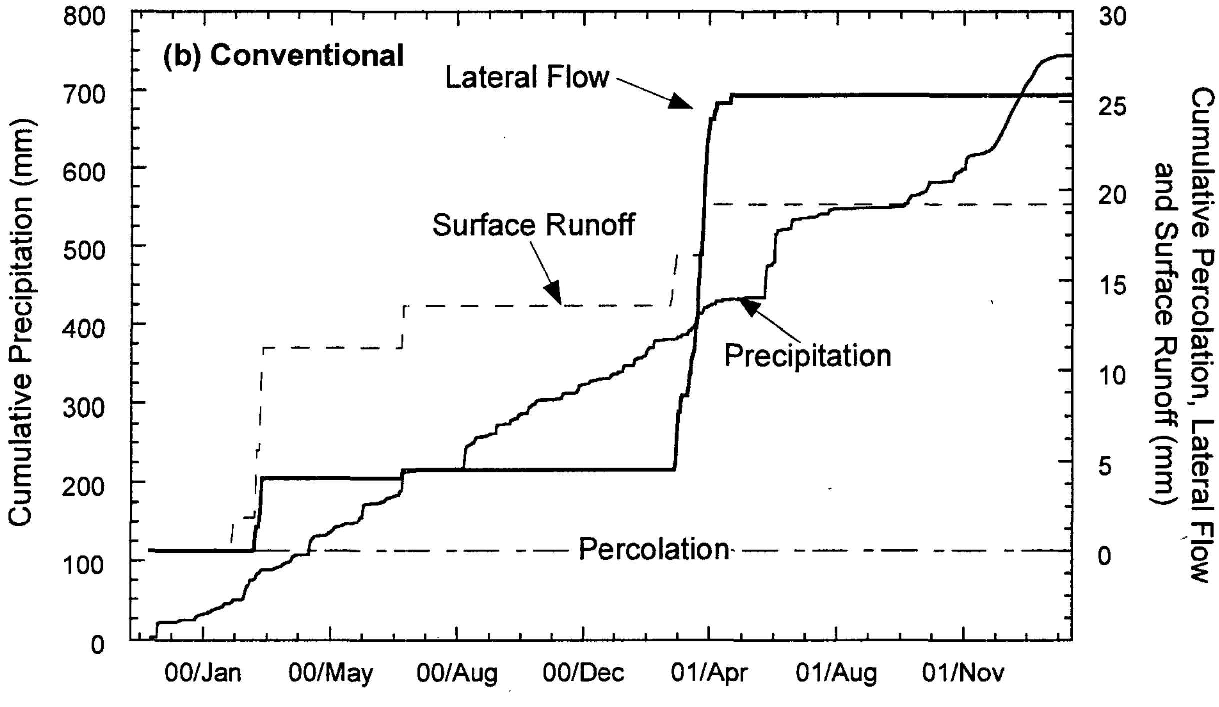


Fig. 4.10. Cumulative Water Balance at the Polson Site: (a) Alternative Cover and (b) Conventional Cover.

4.4.2 Lateral Flow from Conventional Cover

Lateral flow from the conventional cover was caused by the same events that yielded surface runoff. Typically, there was a delay of several hours to days after surface runoff was recorded before lateral flow would begin. During the snowmelt event in Spring 2001, the majority of the melt water infiltrated the cover, rather than running off. This event caused a large quantity of lateral flow (20.4 mm), as opposed to the snow melt event in Spring 2000, which resulted in 4.1 mm of lateral flow.

4.4.3 Soil Water Storage

Soil water storage typically increases during the winter and decreases in the spring and summer. Soil water storage peaks during the spring thaw and begins to decrease around May 1, which coincides with the start of the growing season. The soil water storage capacity was exceeded during Spring 2000 and 2001 for both the alternative cover and conventional covers (see Fig. 4.11).

For both covers, the soil water storage capacity of the upper layers (topsoil and storage layers for alternative cover, topsoil and vegetative layers for conventional cover) is greatly exceeded (see Fig. 4.12). However, the storage capacities that were computed did not account for the capillary barrier effect caused by the textural and hydraulic conductivity contrasts between the silt and fine sand layers in the alternative cover or the vegetative layer and drainage composite in the conventional cover. Nevertheless, for the conventional cover, the exceedance of the soil water storage capacity does correspond closely with a pulse of flow in the drainage layer, as shown in Fig. 4.10.

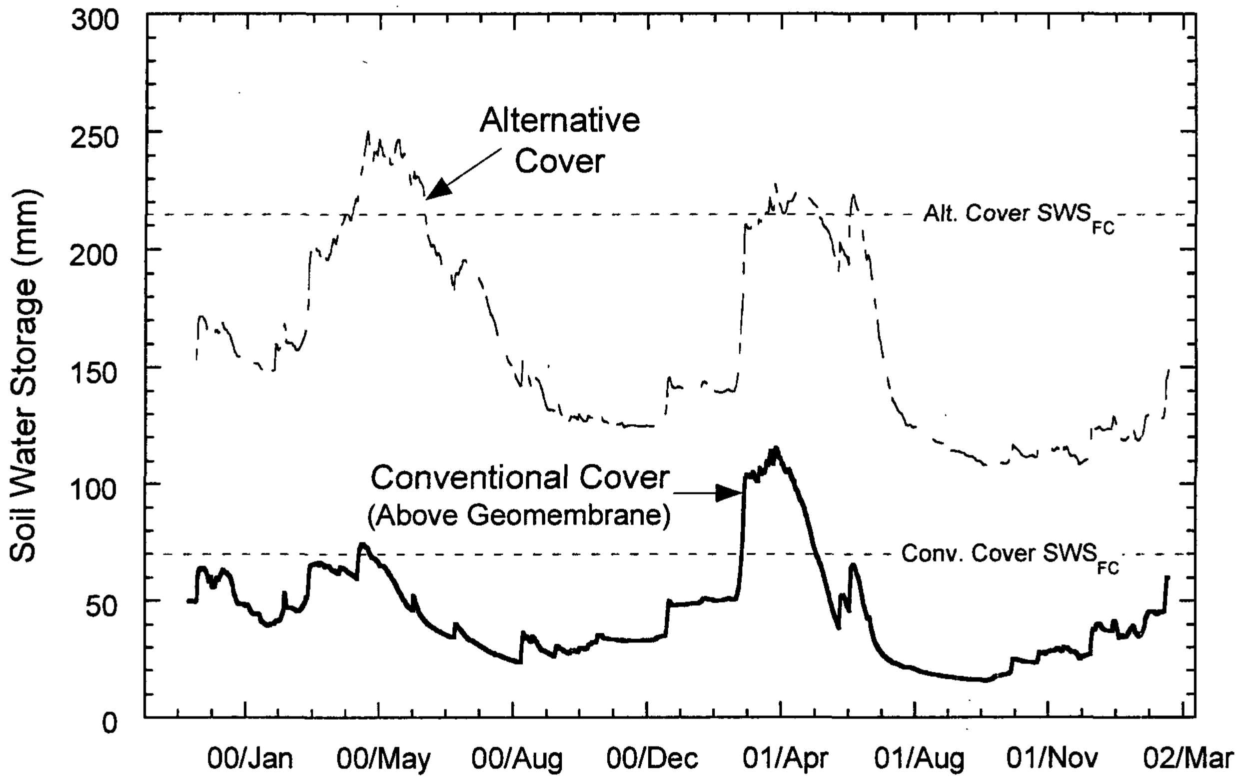


Fig. 4.11. Soil Water Storage for the Covers at the Polson Site.

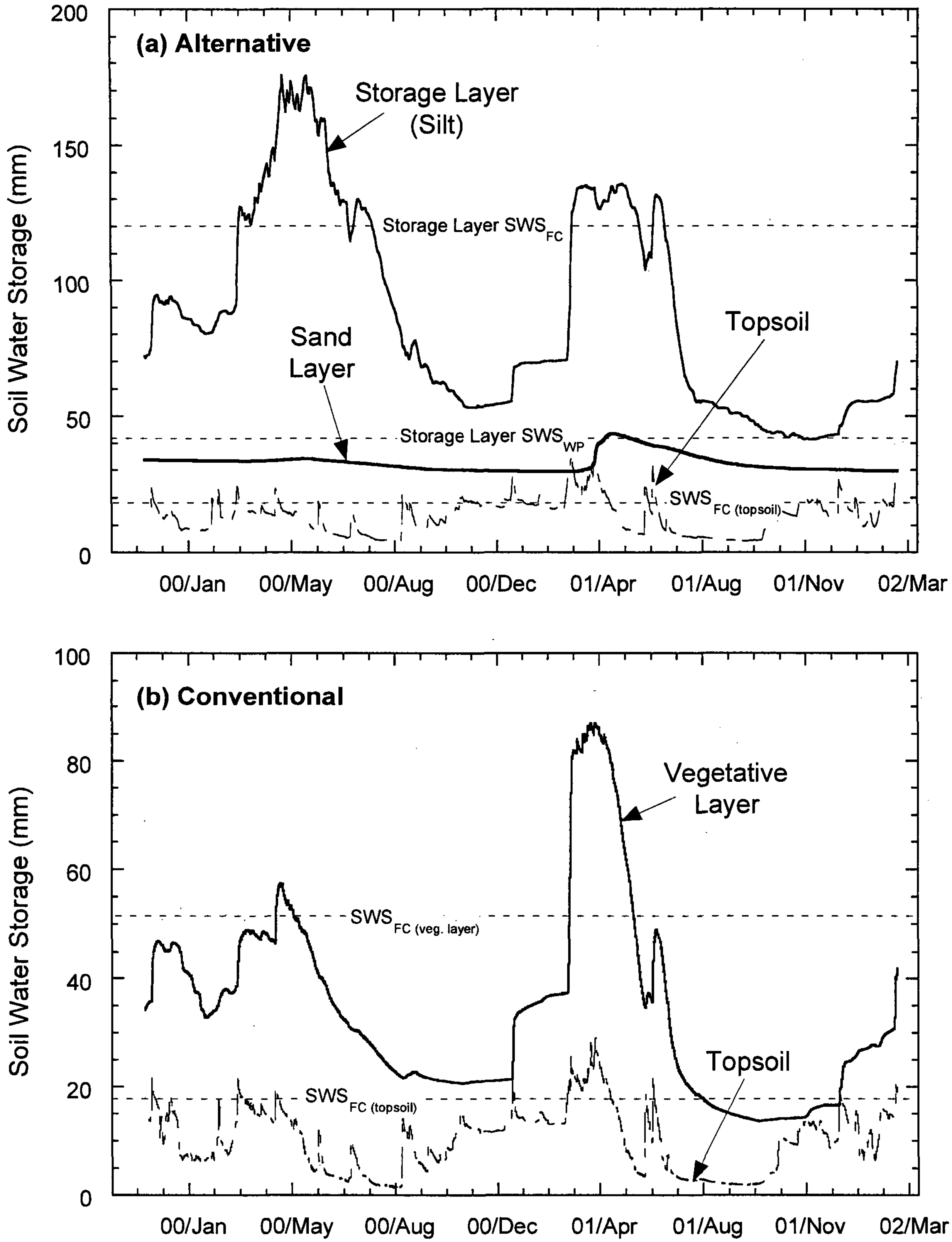


Fig. 4.12. Soil Water Storage in Each Layer at Polson Site: (a) Alternative Cover (b) Conventional Cover.

4.4.4 Percolation

A detailed percolation record is shown in Fig. 4.13 for the Polson site. Percolation from the alternative cover is 0.43 mm, and from the conventional cover it is 0.48 mm. Field observations showed that the drainage pipes leading to the collection basins from both covers settled substantially. The settlement caused the drainage pipes to move inside the collection basins so that the outlet was no longer aligned with the tipping bucket. This problem was corrected on July 13, 2001, but the volume of water missed by the tipping buckets remains unknown. The percolation data presented in Fig. 4.13 were recorded by the tipping bucket, and thus this percolation volume may be underestimated. However, no flushes of the basin were recorded by the float switch during the monitoring period.

The first pulse of percolation recorded for each cover was the result of 30 mm of snowmelt in February 2000. Several more pulses were transmitted by both covers during the monitoring period due to rainfall. Percolation was transmitted when the soil water storage of the lower layers increased, but did not exceed the soil water storage capacity. At the end of the monitoring period (March 2002), snowmelt caused approximately 0.4 mm of percolation from the alternative cover.

Suctions on either side of the capillary break in the alternative cover are shown in Fig. 4.14. These suctions were estimated using water contents measured in the field with WCRs and the soil water characteristic curves measured in the laboratory. The suction in the silt layer increases during the summer, decreases during the winter, and approaches zero in the early spring due to infiltration from snowmelt events. Percolation typically is transmitted shortly after the suction in fine layer decreases below that in the coarser layer.

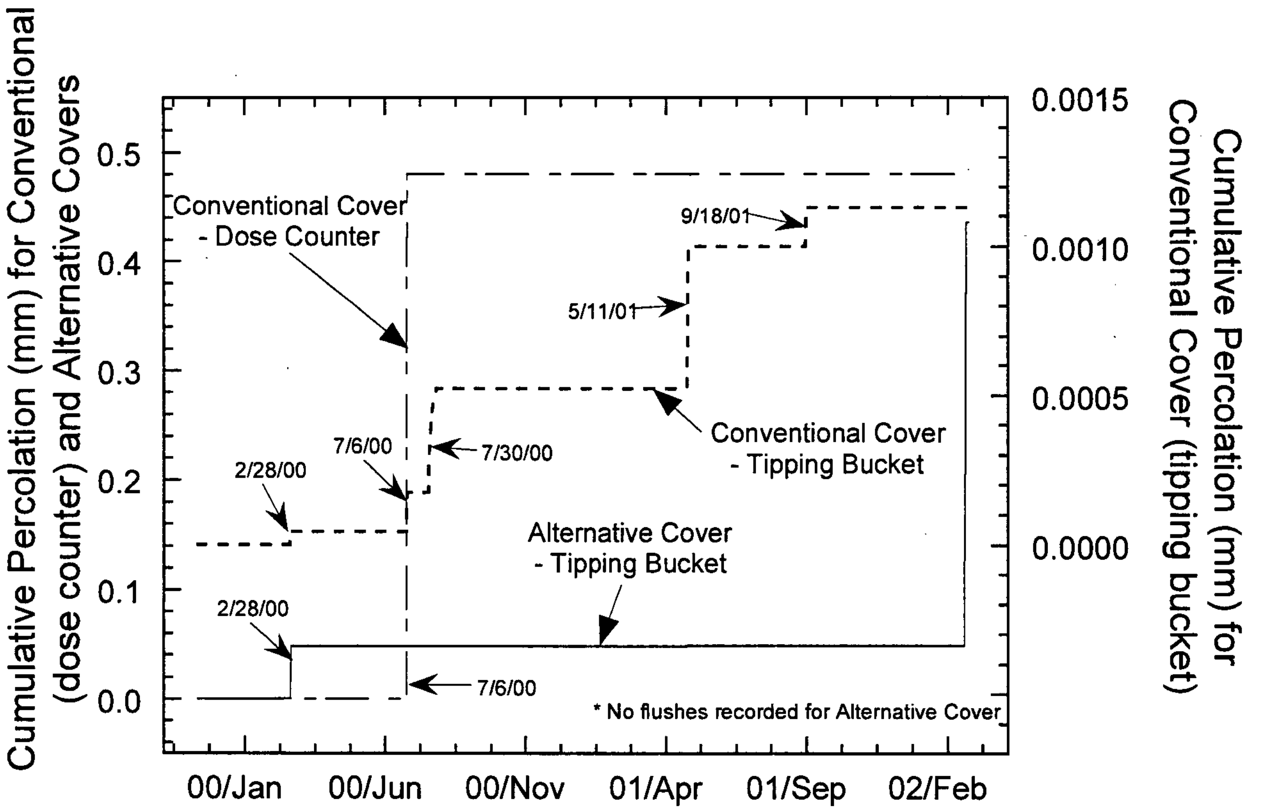


Fig. 4.13 Percolation for the Alternative Conventional Covers at the Polson Site.

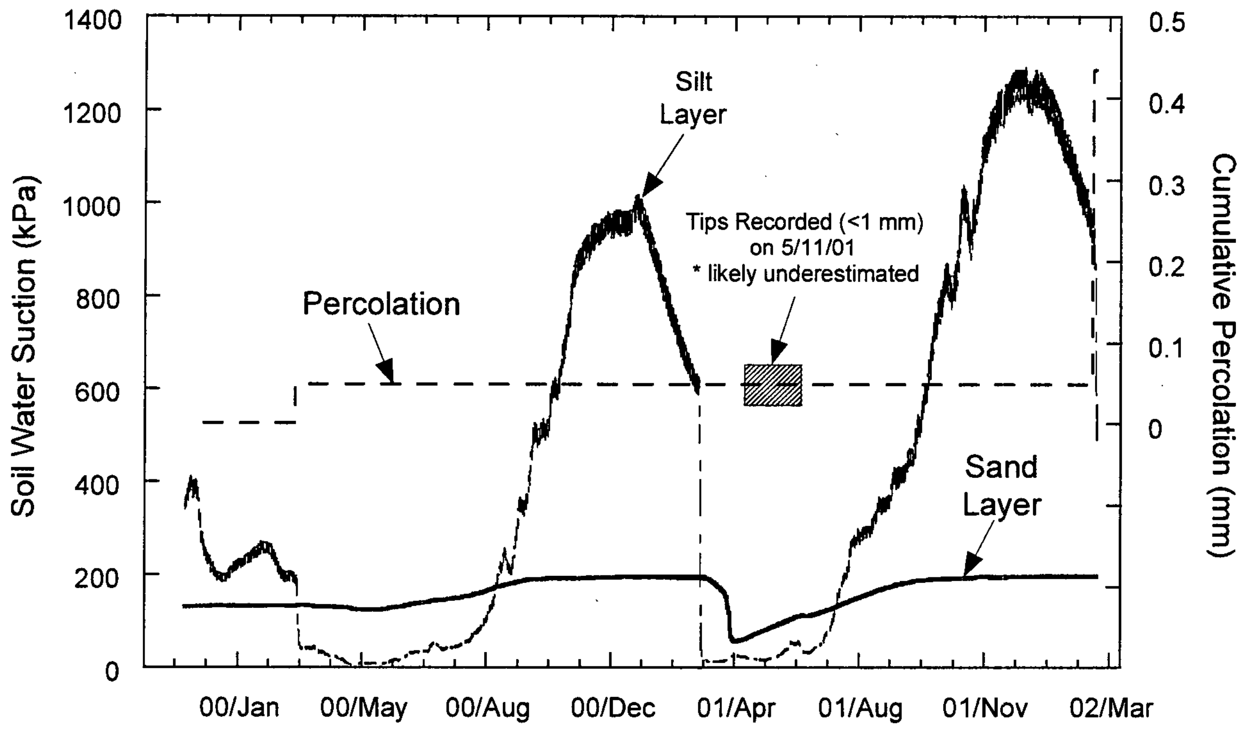


Fig. 4.14. Soil Water Suction Measurements Adjacent to Capillary Break in the Alternative Cover at the Polson Site.

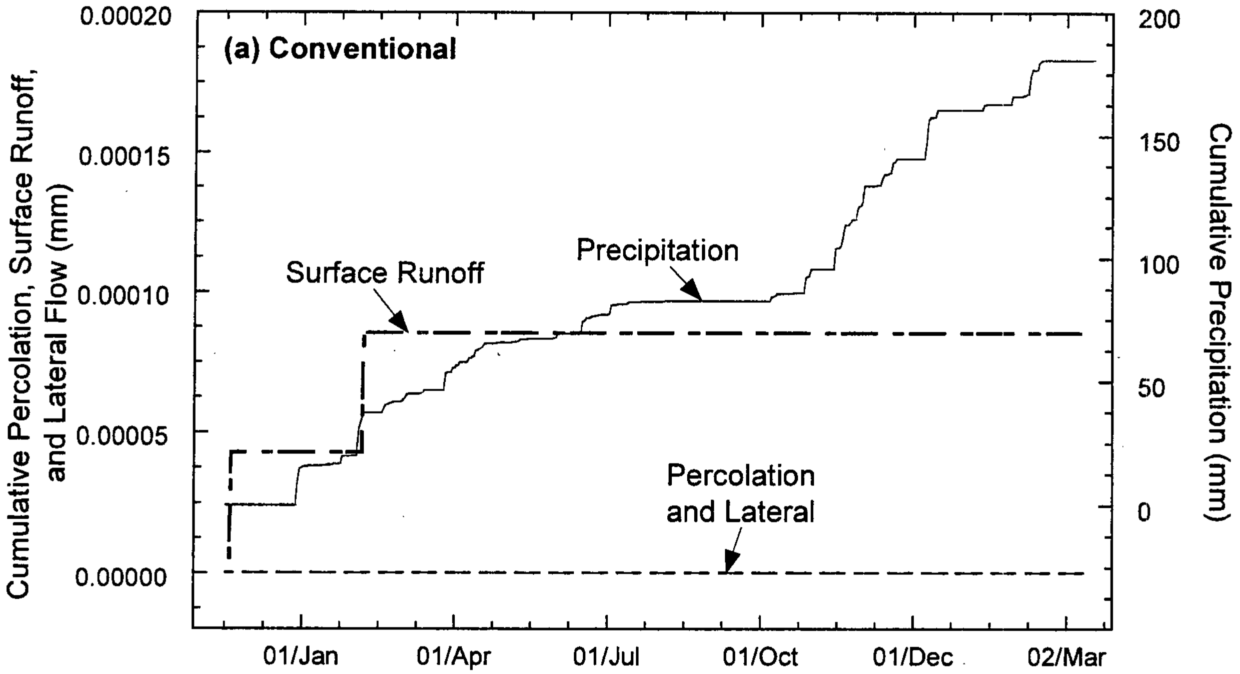
During Spring 2001, breakthrough into the sand layer occurred. The capillary break prevented appreciable water flow into the sand during most of the monitoring period. Only small changes in suction occurred in the sand layer (Fig. 4.14) when the soil water storage of the silt layer increased dramatically (Fig. 4.12). During this period, water contents in the silt layer approached the porosity as a result of the spring thaw.

4.5 BOARDMAN SITE

Construction of the test sections (one conventional cover and two alternative covers) at the Boardman site was completed on November 2, 2000. Data collection began on December 9, 2000. The total precipitation during the monitoring period is 181 mm, of which 12.3% was frozen. The Boardman site has dry summers and wet winters. The water balance of each test section is shown in Fig. 4.15 and 4.16.

4.5.1 Surface Runoff

Virtually no surface runoff was recorded during the monitoring period, despite each test section having a 25% slope. This is likely due to a number of factors, such as absence of intense rain events that have typically produced surface runoff at the other sites, and the higher saturated hydraulic conductivity of the surface layer (2.0×10^{-5} cm/s). Also, soil temperatures within each cover did not drop below 0°C during the monitoring period. Therefore, snowmelt during the spring thaw is not easily shed, as is the case at sites where the ground surface is frozen.



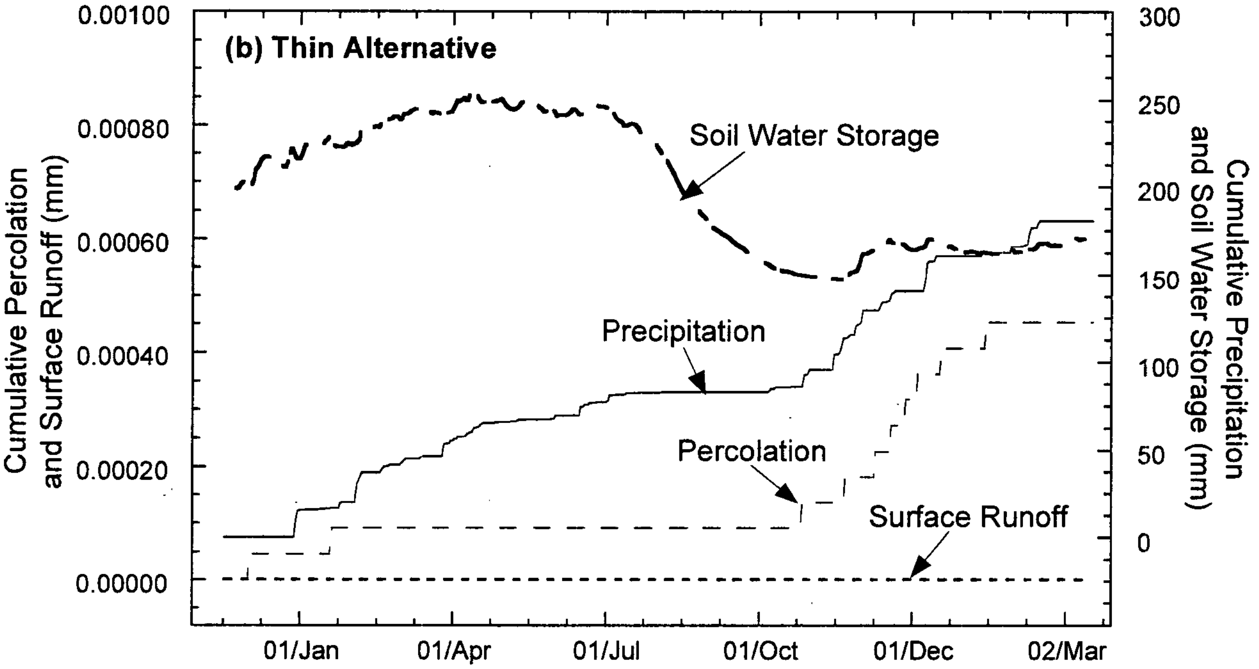


Fig. 4.15. Cumulative Water Balance at the Boardman Site: (a) Conventional Cover and (b) "Thin" Monolithic Barrier.

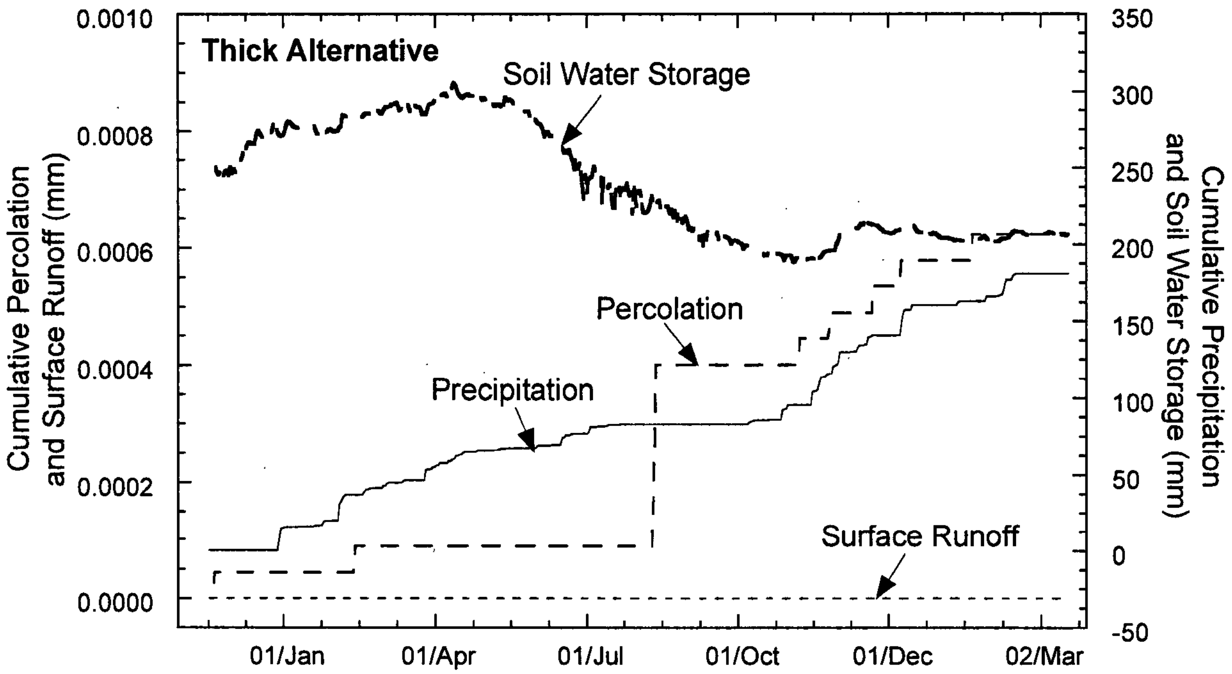


Fig. 4.16. Cumulative Water Balance at the Boardman Site: “Thick” Monolithic Barrier.

4.5.2 Lateral Flow from Conventional Cover

No lateral flow was collected from the conventional cover during the monitoring period.

4.5.3 Soil Water Storage

Soil water storage for each cover is shown in Fig. 4.17. Typically, soil water storage reaches a maximum during spring, as a result of the rainy season during the winter. At the end of April, the vegetation germinates and begins to extract water from the cover. The soil water storage gradually decreases during the summer and reaches a minimum prior to the onset of the rainy season in November.

In the alternative covers, peak volumetric water contents in each soil layer are reached at different times (Fig. 4.18). The time delay from the surface layer to the bottom layer is approximately 5 to 6 months. This indicates that water is reaching the lower soil zones, but is flowing downwards under unsaturated conditions at a slow rate.

The vegetation at the Boardman site appears to be capable of removing all of the available soil water. Water contents in the entire soil profile approach the wilting point by the end of each growing season (Fig. 4.18). For the "thick" monolithic barrier, the water content of the lowest soil zone fluctuates very little, lingering near the wilting point.

4.5.4 Percolation

Virtually no percolation was recorded in any of the test sections during the monitoring period. The cumulative percolation was less than 0.1 mm for each cover.

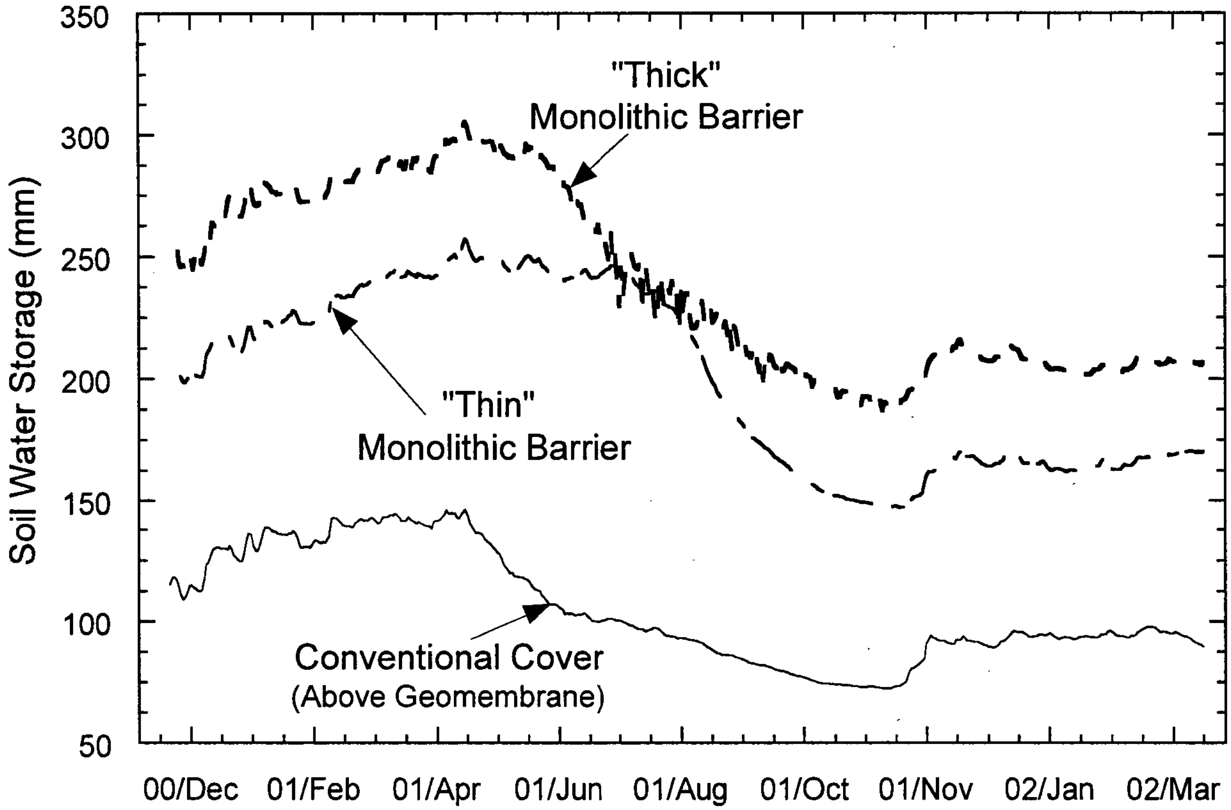


Fig. 4.17. Soil Water Storage for All Covers at the Boardman Site.

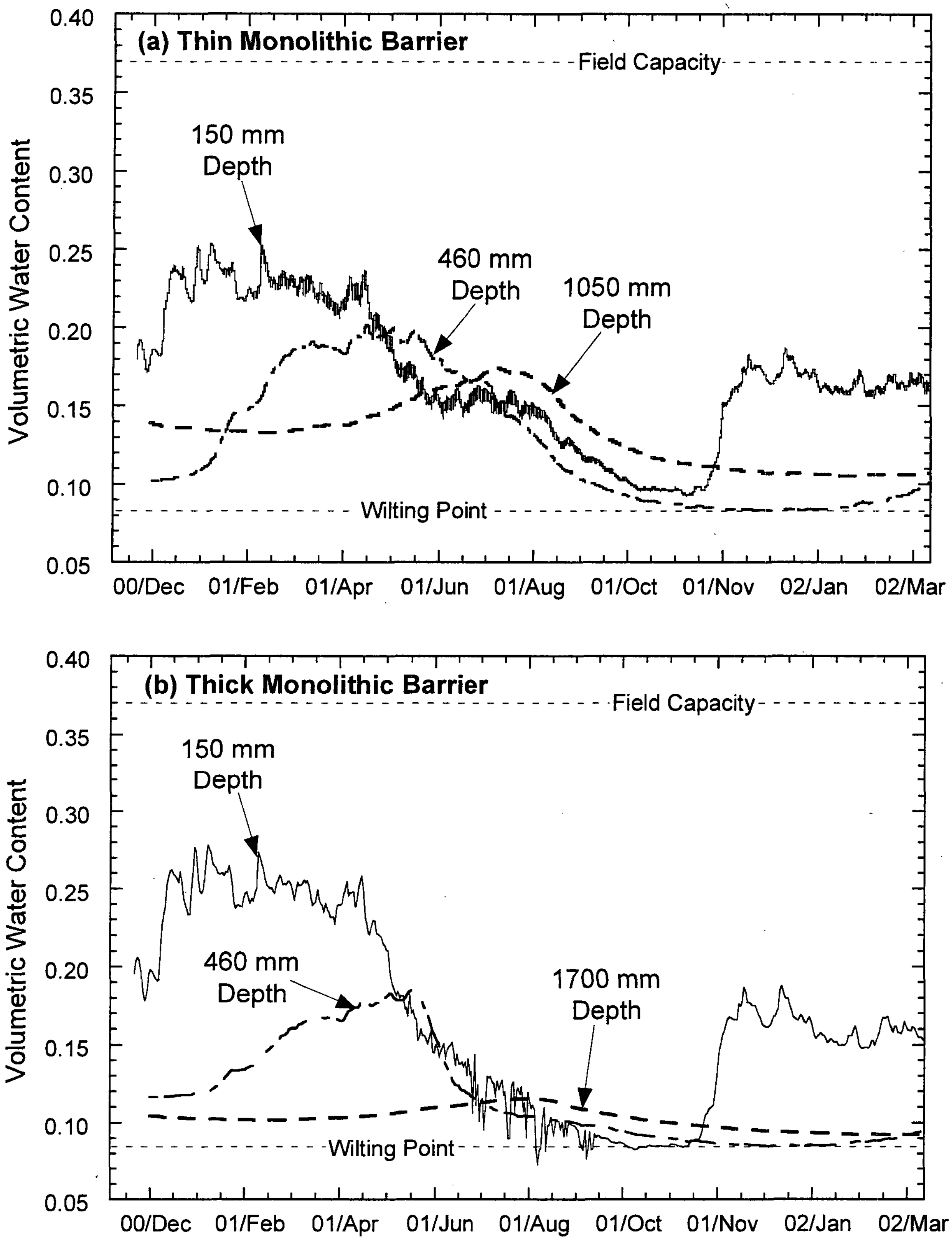


Fig. 4.18. Volumetric Water of Soil Layers at Boardman Site: (a) "Thin" Monolithic Barrier and (b) "Thick" Monolithic Barrier.

4.6 MARINA SITE

Construction of the two test sections (one conventional cover and one alternative cover) at the Marina site was completed on May 25, 2000. Data collection began on May 27, 2000. Total precipitation during the monitoring period is 605 mm, with the majority of the precipitation (72%) occurring during the winter (November through February). The water balance for each test section is shown in Fig. 4.19.

4.6.1 Surface Runoff

Surface runoff during the monitoring period is shown in Fig. 4.19. The surface runoff recorded from the conventional cover was 85.7 mm, which corresponds to 14.2% of precipitation. No surface runoff was recorded from the alternative cover, despite both covers being constructed with the same soil, seeded with the same vegetation, and at the same slope (25%). The difference in surface runoff is attributed to tilling of the surface layer of the alternative cover to improve vegetative growth.

4.6.2 Lateral Flow from Conventional Cover

Lateral flow during the monitoring period is shown in Fig. 4.19. The lateral flow recorded from the conventional cover was 14.5 mm, and occurred nearly exclusively during Winter 2001. Lateral flow began approximately three months after the onset of winter precipitation, and gradually increased until the middle of February 2001. After this time, a malfunction may have occurred in the dosing siphon for the lateral flow collection basin. Surface runoff recorded after February was 38 mm, whereas the lateral flow was only 0.47 mm.

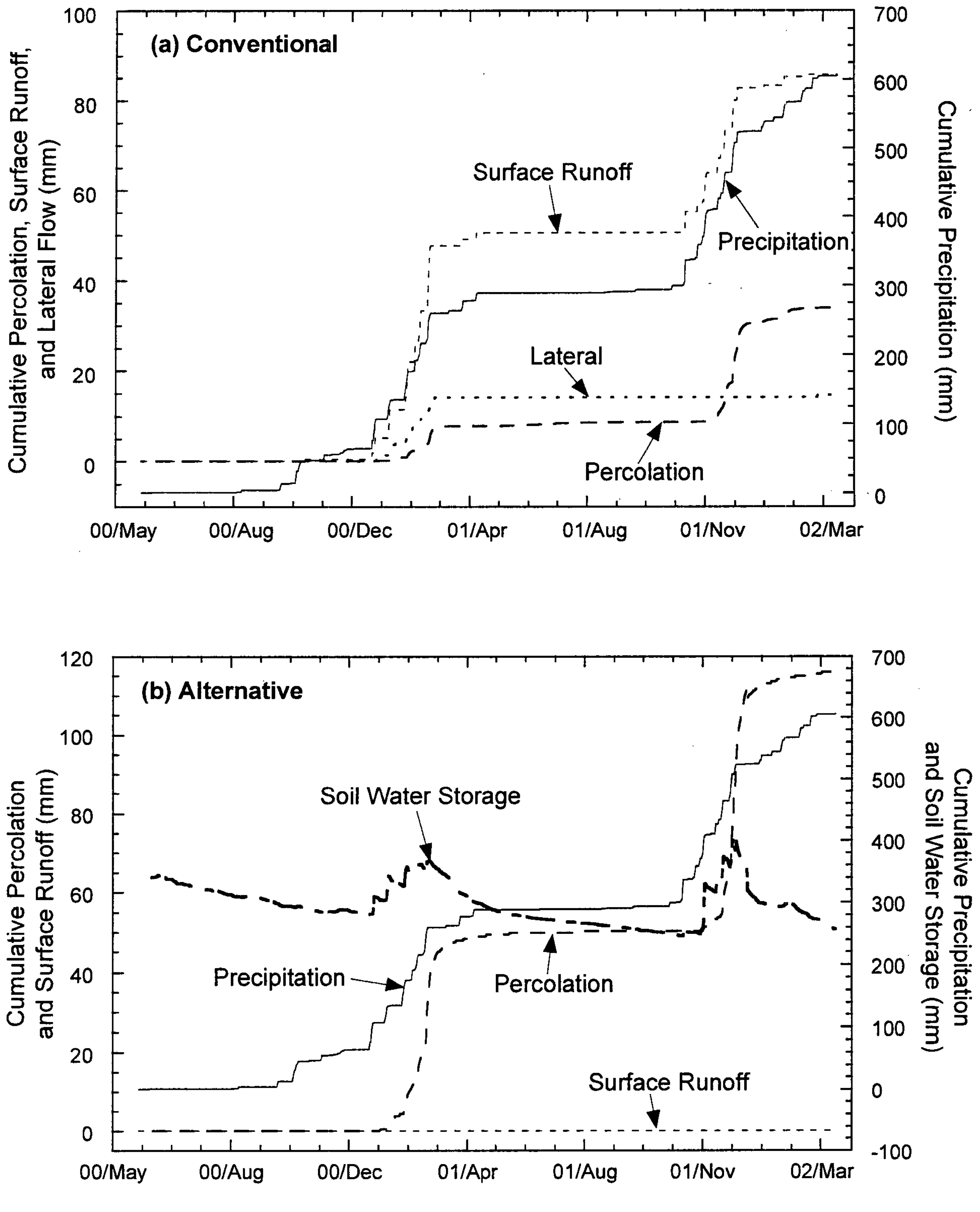


Fig. 4.19. Cumulative Water Balance at the Marina Site: (a) Conventional Cover and (b) Alternative Cover.

4.6.3 Soil Water Storage

Soil water storage records during the monitoring period are shown in Fig. 4.20. Soil water storage for both covers follows a similar trend, with increasing soil water storage during the rainy season (winter) followed by drying the following spring and summer.

For the alternative cover, the soil water storage capacity of the storage layer is never exceeded during the rainy season. However, a small amount of breakthrough into the sand layer (interim cover) occurred during the first year, whereas a large amount of breakthrough occurred during the second year (Fig. 4.21). During the dry summers, the vegetation is able to reduce the soil water storage, and the wilting point is not reached.

4.6.4 Percolation

Percolation for each cover during the monitoring period is shown in Figs. 4.19 and 4.20. The conventional cover transmitted 33.9 mm of percolation, whereas the alternative cover transmitted 115.9 mm of percolation. Most of the percolation occurred during the winter, when evapotranspiration was at its lowest and precipitation at its highest.

Percolation from the conventional cover may have been underestimated because the percolation data are based on measurements made with the tipping bucket rather than from the float switch. The tipping bucket data were used because the collection basin began leaking on approximately December 3, 2001.

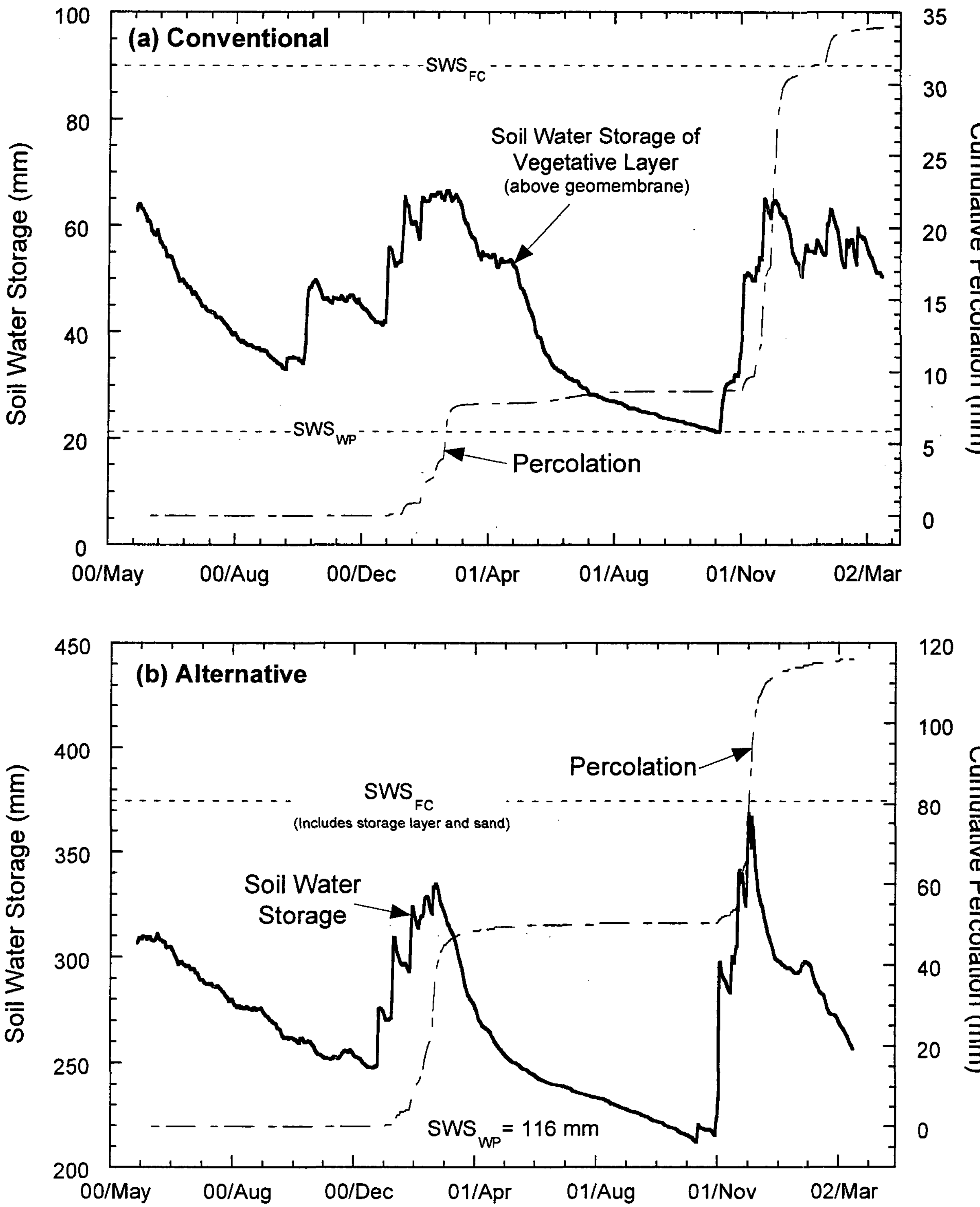


Fig. 4.20. Soil Water Storage at the Marina Site: (a) Conventional Cover and (b) Alternative Cover.

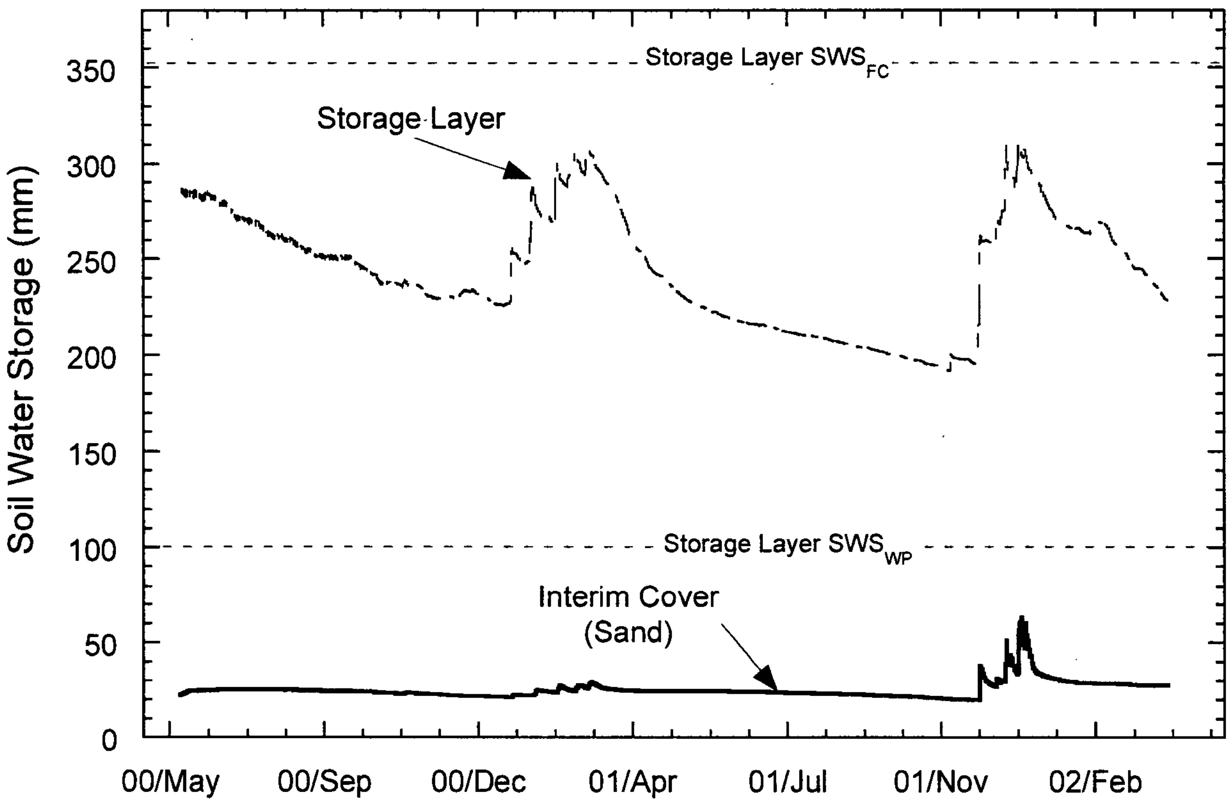


Fig. 4.21. Soil Water Storage of Individual Soil Layers for the Alternative Cover at the Marina Site.

Percolation from the conventional cover was transmitted during periods when the soil water storage of the vegetative layer (above the geomembrane) rose sharply (Fig. 4.21). Percolation was transmitted shortly thereafter because the compacted clay barrier beneath the geomembrane was placed wet of optimum water content. Percolation was still being transmitted by the conventional cover at the end of the monitoring period.

The relatively high percolation rate for this composite cover is probably due to punctures in the geomembrane. The vegetative cover was waste soil from nearby construction projects, and contained pieces of concrete and wire, which may have punctured the geomembrane. The waste soil was placed on top of the geomembrane without a protective layer (e.g., heavy geotextile) at the direction of the site owner even though a protection layer was recommended by the ACAP investigators.

Percolation from the alternative cover was transmitted during similar periods as the conventional cover, even though the soil water storage capacity was not exceeded. This may be due to preferential flow created by objects in the waste soil.

4.7 ALBANY SITE

Construction of the two test sections (conventional cover and alternative cover) at the Albany site was completed on March 18, 2000. Data collection began on April 19, 2000. Total precipitation during the monitoring period was 1615 mm. Irrigation was applied to the test sections to improve vegetative growth. During the monitoring period, 368 mm of irrigation was applied to the alternative cover and 46 mm to the conventional cover. The water balance for each cover is shown in Fig. 4.22.

4.7.1 Surface Runoff

Surface runoff during the monitoring period is show in Fig. 4.22. Surface runoff recorded from the conventional cover was 168.5 mm and from the alternative cover it was 15.4 mm. No surface runoff was generated as a result of irrigation. Precipitation events that occur in this region tend to be very intense, generating large volumes of surface runoff. Surface runoff was 10.6% of the total precipitation (excluding irrigation) for the conventional cover, and 1% of the total precipitation for the alternative cover. Surface ponding was also observed during large storms.

The topsoil layer of the conventional cover eroded significantly because the vegetation was poor. To remedy the erosion problem, the topsoil layer was replaced in Fall 2001, and re-seeded with perennial rye grass on October 29, 2001. The erosion exposed desiccation cracks in the clay barrier approximately 10 to 25 mm wide and 100 to 150 mm deep. These cracks probably induced preferential flow, and may have reduced surface runoff.

Ninety-one percent of the surface runoff (14 mm) from the alternative cover occurred during the first growing season, when the vegetation was not fully established. Surface runoff was only 1% of precipitation due to (1) a loosely placed topsoil layer, (2) the hearty grass understory that was established early, and (3) tilling and trench work performed on the topsoil layer. The soil placed back into the trenches was loosely compacted, creating a sink for precipitation.

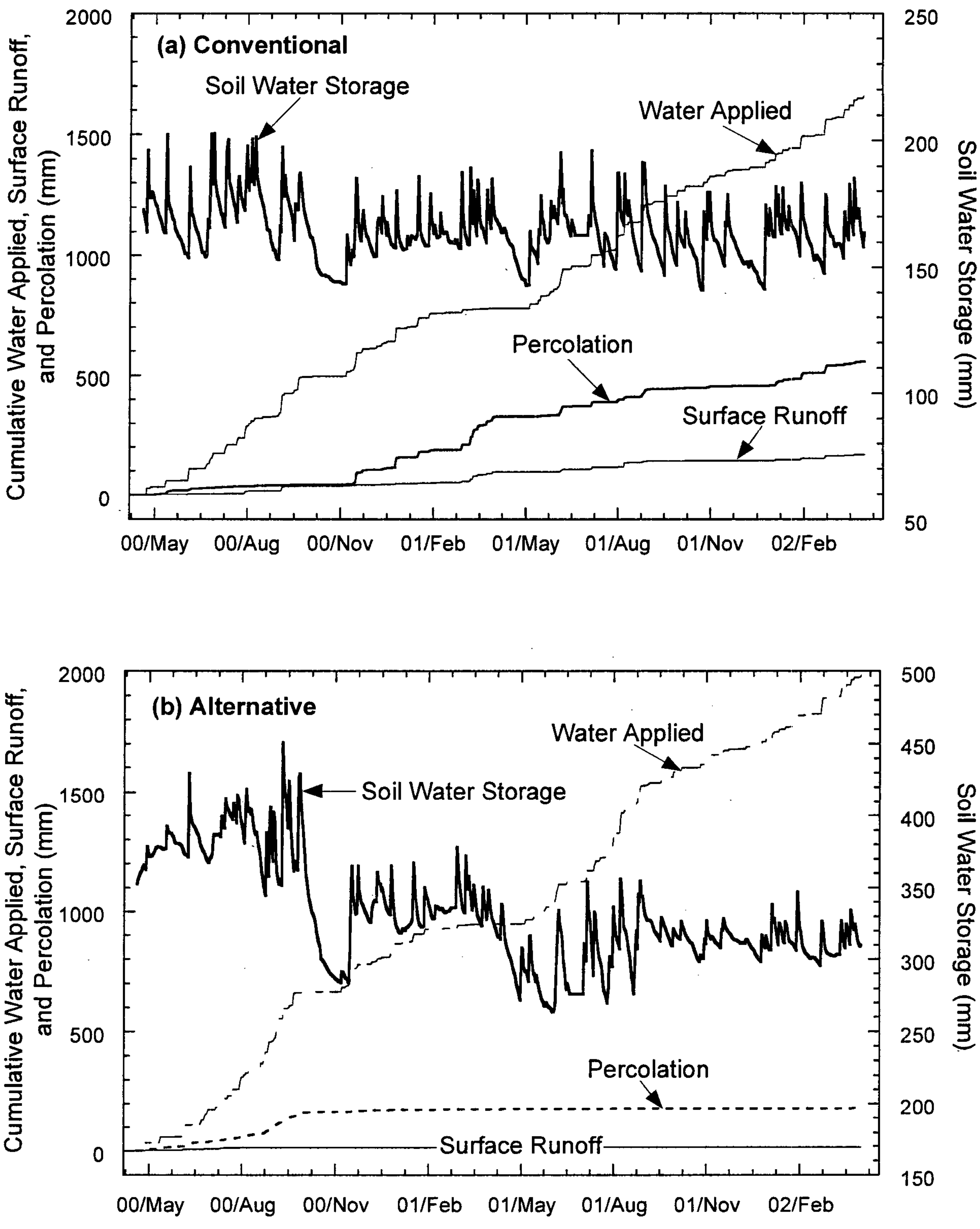


Fig. 4.22. Cumulative Water Balance at the Albany Site: (a) Conventional Cover and (b) Alternative Cover.

4.7.2 Soil Water Storage

The soil water storage record for the Albany site is shown in Fig. 4.23. Soil water storage for both covers fluctuated greatly throughout the entire monitoring period. The climate in Georgia can be characterized as hot and humid, with a lot of sunshine and intense rainstorms. This results in the entire soil profile becoming wet during rain events, followed by drying during subsequent days. The soil water storage capacity of both covers was never exceeded during the monitoring period, and never reached the wilting point.

For the alternative cover, the soil water storage dropped significantly in October 2000 due to the hybrid poplar trees becoming established (removing more available water) combined with a dry period (October 2000 thru mid-November 2000). Since then, soil water storage for the alternative cover has remained about 200 mm lower. In contrast, soil water storage for the conventional cover has remained approximately the same, on average, during the monitoring period.

4.7.3 Percolation

Percolation from both covers during the monitoring period is shown in Fig. 4.24. A large amount of percolation has been transmitted by both the conventional cover (468 mm) and alternative cover (180 mm).

The soil water storage capacity of the conventional cover was never exceeded during the monitoring period, even though significant percolation was recorded. Thus, flow most likely occurred through desiccation cracks. Preferential flow through the desiccation cracks became evident in November 2000, several months after

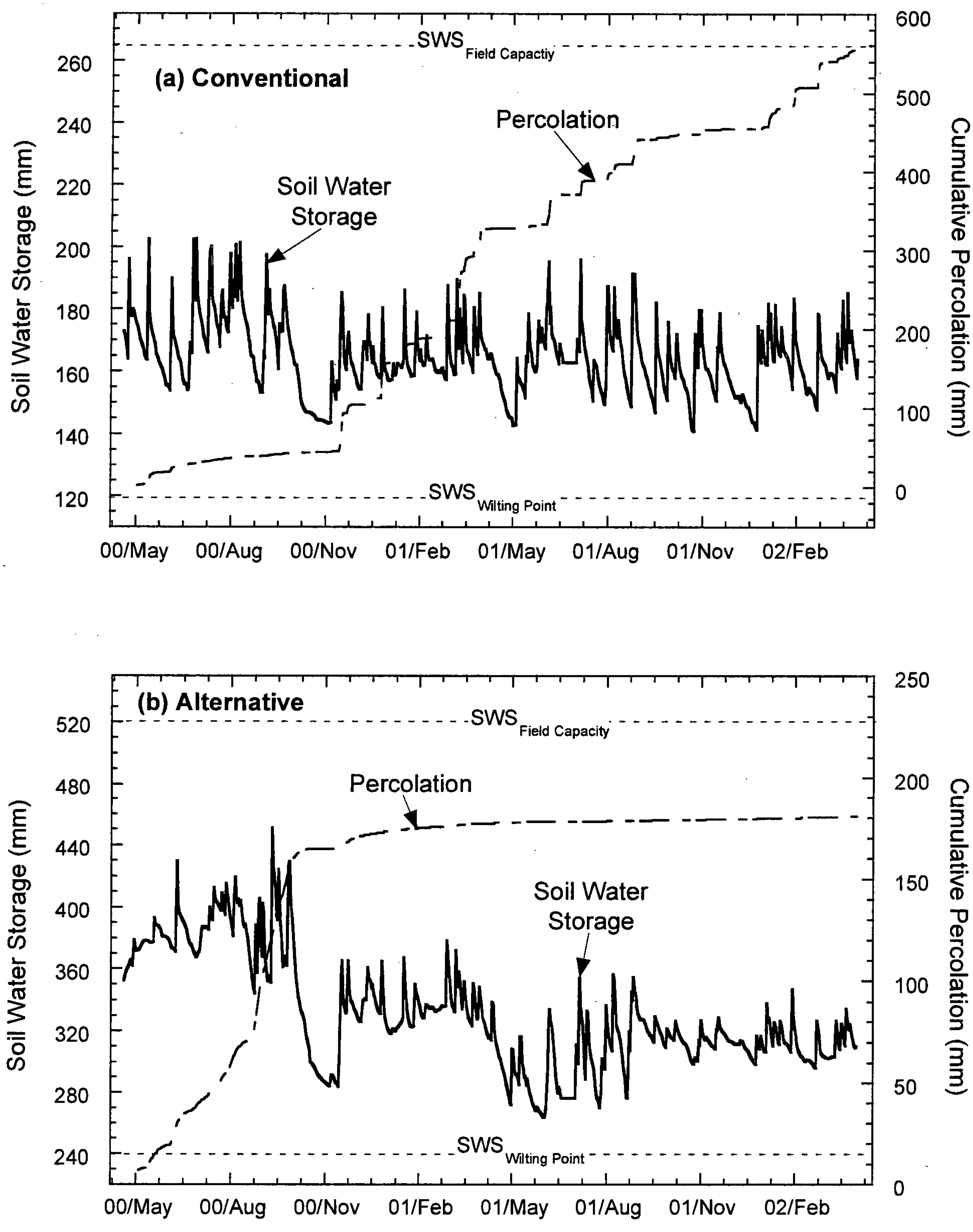


Fig. 4.23. Soil Water Storage Record at the Albany Site: (a) Conventional Cover and (b) Alternative Cover.

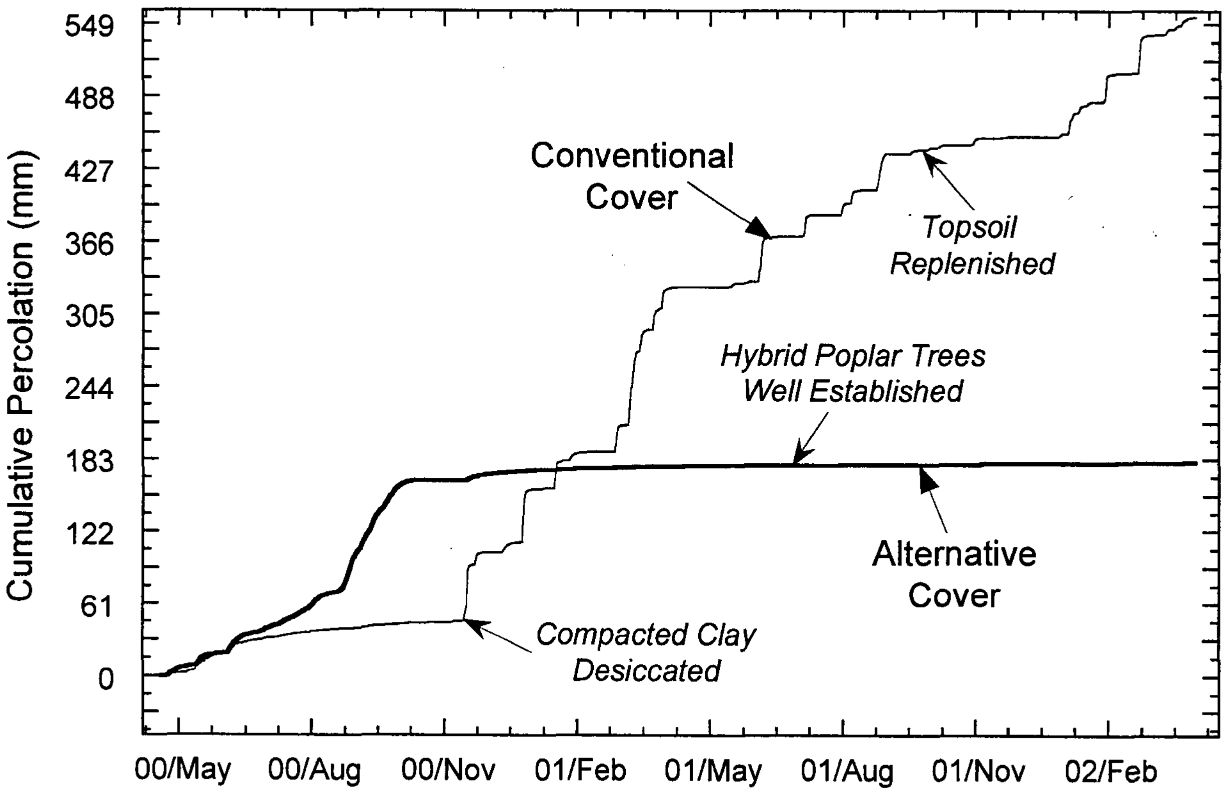


Fig. 4.24. Percolation at the Albany Site from the Conventional and Alternative Covers.

construction. Prior to mid November 2000, the percolation rate from the conventional cover was 83 mm/yr. After November, the percolation rate jumped to 385 mm/yr. In addition, the cumulative percolation increased smoothly prior to November 2000, but afterwards the percolation record was comprised predominately of pulses following precipitation events.

For the alternative cover, percolation was recorded immediately after construction, and sharply increased during the first growing season. In October 2000, the percolation rate diminished, after which only 10% (18 mm) of the total percolation was recorded. This drop in percolation rate can be attributed to transpiration by the hybrid poplar trees. Since January 2001, the percolation rate has been 6 mm/yr.

4.8 CEDAR RAPIDS SITE

Construction of three test sections at the Cedar Rapids site (composite cover, compacted clay cover, and alternative cover) was completed on October 2, 2000. Data collection began on October 3, 2000. Total precipitation during the monitoring period was 772 mm, of which 12.7% was frozen. The water balance for each test section is shown in Figs. 4.25 and 4.26. Data are presented only through October 18, 2001 due to a malfunction of the datalogger. The datalogger was repaired on March 20, 2002.

4.8.1 Surface Runoff

Surface runoff during the monitoring period is shown in Figs. 4.25 and 4.26. Surface runoff was 22.0 mm for the composite cover, 14.9 mm for the compacted clay cover, and 26.8 mm for the alternative cover. Surface runoff ranged between 1.9-3.5% of precipitation, with the alternative cover having the greatest fraction of runoff (3.5%).

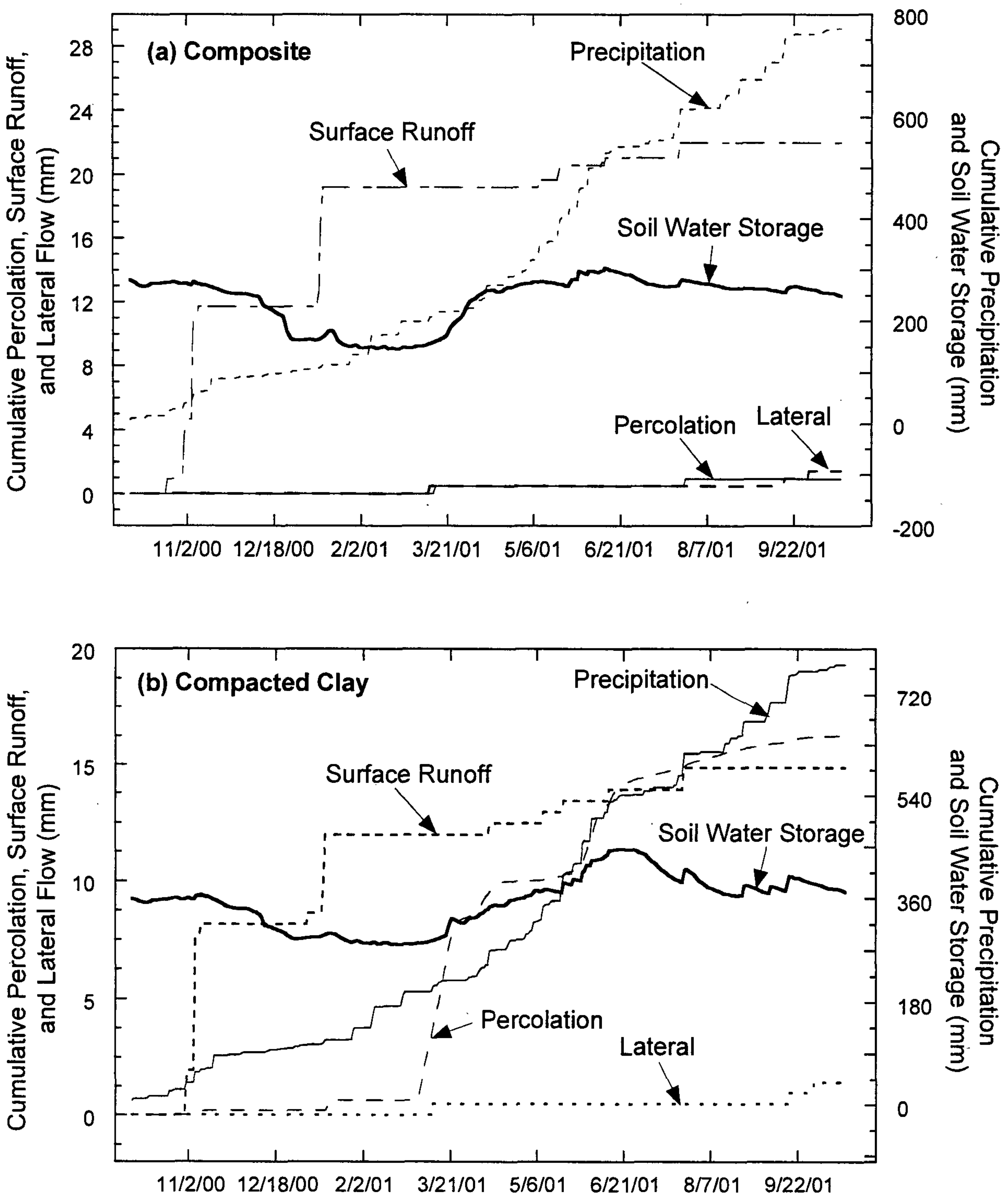


Fig. 4.25. Cumulative Water Balance at the Cedar Rapids Site: (a) Composite Cover and (b) Compacted Clay Cover.

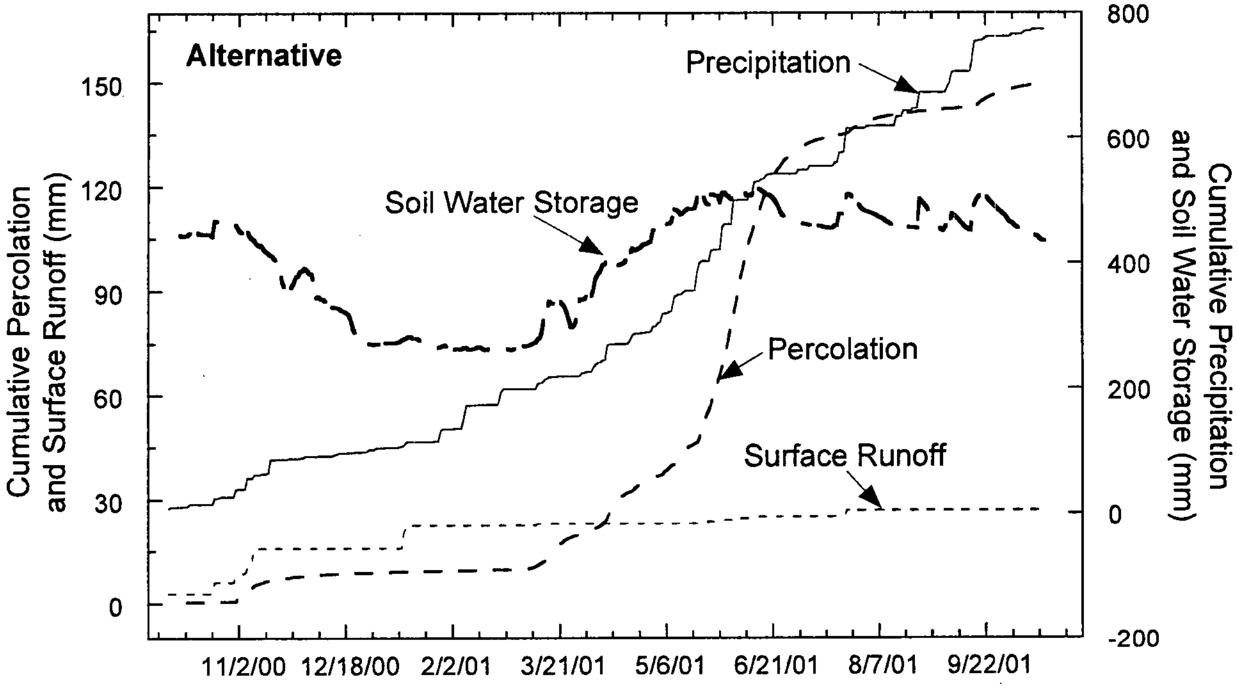


Fig. 4.26. Cumulative Water Balance at the Cedar Rapids Site: Alternative Cover.

The first major surface runoff event occurred on November 6, 2000 as a result of an intense rain event (17.5 mm). After this date, the air temperature dropped below 0°C, causing additional precipitation to be stored as snowpack. In the middle of January 2000, the air temperature rose above 0°C and rain was recorded, causing a large snowmelt event. Surface runoff was next recorded on the alternative cover on March 12, 2001 due to a snowmelt event from the on-set of the spring rains. This event did not produce any surface runoff from the conventional covers, even though the ground was still frozen for all covers (Fig. 4.27). Surface runoff was next recorded on April 11, 2001 for the compacted clay barrier as the result of an intense rain event (23 mm) and on May 10, 2001 for the composite barrier as the result of another intense rain event (23 mm).

4.8.2 Lateral Flow

Lateral flow records for the composite cover and compacted clay cover are shown in Fig. 4.25. Lateral flow was recorded for both the composite cover (1.44 mm) and compacted clay cover (1.44 mm) during the same time periods (March 12, September 12, and October 1, 2001).

4.8.3 Soil Water Storage

Soil water storage records are shown in Fig. 4.28. Hydraulic properties of each layer are presented in Tables 4.3 through 4.5. Soil water storage for each cover reaches a minimum during late summer, and reaches a maximum in late spring after the spring rains and snowmelt.

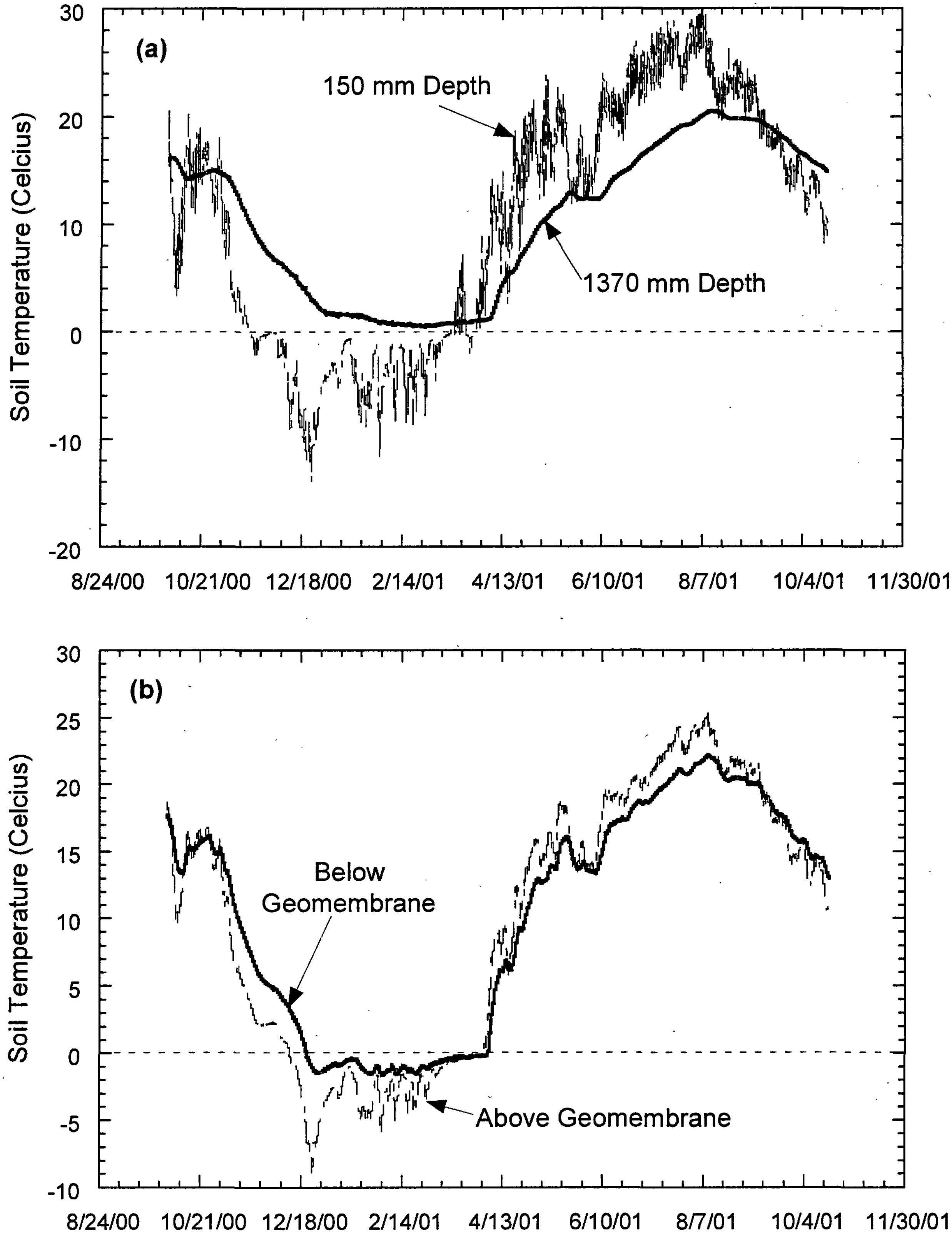


Fig. 4.27. Soil Temperatures in Test Sections: (a) Alternative Cover and (b) Composite Cover.

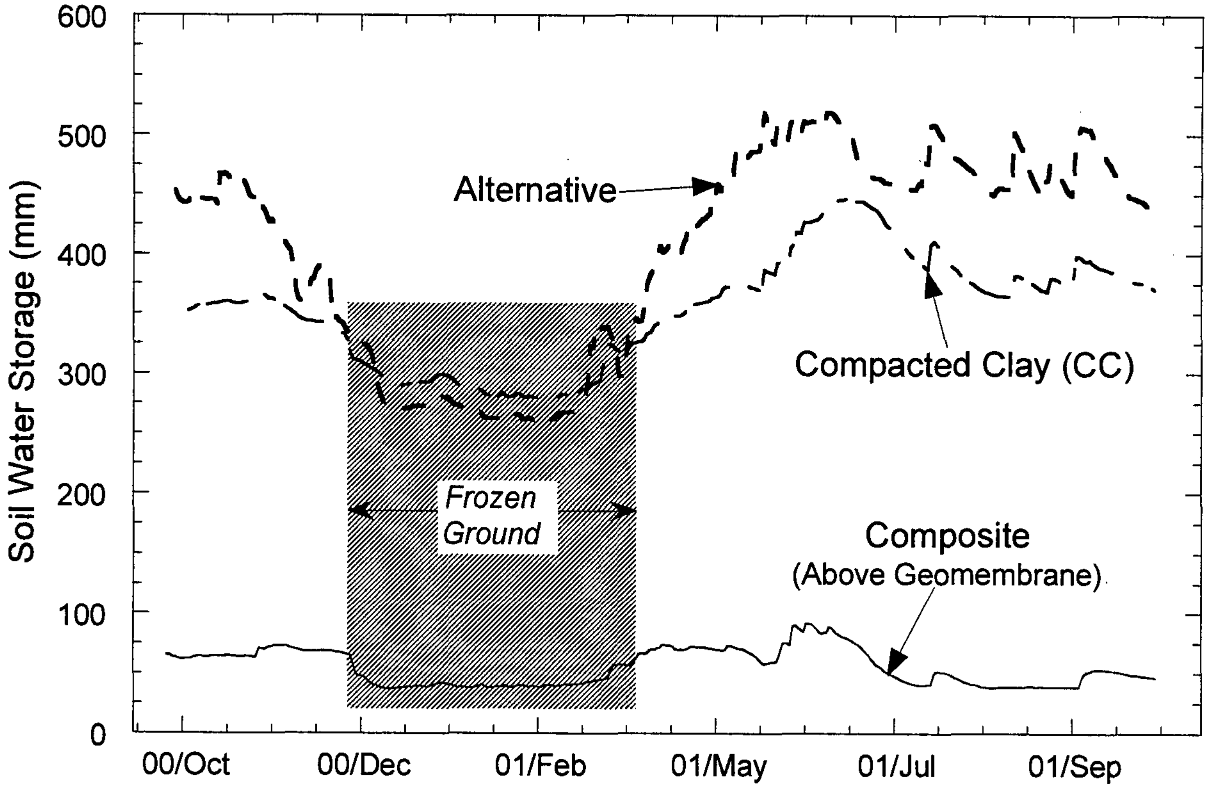


Fig. 4.28. Soil Water Storage at Cedar Rapids Site.

Table 4.3. Hydraulic Properties of the Alternative Cover at the Cedar Rapids Site.

Layer	θ_r	θ_s	α (cm^{-1})	n	Field Capacity	Wilting Point	K_s (cm/s)
Storage	0.00	0.33	0.00017	1.55	0.33	0.18	5.34×10^{-6}
Support	0.00	0.27	0.00028	1.40	0.27	0.15	2.52×10^{-7}
Interim Cover	0.00	0.27	0.00038	1.46	0.27	0.12	3.41×10^{-6}

Hydraulic properties from Gurdal (2002).

Table 4.4. Hydraulic Properties of the Compacted Clay Cover at the Cedar Rapids Site.

Layer	θ_r	θ_s	α (cm^{-1})	n	Field Capacity	Wilting Point	K_s (cm/s)
Topsoil	0.00	0.57	0.00331	1.27	0.49	0.20	2.0×10^{-5}
Barrier	0.00	0.29	0.00052	1.37	0.28	0.13	2.2×10^{-8}
Interim Cover	0.00	0.32	0.00011	1.54	0.32	0.21	2.5×10^{-6}

Hydraulic properties from Gurdal (2002). Laboratory testing not complete (parameters based on 5 of 20 samples collected during construction).

Table 4.5. Hydraulic Properties of the Composite Cover at the Cedar Rapids Site.

Layer	θ_r	θ_s	α (cm^{-1})	n	Field Capacity	Wilting Point	K_s (cm/s)
Topsoil	0.00	0.53	0.00331	1.27	0.45	0.18	5.8×10^{-6}
Barrier	0.00	0.29	0.00010	1.91	0.29	0.17	1.7×10^{-8}
Interim Cover	0.00	0.31	0.00021	1.48	0.31	0.17	7.2×10^{-6}

Hydraulic properties from Gurdal (2002). Laboratory testing not complete (parameters based on 6 of 16 samples collected during construction).

During the winter, the apparent drop in soil water storage is an artifact of frozen ground conditions (Fig. 4.27). The WCRs record only the unfrozen water content, and thus do not reflect the actual volume of water during frozen conditions. Temperatures below 0°C were measured throughout the entire cover profile in the composite cover, to a depth of 600 mm in the compacted clay cover (i.e., bottom of topsoil layer), and to a depth of 920 mm in the alternative cover (bottom of storage layer).

For the composite cover, soil water storage in the topsoil layer increases in early Spring 2001, after the spring thaw (see Fig. 4.29). The soil water storage decreases slightly in the late spring, likely due to evapotranspiration, and then increases after several large rain events. During Summer 2001, soil water storage in the topsoil layer decreases appreciably due to evapotranspiration. Soil water storage reaches the wilting point during the summer.

For the compacted clay cover, soil water storage in the topsoil and compacted clay layers increased significantly due to the spring thaw (see Fig. 4.30a). The capacity of the compacted clay layer was exceeded in late Spring 2001, despite the capacity of the topsoil layer not being exceeded. During the summer, soil water storage in the topsoil layer decreases rapidly to the wilting point, and fluctuates throughout the summer due to rain events. Soil water storage in the compacted clay layer is slowly reduced during the summer, most likely due to water draining through the cover, rather than by evapotranspiration.

For the alternative cover, soil water storage in the storage and support layers increased significantly due to spring thaw (see Fig. 4.30b). The capacity of the support layer was exceeded by late spring, despite the capacity of the storage layer not being

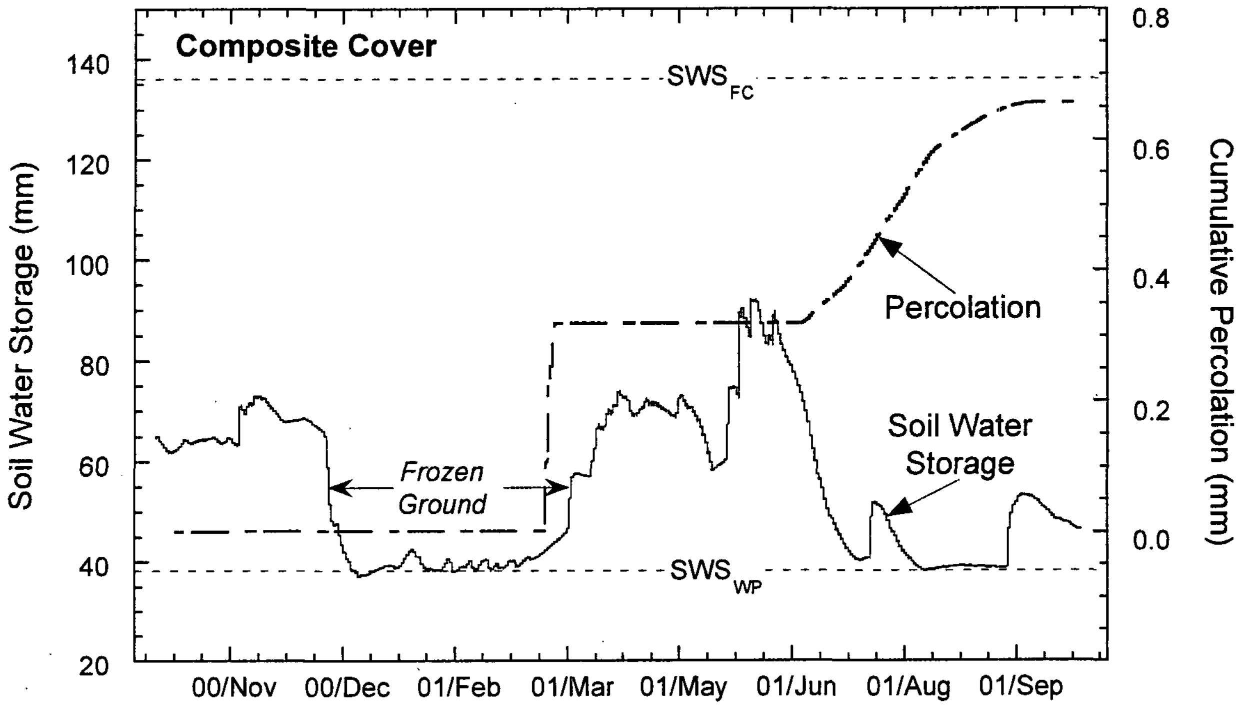


Fig. 4.29. Soil Water Storage of Topsoil Layer and Cumulative Percolation for the Composite Cover at the Cedar Rapids Site.

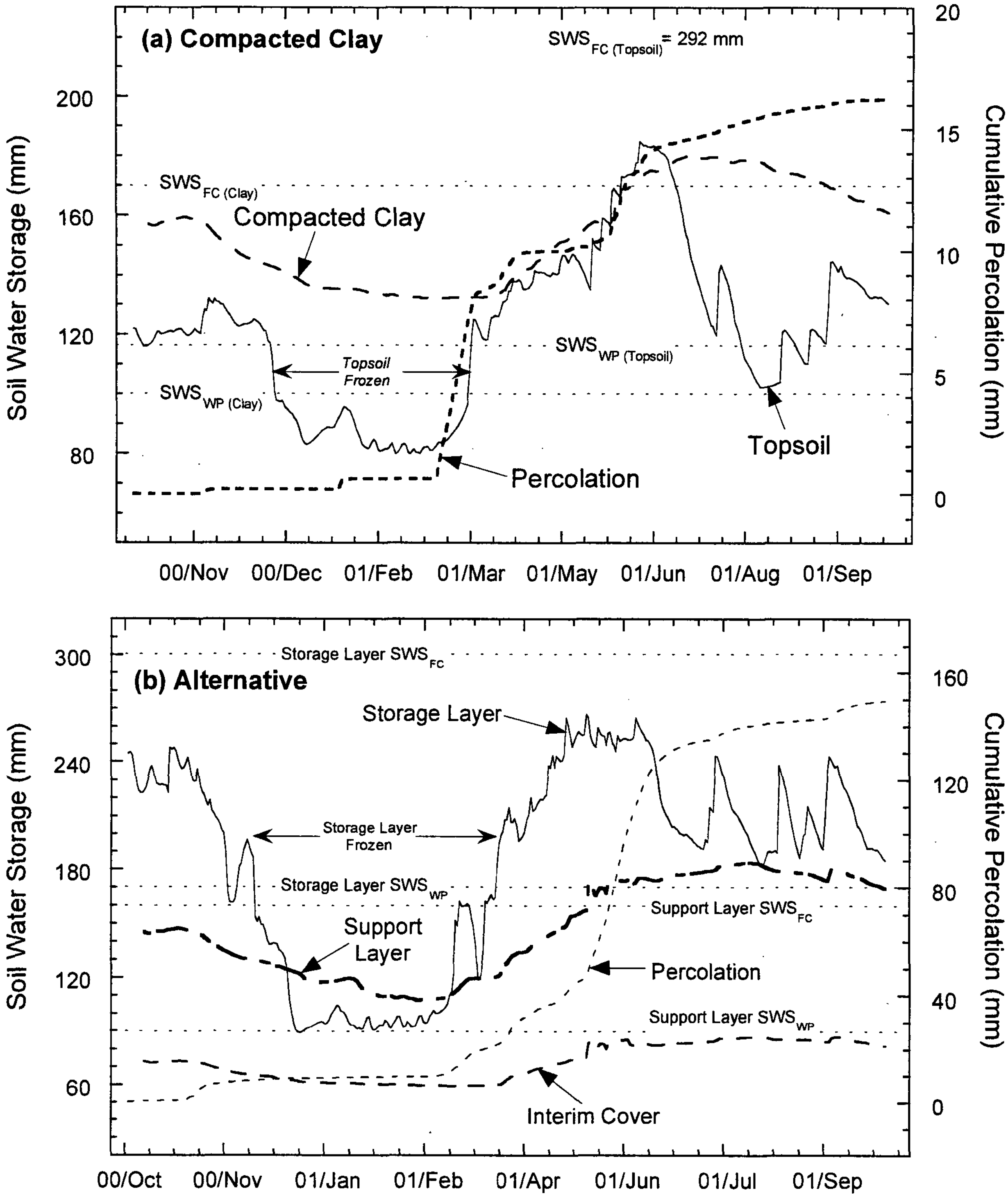


Fig. 4.30. Soil Water Storage of Individual Soil Layers at Cedar Rapids Site: (a) Compacted Clay Cover and (b) Alternative Cover

exceeded. Flow through the storage layer was likely through preferential flow paths, which were likely created by trenching during installation of the trees. During the summer, soil water storage in the storage layer first decreased rapidly, and then fluctuated throughout the summer due to rain events. The trees and the understory of grass are capable of maintaining the soil water storage of the storage layer well below the field capacity during the summer, but little water is removed from the support layer. Water is probably not being removed from the support layer as of yet because the roots have not yet penetrated to this depth.

4.8.4 Percolation

Percolation was recorded from each cover during the monitoring period (Fig. 4.31). The least percolation was from the composite cover (0.94 mm), then the compacted clay cover (16.2 mm), and the alternative cover (149.4 mm).

Percolation was first transmitted from each cover during the same time period (March 10-22, 2001), in response to a large snowmelt event accompanied by rain. All of the snowmelt infiltrated the cover profiles because the ground surface was no longer frozen. During this period, the composite cover transmitted a pulse of percolation (0.45 mm), whereas the compacted clay and alternative covers began to transmit significant percolation regularly throughout the remainder of the monitoring period. Prior to March 10, 10 mm of percolation was transmitted from the alternative cover.

A pulse of percolation was first transmitted from the composite cover in early Spring 2001, due to the spring thaw (Fig. 4.29). Percolation was transmitted again in Summer 2001 after heavy rains. The percolation rate increased as the soil water storage of the topsoil layer decreased, and then tailed off towards the end of the monitoring period, when the topsoil layer reached the wilting point.

For the compacted clay cover, percolation initially was transmitted during warmer periods in the winter. This percolation is probably due to thaw consolidation and drainage. Percolation began again in the spring as field capacity was approached, and then tailed off towards the end of the monitoring period, as the soil water storage in the compacted clay layer decreased (Fig. 4.30a).

For the alternative cover, percolation was readily transmitted through the cover profile, most likely due to preferential flow paths. The percolation rate increased significantly when the soil water storage of the support layer was exceeded in late Spring 2001 (Fig. 4.30b).

4.9 OMAHA SITE

Construction of three test sections (one conventional cover and two alternative covers) at the Omaha site was completed on August 11, 2000. Data collection began on October 5, 2000. Total precipitation recorded during the monitoring period was 719 mm, 8.7% of which was frozen. The water balance for each test section is shown in Figs. 4.32 and 4.33. Precipitation records have not been acquired since December 6, 2001 because the rain gauge malfunctioned.

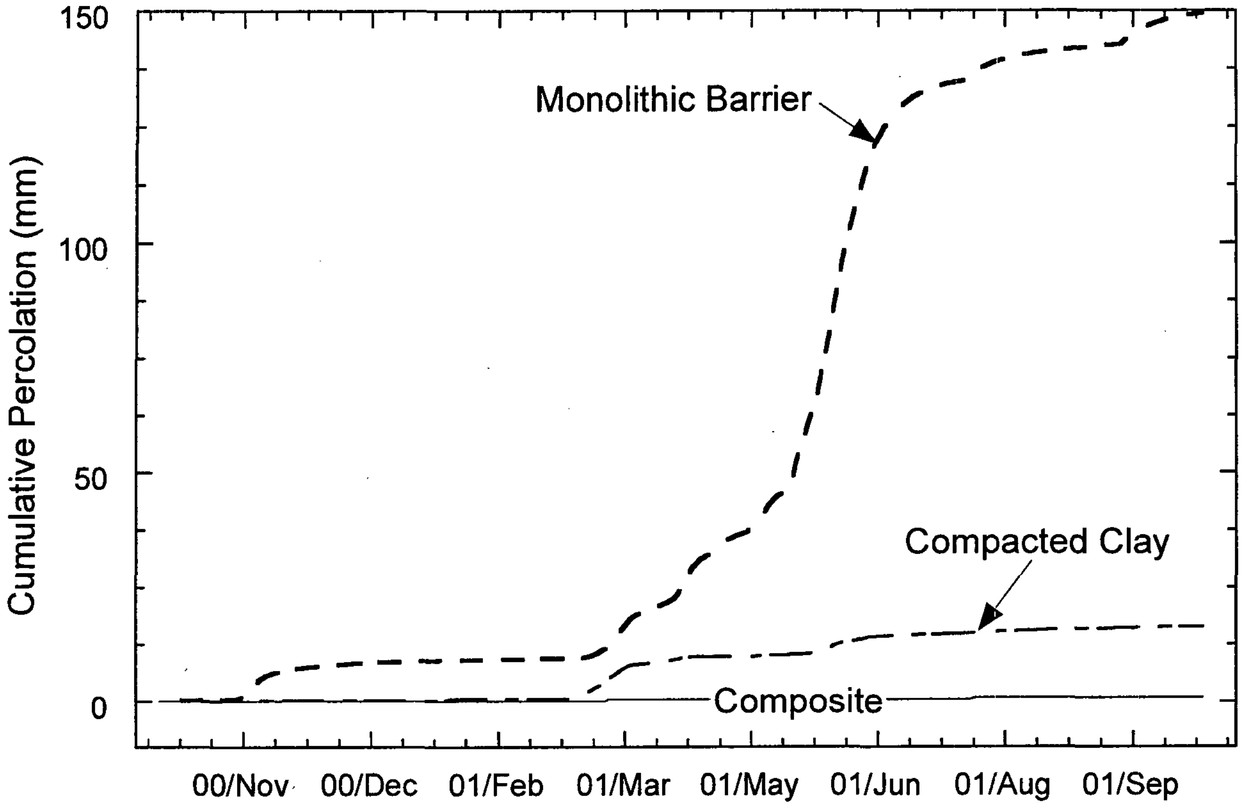


Fig. 4.31. Percolation from Test Sections at Cedar Rapids Site.

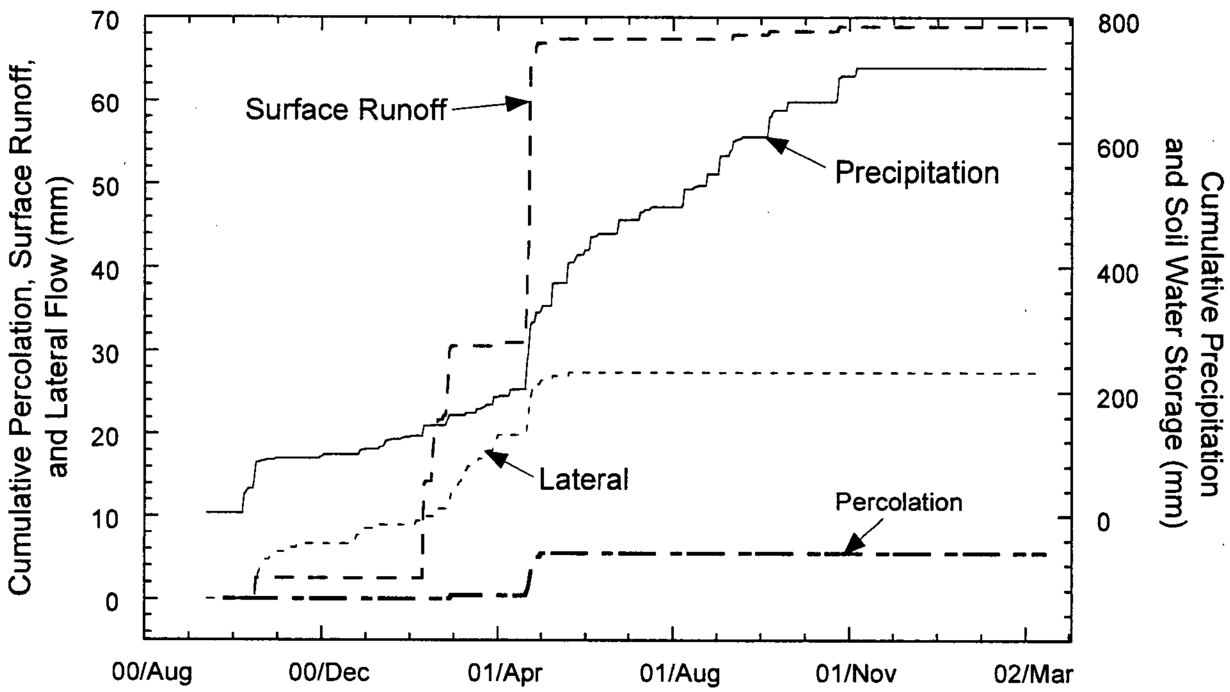
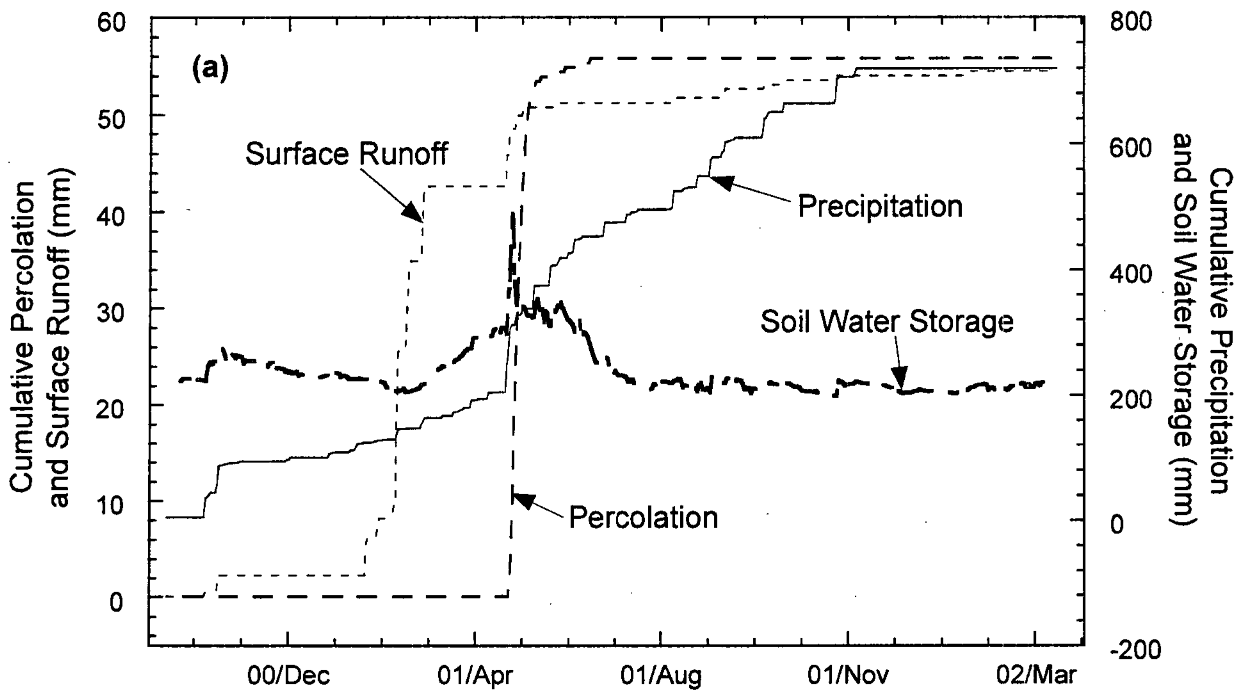


Fig. 4.32. Cumulative Water Balance at the Omaha Site: Conventional Cover.



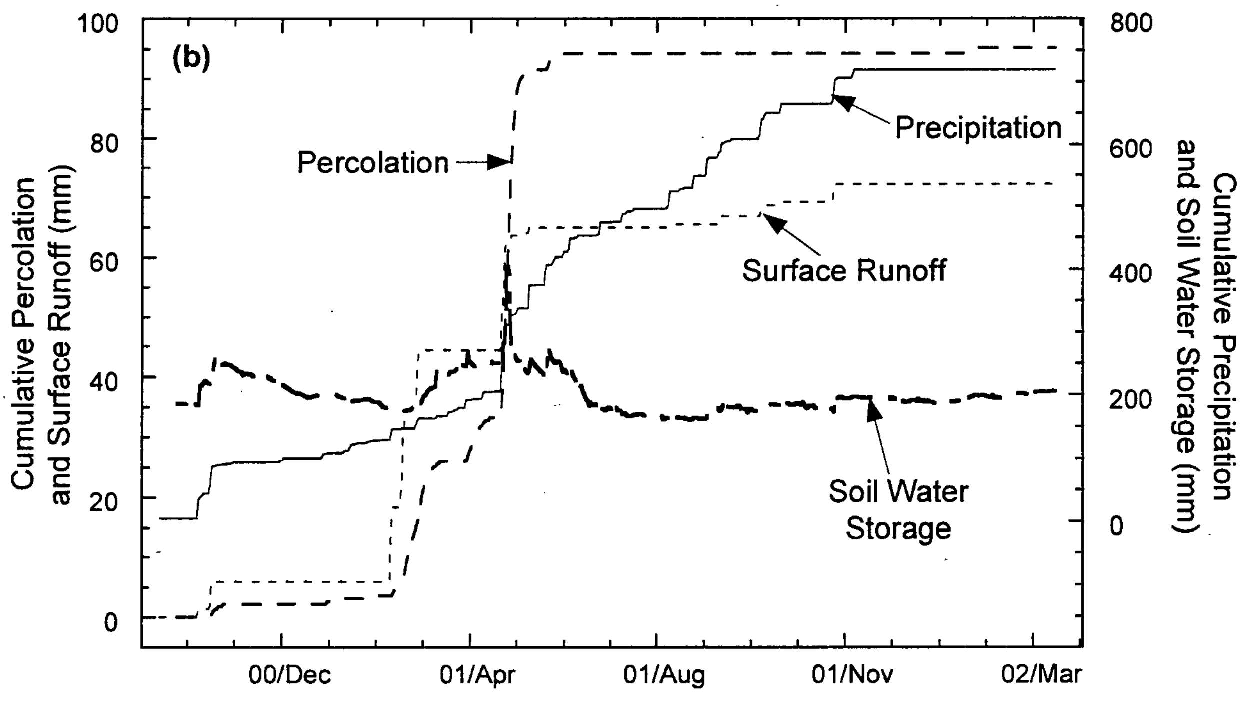


Fig. 4.33. Cumulative Water Balance at the Omaha Site: (a) Thin Capillary Barrier (760 mm) and (b) Thick Capillary Barrier (1060 mm).

4.9.1 Surface Runoff

Surface runoff is shown in Figs. 4.32 ad 4.33. Surface runoff was 68.8 mm from the composite barrier, 72.3 mm from the thin capillary barrier (760 mm), and 54.4 mm from the thick capillary barrier (1060 mm), corresponding to 7.5-10.1% of precipitation. The surface runoff from each cover is comparable because the covers have the same vegetation, slope, and topsoil.

Surface runoff was generated by intense rain and large snowmelt events, such as three large rain events during Spring and Fall 2001 that accounted for 36% of precipitation. Also, snow melt (approximately 39 mm) occurring at the end of February 2001 and the beginning of March 2001 caused considerable surface runoff (28 mm from the composite cover, 38 mm from the thin capillary barrier, and 38 mm from the thick capillary barrier). Between 72-97% of the snowmelt became surface runoff because of frozen ground conditions.

No surface runoff was recorded during Spring 2002. The absence of runoff is likely due to the vegetation being established, and the mild winter in 2002. The mild winter prevented the ground surface from freezing (Fig. 4.34), and therefore precipitation was not shed as easily as in 2001.

4.9.2 Lateral Flow from Conventional Cover

Lateral flow from the conventional cover is shown in Fig. 4.32. Lateral flow during the monitoring period was 27.4 mm, with the majority of flow being the result of snowmelt and intense rain events. Water that infiltrated during the intense rain events reached the geomembrane with very little delay.

4.9.3 Soil Water Storage

The soil water storage record for the Omaha site is shown in Fig. 4.35. Soil water storage for each cover typically begins to increase in late winter due to the spring thaw, and decreases during the summer. The large peaks in soil water storage (Fig. 4.36) are caused by a large and abrupt increase in water content in the sand layer, caused by an intense rain event (132.6 mm) on May 3-13, 2001.

Soil water storage for all covers reaches a peak after the spring thaw in 2001, and begins to decrease during the summer, as expected. Soil water storage in each cover also appears to drop during Winter 2000. However, this drop in soil water storage is an artifact of frozen ground conditions. During Winter 2001, soil water storage is not affected by frozen ground conditions because of the mild winter (Fig. 4.34).

For the alternative covers, the vegetation is capable of removing most of the available soil water during the summer.

4.9.4 Percolation

Percolation during the monitoring period is shown in Fig. 4.37. The conventional cover transmitted 5.5 mm of percolation, the thin (760 mm) capillary barrier transmitted 95.1 mm of percolation, and the thick (1060 mm) capillary barrier transmitted 55.7 mm of percolation. The majority of the percolation from each cover occurred during a single period (May - June 2001), during which a large amount of rainfall was recorded.

Percolation was transmitted from the "thin" capillary barrier on several occasions, with the first being on November 6, 2000 due to 43 mm of rain. Percolation was also transmitted between March 12-15, 2001 due to 23.5 mm of rain and snow melt, and

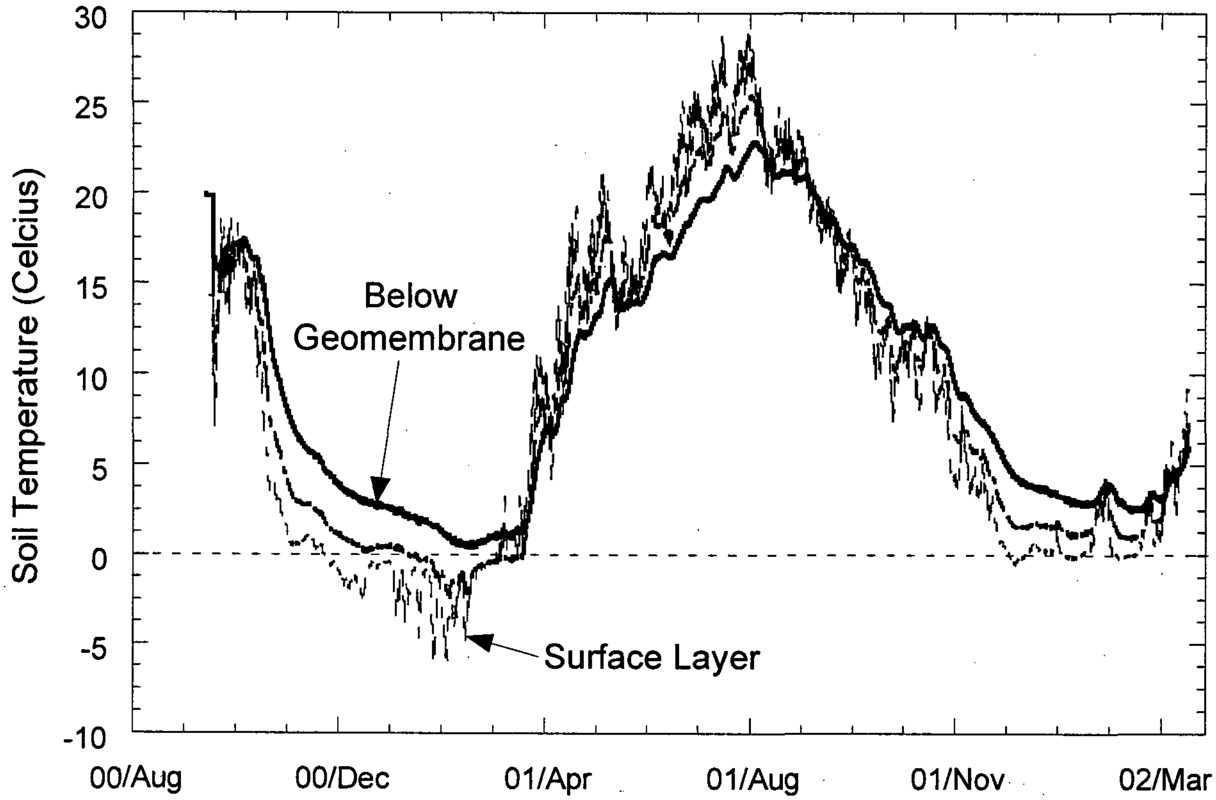


Fig. 4.34. Soil Temperatures in Conventional Cover at the Omaha Site.

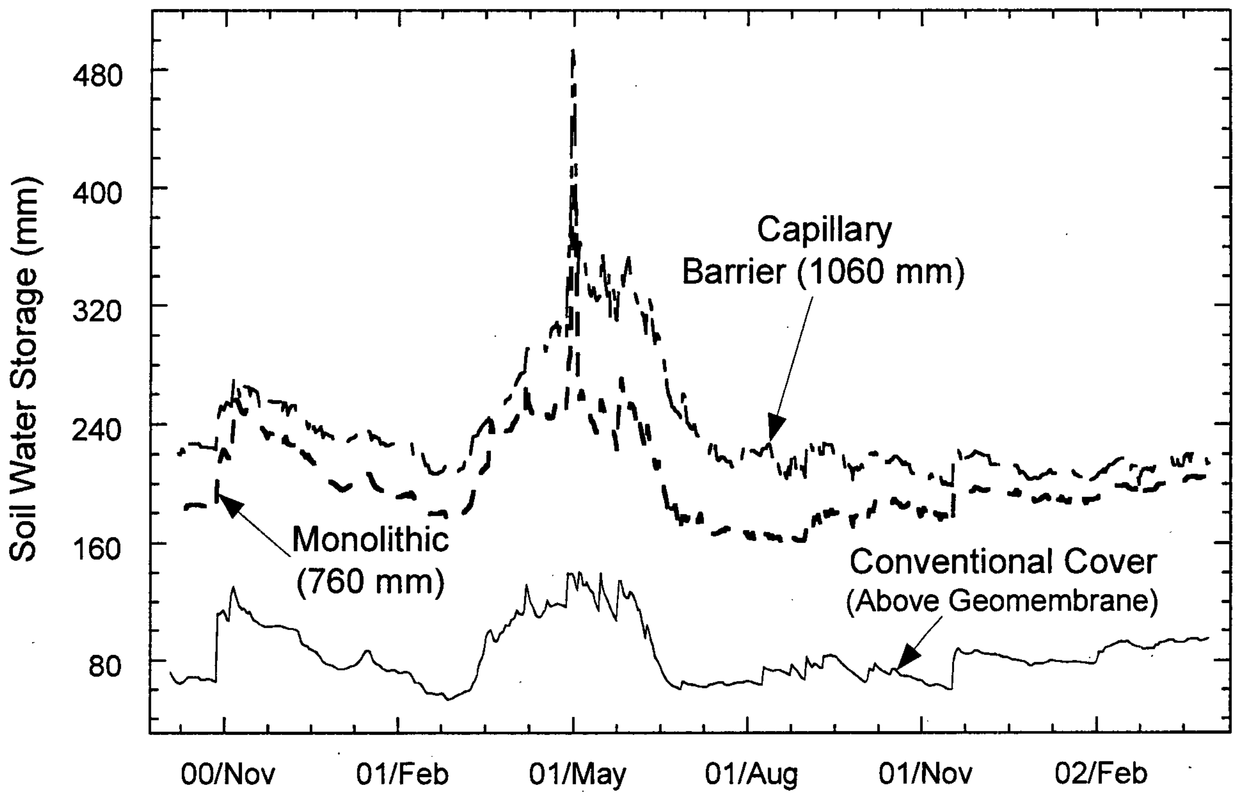


Fig. 4.35. Soil Water Storage at the Omaha Site.

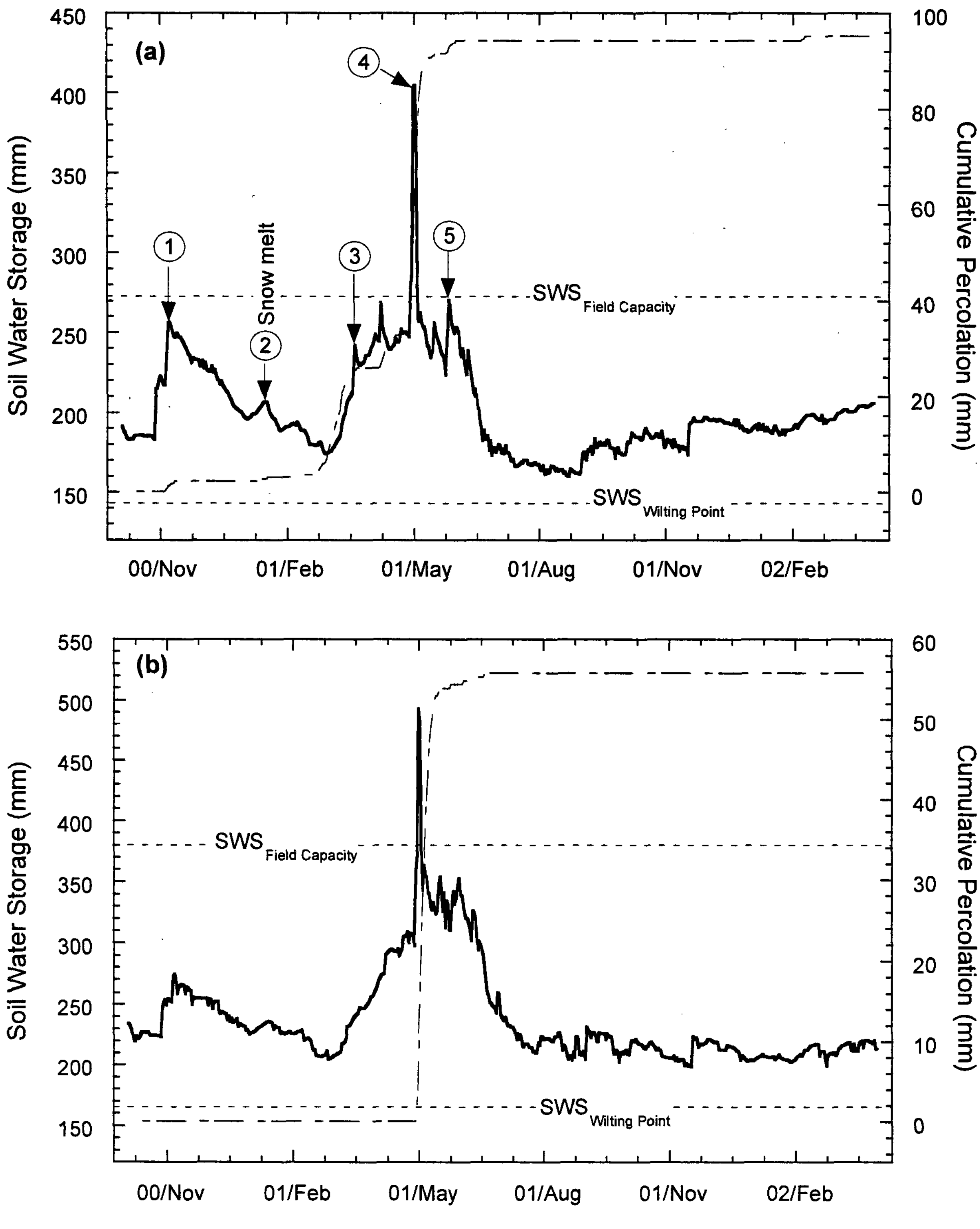


Fig. 4.36. Soil Water Storage and Percolation at Omaha Site: (a) Thin Capillary Barrier (760 mm) and (b) Thick Capillary Barrier (1060 mm).

between May 3-13, 2001 due to 122 mm of rain. The percolation events from the thin capillary barrier correspond to peaks in the soil water storage record, as shown in Fig. 4.36. The exception is the second event, but the storage reported for this event is artificially low due to the impact of frozen soil on water contents reported by the WCRs. The first peak (220 mm) corresponds to the lowest soil water storage that induced percolation. Thus, the soil water storage capacity of the thin capillary barrier appears to be approximately 220 mm.

The thick capillary barrier transmitted less percolation than the thin capillary barrier because the thicker barrier has greater soil water storage capacity. All of the percolation can be attributed to the heavy rain during early May. Percolation from the thick barrier ceased when the soil water storage dropped below 350 mm. Thus, the soil water storage capacity of the thick capillary barrier is at least 350 mm.

4.10 MONTICELLO SITE

Construction of the alternative cover at the Monticello site was completed on June 23, 2000. Data collection began on August 2, 2000. Total precipitation recorded during the monitoring period was 514 mm, 30.5% of which was frozen. The water balance for the test section is shown in Fig. 4.38.

4.10.1 Surface Runoff

Surface runoff during the monitoring period is shown in Fig. 4.38. The total surface runoff was 9.3 mm, or 1.8% of precipitation. Surface runoff was collected in a 20 m by 10 m test plot, within the 3.0 ha portion of the final cover being monitored. Surface

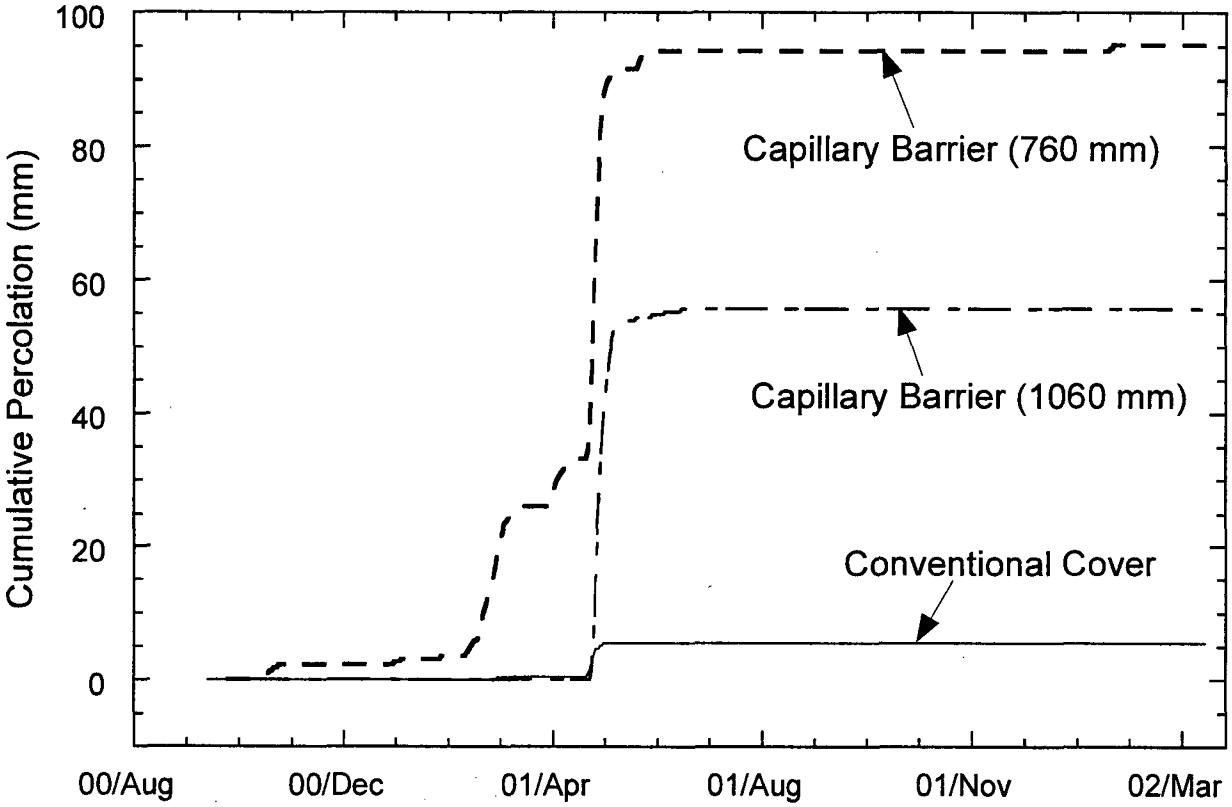


Fig. 4.37. Percolation at the Omaha Site.

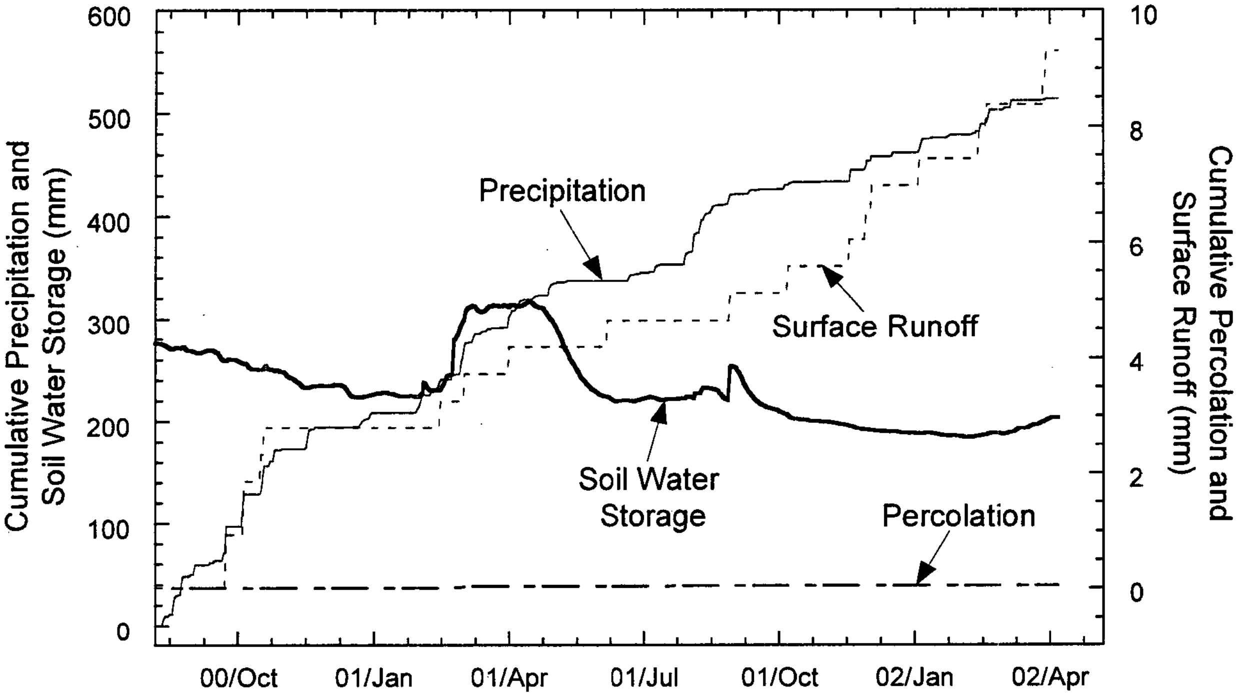


Fig. 4.38. Cumulative Water Balance for the Alternative Cover at the Monticello Site.

runoff is measured in a large area with sparse vegetation, whereas the remainder of the final cover has significantly less bare soil. The vegetative cover differed because the topsoil admixture was obtained from two separate borrow areas, which had different organic content.

Surface runoff occurred during large rainfall events (typically greater than 10 mm), or during large snow melt events. Almost one quarter of the surface runoff came from snowmelt, during which the surface layer was frozen. Soil temperatures below the 200 mm thick surface layer never went below 0°C, and sub-freezing temperatures in the surface layer would only be measured for short durations, typically in January and February.

4.10.2 Soil Water Storage

Soil water storage of entire cover profile for the alternative cover is shown in Fig. 4.39. Hydraulic properties of each layer are presented in Table 4.6.

Soil water storage increased in late winter and early spring, due to large snowmelt and rain events. During the summer, the soil water storage decreases significantly, but does not reach the wilting point. In August and September 2001, Monticello received 73 mm of rainfall, which briefly increased the soil water storage. Soil water storage remained at a minimum during Winter 2002, and began increasing again in early Spring 2002 due to the spring thaw.

The water content in topsoil increases significantly in February 2001, and then rapidly decreases due to water draining into the primary storage layer. During the following summer, the topsoil water content is further reduced by evapotranspiration,

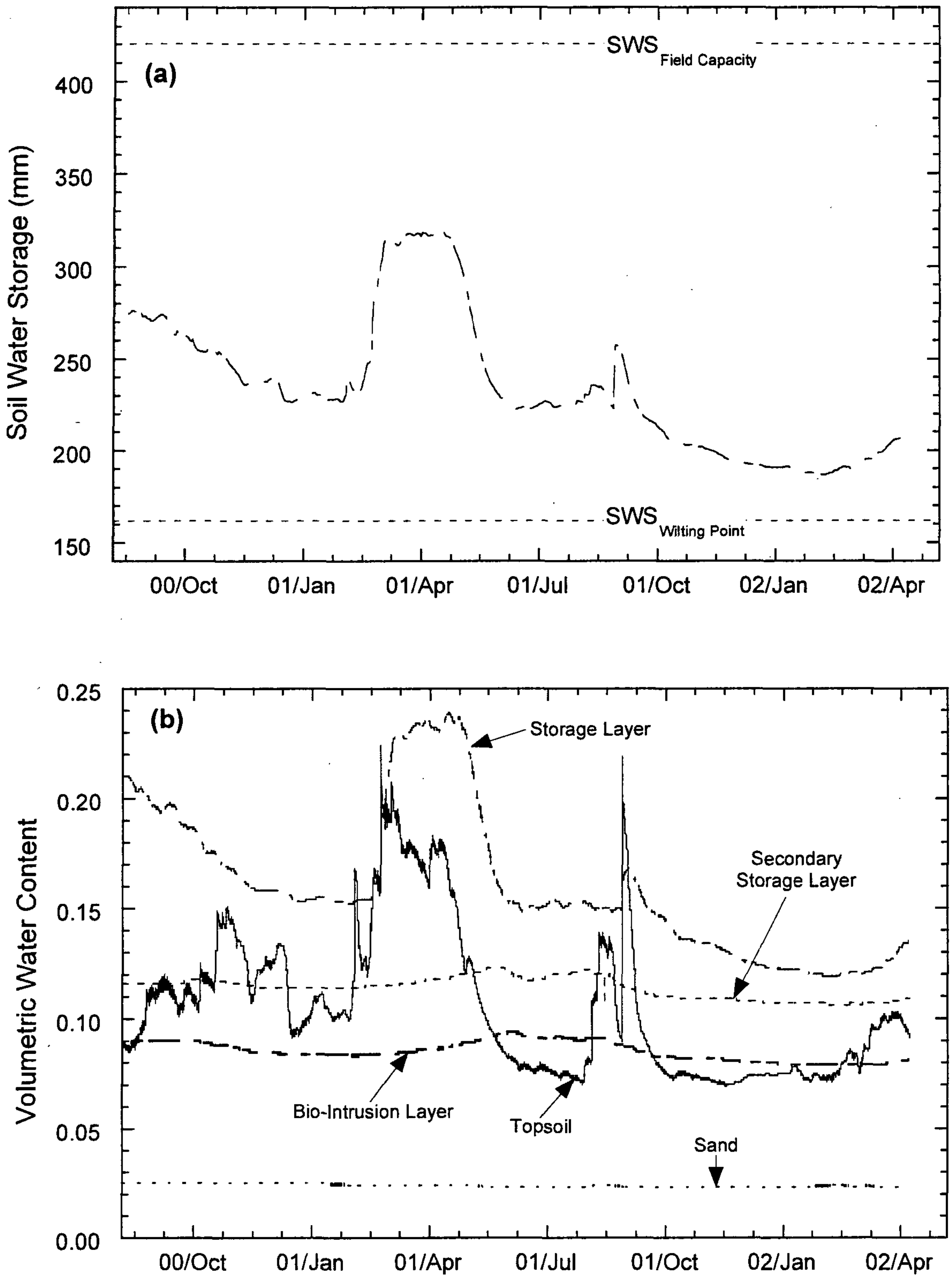


Fig. 4.39. Alternative Cover at the Monticello Site: (a) Soil Water Storage, and (b) Average Water Content in Each Layer

Table 4.6. Hydraulic Properties of the Alternative Cover at Monticello.

Layer	θ_r	θ_s	α	n	Field Capacity	Wilting Point	K_{sat} (cm/s)
Soil/Gravel Admixture [a]	0.00	0.46	0.0163	1.37	0.24	0.06	8.4×10^{-4}
Storage [b]	0.00	0.30	0.000350	1.38	0.30	0.11[c]	3.4×10^{-5}
Bio-Intrusion [a]	0.03	0.29	8.10	1.78	0.03	0.03	1.4×10^{-2}
Secondary Storage [b]	0.00	0.30	0.000350	1.38	0.30	0.11[c]	4.9×10^{-5}
Sand [a]	0.03	0.32	0.5380	1.68	0.04	0.03	8.6×10^{-5}

[a] Hydraulic properties from Meyer and Serne (1999).
[b] Hydraulic properties from Gurdal (2002).
[c] Wilting point based on lowest water content measured in root zone during the monitoring period.

and approaches the wilting point (θ_{WP}=0.06). The water content of the storage layer does not begin decreasing until later Spring 2001, and does not reach the wilting point (θ_{WP}=0.11). Water contents (Fig. 4.39b) below the primary storage layer did not change significantly (less than ± 0.01) throughout the monitoring period.

4.10.3 Percolation

Cumulative percolation during the monitoring period was less than 0.04 mm. Percolation was transmitted through the cover in later Winter 2001 and early Spring 2001, at which time the soil water storage in the cover was at its minimum. Breakthrough into the sand layer during the monitoring period is not apparent in the water content data (Fig. 4.39). However, WCR probes were installed in only three nests, within the 3 ha area. Thus, isolated points of breakthrough would be difficult to capture.

SECTION FIVE
EVALUATION OF WATER BALANCE MODELS

Two models were used to simulate field conditions at eight of the ACAP sites described in Section 3.2. These models are the Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3 (Schroeder et al. 1994) and the Unsaturated Water and Heat Flow (UNSAT-H) Model, Version 2.04 (Fayer and Jones 1990). The models differ appreciably in formulation. HELP uses a water routing approach assuming unit gradient flow, whereas UNSAT-H solves a modified form of Richards' equation describing unsaturated flow, root water uptake, and evaporation from the soil surface. A detailed comparison of the formulations can be found in Khire et al. (1997).

5.1 WATER BALANCE COMPUTATIONS

The water balance of a landfill cover consists of water entering the system from precipitation (P), and water leaving the system via evapotranspiration (ET), lateral drainage (L_o), surface runoff to adjacent areas (R_o), and/or percolation (P_r). The difference between the water entering and exiting the system is the change in soil water storage (ΔS). Mathematically, the water balance is written as (Tanner 1967):

$$P = ET + R_o + L_o + P_r + \Delta S \quad (1)$$

To apply Eq. 1 to the ACAP demonstration, the following assumptions were made: (1) interception of precipitation by the plant canopy is negligible, (2) all water movement is downward, except for lateral flow in drainage layers and (3) no water is stored on the surface. Measurements of P_r, R_o, L_o, P, and ΔS are made continuously in each ACAP test section. ET is obtained by re-arranging Eq. 1:

$$ET = P - P_r - R_o - L_o - \Delta S \tag{2}$$

Because ET is computed as a residual quantity via Eq. 2, it includes the errors inherent in each of the water balance quantities being measured. In addition, Eq. 2 does not account for the dynamic effects in the system on a small time scale. For example, daily ET may be overestimated at times due to a delay in response between percolation and precipitation events. See Appendix 1 for an explanation of the ET computation and the methods used to correct errors in the ET calculation.

5.2 HELP MODEL FORMULATION

HELP is a quasi-two-dimensional hydrologic model used to predict the water balance of landfills, including the cover system (Schroeder et al. 1994). Input parameters include meteorological data (air temperature, solar radiation, and precipitation), soil properties (field capacity and the wilting point, initial water content, saturated hydraulic conductivity, and surface runoff curve number), plant characteristics (maximum LAI and growing season), and design attributes (layer types and thickness). The parameters are used in a series of algorithms to calculate the daily water balance. Schroeder et al. (1994) provide a detailed description of the algorithms.

HELP models water movement from the top of the profile to the bottom, beginning with input of precipitation. Precipitation is rainfall when the mean temperature is above 0°C and no snow cover is present, or is stored as snow pack when the mean temperature is below 0°C. Rainfall is immediately applied to the system, whereas the snow pack must first be melted. HELP calculates snowmelt using the SNOW-17 algorithm when the mean temperature is above 0°C (Anderson 1973). The snowmelt calculation depends on whether rain is occurring when the air temperature is above 0 °C. Rain-on-snowmelt is computed using an energy balance approach, whereas snow melt without rain is computed using air temperature as an index of energy exchange across the snow-air interface (Schroeder et al. 1994). The water applied to the system can become surface runoff, infiltration, and evapotranspiration. HELP also includes water as a result of daily soil thawing. The daily thaw is assumed to be 5 mm, and is assigned as infiltration.

Daily runoff is a function of daily rainfall and a surface retention parameter, which is related to soil properties (water content, field capacity, and wilting point) and a runoff curve number. The curve number can be specified based on an antecedent moisture condition or computed by HELP using an algorithm that accounts for slope length, slope angle, soil texture, and properties of the vegetation. Maximum surface retention occurs when the volumetric water content at the surface is midway between field capacity and the wilting point. When the ground surface is frozen, HELP increases the surface runoff curve number, thereby reducing the infiltration capacity of the soil. The calculated surface runoff approaches the net water applied when frozen ground conditions exist. HELP uses a modification of algorithms from the CREAMS model (Knisel et al. 1985) to predict freezing of the soil. The soil is assumed to be frozen when the average air temperature during the previous 30 days is less than 0 °C. For all model simulations in this study, the curve number computed by HELP was used.

Daily infiltration into the cover is the daily rainfall and snowmelt less surface runoff. Infiltration in excess of the sum of the storage capacity of the cover and percolation is added to the runoff or held as surface water storage (Schroeder et al. 1994). Water that has infiltrated the profile can either flow downwards, leading to percolation, or be removed by evapotranspiration.

Evapotranspiration is assumed to remove water from an "evaporative depth" in the cover, which is defined by the user. Potential evapotranspiration (PET) is computed using the Penman equation (Penman 1963). PET is first applied to evaporation of water or snow on the surface. The remaining PET demand is applied to evaporation of water in the soil profile (PE) and transpiration by plants (PT). Evaporation or transpiration of water within the soil profile cannot exceed the available water, and when the soil is frozen, HELP assumes no soil water evaporation or transpiration takes place.

Actual plant transpiration (APT) is set equal to the potential plant transpiration unless the soil water evaporated (AET) plus the potential plant transpiration (PT) is greater than PET. PT is calculated based on the leaf area index (LAI), which varies throughout the year. The variation is computed using a vegetative growth model, which assumes the vegetation is perennial grass. The growth model computes the total vegetative biomass using maximum LAI (entered by the user), daily temperature and solar radiation, and mean monthly temperatures. Vegetative growth is assumed to begin at the germination date, and continues for three quarters of the growing season. The below ground biomass is assumed to be 20% of the total biomass.

Once the infiltration and evaporative demand is calculated, HELP routes water movement through the profile using Darcy's Law. The soil water storage of each layer is a function of the water content, and the flows into (Q_{in}) and out (Q_{out}) of the layer:

$$\Delta S = Q_{in} - Q_{out} - ET \tag{3}$$

Vertical flow can be unsaturated or saturated. Unsaturated flow only occurs in vertical percolation layers, and is assumed to occur under a unit gradient. Thus, the flux equals the unsaturated hydraulic conductivity, which is described using a Brooks-Corey function (Brooks and Corey 1964) as reported by Campbell (1974):

$$K_{\psi} = K_s \left[\frac{\theta - \theta_r}{\theta_s - \theta_r} \right]^{3+\left(\frac{2}{\lambda}\right)} \tag{4}$$

where K_{ψ} is the unsaturated hydraulic conductivity, K_s is the saturated hydraulic conductivity, θ is the volumetric water content, θ_r is the residual volumetric water content, θ_s is the saturated volumetric water content, and λ is the pore-size distribution index. Residual volumetric water content is estimated based on the wilting point. The pore-size distribution index is estimated using the field capacity and wilting point entered by the user.

Soil barrier layers are assumed to be saturated at all times. Flow through barrier layers only occurs when head accumulates on the barrier layer. The rate of flow is calculated based on Darcy's law. Water flow through geomembranes is assumed to occur via vapor transport and leakage through holes. Vapor transport is modeled using a "hydraulic conductivity" of the geomembrane. Leakage through holes is computed using Giroud's equation (Giroud and Bonaparte 1989).

5.3 UNSAT-H FORMULATION

UNSAT-H is a one-dimensional finite-difference computer program for simulating water and heat flow through soil (Fayer et al. 1992). UNSAT-H predicts the water balance by solving a modified Richards' partial differential equation for liquid and vapor water flow, Fick's law for vapor diffusion, and Fourier's equation for heat flow (Fayer and Jones 1990; Khire et al. 1999). The modified Richards' equation solved by UNSAT-H is (Fayer and Jones 1990):

$$\frac{\partial \theta}{\partial \psi}\frac{\partial \psi}{\partial t} = -\frac{\partial}{\partial z}\left[K_T \frac{\partial \psi}{\partial z} + K_\psi + q_{VT}\right] - S(z,t) \tag{5}$$

where ψ is matric suction, t is time, z is the vertical coordinate, K_ψ is unsaturated hydraulic conductivity, $K_{V\psi}$ is the isothermal water vapor conductivity, $K_T = K_\psi + K_{V\psi}$, q_{VT} is the thermal vapor flux density, and S (z,t) is the sink term representing water uptake by the vegetation. Because UNSAT-H is a one-dimensional model, it cannot compute lateral drainage or simulate flow through holes in geomembranes (Khire 1995). Therefore, UNSAT-H cannot be used to model covers that include lateral drainage layers or geomembranes.

For cover simulations, the upper boundary is treated as a flux boundary where water flow is either downward (infiltration) or upward (evaporation). Precipitation is partitioned into runoff or infiltration based on the infiltration capacity of the soil. UNSAT-

H does not consider absorption and interception of water by vegetation (Khire 1995). The lower boundary can be assigned as a unit gradient, constant head, a specified boundary flux, or as an impermeable boundary. For all simulations conducted during this study, the unit gradient boundary was used. The unit gradient option corresponds to gravity-induced drainage and is appropriate for profiles that extend below the root zone and in which drainage is not impeded. With the unit gradient condition, the calculated drainage flux depends on the liquid water conductivity of the lower boundary node. Because UNSAT-H is one-dimensional, the runoff computation does not consider slope angle or slope length.

Water that has infiltrated the surface of the profile flows downward in accordance with the modified Richards' equation, and can be removed from the profile by evaporation, transpiration, or percolation. Evaporation from the soil surface is computed using Fick's Law, with the gradient being calculated using the difference between the relative humidity of the atmosphere and the soil gas. Transpiration is assumed to occur at the potential transpiration (PT) rate unless water stress exists. PT is partitioned from PET using the Ritchie and Burnett (1971) formulation, which is a function of LAI. Water stress is computed using the limiting function in Feddes and Zaradny (1978), which requires the anaerobiosis point, limiting point, and wilting point as inputs.

The LAI is seasonally variable and is input as a LAI function. PT demand is applied to each node proportional to the root length density using a volumetric sink term in Richards' equation. After the PT demand is distributed to each node, actual transpiration is calculated by multiplying the potential sink term at each node by the transpiration limiting function, which is a function of water content. When the water content exceeds the anaerobiosis point or is below the wilting point, the limiting function equals zero. When the water content is between the limiting and wilting points, the limiting function is computed by linear interpolation between 0-1. For water contents between the anaerobiosis and limiting points, the limiting function equals 1.0.

5.4 INPUT DATA

Properties obtained from laboratory testing conducted on soil and vegetative samples collected from each site were used to formulate the input parameters. When data were missing, estimates of the input parameters were made based on data from the literature or using data from other ACAP sites.

5.4.1 Meteorological Data

HELP and UNSAT-H require the following daily meteorological data: precipitation, air temperature, solar radiation, wind speed, relative humidity, cloud cover, dew point, surface albedo, and initial snow accumulation. The meteorological data were collected at each site using a weather station. Some of the meteorological inputs for HELP are shown in Table 5.1.

At sites that receive snow, snow was melted and added to the total daily precipitation. HELP has a snowmelt algorithm built into the program (Section 5.2). For UNSAT-H, the restricted degree-day radiation balance approach (Kustas et al. 1994) was used to calculate the daily snowmelt (M):

$$M = a_r T_D + m_Q R_n \tag{6}$$

Table 5.1. Meteorological Inputs for HELP

Site	Number of Simulation Years	Day 1 Date	Avg. Wind Speed (km/hr)	Quarterly Relative Humidity (%)			
				1st	2nd	3rd	4th
Altamont	1	1-Jan-01	20.1	80.2	55.6	56.1	62.3
Omaha	1	1-Jan-01	11.1	80.5	71.9	71.3	65.7
Boardman	1	1-Jan-01	8.8	84.7	57.4	42.4	62.0
Sacramento	2	1-Jan-00	8.8	79.1	66.3	48.6	64.3
Polson	2	1-Jan-00	7.9	87.0	62.9	44.7	73.1
Helena	2	1-Jan-00	9.6	75.9	54.1	41.7	59.5
Albany	1	1-Jan-01	3.9	70.3	65.3	75.8	71.6
Marina	1	1-Jan-01	8.6	78.3	82.2	83.0	84.7

where T_D is the daily average air temperature, R_n is the net solar radiation, a_r is the restricted degree-day factor, and m_Q is the conversion factor for energy flux density to snow melt depth. The value for m_Q was 0.026 cm/d per W/m^2 (each 1 W/m^2 of daily average energy results in 0.026 cm/d of snowmelt depth) and a_r was 0.23 cm/°C (Kustas et al. 1994). Snow was only melted when the air temperature was above 0 °C. The daily net solar radiation was calculated as the average of the hourly solar radiation measured on site multiplied by an albedo of 0.74 (Winkler 1999).

5.4.2 Initial Conditions

The initial condition for HELP consisted of assigning the initial water content of each layer, as measured by WCR probes in the test sections (Section 3.1.2). The initial conditions for UNSAT-H were specified by assigning the initial suction at each node. The suctions for each layer were calculated using the van Genuchten equation (see discussion in Section 5.3) and the average water content of the layer. All nodes within a layer were assigned the same suction. A summary of the initial water contents and suctions assigned to each layer is in Table 5.2 and 5.3.

5.4.3 Hydraulic Properties

HELP requires the saturated hydraulic conductivity, field capacity, wilting point, and saturated water content (porosity) as input. UNSAT-H requires the saturated hydraulic conductivity and the soil water characteristic curve. For this study, the soil

Table 5.2. Hydraulic Properties Input to UNSAT-H.

Site	Test Section	Component (Top to Bottom)	Thickness (mm)	Van Genuchten Parameters				K_s (cm/s)	Calculated	Measured
				θ_r	θ_s	θ (cm^{-1})	n		Soil Suction (kPa)	Initial Water Content (vol/vol)
Altamont	Monolithic	Vegetative Cover	460	0.00	0.36	0.00395	1.18	2.8×10^{-6}	910	0.19
		Support Layer	600	0.00	0.37	0.00172	1.22	2.8×10^{-6}	2461	0.16
		Interim Cover	300	0.00	0.39	0.00172	1.22	4.3×10^{-5}	3317	0.16
Omaha	"Thin" Capillary	Topsoil	150	0.00	0.48	0.00015	1.61	6.1×10^{-6}	4673	0.14
		Vegetative Cover	460	0.00	0.44	0.00039	1.97	6.1×10^{-6}	543	0.19
		Sand	150	0.05	0.41	0.03500	7.22	2.1×10^{-2}	5	0.06
		Interim Cover	300	0.00	0.40	0.00077	1.28	6.1×10^{-6}	808	0.24
	"Thick" Capillary	Topsoil	150	0.00	0.44	0.00015	1.61	4.5×10^{-7}	6565	0.11
		Vegetative Cover	760	0.00	0.42	0.00039	1.97	1.4×10^{-7}	554	0.18
		Sand	150	0.05	0.41	0.03500	7.22	2.0×10^{-2}	5	0.06
		Interim Cover	300	0.00	0.42	0.00077	1.28	5.2×10^{-7}	709	0.26
Boardman	"Thin" Capillary	Vegetative Cover	1220	0.00	0.46	0.00176	1.29	1.9×10^{-5}	4423	0.13
		Interim Cover	300	0.00	0.46	0.00356	1.34	1.7×10^{-5}	566	0.17
	"Thick" Capillary	Vegetative Cover	1840	0.00	0.45	0.00176	1.29	1.4×10^{-5}	4695	0.13
		Interim Cover	300	0.00	0.46	0.00356	1.34	1.9×10^{-5}	831	0.15

Table 5.2. Hydraulic Properties Input to UNSAT-H *(continued)*.

Site	Test Section	Component (Top to Bottom)	Thickness (mm)	Van Genuchten Parameters				K_s (cm/s)	Calculated	Measured
				θ_r	θ_s	θ (cm^{-1})	n		Soil Suction (kPa)	Initial Water Content
Sacramento	"Thin" Monolithic	Topsoil	150	0.00	0.44	0.00670	1.38	9.0×10^{-7}	173	0.17
		Vegetation Cover 1	920	0.00	0.37	0.00650	1.26	4.0×10^{-4}	2354	0.10
		Interim Cover	460	0.00	0.37	0.00750	1.33	1.3×10^{-4}	314	0.13
	"Thick" Monolithic	Topsoil	150	0.00	0.46	0.00670	1.38	9.0×10^{-7}	96	0.22
		Vegetation Cover 2	1840	0.00	0.43	0.00300	1.30	1.7×10^{-7}	1657	0.13
		Vegetation Cover 1	460	0.00	0.41	0.00650	1.26	4.0×10^{-4}	4819	0.09
		Interim Cover	460	0.00	0.31	0.00750	1.33	1.3×10^{-4}	181	0.13
Polson	Capillary	Topsoil	150	0.00	0.40	0.06761	1.40	4.9×10^{-5}	38	0.11
		Sandy Silt	460	0.00	0.44	0.01951	1.27	4.7×10^{-7}	246	0.16
		Silty Sand	600	0.00	0.40	0.07113	1.43	9.8×10^{-5}	129	0.06
		Interim Cover	460	0.03	0.32	0.31060	3.00	6.1×10^{-3}	5	0.03
Helena	Capillary	Topsoil	150	0.00	0.37	0.06070	1.36	5.0×10^{-7}	393	0.05
		Vegetative Cover	1200	0.00	0.43	0.01292	1.19	2.2×10^{-7}	3402	0.14
		Gravel	300	0.05	0.41	0.24630	3.00	7.1×10^{-1}	1	0.10
		Interim Cover	150	0.00	0.43	0.01292	1.19	2.2×10^{-7}	280	0.22
Albany	ECap	Vegetative Cover	600	0.00	0.44	0.00144	1.37	1.9×10^{-7}	247	0.27
		Foundation Layer	700	0.00	0.35	0.00029	1.49	6.0×10^{-7}	672	0.23
		Interim Cover	150	0.00	0.38	0.00020	1.52	2.0×10^{-6}	914	0.25
	Compacted Clay	Topsoil	150	0.00	0.34	0.00017	1.22	1.3×10^{-4}	6976	0.20
		Barrier Layer	460	0.00	0.35	0.00046	1.58	7.3×10^{-8}	318	0.24
		Interim Cover	150	0.00	0.38	0.00015	1.79	3.2×10^{-7}	1049	0.23
Marina	Monolithic	Vegetative Cover	1220	0.00	0.34	0.00235	1.39	6.7×10^{-8}	615	0.23
		Interim Cover	300	0.07	0.39	0.05300	2.85	3.6×10^{-3}	18	0.07

Table 5.3. Hydraulic Properties Input to HELP.

Site	Test Section	Layer	Thickness (mm)	Soil Texture Number	Total Porosity	Field Capacity	Wilting Point	K_s (cm/s)	Initial Water Content
Altamont	Monolithic	Vertical Percolation	460	-	0.36	0.32	0.17	2.8×10^{-6}	0.19
		Vertical Percolation	600	-	0.37	0.34	0.18	2.8×10^{-6}	0.16
		Vertical Percolation	300	-	0.39	0.36	0.19	4.3×10^{-5}	0.16
	Composite	Vertical Percolation	300	-	0.36	0.32	0.17	2.0×10^{-5}	
		Lateral Drainage	5	20	-	-	-	-	-
		Geomembrane	1.5	36	-	-	-	-	-
		Soil Barrier	300	-	0.31	0.29	0.15	2.2×10^{-7}	
		Vertical Percolation	300	-	0.31	0.29	0.15	7.8×10^{-5}	
		Vertical Percolation	300	-	0.35	0.33	0.17	2.2×10^{-7}	
Helena	Capillary	Vertical Percolation	150	-	0.37	0.13	0.03	5.0×10^{-7}	0.05
		Vertical Percolation	1200	-	0.43	0.32	0.16	2.2×10^{-7}	0.14
		Vertical Percolation	300	-	0.41	0.05	0.05	7.1×10^{-1}	0.10
		Vertical Percolation	150	-	0.43	0.32	0.16	2.2×10^{-7}	0.22

Table 5.3. Hydraulic Properties Input to HELP *(continued)*.

Site	Test Section	Layer	Thickness (mm)	Soil Texture Number	Total Porosity	Field Capacity	Wilting Point	K_s (cm/s)	Initial Water Content
Omaha	"Thin" Capillary	Vertical Percolation	150	-	0.48	0.48	0.33	$6.1x10^{-6}$	0.14
		Vertical Percolation	460	-	0.44	0.43	0.2	$6.1x10^{-6}$	0.19
		Vertical Percolation	150	-	0.41	0.05	0.05	$2.1x10^{-2}$	0.06
		Vertical Percolation	300	-	0.4	0.39	0.22	$6.1x10^{-6}$	0.24
	"Thick" Capillary	Vertical Percolation	150	-	0.44	0.44	0.3	$4.5x10^{-7}$	0.11
		Vertical Percolation	760	-	0.42	0.41	0.19	$1.4x10^{-7}$	0.18
		Vertical Percolation	150	-	0.41	0.05	0.05	$2.0x10^{-2}$	0.06
		Vertical Percolation	300	-	0.42	0.40	0.23	$5.6x10^{-7}$	0.26
	Composite	Vertical Percolation	150	-	0.4	0.40	0.27	$1.5x10^{-6}$	0.12
		Vertical Percolation	300	-	0.44	0.43	0.2	$6.9x10^{-7}$	0.18
		Drainage Composite	5	20	-	-	-	-	-
		Geomembrane	1	35	-	-	-	-	-
		Soil Barrier	460	-	0.38	0.38	0.07	$3.2x10^{-6}$	0.21
		Vertical Percolation	300	-	0.44	0.42	0.24	$1.3x10^{-6}$	0.27
Boardman	"Thin" Capillary	Vertical Percolation	1220	-	0.46	0.42	0.18	$1.9x10^{-5}$	0.13
		Vertical Percolation	300	-	0.46	0.37	0.12	$1.7x10^{-5}$	0.17
	"Thick" Capillary	Vertical Percolation	1840	-	0.45	0.41	0.17	$1.4x10^{-5}$	0.13
		Vertical Percolation	300	-	0.46	0.37	0.12	$1.9x10^{-5}$	0.15
	Composite	Vertical Percolation	900	-	0.45	0.41	0.17	$3.8x10^{-5}$	0.13
		Lateral Drainage	5	20	-	-	-	-	-
		Geomembrane	1.5	36	-	-	-	-	-
		GCL	6	17	0.75	-	-	$3.3x10^{-9}$	-
		Vertical Percolation	300	-	0.46	0.37	0.12	$7.2x10^{-6}$	0.11
Sacramento	"Thin" Monolithic	Vertical Percolation	150	-	.44	0.30	.08	$9.0x10^{-7}$	0.17
		Vertical Percolation	920	-	.37	0.28	.11	$4.0x10^{-4}$	0.10
		Vertical Percolation	460	-	.37	0.26	.08	$1.3x10^{-4}$	0.13

Table 5.3. Hydraulic Properties Input to HELP *(continued)*.

Site	Test Section	Layer	Thickness (mm)	Soil Texture Number	Porosity	Field Capacity	Wilting Point	K_s (cm/s)	Initial Water Content
Sacramento	"Thick" Monolithic	Vertical Percolation	150	-	0.46	0.31	0.08	$9.0x10^{-7}$	0.22
		Vertical Percolation	1840	-	0.43	0.37	0.14	$1.7x10^{-7}$	0.133
		Vertical Percolation	460	-	0.41	0.31	0.12	$4.0x10^{-4}$	0.09
		Vertical Percolation	460	-	0.31	0.22	0.07	$1.3x10^{-4}$	0.13
Polson	Capillary	Vertical Percolation	150	-	0.4	0.11	0.02	$4.9x10^{-5}$	0.11
		Vertical Percolation	460	-	0.44	0.26	0.1	$4.7x10^{-7}$	0.157
		Vertical Percolation	600	-	0.4	0.10	0.02	$9.8x10^{-5}$	0.057
		Vertical Percolation	460	-	0.32	0.03	0.03	$6.1x10^{-3}$	0.03
	Composite	Vertical Percolation	150	-	0.41	0.12	0.03	$4.9x10^{-5}$	0.10
		Vertical Percolation	460	-	0.42	0.11	0.02	$9.0x10^{-5}$	0.07
		Lateral Drainage	5	20	-	-	-	-	-
		Geomembrane	1.5	36	-	-	-	-	-
		Soil Barrier	460	-	0.42	0.26	0.10	$5.0x10^{-7}$	0.13
		Vertical Percolation	460	-	0.32	0.05	0.05	$6.1x10^{-3}$	0.03
Albany	Compacted Clay	Vertical Percolation	150	-	0.34	0.34	0.26	$1.3x10^{-4}$	0.20
		Soil Barrier	460	-	0.35	0.34	0.11	$7.3x10^{-8}$	0.24
		Vertical Percolation	150	-	0.38	0.38	0.18	$3.2x10^{-7}$	0.23
	ECap	Vertical Percolation	600	-	0.44	0.41	0.14	$1.9x10^{-7}$	0.27
		Vertical Percolation	700	-	0.35	0.35	0.17	$6.0x10^{-7}$	0.23
		Vertical Percolation	150	-	0.38	0.38	0.20	$2.0x10^{-6}$	0.25
Marina	Monolithic	Vertical Percolation	1220	-	0.34	0.29	0.08	$6.7x10^{-8}$	0.23
		Vertical Percolation	300	-	0.39	0.07	0.06	$3.6x10^{-3}$	0.07
	Composite	Vegetative Cover	300	-	0.35	0.30	0.09	$4.5x10^{-6}$	0.21
		Geomembrane	1.5	36	-	-	-	-	-
		Soil Barrier	300	-	0.45	0.30	0.04	$2.5x10^{-8}$	0.41
		Vertical Percolation	600	-	0.35	0.07	0.06	$3.6x10^{-3}$	0.09

water characteristic curve used in UNSAT-H was defined using the van Genuchten equation:

$$\theta = \theta_r + (\theta_s + \theta_r)\left[\frac{1}{1+(\alpha\psi)^n}\right]^{1-1/n} \tag{7}$$

where θ_r is the residual water content, θ_s is the saturated water content, and α and n are empirical parameters obtained by fitting Eq. 7 to soil water characteristic curves measured in the laboratory.

The unsaturated hydraulic conductivity (K_ψ) was defined by the van Genuchten-Mualem equation, the parameters θ_s, θ_r α, and n in Eq. 7, and the saturated hydraulic conductivity:

$$K_\psi(\Theta) = K_s\Theta^{0.5}\left[1-(1-\Theta^{n/(n-1)})^{1-1/n}\right]^2 \tag{8}$$

In Eq. 8, Θ is the relative saturation, which is defined as

$$\Theta = \frac{\theta - \theta_r}{\theta_s - \theta_r} \tag{9}$$

Saturated hydraulic conductivities and the parameters θ_s, θ_r α, and n were obtained from laboratory tests conducted on undisturbed specimens collected from each test section in thin-walled sampling tubes and as blocks. A summary of these measurements can be found in Gurdal (2002). For this study, the geometric mean saturated hydraulic conductivity and the geometric mean α parameter were assigned to each layer. For the n parameter, the arithmetic mean was used. The geometric mean was used for the saturated hydraulic conductivity and α because these parameters appear log-normally distributed. An arithmetic mean was used for n because it appears to be normally distributed (Gurdal 2002). A summary of the saturated hydraulic conductivities, and the α and n parameters that were used, is in Table 5.2. A tortuosity of 0.68 was used for vapor flow in the UNSAT-H simulations.

Field capacity was assumed to be the volumetric water content at a matric suction of 33 kPa, as defined using Eq. 7 and the parameters θ_s, θ_r α, and n in Table 5.2. For humid sites, the common 1500 kPa definition of the wilting point water content was used (Hillel 1998). In semi-arid and arid climates, however, the wilting point often corresponds to much higher suctions (Gee et al. 1999). For the semi-arid and arid sites, the wilting point was estimated as the lowest average water content measured in the lower portion of the root zone during the growing season. That is, the vegetation was assumed to remove all of the available water in the soil during the growing season. The topsoil layer was excluded from the wilting point determination because the topsoil is dried to a lower water content by transpiration as well as evaporation. The wilting, limiting, and anaerobiosis points input to UNSAT-H are shown in Table 5.4.

5.4.4 Geosynthetic Properties

HELP was the only model used to simulate covers with geomembranes. The geomembrane was assigned a hydraulic conductivity of 2.0×10^{-13} cm/s (HDPE) or 4.0×10^{-13} cm/s (LLDPE). Geosynthetic clay liners were assigned a saturated hydraulic conductivity of 3.0×10^{-9} cm/s, and geocomposite drainage layers were assigned a saturated hydraulic conductivity of 10 cm/s. Holes in the geomembrane were assigned to have an area of 1 cm^2 and a frequency of 50 holes/ha to replicate the condition in the

Table 5.4 Transpiration Parameters Input to UNSAT-H.

Site	Wilting Point Suction (cm)	Limiting Point Suction (cm)	Anaerobiosis Suction (cm)
Altamont	62,500	5018	330
Omaha	15,000	6832	330
Boardman	60,000	4126	330
Sacramento	62,500	2840	330
Polson	36,000	1488	330
Helena	36,000	2847	330
Albany	15,000	5651	330
Marina	45,000	2694	330

test section (i.e., a single 1 cm^2 hole was place in the test sections with a geomembrane).

5.4.5 Vegetation Data

5.4.5.1 Growing Season

Dates for the growing season were obtained from historical data provided by the Western Regional Climate Center (RCC), Southeast RCC, Midwestern RCC, and High Plains RCC. For sites where freezing occurs, the growing season was assumed to begin after the final frost in the spring and no later than the first frost in the fall. In tropical climates, the growing season is defined by the rainy season. During the dry season, the vegetation goes dormant. The growing dates input to HELP and UNSAT-H are shown in Tables 5.5 and 5.6. The dates are entered in Julian day relative to the starting date of the data. For example, the start date for HELP is always January 1. However, the start date for UNSAT-H is based on the first day data collection began.

5.4.5.2 Leaf Area Index (LAI)

The LAI was measured on samples collected from the field for two of the ACAP sites (Sacramento and Albany). The samples were collected from 1 m x 1 m areas, sealed in plastic bags, and then analyzed in the laboratory. A Li-Cor LI-3100 area meter was used for the area measurements. For those sites where LAI was not measured, the LAI was estimated based on photographs and the type of vegetation.

For HELP, only the maximum LAI was entered. Algorithms in HELP were used to define the LAI function throughout the growing season. An LAI and Julian date are input

Table 5.5. Vegetation Input Parameters for HELP.

Site	Test Section	Evap. Zone Depth (mm)	Growing Season (Julian Day)		Maximum LAI	
			Germinate	Harvest	Year 1	Year 2
Altamont	Monolithic	1060	245	183	1.01	1.50
	Composite	300				
Sacramento	"Thin" Monolithic	1070	245	183	1.25	1.60
	"Thick" Monolithic	2450			1.95	2.50
Helena	Capillary	1350	135	263	0.77	1.50
Polson	Capillary	1210	130	271	0.82	2.50
	Composite	610				
Boardman	"Thin" Monolithic	1220	115	288	0.94	1.50
	"Thick" Monolithic	1840				
	Composite	900				
Marina	Monolithic	1220	275	153	0.88	1.50
	Composite	300				
Albany	ECap	1300	80	312	2.50	4.50
	Compacted Clay	600			0.11	0.20
Omaha	"Thin" Capillary	610	113	287	1.30	1.50
	"Thick" Capillary	910				
	Composite	460				

Table 5.6. Parameters for LAI Functions for UNSAT-H.

Site	Test Section	1st Year			2nd Year		
		Event	**Julian Day**	**LAI**	**Event**	**Julian Day**	**LAI**
Altamont	Monolithic	Day 1	1	0.0	Day 1	1	1.2
		Seed	20	0.0	Maximum	204	1.5
		Maximum	204	1.0	Harvest	234	0.0
		Harvest	234	0.0	Germinate	296	0.0
		Germinate	296	0.0	Maximum	326	1.5
		Maximum	326	0.5	End of Year	366	1.5
		End of Year	366	1.2			
Omaha	Capillary	Day 1	1	0.0	Day 1	1	0.4
		Harvest	8	0.0	Harvest	8	0.0
		Germinate	200	0.0	Germinate	200	0.0
		Maximum	344	1.3	Maximum	230	1.5
		End of Year	366	0.4	Maximum	344	1.5
					End of Year	366	0.4
Sacramento	"Thin" Monolithic	Day 1	1	0.0	Day 1	1	0.0
		Germinate	35	0.0	Germinate	35	0.0
		Seed	95	0.0	Maximum	65	1.6
		Maximum	309	1.3	Maximum	309	1.6
		Harvest	339	0.0	Harvest	339	0.0
		End of Year	366	0.0	End of Year	366	0.0
	"Thick" Monolithic	Day 1	1	0.0	Day 1	1	0.0
		Germinate	35	0.0	Germinate	35	0.0
		Seed	95	0.0	Maximum	65	2.5
		Maximum	309	2.0	Maximum	309	2.5
		Harvest	339	0.0	Harvest	339	0.0
		End of Year	366	0.0	End of Year	366	0.0

Table 5.6. Parameters for LAI Function for UNSAT-H *(continued)*.

Site	Test Section	1st Year			2nd Year		
		Event	**Julian Day**	**LAI**	**Event**	**Julian Day**	**LAI**
Polson	Capillary	Day 1	1	0.0	Day 1	1	0.0
		Seed	144	0.0	Germinate	173	0.0
		Germinate	173	0.0	Maximum	203	2.5
		Maximum	284	0.8	Maximum	284	2.5
		Harvest	314	0.0	Harvest	314	0.0
		End of Year	366	0.0	End of Year	366	0.0
Helena	Capillary	Day 1	1	0.0	Day 1	1	0.0
		Seed	35	0.0	Germinate	209	0.0
		Germinate	209	0.0	Maximum	239	1.5
		Maximum	307	0.8	Maximum	307	1.5
		Harvest	337	0.0	Harvest	337	0.0
		End of Year	366	0.0	End of Year	366	0.0
Albany	ECap	Day 1	1	0.4	Day 1	1	4.5
		Maximum	172	2.5	Maximum	172	4.5
		Harvest	202	0.0	Harvest	202	0.0
		Germinate	336	0.0	Germinate	336	0.0
		End of Year	366	4.5	End of Year	366	4.5
	Compacted Clay	Day 1	1	0.02	Day 1	1	0.2
		Maximum	172	0.1	Maximum	172	0.2
		Harvest	202	0.0	Harvest	202	0.0
		Germinate	336	0.0	Germinate	336	0.0
		End of Year	366	0.2	End of Year	366	0.2
Marina	Monolithic	Day 1	1	0.0	Day 1	1	0.2
		Harvest	6	0.0	Harvest	6	0.0
		Seed-Germinate	127	0.0	Germinate	127	0.0
		Maximum	157	0.1	Maximum	157	1.5
		Maximum	341	0.9	Maximum	341	1.5
		End of Year	366	0.2	End of Year	366	0.2
Boardman	Monolithic	Day 1	1	0.0	Day 1	1	0.0
		Seed	63	0.0	Germinate	137	0.0
		Germinate	137	0.0	Maximum	167	1.5
		Maximum	167	0.2	Maximum	280	1.5
		Maximum	280	0.9	Harvest	310	0.0
		Harvest	310	0.0	End of Year	366	0.0
		End of Year	366	0.0			

to UNSAT-H. A typical LAI function that was used for UNSAT-H is shown in Fig. 5.1. For the first growing season, the LAI was assumed to increase linearly from the first day of the growing season or the seed date (which ever was later) to the point where the LAI would typically begin to decrease as it nears the dormant period. For the second season, the LAI was assumed to reach its maximum 30 days after the germination date, remain at the maximum throughout most of the growing season, and to decrease linearly 30 days prior to the harvest date. The LAI functions were input directly to UNSAT-H. UNSAT-H uses the germination and harvest dates, as well as the user-defined LAI function. The days entered do not correspond to the Julian day, but rather to the day relative to the start date.

A summary of the LAI parameters that were input is in Tables 5.5 and 5.6. Each of the LAI functions input to UNSAT-H is shown in Appendix 2. An albedo of 0.25 was assigned for every site. A bare soil surface fraction of 0.5 for used for the first year. For the second year, the bare surface fraction was assumed to be 0.25 to simulate establishment of the vegetation.

5.4.5.3 Root Depth, Growth, and Density

The maximum rooting depth for UNSAT-H and the evaporative depth for HELP was assumed to be the depth of the root barrier, or for test sections with composite barriers, the depth of the geomembrane. Root growth at each site was estimated using rates reported in the literature. Roots for crop plants typically elongate 10 mm or more per day (Russell 1977), whereas roots of plants in natural ecosystems may only

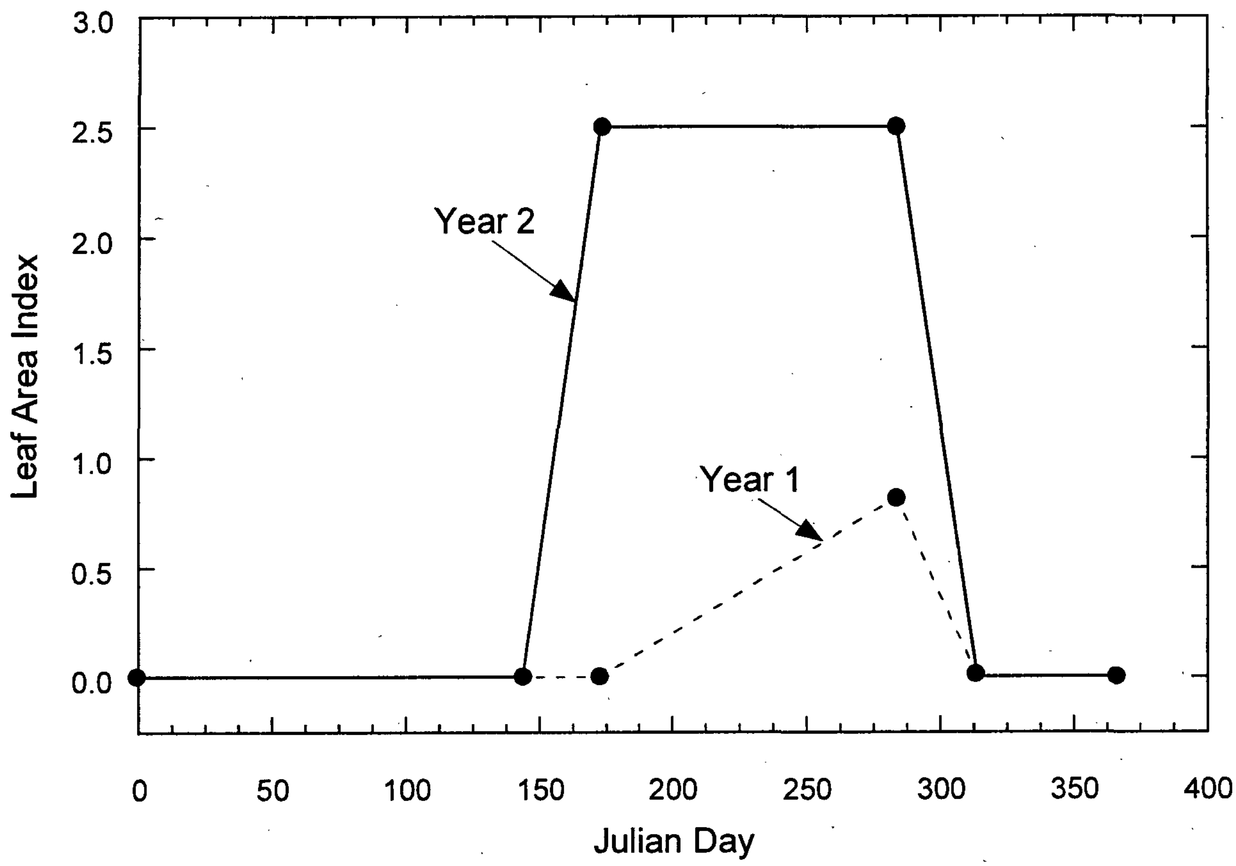


Fig. 5.1.. LAI Function Input to UNSAT-H for Polson Site.

elongate at 1 mm/d (Bundrett and Kendrick 1990). The maximum root growth is between 5 and 21 mm/d (Roche et al. 1994, Mahoney and Rood 1998).

Growth rates between 5 and 10 mm/day are more typical. Factors that affect the rate of elongation include the amount of nutrients available, degree of soil compaction, type of soil (granular or clayey), and climate (wet or dry). Root growth rates chosen for each test cover were selected based on a relative scale (between 0 and 10 mm/day) using the factors previously described, and are summarized in Table 5.7. For example, a test section was assigned a higher root growth rate if the cover profile was composed of soil that had sufficient nutrients and available water, and was lightly compacted. In contrast, a test section was assigned a lower growth rate if the cover profile had little nutrients and available water, and was compacted greater than 95% of maximum dry unit weight per standard Proctor.

The root length density function was estimated for each test cover, and is shown in Table 5.8. At several sites, measurements of the root length density function were made on undisturbed soil samples extending from the surface to a depth of approximately 900 mm. The Weaver-Darland box method described in Bohm (1979) was used to collect the samples. The density measurements were made in the laboratory using the method described in Liang et al. (1989). For the other sites, the root length density function was estimated based on data collected from the sites where samples were collected. Each root length density function was fit with the exponential model used in UNSAT-H:

$$R = a\, e^{-zb} + c \qquad (8)$$

Table 5.7. Rates of Root Growth Input to UNSAT-H.

Site	Test Section	Root Growth Rate (mm/d)
Altamont	Monolithic Barrier	3.0
Sacramento	Monolithic Barriers	5.0
Helena	Capillary Barrier	5.0
Polson	Capillary Barrier	7.5
Boardman	Monolithic Barriers	7.5
Marina	Monolithic Barrier	7.5
Albany	ECap	10.0
	Compacted Clay Barrier	3.0
Omaha	Capillary Barriers	6.0

Table 5.8. RLD Function at ACAP Sites.

Site	Vegetation Type	Root Length Density Parameters		
		a	b (cm^{-1})	c
Altamont	Local Grasses	0.44	0.079	0.005
Boardman	Crested Wheat Grass	0.30	0.070	0.013
Sacramento	Grasses and shrubs	0.61	0.110	0.007
Marina [a]	Grasses	0.61	0.110	0.007
Omaha [a]	Grasses	0.61	0.110	0.007
Polson	Grasses, forbs, and shrubs	0.12	0.019	0.00
Helena	Grasses	0.38	0.029	0.00
Albany [b]	Grass + Poplar Trees	0.01	0.050	0.005
Low (Winkler 1999)		**0.06**	**0.061**	**0.012**
High (Winkler 1999)		**1.00**	**0.077**	**0.080**

[a] Based on RLD measured at Sacramento
[b] RLD function defined for Albany is for grass only.

where z is the depth, and a, b, and c are empirical parameters. The root length density function curves for the ACAP sites are shown in Fig. 5.2, as well as upper and lower bounds based on a literature review by Winkler (1999). The root length density functions for the Cedar Rapids, Omaha, and Marina sites are based on the root length function of the Sacramento site. The Sacramento site was chosen because its root length density function is in middle of the range defined by the upper and lower boundaries provided by Winkler (1999).

5.4.5.4 Runoff Curve Number

A runoff curve number is input to HELP to estimate the rainfall-runoff relationship. The method for selecting a curve number considers the slope, slope length, texture of the surface layer, and level of vegetation. The level of vegetation is a range between 1 (bare ground) and 5 (excellent stand of grass). The input to HELP for each test section is shown in Table 5.9.

5.4.6 Design Input

Inputs required for HELP and UNSAT-H that are based on test section characteristics (area and slope) and site location (elevation and latitude) are summarized in Table 5.10.

5.4.7 Simulation Control Parameters for UNSAT-H

UNSAT-H requires the user to specify the nodal spacing throughout the entire profile of the soil cover (Fig. 5.3). A nodal spacing of 1 mm was used near the

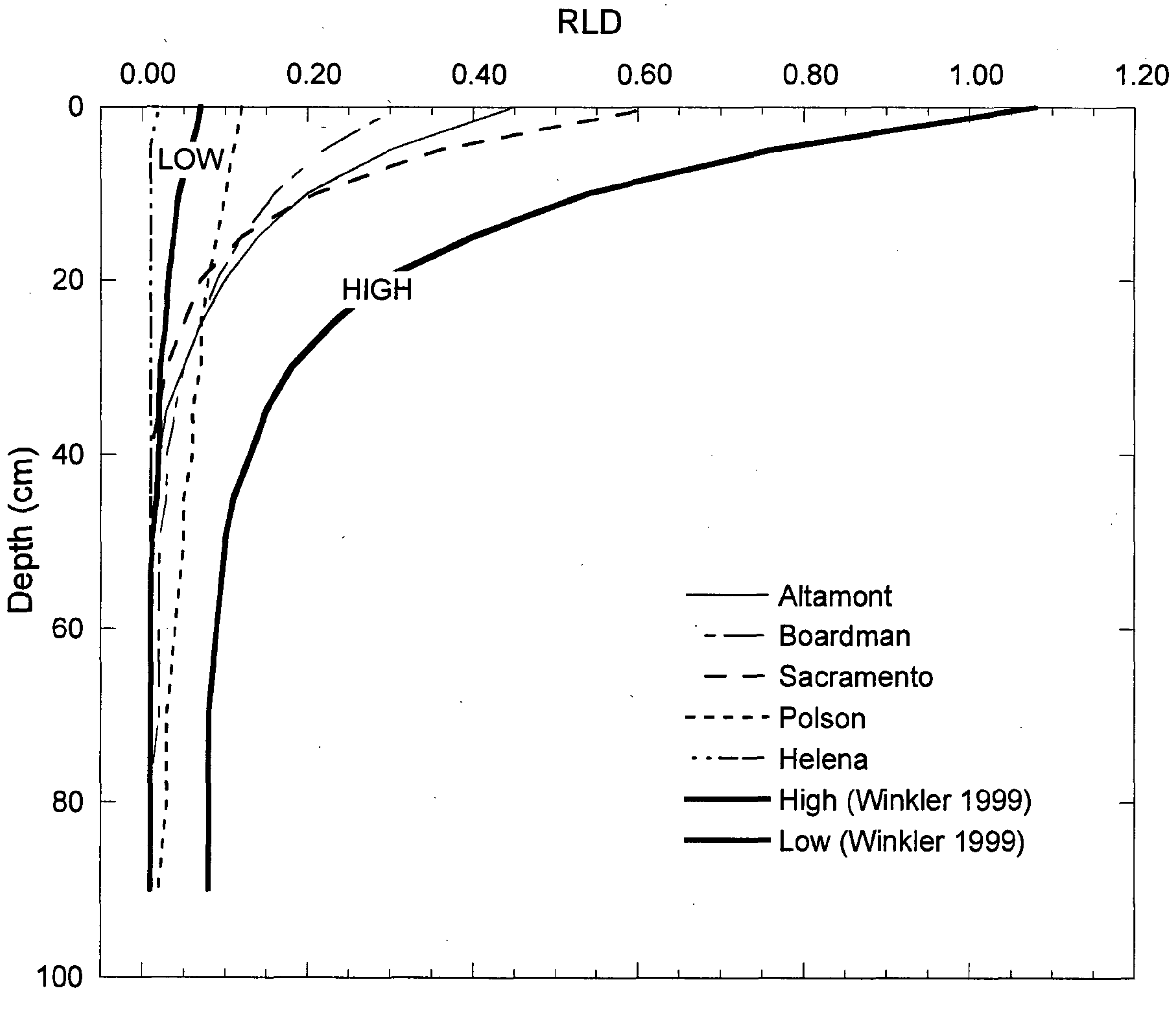


Fig. 5.2. Root Length Density Functions Measured at ACAP Sites with Upper and Lower Bounds Defined by Winkler (1999).

Table 5.9 Runoff Curve Numbers Computed by HELP.

Site	Test Section	Slope (%)	Slope Length (m)	Topsoil Texture Number	Vegetation (1-5)		Runoff Curve Number	
					2000	2001	2000	2001
Altamont	Monolithic	5	20	25	-	2	-	94.1
	Composite	5	20	25	-	2	-	94.1
Omaha	Capillary	25	20	25	-	3	-	91.4
	Composite	25	20	25	-	3	-	91.4
Boardman	Capillary	25	20	22	-	2	-	94.4
	Composite	25	20	22	-	2	-	94.4
Sacramento	Monolithic	5	20	27	2	3	91.1	91.1
Polson	Capillary	5	20	7	2	3	84.7	77.3
	Composite	5	20	7	2	3	84.7	77.3
Helena	Capillary	5	20	27	2	2	94.1	94.1
Albany	ECap	5	20	10	-	4	-	82.3
	Compacted Clay	5	20	10	-	2	-	90.9
Marina	Monolithic	25	20	10	-	4	-	83.1
	Composite	25	20	13	-	2	-	92.9

Table 5.10. Design Inputs for HELP and UNSAT-H.

Site	Construction End Date	UNSAT-H Data Start Date	Test Section Area (ha)	Elevation (m)	Latitude (deg)	Slope (%)
Altamont	8/30/00	11/10/00	0.1	457	37.7	5
Omaha	8/11/00	10/5/00	0.1	85	41.3	25
Boardman	11/2/00	12/9/00	0.1	178	45.7	5
Sacramento	7/25/99	7/29/99	0.1	61	38.5	5
Polson	10/19/99	11/19/99	0.1	893	48.3	5
Helena	10/18/99	10/19/99	0.1	1247	46.6	5
Albany	3/18/00	4/19/00	0.1	73	31.6	5
Marina	5/25/00	5/27/00	0.1	31	36.6	25

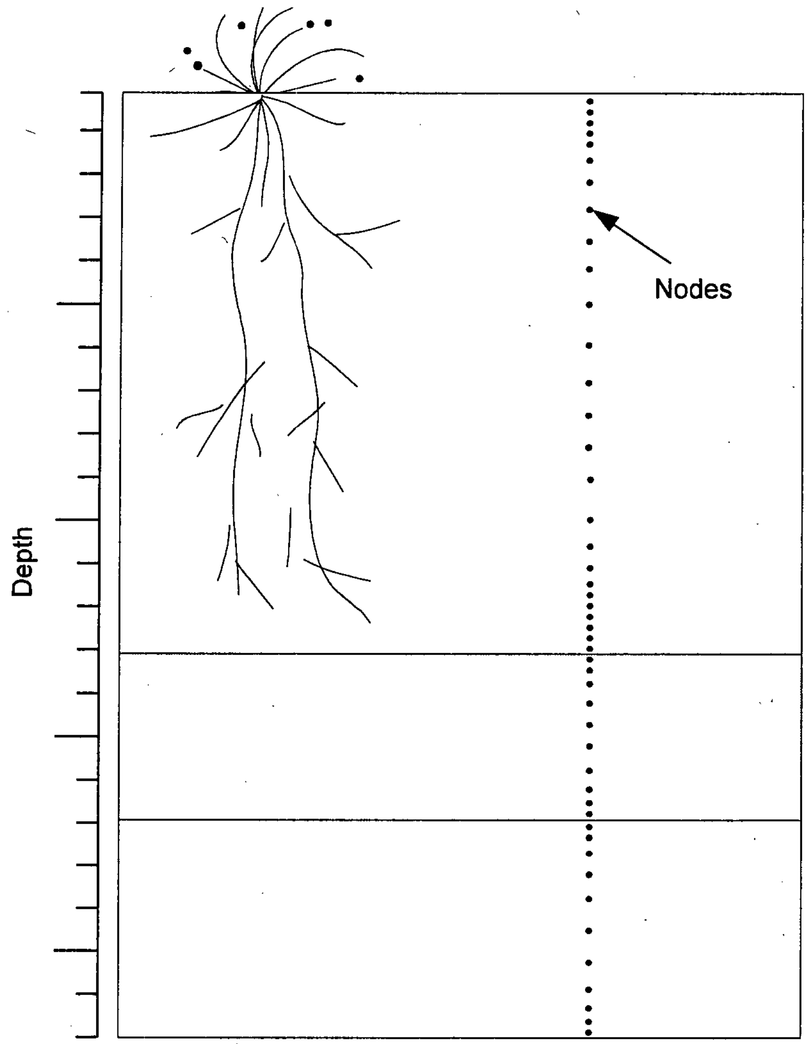


Fig. 5.3. Schematic of Typical Nodal Spacing Used in UNSAT-H.

boundaries, and at interfaces between layers. The spacing increased with depth or distance from a boundary or layer interface. A maximum nodal spacing of 50 mm was used.

Four iterations were allowed for solving the water flow equation. A time step control parameter of 0.001, a maximum allowable time step of 0.25 hr, and a minimum allowable time step of 10^{-5} hr were used. Also, a maximum time step factor of 1, a rainfall initiation factor or 0.001, and a time step reduction factor of 0.1 were used.

5.5 COMPARISON BETWEEN ACTUAL AND SIMULATION RESULTS

Water balance simulations with UNSAT-H and HELP were performed on each test section from ACAP, with the exception of the Cedar Rapids site and the Monticello site. Simulations were not run for these two sites because of large data gaps. The UNSAT-H and HELP simulations were run from the first day of data collection until April 2002. This section describes comparisons of measured and predicted surface runoff, lateral flow (if applicable), soil water storage, evapotranspiration, and percolation.

Initial simulations made with UNSAT-H and HELP using the measured hydraulic properties in Tables 5.11 and 5.12 greatly over-predicted surface runoff. The over predictions by UNSAT-H ranged from 0 to 85.6% of precipitation, and those by HELP ranged from 0.1 to 57.1% of precipitation. By greatly over-predicting surface runoff, the volume of water that infiltrates the cover is grossly underestimated. Therefore, all subsequent flow processes are incorrect. (Khire et al. 1997). This discrepancy is believed to be caused by the hydraulic conductivity of the surface layer (top soil) being too low. Hydraulic conductivity of the surface layer was measured on specimens collected immediately after construction that probably did not include macroscopic

Table 5.11. Surface Runoff Predictions From Original and Adjusted Simulations Using UNSAT.

Site	Test Section	Field Surface Runoff (mm)	Original Simulation			Decreased Surface Runoff	
			Surface Layer K_s (cm/s)	SRO (mm)	Over-Prediction (%)	Surface Layer K_s (cm/s)	SRO (mm)
Altamont	Monolithic	26	2.8×10^{-6}	325	61.3%	2.8×10^{-4}	2[a]
Sacramento	Monolithic (1070 mm)	120	9.0×10^{-7}	899	68.2%	9.4×10^{-5}	51
	Monolithic (2450 mm)	68	9.0×10^{-7}	899	72.7%	2.8×10^{-4}	27[b]
Helena	Capillary	28	5.0×10^{-7}	359	85.6%	2.8×10^{-4}	33
Polson	Capillary	23	4.9×10^{-5}	288	35.6%	2.8×10^{-4}	107
Boardman	Monolithic (1220 mm)	0	1.9×10^{-5}	0	0.0%	-[c]	-[c]
	Monolithic (1840 mm)	0	1.4×10^{-5}	0	0.0%	-[c]	-[c]
Marina	Monolithic	0	6.7×10^{-8}	430	71.0%	2.8×10^{-4}	122[a]
Albany	ECap	15	1.9×10^{-7}	1590	79.4%	2.8×10^{-4}	0[d]
	Compacted Clay	169	1.3×10^{-4}	366	11.9%	2.8×10^{-4}	357
Omaha	Capillary (760 mm)	72	6.1×10^{-6}	0	-10.0%	-[c]	-[c]
	Capillary (1060 mm)	54	4.5×10^{-7}	155	14.0%	2.8×10^{-4}	43

[a] Split vegetative cover into two sub layers with a 150 mm surface layer.
[b] Increased K_s of vegetative cover underneath surface layer to decrease surface runoff appreciably. Made vegetative cover of thick barrier equal to vegetative cover of thin barrier ($K^s = 3.98 \times 10^{-4}$ cm/s).
[c] Additional simulation not conducted because "original" simulation predicted less than or equal amount of surface runoff as measured in field.
[d] Increased K_s of entire surface layer, rather than creating a 150 mm sub-layer, to decrease surface runoff appreciably.

Table 5.12 Surface Runoff (SRO)Predictions From Original and Adjusted Simulations Using HELP.

Site	Test Section	Field SRO (mm)	Original Simulation				Decreased Surface Runoff		
			Surface Layer K_s (cm/s)	Curve Number (CN)	SRO (mm)	Over-Prediction (%)	Surface Layer K_s (cm/s)	Curve Number (CN)	SRO (mm)
Altamont	Composite	15	2.0×10^{-5}	94.1	44	3.7%	2.0×10^{-5}	88.1	16
	Monolithic	26	2.8×10^{-6}	94.1	52	5.2%	2.8×10^{-4}	94.1	20
Sacramento	Monolithic (1070 mm)	120	9.0×10^{-7}	91.1	97	-2.0%	9.4×10^{-5}	91.1	85
	Monolithic (2450 mm)	68	9.0×10^{-7}	91.1	105	3.2%	9.4×10^{-5}	91.1	80
Helena	Capillary	28	5.0×10^{-7}	94.1	25	-0.8%	-[a]	-[a]	-[a]
Polson	Composite	19	4.9×10^{-5}	84.7	49	3.4%	4.9×10^{-5}	77.3	13
	Capillary	23	4.9×10^{-5}	84.7	54	4.2%	4.9×10^{-5}	77.3	9
Boardman	Composite	0	3.8×10^{-5}	94.4	2	1.1%	-[a]	-[a]	-[a]
	Monolithic (1220 mm)	0	1.9×10^{-5}	94.4	0.2	0.1%	-[a]	-[a]	-[a]
	Monolithic (1840 mm)	0	1.4×10^{-5}	94.4	0.2	0.1%	-[a]	-[a]	-[a]
Marina	Composite	86	4.5×10^{-6}	92.9	257	28.2%	2.8×10^{-4}	92.9	164
	Monolithic	0	6.7×10^{-8}	83.1	151	25.0%	2.8×10^{-4}	83.1	6
Albany	ECap	15	1.9×10^{-7}	90.9	459	22.4%	2.8×10^{-4}	82.3	32
	Compacted Clay	166	1.3×10^{-4}	90.9	697	31.9%	1.3×10^{-4}	82.3	639
Omaha	Composite	67	1.5×10^{-6}	92.0	479	57.1%	2.8×10^{-4}	92.0	89
	Capillary (760 mm)	72	6.1×10^{-6}	94.4	136	8.9%	2.8×10^{-4}	94.4	119
	Capillary (1060 mm)	54	4.5×10^{-7}	94.4	164	15.1%	2.8×10^{-4}	94.4	123

[a] Additional simulation not conducted because "original" simulation predicted less than or equal amount of surface runoff as measured in field.

features (desiccation and freeze-thaw cracks, root holes, worm holes, etc.) that affect the saturated hydraulic conductivity at field scale. In addition, tilling was conducted at three sites (Albany, Cedar Rapids, and Marina) subsequent to construction to facilitate vegetative growth, and probably increased the saturated hydraulic conductivity above that measured immediately after construction.

To account for these post-construction changes in hydraulic conductivity, another set of simulations was conducted using different parameters for the surface layer. The saturated hydraulic conductivity of the upper most layer was adjusted until the runoff predicted by UNSAT-H and HELP was similar to that measured in the field. If a topsoil layer did not exist, the surface layer was divided into two layers, with the uppermost layer being 150 mm thick.

Graphs of the water balance predicted using UNSAT-H and HELP with the original parameters used as input are shown in Appendices 4 and 5. Simulations conducted with "original" parameters refer to simulations using the saturated hydraulic conductivity measured immediately after construction. Graphs illustrating the predicted water balance form UNSAT-H and HELP using adjusted parameters, as compared to field measurements, are shown in Section 5.5.1 and 5.5.2. Simulations conducted with "adjusted" parameters refer to simulations using adjusted saturated hydraulic conductivities and surface runoff curve numbers (HELP only)

UNSAT-H calculates surface runoff as the difference between precipitation and infiltration, the later being a function of the water content of the soil, and the hydraulic properties of the cover layers. The infiltration rate decreases as the wetted depth increases, and approaches the lowest saturated hydraulic conductivity of any layer within the wetted depth. For many cases, predictions of surface runoff made with

UNSAT-H came considerably closer to that measured in the field when the surface layer had a saturated hydraulic conductivity of 2.8×10^{-4} cm/s. For some cases, adjusting the saturated hydraulic conductivity of the surface layer was not necessary. For other cases, however, increasing the saturated hydraulic conductivity of the surface layer was not sufficient to match the predicted and measured runoff.

An example of the latter case is shown in Fig. 5.4, in which multiple simulations were conducted by varying the saturated hydraulic conductivity of topsoil layer in the thick monolithic barrier at Sacramento. UNSAT-H did not predict a surface runoff less than 267 mm (field surface runoff was 68 mm), even when the saturated hydraulic conductivity of the topsoil was increased to 1.0×10^{-3} cm/s. The only means of decreasing the predicted surface runoff sufficiently was to increase the saturated hydraulic conductivity of the storage layer below the topsoil layer from 1.7×10^{-7} cm/s (measured) to 4.0×10^{-4} cm/s (i.e., same hydraulic conductivity as was measured for the thin monolithic barrier).

As was obtained for the thick barrier at Sacramento, UNSAT-H over-predicted surface runoff for the alternative (Fig. 5.5) and conventional covers at Albany regardless of the saturated hydraulic conductivity that was used for the surface layer. For the alternative cover, the saturated hydraulic conductivity of the entire surface layer (600 mm) had to be increased to 2.8×10^{-4} cm/s to replicate the field runoff. For the conventional cover, accurately predicting the surface runoff was not possible without increasing the saturated hydraulic conductivity of the compacted clay barrier to 7.3×10^{-5} cm/s.

HELP fared considerably better than UNSAT-H at predicting the measured surface runoff, even though the same hydraulic properties were used for both models.

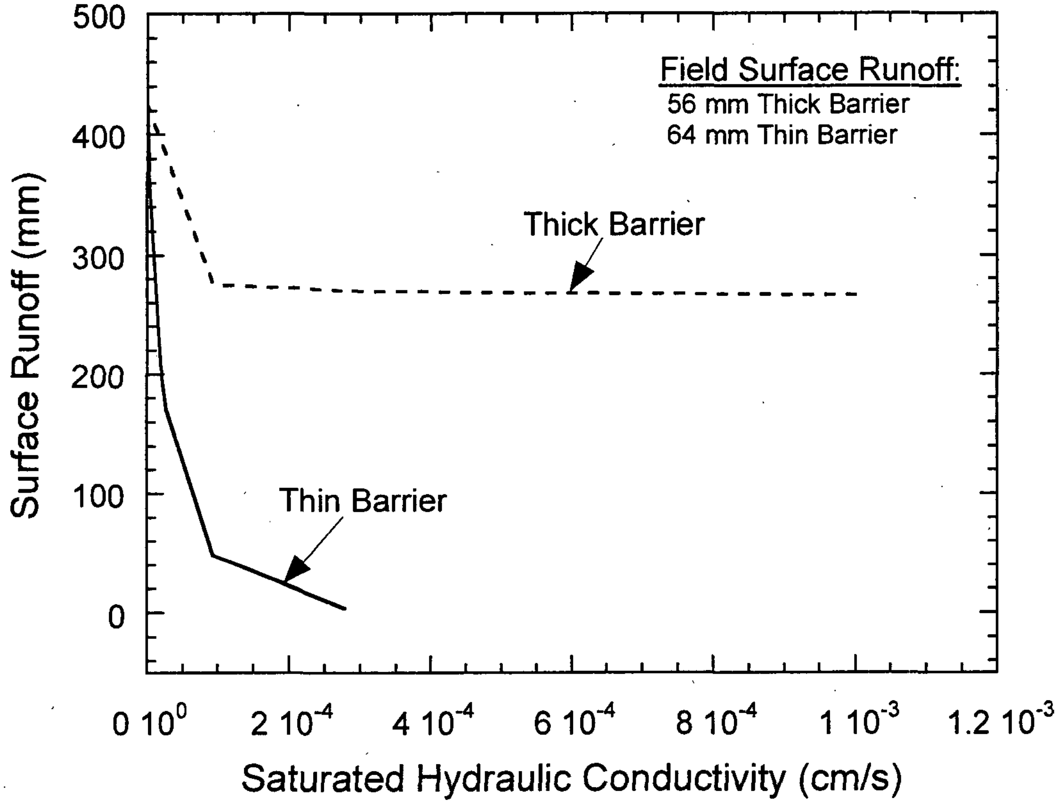


Fig. 5.4. Surface Layer Adjustment for Alternative Covers at Sacramento Site Using UNSAT-H.

HELP was more accurate because a surface runoff curve number (based on slope, vegetation cover, and soil texture) initially partitions rainfall into surface runoff and infiltration. The curve number is entered by the user, and is used to calculate a maximum retention parameter. The retention parameter is adjusted by HELP, depending on the water content of the vegetative zone, and frozen ground conditions. As the water content of the vegetative zone increases, the retention parameter decreases, and the amount of precipitation that becomes surface runoff increases. All of the precipitation will become surface runoff if the vegetative zone becomes saturated.

Surface runoff could be significant for covers that have little soil water storage capacity, lower saturated hydraulic conductivity, and receive intense rain events. The vegetative zone for the conventional cover at Albany only includes the 150 mm topsoil layer, because HELP assumes that the compacted clay barrier is saturated at all times. Therefore, the conventional cover has approximately 45 mm of storage (based on porosity), which is often approached during the intense rain events at Albany.

To more accurately predict surface runoff for the alternative cover at Albany using HELP, the surface runoff curve number and the saturated hydraulic conductivity of the entire storage layer had to be adjusted (Fig. 5.5). Surface runoff was accurately predicted when the curve number was 82.3 and the saturated hydraulic conductivity was 2.8×10^{-4} cm/s.

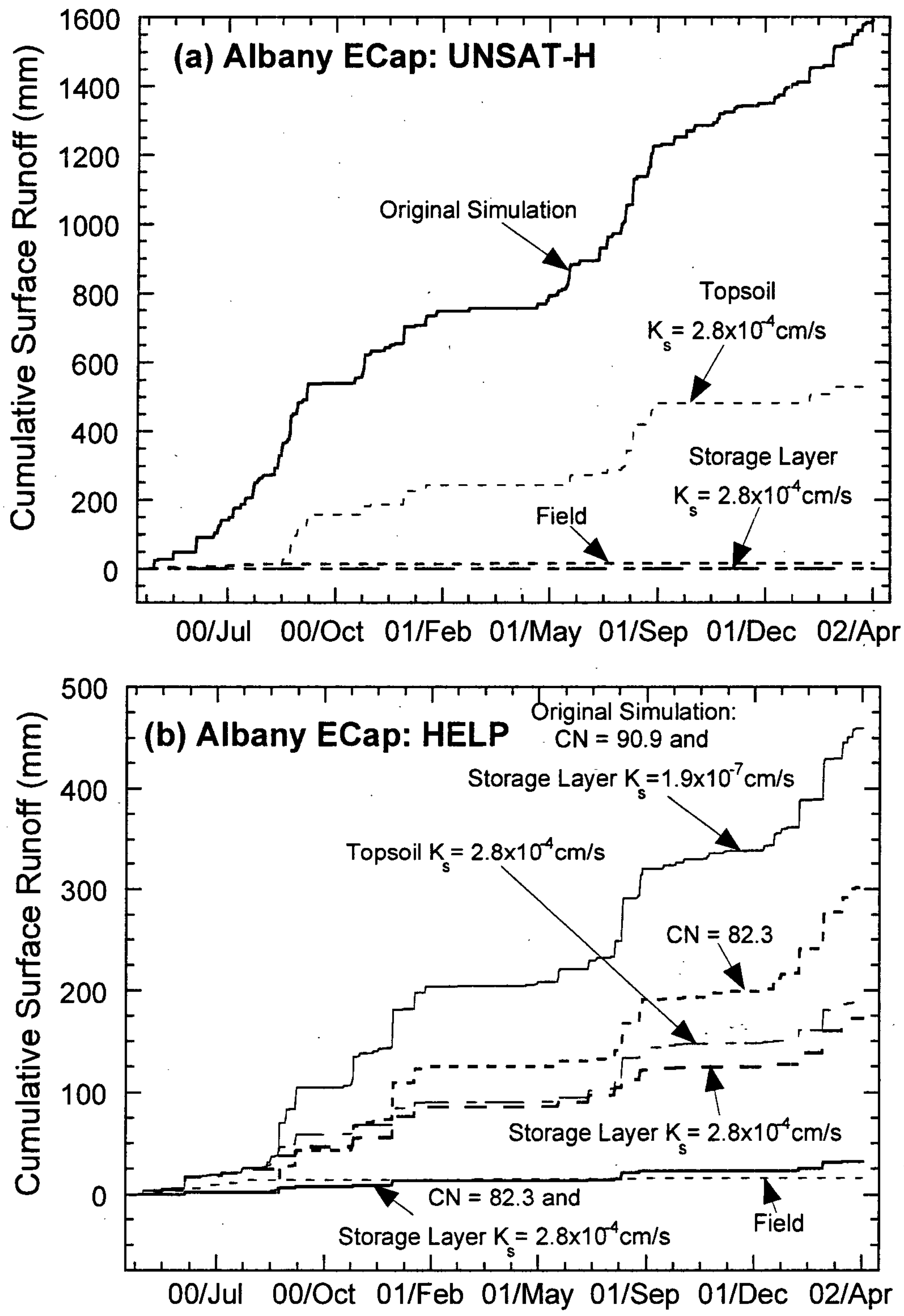


Fig. 5.5. Adjustment of Hydraulic Conductivity and Curve Number for Surface Layer for ECap Cover at Albany Site: (a) UNSAT-H and (b) HELP.

5.5.1 Alternative Covers

The following sections provide a comparison of the water balance measured at each site and predictions made with HELP and UNSAT-H using the measured hydraulic properties, and hydraulic properties that were adjusted so that the surface runoff predicted by the models was comparable to that measured in the field.

5.5.1.1 Altamont Site

Water balance measurements and predictions by HELP and UNSAT-H are shown in Fig. 5.6. The saturated hydraulic conductivity of the surface layer (150 mm) was set at 2.8×10^{-4} cm/s in UNSAT-H, and the runoff curve number was reduced to 88.1 in HELP, so that the predicted runoff would be comparable to that occurring in the field.

HELP under-predicted surface runoff by 6.6 mm during the entire monitoring period. HELP was able to predict the occurrence of surface runoff for the majority of runoff events measured in the field. However, between December 15, 2001 and January 2, 2002, approximately 100 mm of rain fell at Altamont, which caused 20.6 mm of surface runoff in the field. HELP greatly under-predicted surface runoff for this period (only 6.8 mm of surface runoff was predicted).

HELP under-predicted soil water storage during the winter months (rainy season), and during the dry season. After the winter rains cease, the soil water storage in the field gradually decreases, reaching a minimum at the end of the dry season. In contrast, HELP removes all of the available water from the cover profile immediately after the winter rains cease, causing the soil to reach the wilting point at the end of April. After the wilting point is reached, HELP no longer predicts evapotranspiration until the winter rains occur again.

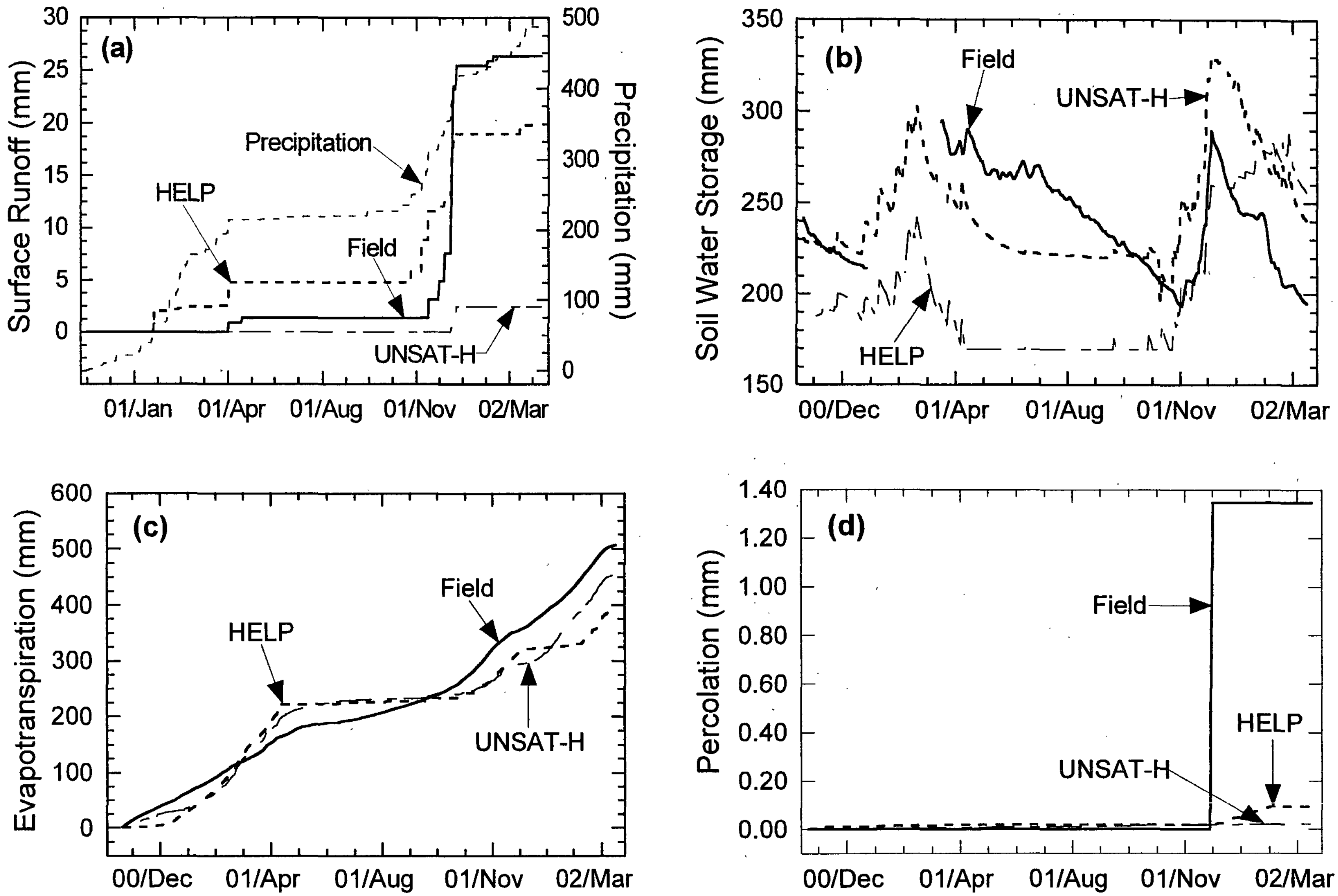


Fig. 5.6. Comparison of Water Balance Data for the Altamont Site to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

Even though the soil water storage capacity of the alternative cover at Altamont (460 mm based on field capacity) was never reached, 1.3 mm of percolation was measured at the end of December 2001. HELP under-predicted percolation, predicting only 0.1 mm. HELP began predicting percolation during the same time as occurred in the field, but HELP predicted that the percolation extended over two months, rather than the sudden pulse of percolation observed in the field.

UNSAT-H under-predicted surface runoff measured in the field by 18.2 mm when the adjusted hydraulic conductivity of the surface layer was used as input. The original hydraulic conductivity of the surface layer (measured immediately after construction) was 2.8×10^{-6} cm/s. The saturated hydraulic conductivity used for these simulations was 2.8×10^{-4} cm/s, and was not refined specifically for the Altamont site. The predicted surface runoff probably would have been closer if a more accurate hydraulic conductivity was assigned to the surface layer. Samples are being collected at each site during 2002-03 to better characterize the saturated hydraulic conductivity operative in the field.

UNSAT-H was able to follow the soil water storage trend observed in the field during the first year of the monitoring period, but was not able to reach the minimum soil water storage observed in the field by the end of the dry season. UNSAT-H, similar to HELP, did not predict evapotranspiration during the dry season, resulting in no change in soil water storage during this period. During the second winter, UNSAT-H predicted higher soil water storage than occurred in the field. This over-estimate is most likely due to the over-estimation of soil water storage during the dry season, the under-estimation of surface runoff at the end of December 2001, and the under-estimation of evapotranspiration.

5.5.1.2 Sacramento Site

The measured water balance and predictions by HELP and UNSAT-H for the thin and thick barriers in Sacramento are shown in Figs. 5.7 and 5.8. To predict runoff better, the saturated hydraulic conductivity assigned to the surface layer (uppermost 150 mm) for the thin barrier was set at 9.4×10^{-5} cm/s in HELP and UNSAT-H. For the thick barrier, the hydraulic conductivity of the surface layer was assigned 9.4×10^{-5} cm/s in HELP, and 2.8×10^{-4} cm/s in UNSAT-H. Also, the saturated hydraulic conductivity of the storage layer in the thick barrier had to be increased to 4.0×10^{-4} cm/s (similar to that in the thin barrier) for UNSAT-H. When the saturated hydraulic conductivity of the storage layer for the thick barrier was not increased, surface runoff was greatly over-estimated (see Appendix 2).

HELP was able to predict the occurrence of surface runoff during the entire monitoring period, but under-predicted surface runoff by 35 mm for the thin barrier, and by 12 mm for the thick barrier. The largest discrepancy was in February 2001 and December 2001. During these two periods, the measured surface runoff was approximately 25% of precipitation for the thin barrier. In contrast, surface runoff was only 10.5% of precipitation over the entire monitoring period. Surface runoff may have been greater during these two periods because of intense rain events. In both February and December 2001, 90 mm of rainfall was measured.

HELP was able to predict the trend in soil water storage fairly closely prior to Winter 2001. After Winter 2001, HELP grossly under-predicted soil water storage for both covers. This discrepancy is due to (1) the prediction of percolation during the first two winters, when no percolation actually occurred, and (2) predicting greater evapotranspiration during Spring 2001 than occurred in the field.

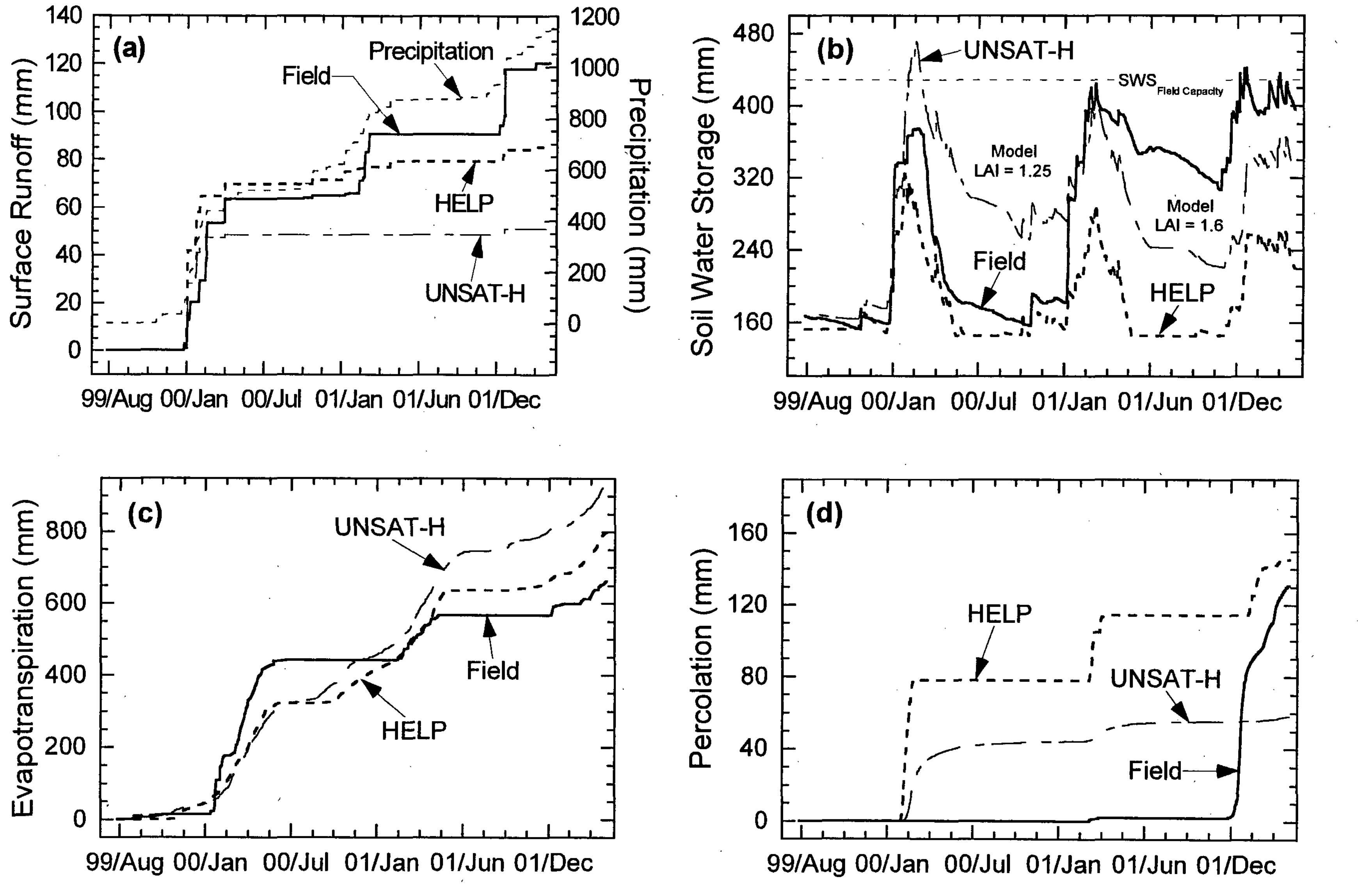


Fig. 5.7. Comparison of Water Balance Data for the Sacramento Site (Thin Monolithic Barrier) to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

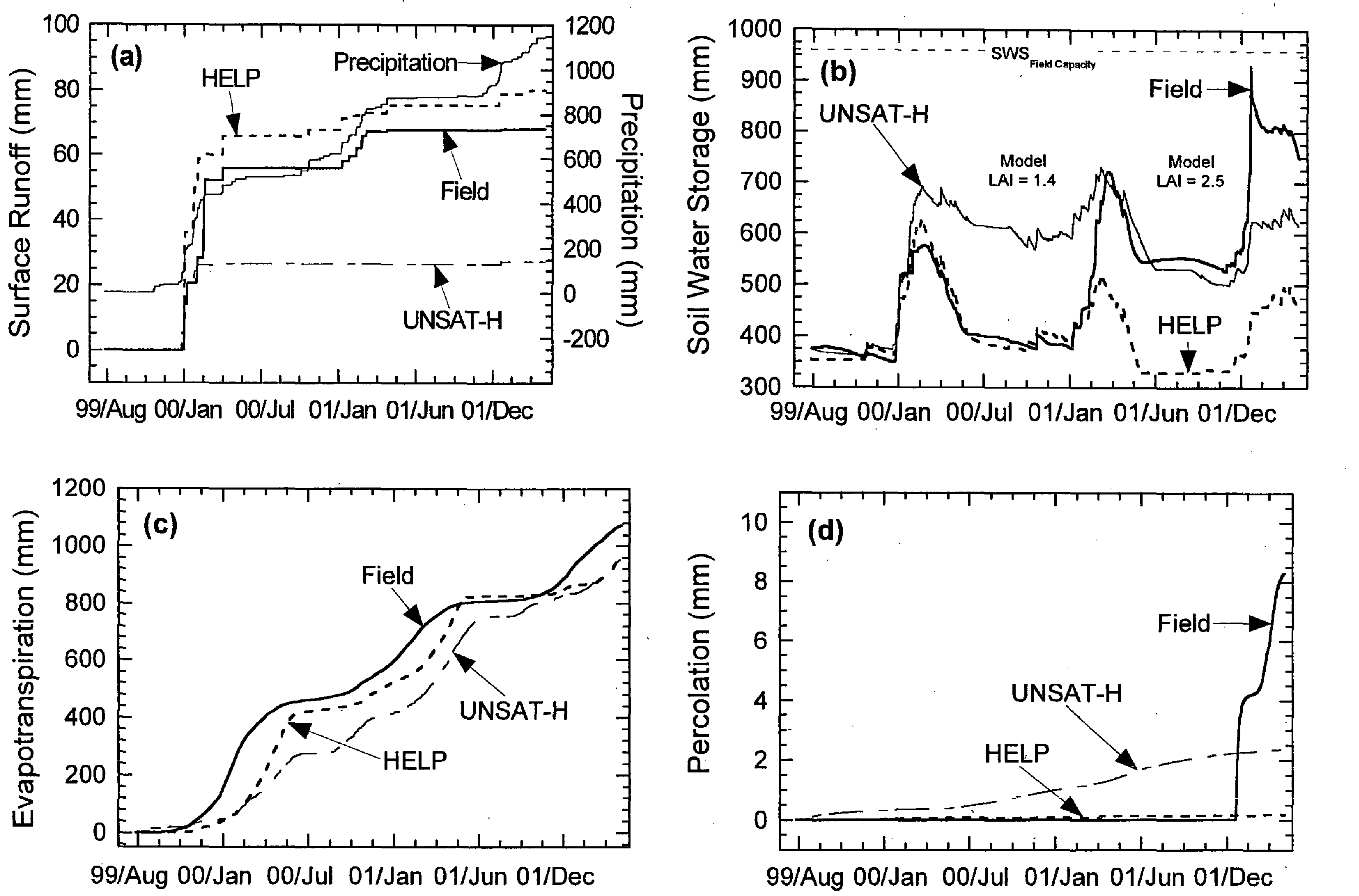


Fig. 5.8. Comparison of Water Balance Data for the Sacramento Site (Thick Monolithic Barrier) to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

Another likely cause of the under-prediction is due to the method by which HELP outputs soil water storage. HELP outputs a weighted average of the volumetric water content of the evaporative zone, rather than the soil water storage of the entire cover profile (such as from UNSAT-H). To compare the soil water storage calculated from HELP with the soil water storage from UNSAT-H and that calculated by the WCRs in each test section, the soil water storage of the evaporative zone from HELP was added to the initial soil water storage of the other layers measured in the field. The flaw in this approach is that any water that is routed by HELP to the layers below the evaporative zone will not be captured. For example, HELP under-predicted the maximum soil water storage for the thin barrier at Sacramento by 70 mm (March 2001) when the interim cover was not included in the calculation of soil water storage measured in the field (see Fig. 5.9). However, HELP over-predicted soil water storage by 133 mm when the interim cover was included in the soil water storage calculation.

During Spring 2001, HELP removed all of the available soil water in the evaporative zone by evapotranspiration and percolation (thin barrier only), whereas significantly less evapotranspiration and percolation actually occurred in the field. The vegetation at the Sacramento site most likely went dormant several months earlier than expected, but a typical growing season was used in the HELP simulations.

HELP grossly over-predicted percolation from the thin barrier during most of the monitoring period, but under-predicted percolation that occurred at the end of the monitoring period for both covers. At no time during the monitoring period did HELP predict that the soil water storage was exceeded. The large amount of percolation transmitted through the thin barrier can be attributed to the high saturated hydraulic

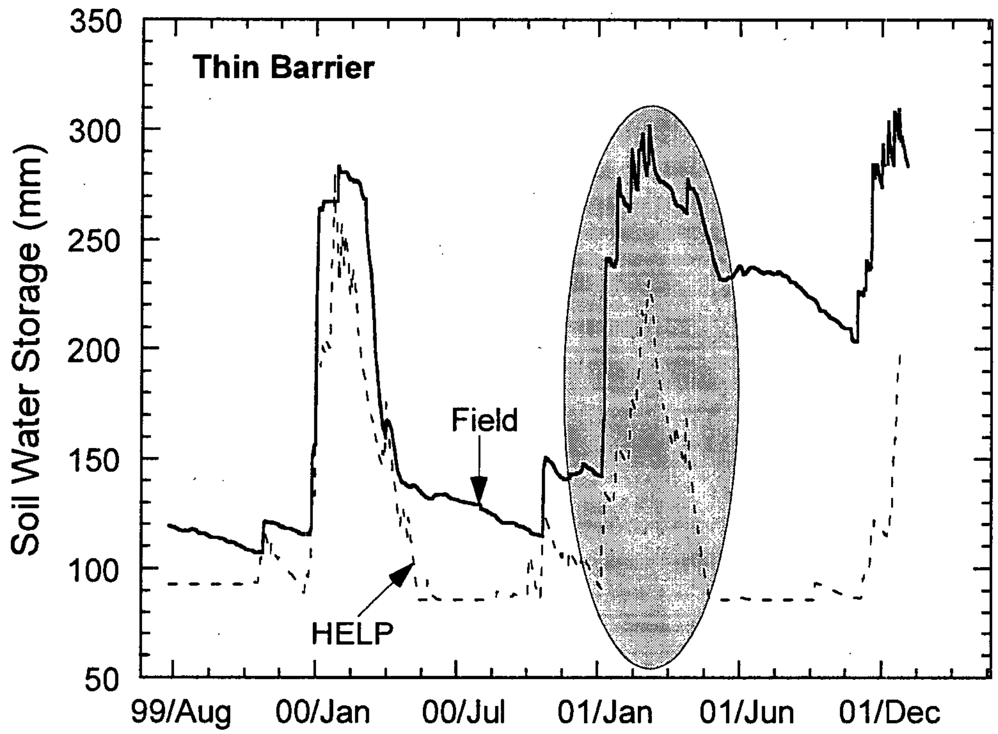


Fig. 5.9. Soil Water Storage Predicted by HELP and Measured in Field for the Thin Monolithic Barrier at the Sacramento Site.

conductivity of the storage layer (4.0×10^{-4} cm/s). For the thick barrier, the combination of additional thickness and the lower saturated hydraulic conductivity of the storage cover (1.7×10^{-7} cm/s) limited percolation to less than 1 mm during the monitoring period.

UNSAT-H did not perform as well HELP in predicting occurrences of surface runoff during the monitoring period. UNSAT-H under-predicted surface runoff by 69.2 mm for the thin barrier, and by 40.9 mm for the thick barrier. The majority of surface runoff predicted by UNSAT-H occurred from mid-January to mid-February 2000. During this period, UNSAT-H only slightly under-predicted surface runoff from the thin barrier (6 mm), but grossly under-predicted surface runoff from the thick barrier by (26 mm). The inaccuracy for the thick barrier is likely due to the surface layer being assigned a saturated hydraulic conductivity that is too high.

The trend in soil water storage was predicted by UNSAT-H. However, UNSAT-H did not predict the minimum and maximum soil water storage measured in the field. UNSAT-H under-predicted evapotranspiration prior to Winter 2001, which caused an over-prediction in peak soil water storage in Winter 2000. Also, UNSAT-H did not extract water to the wilting point (151 mm thin barrier, 351 mm thick barrier) in Summer 2000, as occurred in the field. Evapotranspiration may have been under-predicted due to an under-estimate of maximum LAI. The LAI was measured at Sacramento, but the vegetation samples were not collected during the peak of the growing season, when LAI is at a maximum.

Percolation was only transmitted from the two covers at the end of the monitoring period (131 mm for the thin barrier and 8.3 mm for the thick barrier). During Winter 2000 and 2001, UNSAT-H predicted that the soil water storage would exceed the capacity of the thin barrier, which caused 58 mm of percolation. For the thick barrier, 2.4 mm of percolation was predicted to occur throughout the entire monitoring period.

5.5.1.3 Helena Site

The measured water balance and predictions made with HELP and UNSAT-H are shown in Fig. 5.10. For UNSAT-H, the saturated hydraulic conductivity assigned to the surface layer (150 mm) was 2.8×10^{-4} cm/s to improve the runoff prediction.

HELP under-predicted surface runoff by only 3 mm during the monitoring period, despite missing a snowmelt event in March 2001, and over-predicting surface runoff during Spring 2001. The field data show that 14 mm of surface runoff occurred during a snowmelt in March 2001, even though only 4 mm of water was applied using the snowmelt algorithm (described in Section 5.4.1). This discrepancy may be due to snow being melted prior to March 2001 by the snowmelt algorithms used in HELP and UNSAT-H, or that snowfall was not accurately measured during Winter 2001.

During two rain events in June 2001 (28.7 mm) and July 2001 (24.9 mm), HELP predicted that surface runoff was approximately 25% of precipitation, whereas less than 1 mm of surface runoff was measured. The high percentage of surface runoff during those two events may be due to the intense precipitation that occurred in June and July 2001, which is atypical for Helena. The saturated hydraulic conductivity of the surface layer may also have been too low to allow the water to infiltrate sufficiently.

The field data show that soil water storage increases during the spring (snowmelt) and summer (rainy season), and decreases in the fall and winter. HELP greatly under-predicts soil water storage during nearly the entire monitoring period.

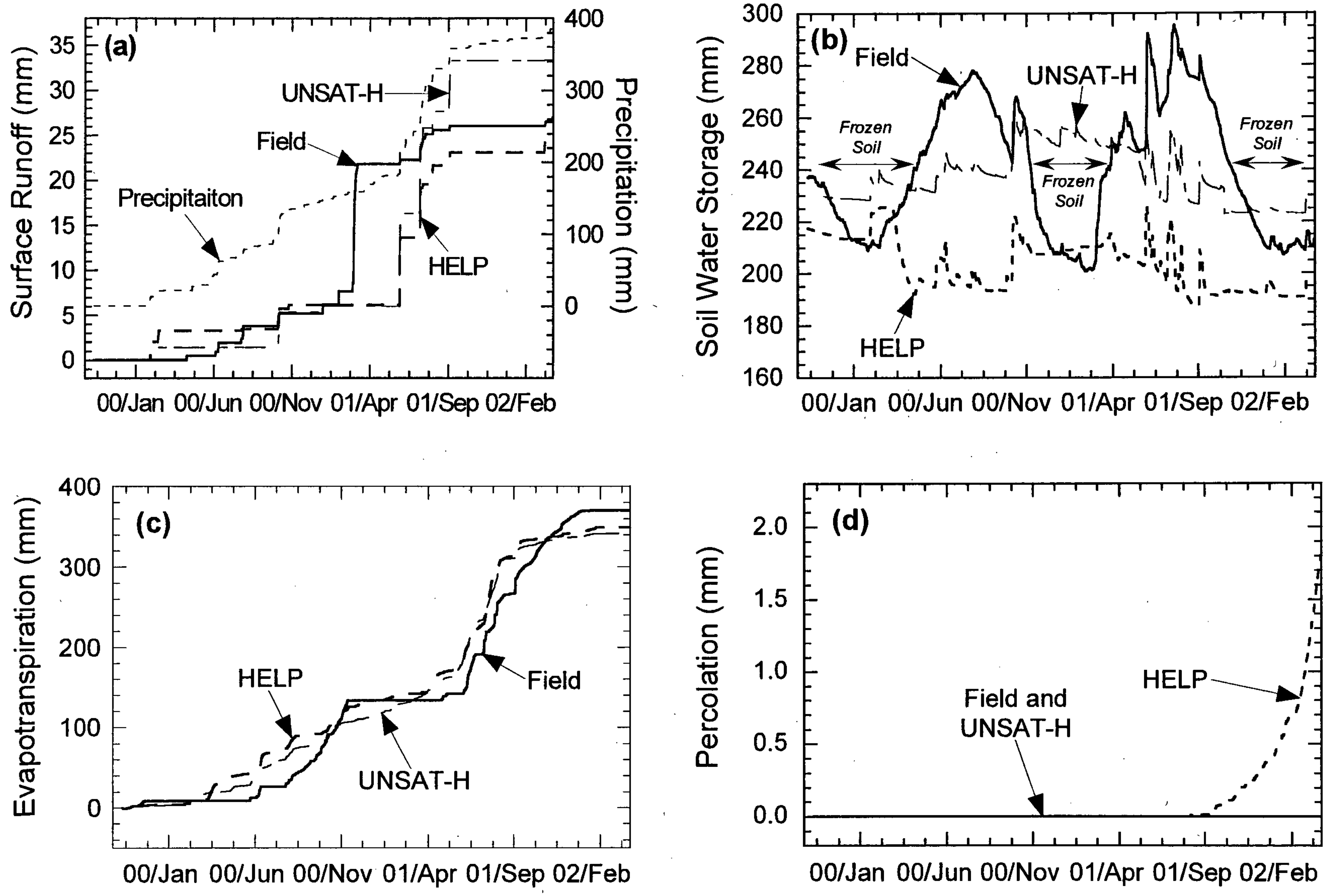


Fig. 5.10. Comparison of Water Balance Data for the Helena Site to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

During the spring, HELP under-predicts soil water storage by approximately 70 mm. The field data show a large increase in soil water storage in the spring, whereas HELP only shows small peaks in soil water storage that diminish rapidly. This may be due to HELP over-predicting evapotranspiration during these periods, or draining water to lower layers (below the evaporative zone). HELP predicted 2.3 mm of percolation from the cover, beginning in September 2001, despite no percolation being measured during the monitoring period.

UNSAT-H over-predicted surface runoff by only 5 mm during the monitoring period. However, like HELP, UNSAT-H missed the snowmelt event in March 2001, and over-predicted surface runoff.

UNSAT-H was able to follow the trend in soil water storage measured in the field better than HELP, but still under-predicted soil water storage in the summer by 30 mm, and over-predicted soil water storage in the winter by approximately 20 mm. During Winter 2001, UNSAT-H over-predicted soil water storage by almost 55 mm. The large apparent drop in soil water storage measured in the field is a result of frozen soil (see Section 4.3.2), in which case both HELP and UNSAT-H predictions would more closely follow the soil water storage trend.

UNSAT-H closely predicts the trend in evapotranspiration calculated from the field data, except during the winter. The potential artificial drop in soil water storage during the winter causes an artificial increase in evapotranspiration, whereas UNSAT-H predicts very little evapotranspiration.

UNSAT-H does not predict any percolation during the monitoring period, which is consistent with the field data.

5.5.1.4 Polson Site

The measured water balance and predictions made with HELP and UNSAT-H are shown in Fig. 5.11. To predict surface runoff better, the saturated hydraulic conductivity assigned to the surface layer (150 mm) for UNSAT-H was 2.8×10^{-4} cm/s. For HELP, the runoff curve number was reduced to 77.3.

HELP under-predicted surface runoff by 11.3 mm for the entire monitoring period, but most of the under-prediction occurred February 2000. During this time period, 11.7 mm of surface runoff was measured, most of which was caused by snowmelt. HELP predicted only 2 mm of surface runoff during the same time period, despite predicting frozen ground conditions.

Surface runoff predicted by HELP using the original parameters is shown in Fig. 5.12, along with predictions using a higher saturated hydraulic conductivity and a lower runoff curve number. During Winter 2000, the HELP simulations using the original parameters and an elevated saturated hydraulic conductivity accurately predict surface runoff, but greatly over-predict runoff during the following winters. In contrast, lowering the curve number results in a poor prediction during Winter 2000, but a close prediction in subsequent winters. This may suggest that the saturated hydraulic conductivity needs to be increased, and the curve number reduced over-time.

The field data show that soil water storage increases in the spring, and decreases dramatically in the summer. A similar trend is evident in soil water storage predicted by HELP. However, HELP under-predicted soil water storage in Spring 2000 by 70 mm, and in Spring 2001 by 35 mm, because percolation was over-predicted. HELP allowed water to drain from the profile, rather than being retained in soil water storage.

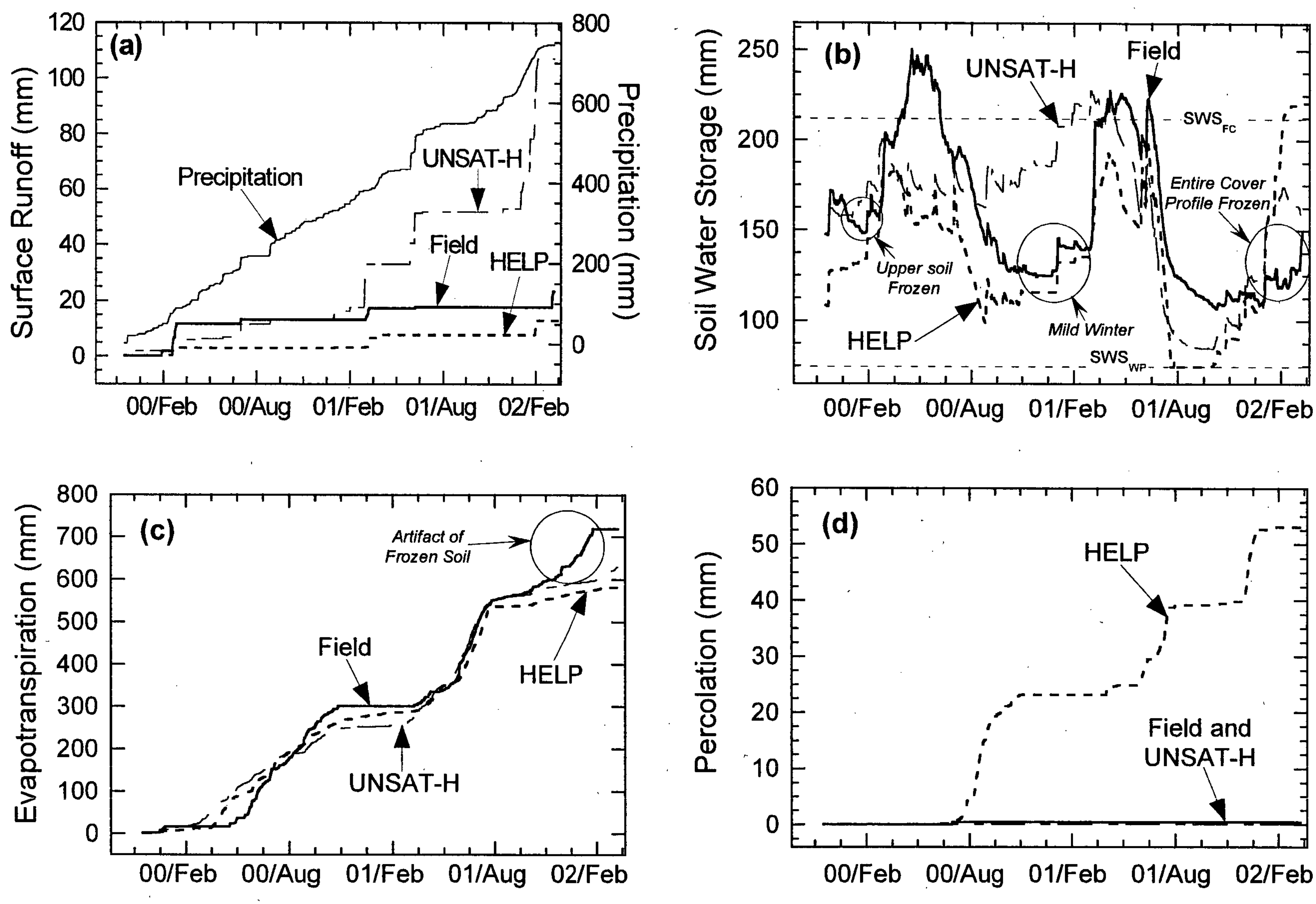


Fig. 5.11. Comparison of Water Balance Data for the Polson Site to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

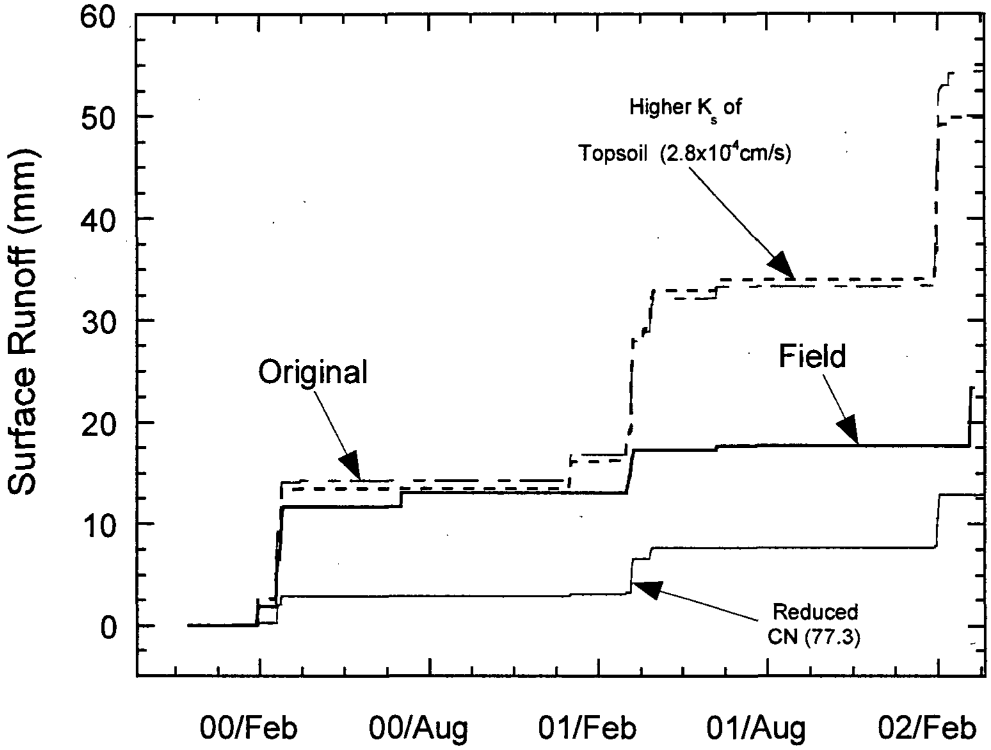


Fig. 5.12. Measured Surface Runoff and Predictions by HELP for the Alternative Cover at Polson Using Original and Adjusted Parameters for the Surface Layer.

During Winter 2002, HELP and UNSAT-H predicted soil water storage to increase significantly earlier than occurred in the field. This is likely due to frozen ground conditions that occurred in the field. Soil temperatures below 0°C were measured in the entire cover profile between December 22, 2001 and March 14, 2002, and any precipitation that infiltrated the cover probably was not detected by the WCR probes. This is also realized in the evapotranspiration data, which was calculated to increase during Winter 2002, whereas little or no evapotranspiration was anticipated.

HELP predicted percolation in Summer 2000 and 2001, as a result of snowmelt during the spring, because the influence of the capillary break between the finer and coarser layers is not simulated. HELP continued to drain water downwards until it finally became percolation. The percolation predicted in Winter 2002 is likely due to the large increase in soil water storage that was predicted, which should have been either stored as snowpack or as added to soil water storage.

UNSAT-H over-predicted surface runoff by 83.7 mm, despite using an increased saturated hydraulic conductivity for the surface layer. The low saturated hydraulic conductivity of the underlying layer controls the infiltration rate for the cover, and causes the surface layer to saturate quickly during intense rain events and large snowmelt events. Once the surface layer approaches saturation, additional precipitation is shed as runoff. More than half of the predicted surface runoff (54 mm) occurred after January 2002, caused by 71 mm of snowmelt and 53 mm or rainfall.

Soil water storage predicted by UNSAT-H did not follow the measured trend until Summer 2001. UNSAT-H under-predicted soil water storage by 50 mm in Winter 2000, and over-predicted soil water storage by 63 mm in Summer 2000. Soil water storage predicted by UNSAT-H peaked prior to that measured in the field during each winter, as was found for HELP. During Summer 2000, UNSAT-H did not predict the minimum soil water storage that occurred in the field. The maximum LAI assigned for 2000 was probably too low (0.82). The following summer, a maximum LAI of 2.5 was assigned, and UNSAT-H predicted the drop in soil water storage more accurately. However, UNSAT-H did under-predict the minimum soil water storage reached in Summer 2001 by 31 mm.

UNSAT-H did not predict any percolation during the monitoring because the capillary barrier effect is simulated by the model. As a result, the soil water storage can exceed the storage capacity based on field capacity, without appreciable drainage into the underlying coarser layer.

5.5.1.5 Boardman Site

The measured water balance and predictions made with HELP and UNSAT-H are shown in Figs. 5.13 and 5.14 for the Boardman site. The saturated hydraulic conductivity assigned to the surface layer and the surface runoff curve number did not have to be adjusted for either HELP or UNSAT-H, because both models predicted less than 1 mm of surface runoff and percolation during the monitoring period for both alternative covers. No surface runoff or percolation was measured from either cover. Therefore, graphs of surface runoff and percolation are not presented in this section.

HELP and UNSAT-H under-predicted soil water storage in Winter and Spring 2001, and over-predicted soil water storage in Summer and Fall 2001. The trend in soil water storage predicted by both models during Winter 2002 appears to match that observed in the field, but the magnitude is biased by the over-prediction of soil water storage during the previous year.

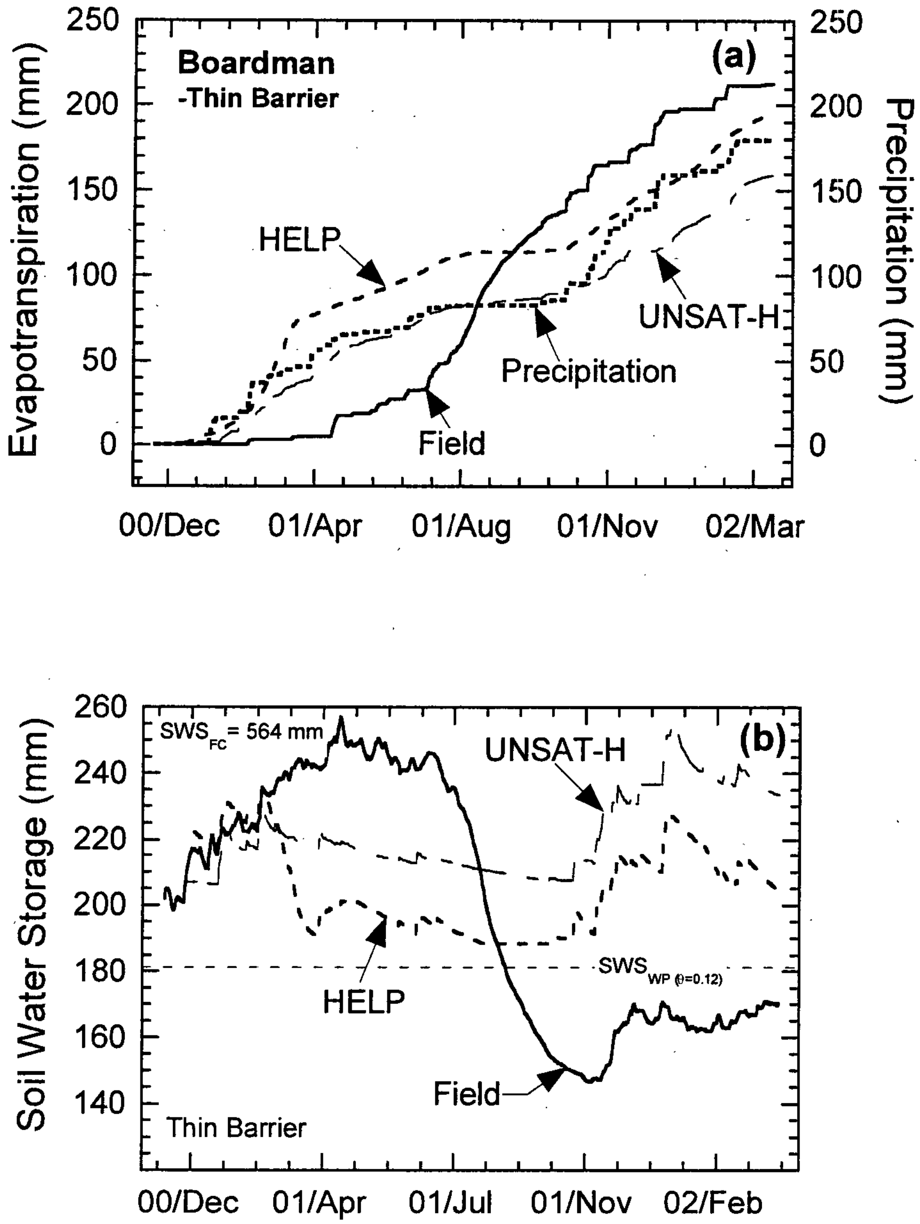
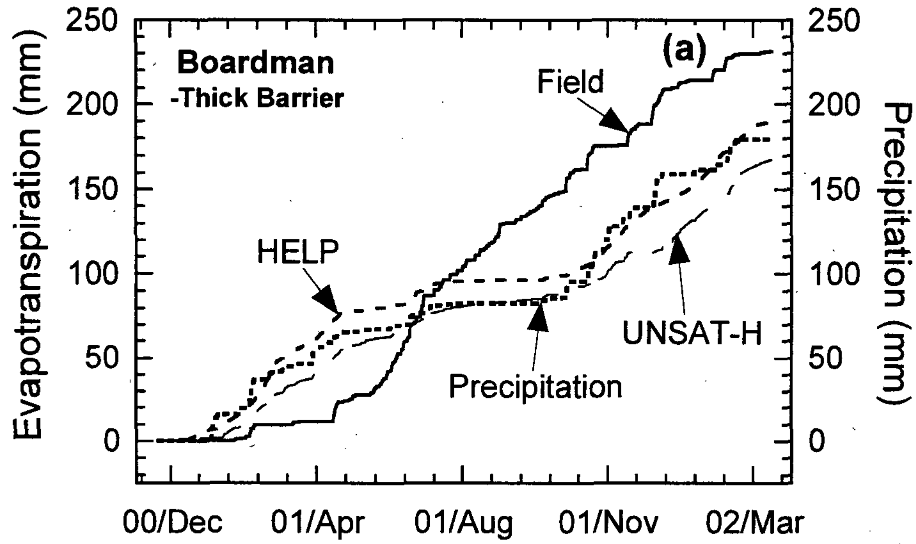


Fig. 5.13. Field Data and Predictions from HELP and UNSAT-H for the Thin Monolithic Barrier at the Boardman Site: (a) Evapotranspiration and (b) Soil Water Storage.



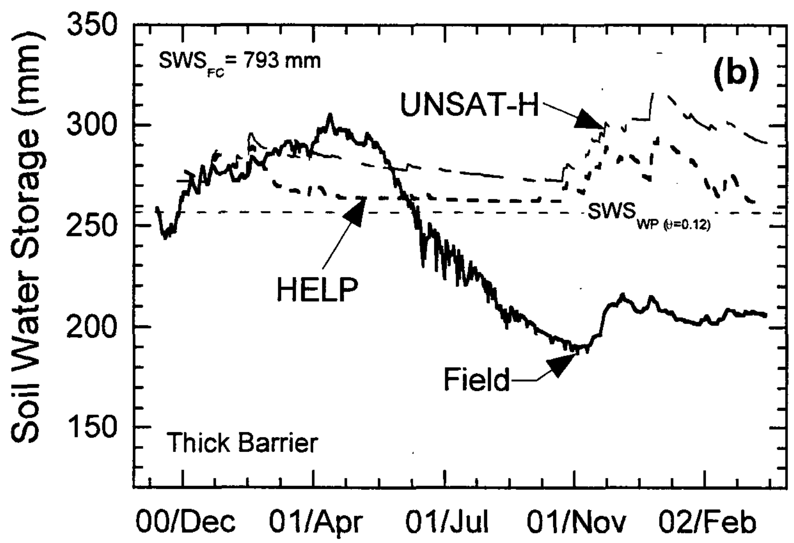


Fig. 5.14. Field Data and Predictions from HELP and UNSAT-H for the Thick Monolithic Barrier at the Boardman Site: (a) Evapotranspiration and (b) Soil Water Storage.

During Spring 2001, both models over-predicted evapotranspiration, which was followed by an under-prediction in Summer 2001. These errors in evapotranspiration mimic the errors in soil water storage, and suggest that properties of the vegetation may not have been chosen properly. To evaluate if the wilting point used in HELP (based on a suction of 1500 kPa) was responsible for the under-prediction of evapotranspiration in Summer 2001 (Fig. 5.15), additional simulations were conducted, where the wilting point for HELP was assigned the lowest water content (θ = 0.06) measured in the thick barrier during the monitoring period (excluding the WCR probe closest to the surface). Additional simulations of this type were not conducted for UNSAT-H, because the wilting point assigned to UNSAT-H was based on a suction of 6000 kPa (θ = 0.07).

For the simulation with a lower wilting point, HELP under-predicted soil water storage by rapidly removing soil water until the wilting point was reached during Summer 2001. Therefore, an addition simulation was conducted, with a lower wilting point and a reduced LAI (from 1.5 to 0.5). For this simulation, HELP accurately predicts the soil water storage reduction during Summer 2001.

5.5.1.6 Marina Site

The measured water balance and predictions made with HELP and UNSAT-H are shown in Fig. 5.16-5.18. The saturated hydraulic conductivity assigned to the surface layer (150 mm) for HELP and UNSAT-H was 2.8×10^{-4} cm/s. When the study was initiated, van Genuchten parameters were available for only a limited number of tests (storage layer: α = 0.00035 cm^{-1}, n = 1.4; interim cover: α = 0.053 cm^{-1}, n = 2.85). Further laboratory testing yielded different van Genuchten parameters (storage

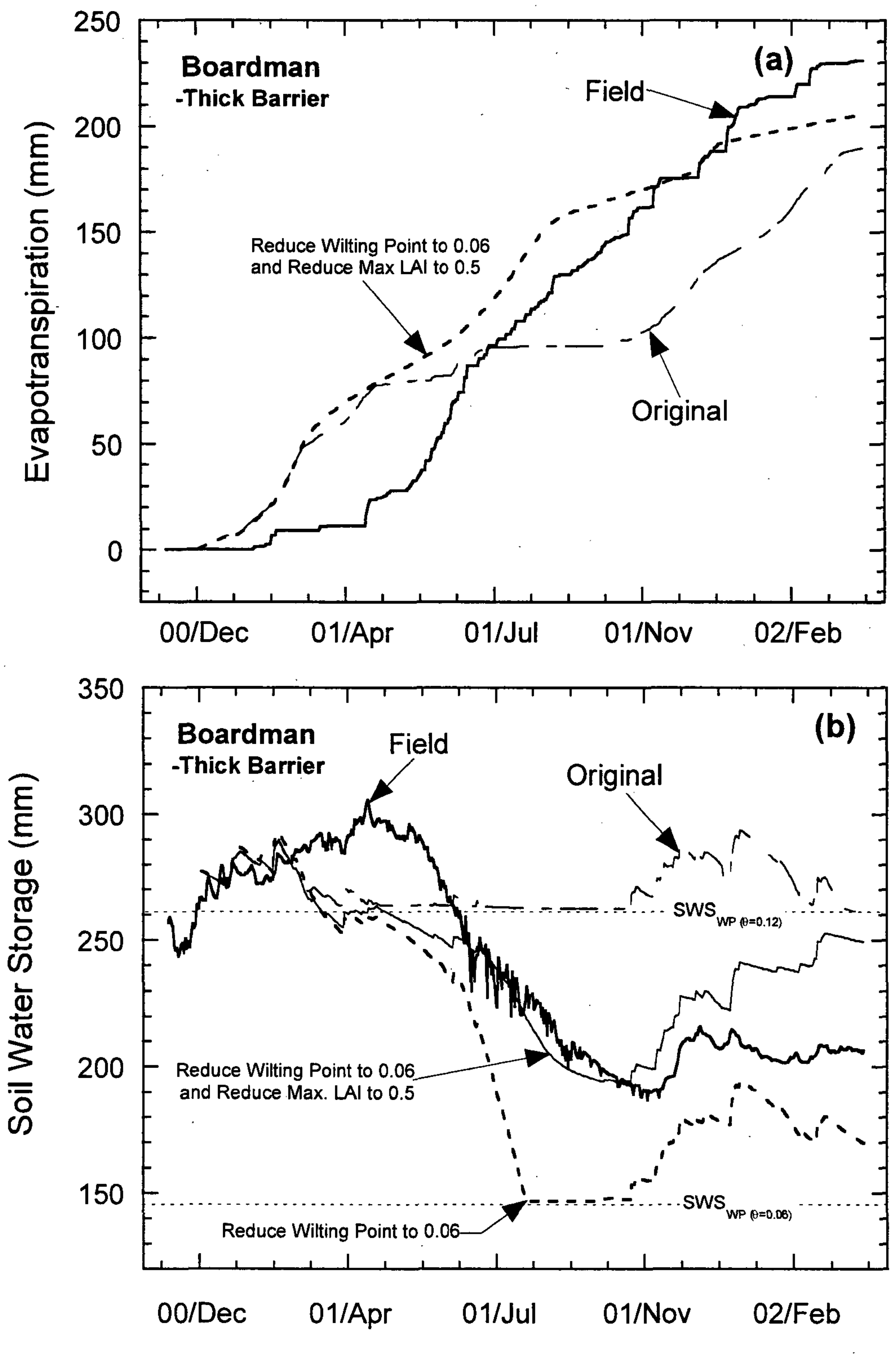


Fig. 5.15. Field Data and Predictions by HELP for the Thick Monolithic Barrier at the Boardman Site Using Adjusted Wilting Point and LAI Parameters: (a) Evapotranspiration and (b) Soil Water Storage.

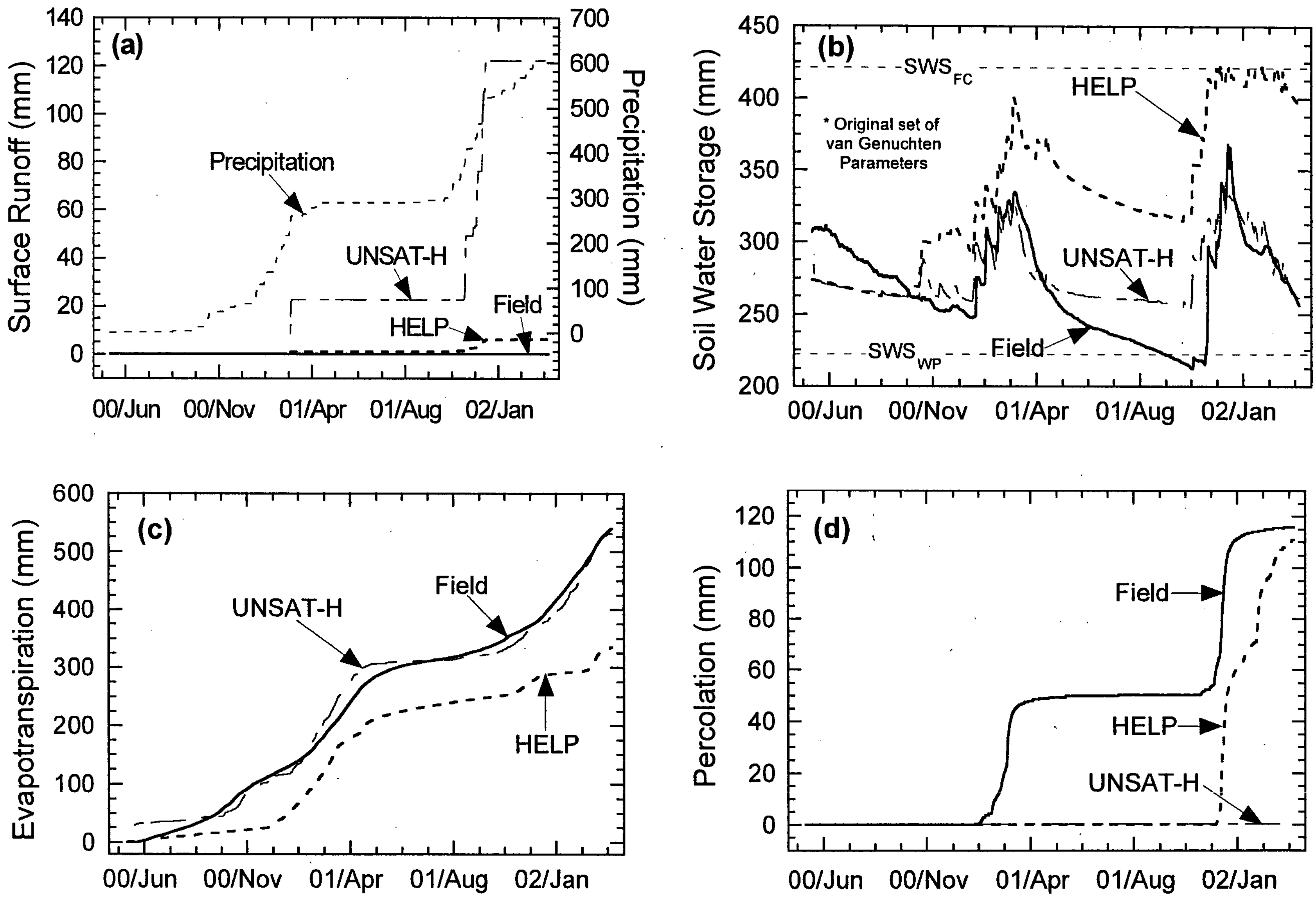


Fig. 5.16. Comparison of Water Balance Data for the Marina Site to Predictions Made with UNSAT-H and HELP Using First Parameter Set: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

layer: α = 0.00235 cm^{-1}, n = 1.4; interim cover: α = 0.0492 cm^{-1}, n = 3.46). The second parameter set reduced the soil water storage capacity of the cover (θ_{FC} reduced from 0.33 to 0.29), and the wilting point (θ_{WP} reduced from 0.17 to 0.08). Simulations were conducted using both parameter sets to assess how uncertainty in the hydraulic properties could affect the predictions.

Surface runoff was not measured in the field due to the surface layer being tilled. The absence of surface runoff was not expected, because of the 25% slope. HELP slightly over-predicted surface runoff, despite an increased saturated hydraulic conductivity of the surface layer, and a low runoff curve number (83.1). HELP predicted surface runoff during rainfall events greater than 15 mm, and on days following these large rainfall events.

The field data show that soil water storage increases in the winter, and decreases in the spring and summer. A similar trend is evident in soil water storage predicted by HELP. However, HELP over-predicted soil water storage in Winter 2001 (by 70 mm) and in Winter 2002 (by 30 mm). The over-prediction of soil water storage during the winter (rainy season) is due to the under-prediction of evapotranspiration during the previous summer. The rapid drop in soil water storage measured in the field is also due to percolation transmitting through the cover. In Summer 2001, HELP under-predicted percolation by 50 mm.

HELP closely matched the total amount of percolation that was transmitted through the cover during the entire monitoring period, but significantly under-predicted percolation in Winter 2001, and over-predicted percolation in Winter 2002 (i.e., the errors compensated). The field data show that the soil water storage capacity had never been exceeded. Therefore, percolation was likely transmitted through preferential flow paths, which HELP cannot simulate.

Use of the second set of van Genuchten parameters resulted in small changes in the predictions of evapotranspiration, surface runoff, and soil water storage. Therefore, these graphs are not shown. However, percolation predicted by HELP increased substantially when the second parameter set (see Figs. 5.17) was used as input.

To better understand the reason for the reduction in soil water storage during Summer 2001, an additional HELP simulation was conducted using a higher maximum LAI of 2.5 for 2001 (Fig. 5.17). The second set of van Genuchten parameters was used as input for this simulation. HELP over-predicted soil water storage by 103 mm using an LAI of 1.5 during Summer 2001, but only over-predicted soil water storage by 24 mm using an LAI of 2.5 (Fig. 5.17). When the rainy season began in Fall 2001 and Winter 2002, the HELP simulation with LAI = 2.5 provided more available soil water storage because of a large reduction in soil water storage predicted during the previous summer. As a result, HELP more closely predicted percolation during Winter 2002. Percolation was slightly over-predicted by only 8 mm.

UNSAT-H (using the first set of van Genuchten and LAI parameters) did not accurately predict surface runoff, when the saturated hydraulic conductivity of the surface layer was increased (Fig. 5.18). UNSAT-H over-predicted surface runoff by 122 mm, corresponding to events in the beginning of March 2001 (22 mm) and December 2001 (100 mm). Infiltration into the cover during these periods is controlled by the low

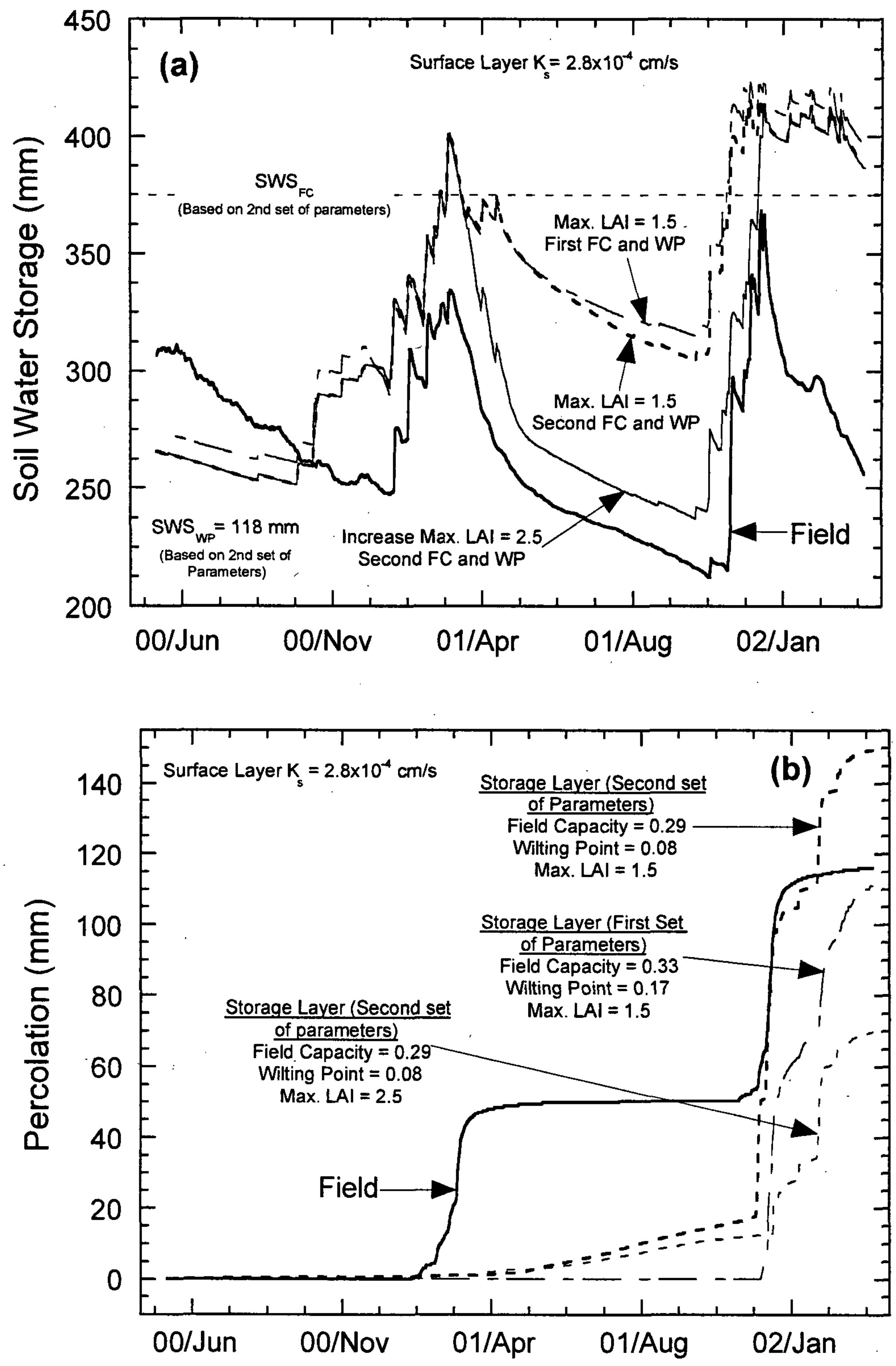


Fig. 5.17. Comparison of Water Balance Data for the Alternative Cover at the Marina Site to Predictions Made with HELP Using Adjusted van Genuchten and LAI Parameters: (a) Soil Water Storage and (b) Percolation.

saturated hydraulic conductivity of the storage layer below the surface layer. During large rain events, the surface layer becomes saturated, and precipitation is shed as surface runoff because water cannot penetrate quickly into the storage layer.

UNSAT-H was able to predict the trend in soil water storage more closely than HELP (Fig. 5.18). However, UNSAT-H predicted the soil water storage would immediately drop at the start of the monitoring period (May 2000). This is likely due to an inappropriate LAI. A maximum LAI of 0.8 was assigned for the first growing season (harvest date in June), even though the test section was not seeded to the test section until November 2000. During Summer 2001, UNSAT-H over-predicted soil water storage, as was found for HELP.

UNSAT-H grossly under-predicted percolation by 115 mm. This may be due to the over-predictions of surface runoff during times when percolation was transmitted through the cover.

An additional UNSAT-H simulation was conducted using adjusted parameters, as was done for HELP, to determine if the predictions by UNSAT-H would change. For this simulation, the second set of van Genuchten parameters was used with a maximum LAI of 2.5 for 2001 (see Fig. 5.18).

When the adjusted parameters were used, UNSAT-H predicted substantially more surface runoff than occurred in the field and was predicted using the first set of parameters (Fig. 5.18). This may have been due to a reduction in the field capacity of the storage layer, which caused the uppermost surface layer to become saturated quicker during periods of high rainfall. Precipitation was more easily shed as runoff during these periods.

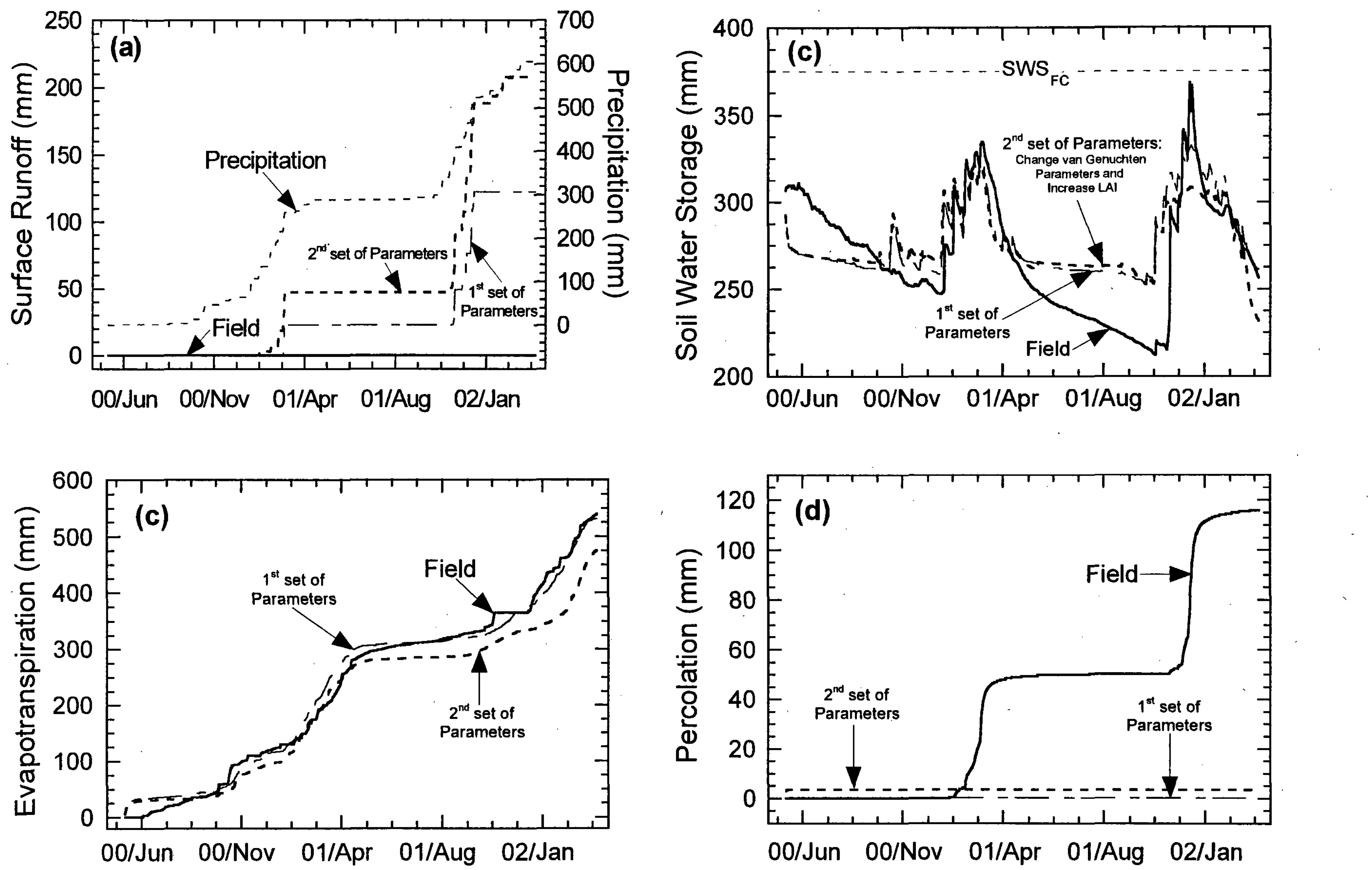


Fig. 5.18. Comparison of Water Balance Data at the Marina Site and Predictions Made with UNSAT-H Using Adjusted Parameters: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

The trend in soil water storage predicted by UNSAT-H did not change significantly from the first set of parameters to the second, which is opposite of what occurred for HELP.

The only difference was approximately 3 mm of percolation being predicted at the start of the monitoring period. The percolation was caused by drainage of water from the 300-mm-thick sand layer, which had an initial water content of 0.07.

5.5.1.7 Albany Site

The measured water balance and predictions made by HELP and UNSAT-H are shown in Fig. 5.19. The saturated hydraulic conductivity assigned to the storage layer (600 mm) for HELP and UNSAT-H was set at 2.8×10^{-4} cm/s, and the runoff curve number for HELP was reduced to 82.3.

HELP over-predicted surface runoff by 16.4 mm, and was not able to match the occurrences of surface runoff, with the exception of two runoff events. The majority of the surface runoff (14 mm) measured in the field occurred within the first four months of the monitoring period, of which, HELP only predicted 16% of that measured in the field. After this period, surface runoff became negligible due to well-established vegetation. HELP could not accurately predict precipitation being trapped by the grass and trees even with a maximum LAI of 4.5, and a reduced runoff curve number.

Irrigation was applied to the alternative cover at Albany during times of plant stress. Surface runoff was never measured in the field during irrigation, because the irrigation was applied using a water drip line. In contrast, HELP predicted surface runoff on days that irrigation was applied.

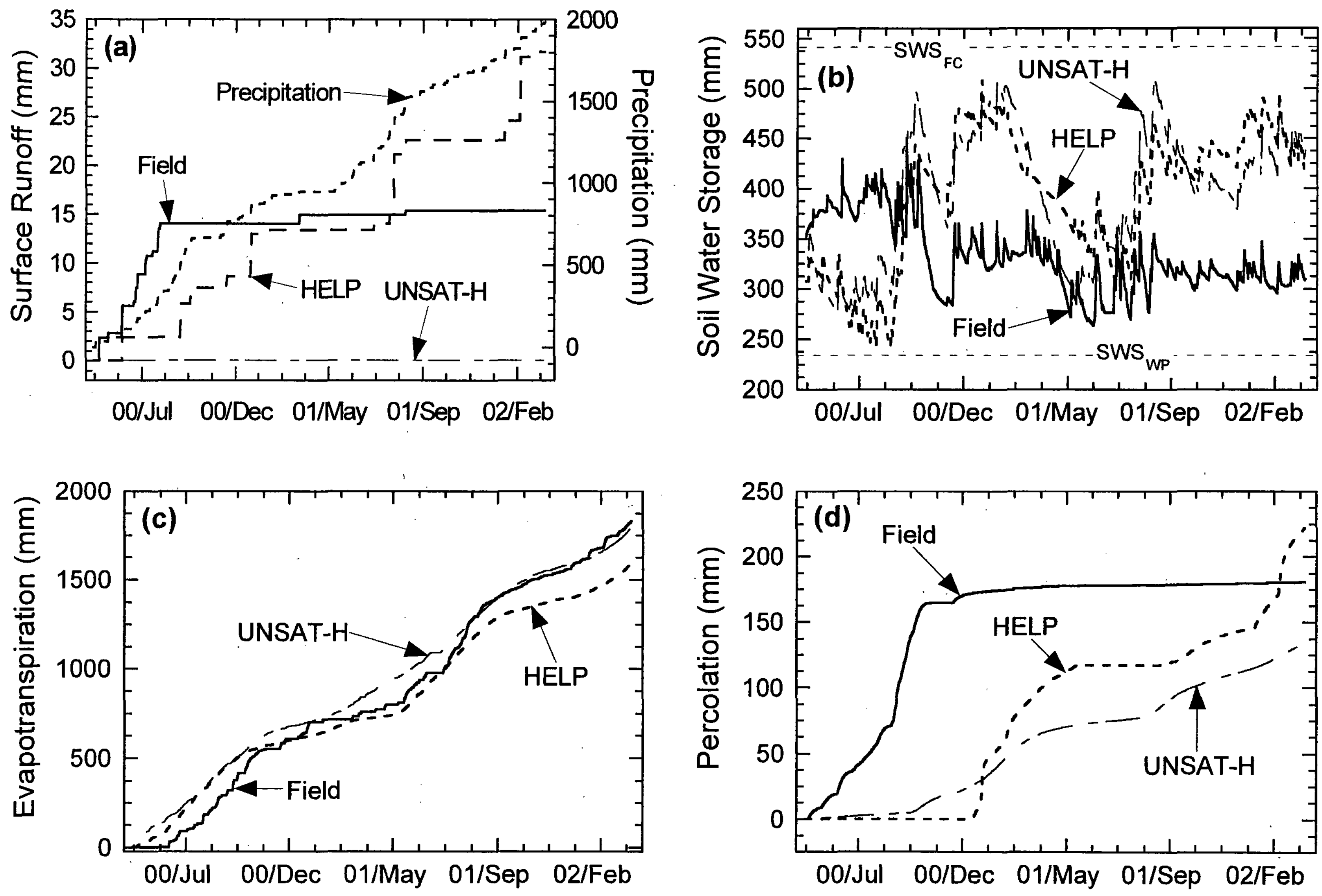


Fig. 5.19. Comparison of Water Balance Data for the Albany Site to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

The field data show rapid fluctuations in soil water storage over a short period, without exceeding the storage capacity of the cover. There also is a distinguishable drop in storage at the beginning of October 2000, after which the soil water storage fluctuates at a lower level. This drop in storage corresponded to a large decrease in the percolation rate, and was maintained by the maturing trees.

HELP and UNSAT-H initially under-predicted soil water storage by approximately 200 mm, which is likely due to an over-prediction of evapotranspiration. A maximum LAI of 2.5 was used for both models during the first growing season. However, the vegetation likely had not been established prior to October 2000.

HELP and UNSAT-H grossly over-predicted soil water storage during the remainder of the monitoring period, with the exception of Summer 2001. Both models predicted a large drop in soil water storage during Winter and Spring 2001, which corresponded to a prediction of a large amount of percolation. During this period, HELP predicted 116 mm of percolation, whereas UNSAT-H predicted 70 mm of percolation. In contrast, only 13 mm of percolation occurred in the field during this period.

At the end of Summer 2001, HELP and UNSAT-H predicted an increase in soil water that was significantly greater than measured. The storage increased because the models under-predicted evapotranspiration during June-August 2001. Even with a maximum LAI of 4.5, neither model could predict the large amount of soil water removal by the hybrid poplar trees.

Prior to January 1, 2001, almost 95% of the percolation had been transmitted through the alternative cover at Albany. After this time, the percolation rate significantly decreased to a rate of 6 mm/yr. In contrast, percolation predicted by the models prior to January 1, 2001 was less than 23% of the total percolation. After

January 1 2001, HELP predicted a percolation rate of 143 mm/yr, and UNSAT-H predicted a percolation rate of 82 mm/yr.

5.5.1.8 Omaha Site

The measured water balance and predictions by HELP and UNSAT-H for the two monolithic barriers at the Omaha site are shown in Fig. 5.20 and Fig. 5.21. The saturated hydraulic conductivity assigned to the surface layer (150 mm) for both covers was set at 2.8×10^{-4} cm/s for HELP and UNSAT-H (thick barrier only). The UNSAT-H simulations for both barriers were conducted using only the top portion of the covers (above the sand layer), because large numerical errors were encountered when the capillary break was included. Despite refinements to the spatial and temporal discritization, the error could not be eliminated. HELP simulations were conducted using the entire cover profile.

HELP over-predicted surface runoff by 46 mm for the thin barrier, and by 69 mm for the thick barrier. Even though HELP was able to predict the occurrences of surface runoff throughout the monitoring period, each event was over-predicted. The largest over-prediction for both covers occurred during May 2001, when the site received 200 mm of rainfall. In May 2001, HELP over-predicted surface runoff by 15.3% of precipitation for the thin barrier, and by 23.3% of precipitation for the thick barrier. The discrepancy is likely due to the storage layer being assigned a saturated hydraulic conductivity (which controls the infiltration rate) that was too low, or a malfunction with the surface runoff collection system (surface runoff may have been under reported).

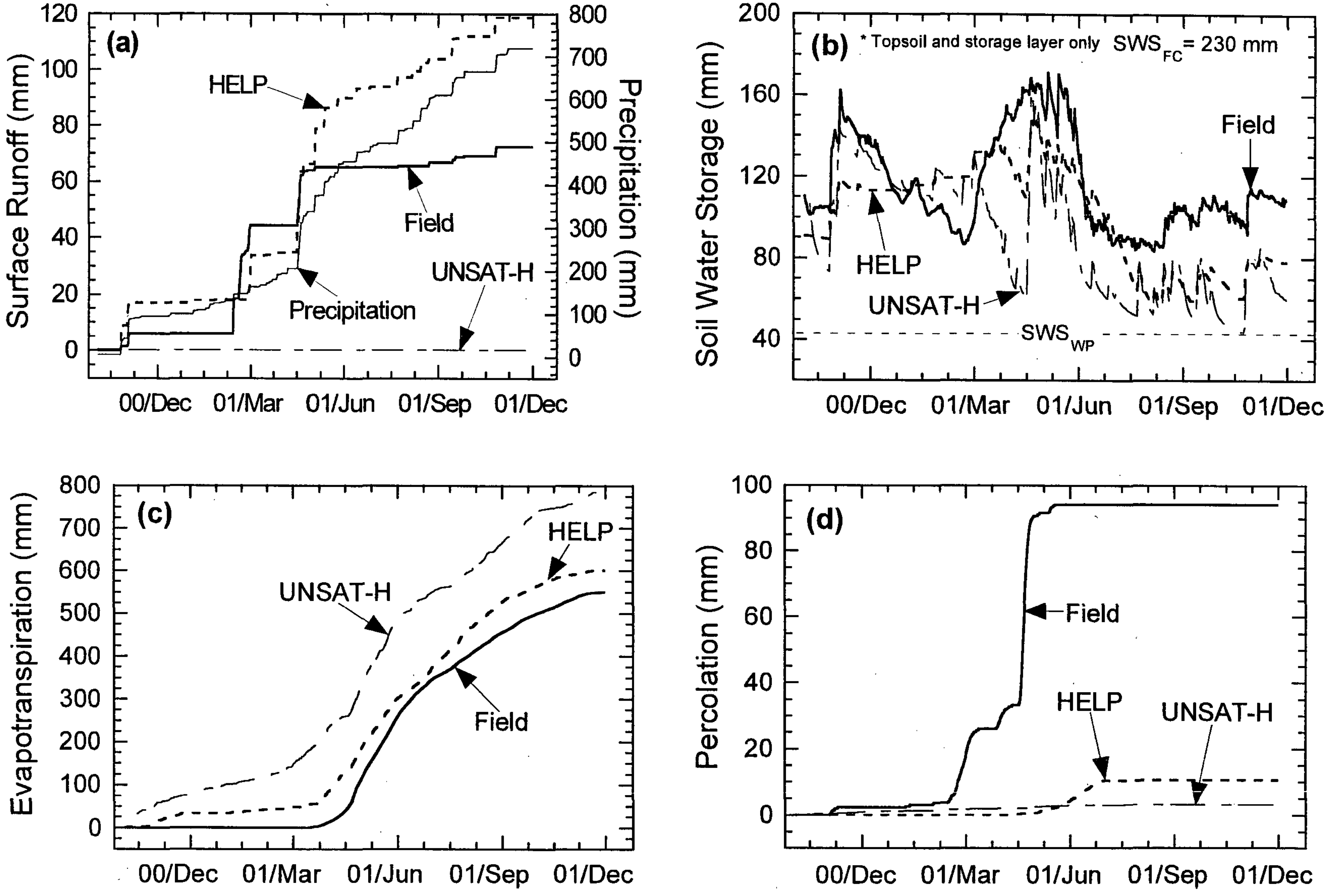


Fig. 5.20. Comparison of Water Balance Data for the Omaha Site (Thin Monolithic Barrier) to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

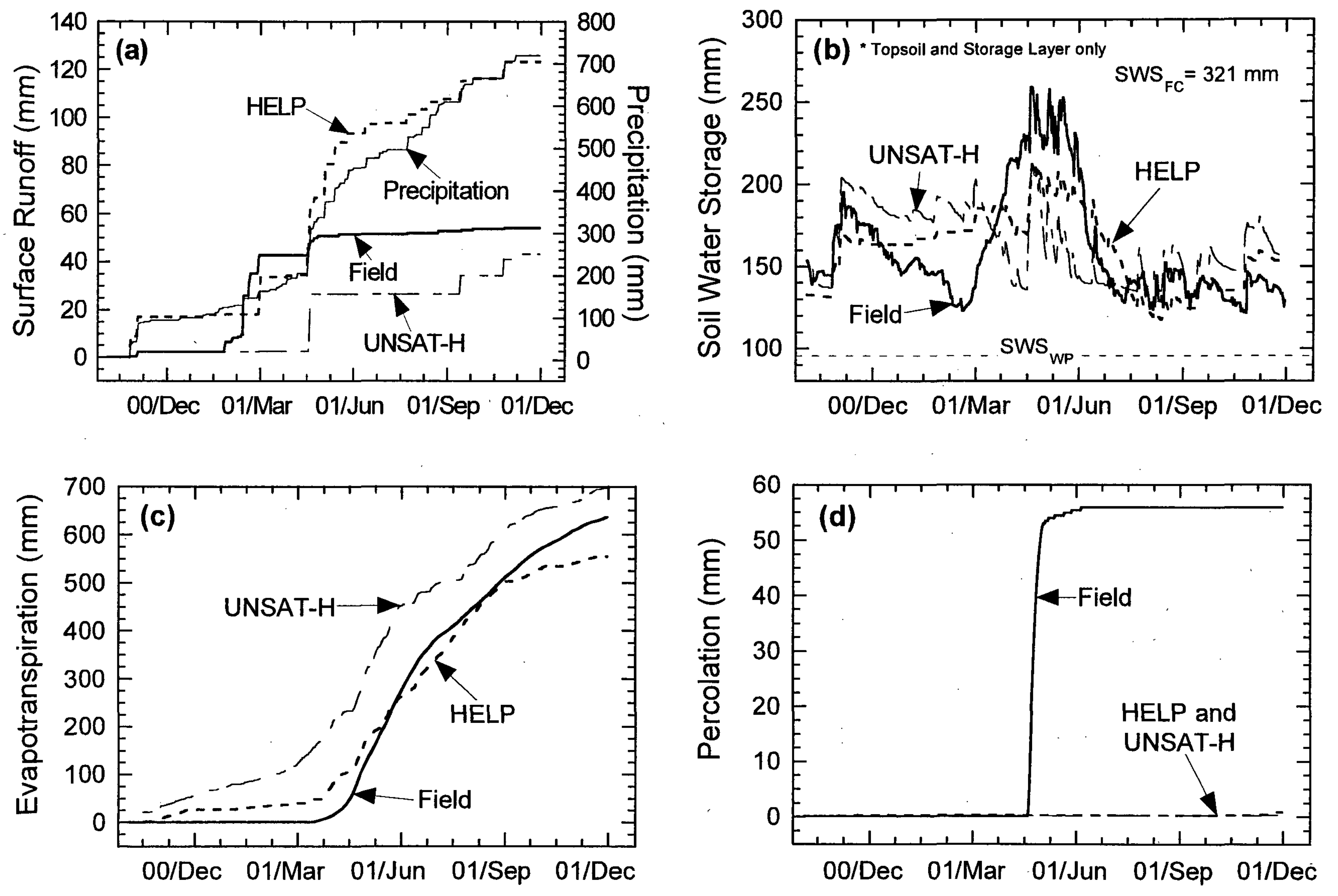


Fig. 5.21. Comparison of Water Balance Data for the Omaha Site (Thick Monolithic Barrier) to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Percolation.

UNSAT-H over-predicted surface runoff by 72 mm for the thick barrier, and under-predicted surface runoff by 11 mm for the thin barrier. UNSAT-H did not predict surface runoff for the thin barrier during the entire monitoring period when the hydraulic properties of the topsoil were used as input. The saturated hydraulic conductivity of the topsoil and storage layers for the thin barrier is higher than that for the thick barrier. Additional simulations using higher saturated hydraulic conductivity for the surface layer were not necessary and were not conducted.

For the thick barrier, UNSAT-H was not able to predict the occurrence of surface runoff in late Winter and early Spring 2001, but over-predicted surface runoff events throughout the remainder of the monitoring period. Surface runoff measured in the field during Winter/Spring 2001 was caused by frozen ground conditions (February 5 – March 27, 2001). UNSAT-H does not account for frozen ground and, therefore, allowed the precipitation to infiltrate the cover. The over-prediction of surface runoff during the rest of the monitoring period is likely due to the saturated hydraulic conductivity assigned to the surface layer of the thick barrier being too low.

HELP was able to follow a similar soil water storage trend as measured in the field. HELP under-predicted soil water storage during most of the monitoring period, but over-predicted soil water storage during Winter and early Spring 2001 (Fig. 5.21b). The field data show the soil water storage dropped significantly during the winter. This drop in soil water storage may be artificial, because the WCR probes used to measure water content are affected by soil temperature, and by phase change (liquid to solid) in the soil water when the ground becomes frozen (See Section 4.9). When the ground temperature rises in late March to April, the measured soil water storage rises.

UNSAT-H predicted soil water storage more accurately than HELP, especially during late Fall 2000. However, both models predicted a reduction in soil water storage in Spring 2001, which was not observed in the field. Higher evapotranspiration was likely predicted due to an over-estimate of the maximum LAI.

Because evapotranspiration was over-predicted in Spring 2001, UNSAT-H predicted that both covers would have sufficient storage capacity to prevent percolation during Spring 2001. As a result, percolation from the thin barrier (Fig. 5.20D) and the thick barrier (Fig. 5.21d) was grossly under-predicted.

5.5.2 Conventional Covers

The following sections provide a comparison of the water balance measured for conventional covers at six sites and predictions made with HELP using the measured hydraulic properties, and hydraulic properties that were adjusted so that the surface runoff predicted by the models were comparable to that measured in the field. All of the covers are composite covers, except for the compacted clay cover constructed at Albany. UNSAT-H simulations were not conducted for composite covers, but were conducted for the compacted clay cover at Albany. UNSAT-H simulations were not conducted for the composite covers, because UNSAT-H cannot simulate lateral flow or flow through defects in geomembranes. Soil water storage presented in this section includes only the water stored in soil layers above the geomembrane.

5.5.2.1 Altamont Site

The measured water balance and predictions made by HELP for the composite cover at the Altamont site are shown in Fig. 5.22. A datalogger error resulted in a large

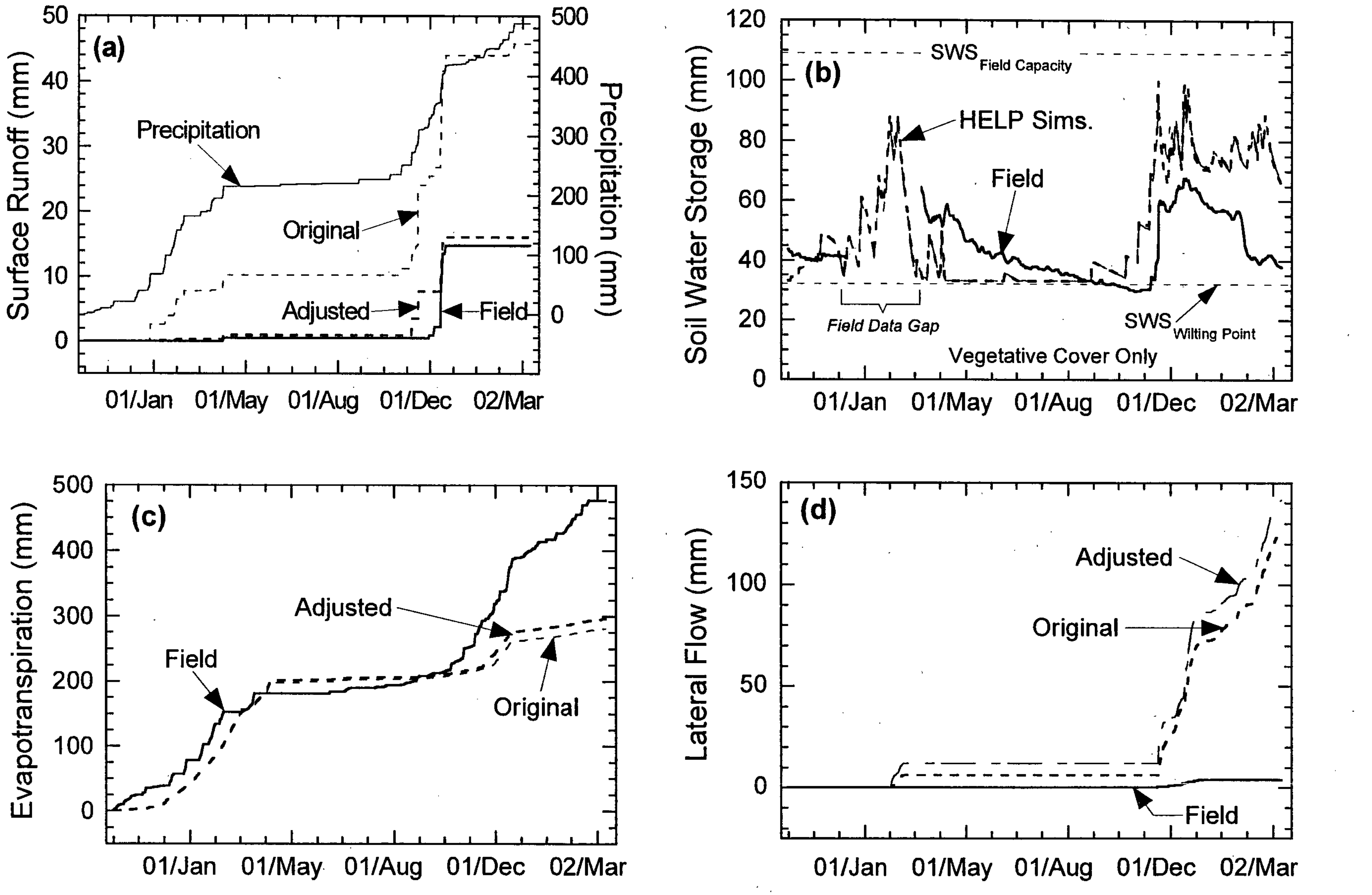


Fig. 5.22. Comparison of Water Balance Data for the Altamont Site (Composite Cover) to Predictions Made with HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Lateral Flow.

data gap between January 10, 2001 and March 29, 2001. However, meteorological input for HELP were obtained from a nearby weather station. To predict surface runoff better, the runoff curve number assigned to the surface layer (300 mm) was reduced from 94.1 to 88.1.

When the adjusted runoff curve number was used, HELP over-predicted surface runoff by 1.2 mm. However, HELP had difficulty predicting small runoff events on the same day as occurred on the cover.

HELP predicted 141.6 mm of lateral flow during the monitoring period, despite only 3.8 mm of lateral flow being measured. HELP predicted a large amount of lateral flow, primarily because evapotranspiration was under-predicted. In the beginning of March 2001, HELP predicted 11.8 mm of lateral flow. However, because of a datalogger error, this prediction of lateral flow cannot be checked. HELP did not predict lateral flow again until December 2001, after which HELP predicted lateral flow at a rate of approximately 1 mm/day.

Measured and predicted soil water storage of the vegetative layer (above cover geomembrane) are shown in Fig. 5.22b. The field data show that soil water storage increases in the fall and winter, and decreases during the spring. Soil water storage reaches the wilting point by the end of the summer. A similar trend is evident in soil water storage predicted by HELP. However, HELP over-predicted the peak soil water storage by 24 mm during Winter 2001, and by 31 mm during Winter 2002.

During Spring 2001, HELP predicted that soil water storage would reach the wilting point earlier than measured. This is may be due to the maximum LAI used in HELP being too high. During early Fall 2001, HELP predicted an increase in soil water storage more than two months prior to the measure soil water storage, and significantly over-predicted soil water storage for the remainder of the monitoring period. HELP likely over-predicted soil water storage and lateral flow after December 2001, because of a gross under-prediction of evapotranspiration.

HELP did not predict any percolation during the monitoring period, which is consistent with the field data.

5.5.2.2 Polson Site

The measured water balance and predictions made by HELP for the composite cover at the Polson site are shown in Fig. 5.23. To predict surface runoff better, the runoff curve number assigned to the surface layer (150 mm) was reduced from 84.7 to 77.3.

When the curve number was reduced, HELP under-predicted surface runoff by 6.8 mm, of which 93% of the error occurred during a single runoff event at the end of February 2000. For the same runoff event, the original HELP simulation (CN= 84.7) slightly over-predicted surface runoff by 2 mm. However, HELP over-predicted surface runoff by 35.1 mm for the entire monitoring period in the original simulation. Measured surface runoff in February 2000 was 78% of precipitation, due to frozen ground conditions. HELP accurately predicted frozen ground conditions, and increased the curve number for each simulation to improve the prediction of surface runoff. However, the curve number for the adjusted HELP simulation was only increased to 95 (for initial CN $\leq$ 80), whereas the curve number for the original HELP simulation was increased to 98 (for initial CN $\geq$ 80). This suggests that the runoff curve number should be adjusted over time, rather than from the start of the monitoring period.

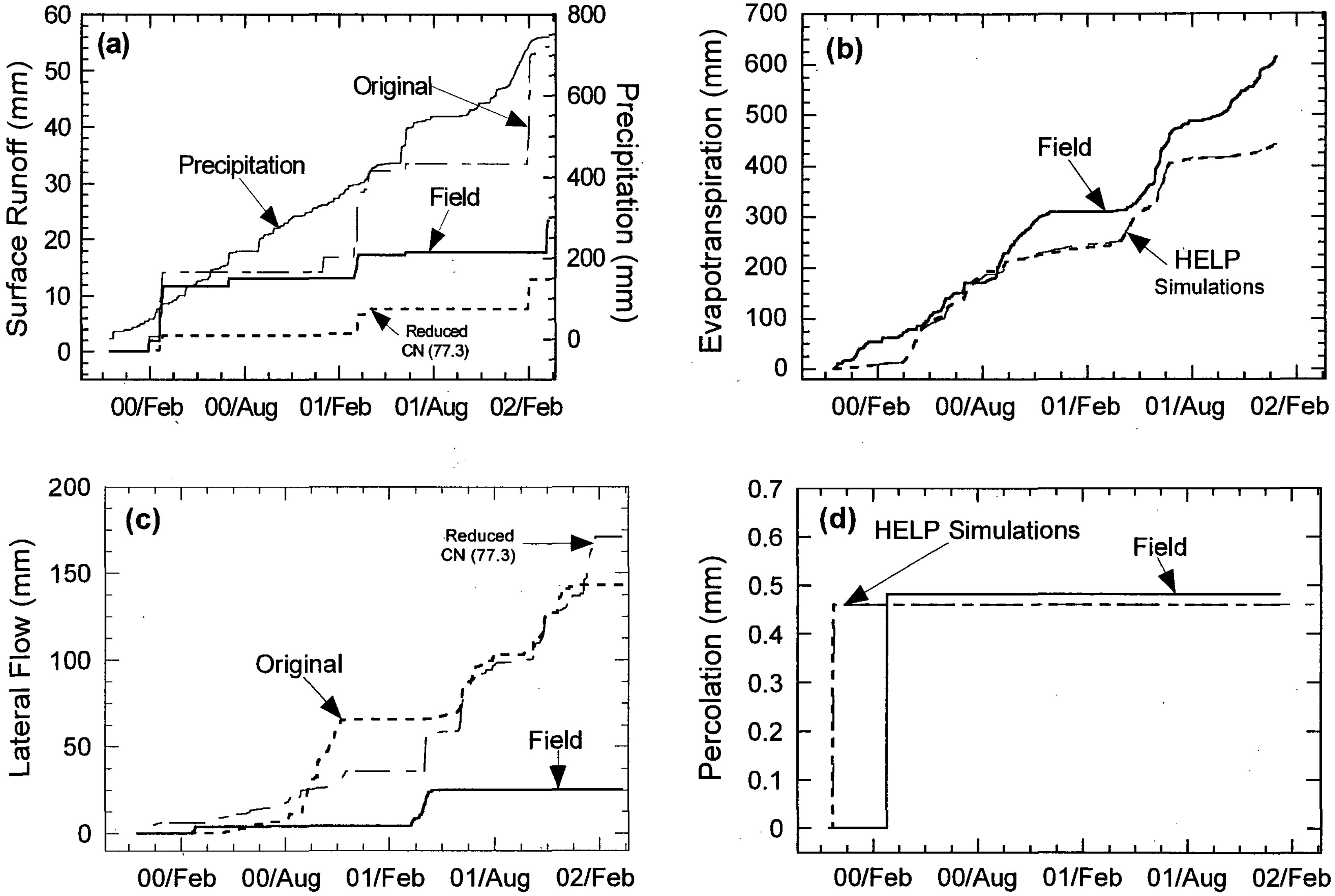


Fig. 5.23. Comparison of Water Balance Data for the Polson Site (Composite Cover) to Predictions Made with HELP: (a) Surface Runoff, (b) Evapotranspiration, (c) Lateral Flow, and (d) Percolation.

HELP grossly over-predicted lateral flow by 145.6 mm over the entire monitoring period. HELP predicted lateral flow would occur due to the spring melt, and steadily increase during the summer. HELP predicted that lateral flow would cease at the on-set of winter, and frozen ground conditions.

Measured and predicted soil water storage for the topsoil and vegetative layers are shown in Fig. 5.24. The field data show that soil water storage begins to increase in the fall, and reaches a peak during the spring, as a result of the spring thaw. The soil water storage decreases during the summer, and approaches the wilting point. A similar trend is evident in soil water storage predicted by HELP. However, HELP typically under-predicts soil water storage.

HELP initially under-predicts soil water storage by 30 mm, because HELP artificially removed water from the topsoil and vegetative layers via evaporation prior to the date that data collection began. HELP must begin the simulation on January 1 of each year, and therefore requires the user to input data between January 1 and the date that data collection began. For this study, a value of zero was entered for precipitation, solar radiation, and temperature.

During Spring 2000, HELP slightly over-predicts the peak soil water storage measured by 5 mm, but predicts the peak to occur one month earlier than actually occurred. HELP also predicted a rapid reduction of soil water storage beginning approximately one month too early in Spring 2000, and in Spring 2001. This may be due to the germination date (May 1) that was assigned being too early or due to the unit gradient assumption of vertical flow used in HELP.

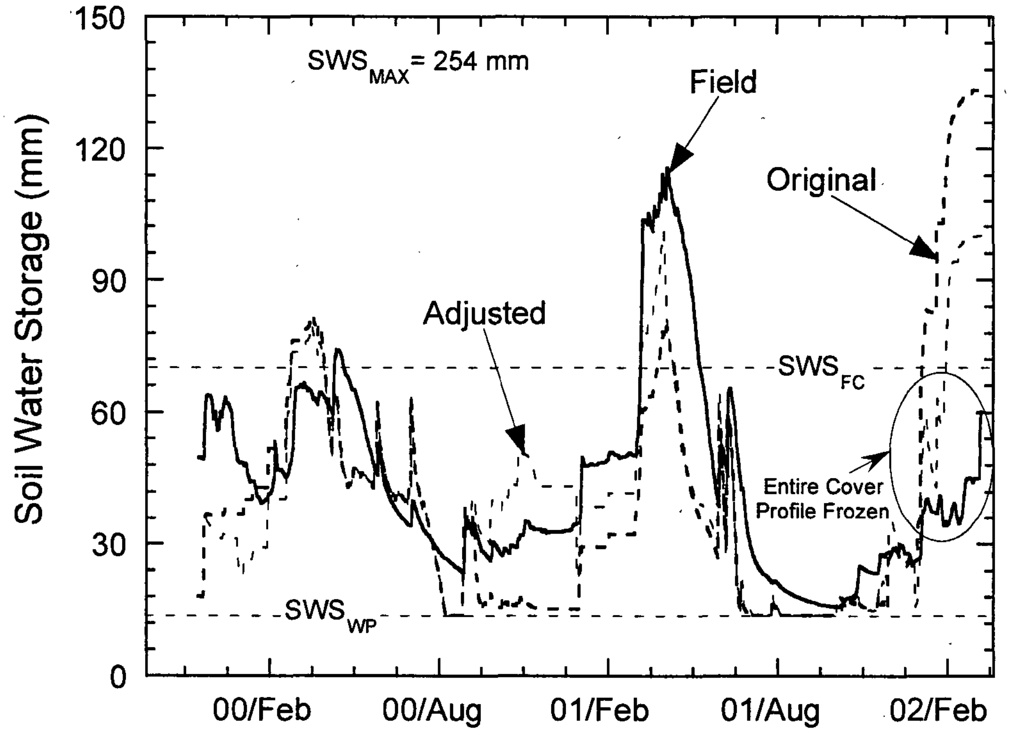


Fig. 5.24. Comparison of Soil Water Storage Measured at Polson Site (Composite Cover) and Predictions Made with HELP.

In Fall 2001, the measured and predicted soil water storage reach the wilting point. During Winter 2002, HELP predicted the soil water storage to increase significantly almost 1.5 months prior to that measured in the field. During this period, soil temperatures measured in the entire cover profile were below 0°C. Thus, the soil water storage computed from the WCR measurements is too low. Also, HELP may not have accurately predicted snowpack, and allowed precipitation to infiltrate the cover.

The measured and predicted soil water storage exceeded the capacity of the upper portion of the composite cover each spring, but did not result in any percolation. HELP accurately predicted the amount of percolation, and even predicted that the percolation would be a pulse, rather than a gradual increase. However, HELP predicted the pulse would occur approximately three months prior to the actual occurrence. The pulse of percolation predicted by HELP was caused by the 460-mm-thick interim cover layer draining to the wilting point (θ_{WP} = 0.029), from a water content of 0.030 [i.e., (0.030-0.029) 460 mm = 0.46 mm percolation].

5.5.2.3 Boardman Site

The measured water balance and predictions by HELP for the composite cover at the Boardman site are shown in Fig. 5.25. Two simulations were conducted for the composite cover, with the only difference being the wilting point that was input. For the original simulation, a wilting point of 0.12 was used, which is based on a suction of 1500 kPa. For the adjusted simulation, a wilting point of 0.07 was used, which is based on the lowest water content measurement in the root zone of the vegetative layer (excluding the top most WCR probe) during the monitoring period.

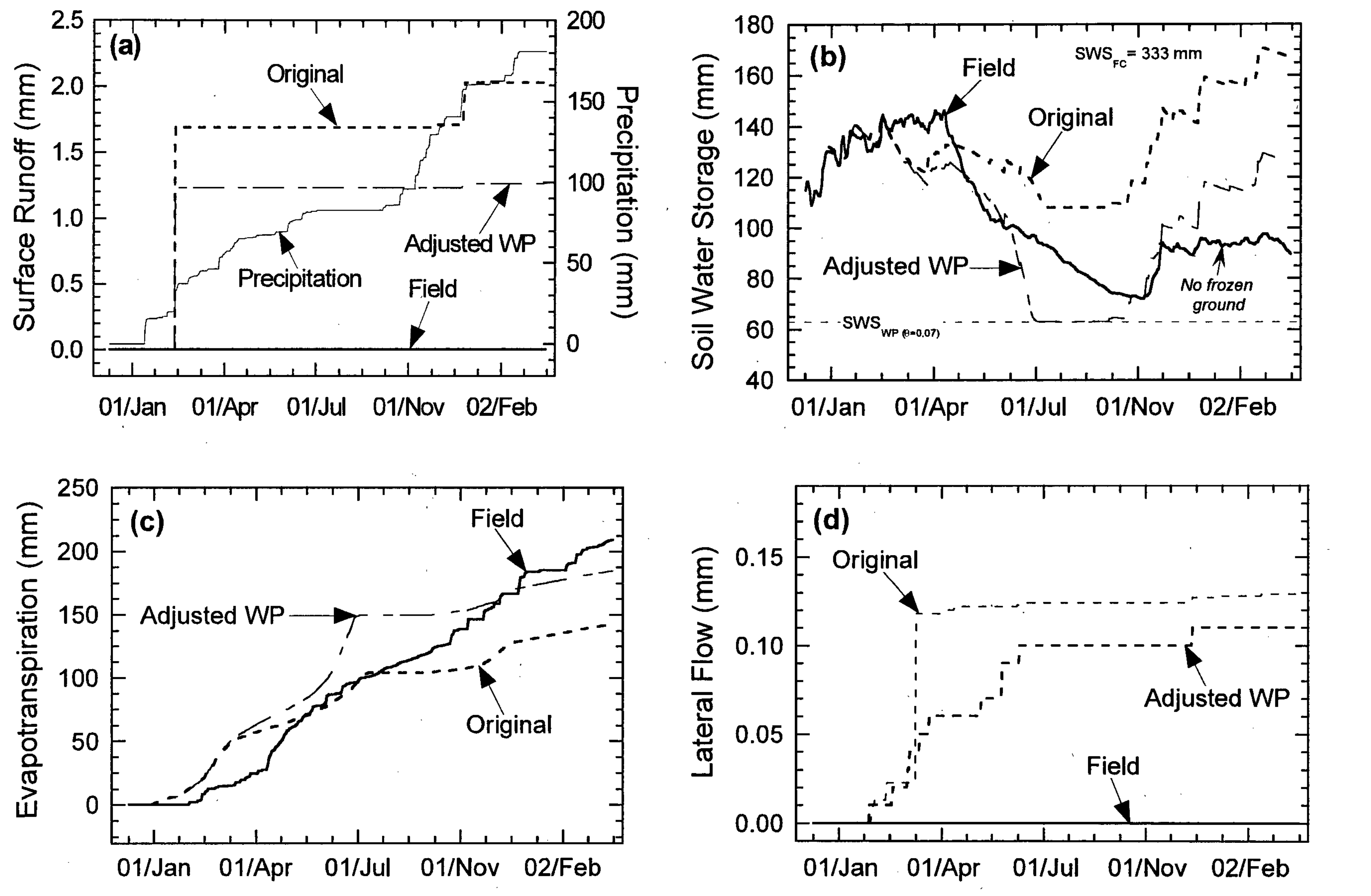


Fig. 5.25. Comparison of Water Balance Data for the Boardman Site (Composite Cover) to Predictions Made with HELP: (a) Surface Runoff, (b) Soil Water Storage, (c) Evapotranspiration, and (d) Lateral Flow.

Both HELP simulations predicted 1.3 mm of surface runoff, even though no surface runoff was measured. HELP predicted 98% of the surface runoff at the end of February 2000, which was caused by the largest rain event (10.2 mm) recorded at Boardman during the monitoring period. The second runoff event (0.03 mm) was predicted during the second largest rain event (8.6 mm). HELP most likely predicted surface runoff due to a slight over-estimate of the surface runoff curve number (94.4).

The field data show that soil water storage increases during the winter to a maximum during the spring, and then decreases at the start of the growing season to approximately the wilting point in the fall. A similar trend is evident in soil water storage predicted by HELP. However, HELP predicted the on-set of decreasing soil water storage two months early, and the minimum soil water storage three months early. HELP also over-predicted soil water storage during Winter 2002.

During Winter 2001, HELP began removing water from the vegetative layer, even though the vegetation had not yet germinated. This may have been caused by (1) incorrect predictions of snow cover (the evaporation rate increased significantly after HELP predicted rain, rather than snow, at the end of February 2001), (2) over-estimating the maximum evaporation depth (HELP computed a maximum depth of 920 mm, which is based on the saturated hydraulic conductivity of the vegetative layer), and/or (3) over-estimating the evaporation rate. Once the vegetation germinated, HELP predicted the removal of all available soil water in the 900 mm thick vegetative within three months. This may have been due to an over-estimate of the maximum LAI (0.94). LAI measurements were not made at Boardman.

During Winter 2002, HELP over-predicted soil water storage because evapotranspiration was under-predicted, which is the opposite trend as seen in the previous year. The measured soil water storage began to increase at the on-set of the winter, but did not increase to the same storage measured during the previous year.

HELP predicted 0.1 mm of lateral flow, and no percolation, which is consistent with the field data.

5.5.2.4 Marina Site

The measured water balance and prediction by HELP for the composite cover at the Marina site are shown in Fig. 5.26. To predict surface runoff better, the saturated hydraulic conductivity of the surface layer (150 mm) was set at 2.8×10^{-4} cm/s, and the curve number was reduced from 92.9 to 86.0.

HELP over-predicted surface runoff by 72 mm during the monitoring period. However, the greatest over-prediction occurred in December 2001, when HELP predicted surface runoff to be 42% of precipitation (measured surface runoff was 11%). During this period, HELP predicted the vegetative layer to be near saturation, which resulted in a greater percentage of the precipitation being shed as runoff.

HELP over-predicted lateral flow by 76.9 mm, but this over-prediction may be artificially inflated due to a malfunction in the lateral flow collection system (See Section 4.6.2). Measured and predicted lateral flow first occurred in January 2001 due to heavy rains, and ceased towards the end of the rainy season in March 2001. HELP predicted lateral flow to occur again in December 2001, and steadily increase at a rate of approximately 0.5 mm/day to the end of the monitoring period. During this period, the

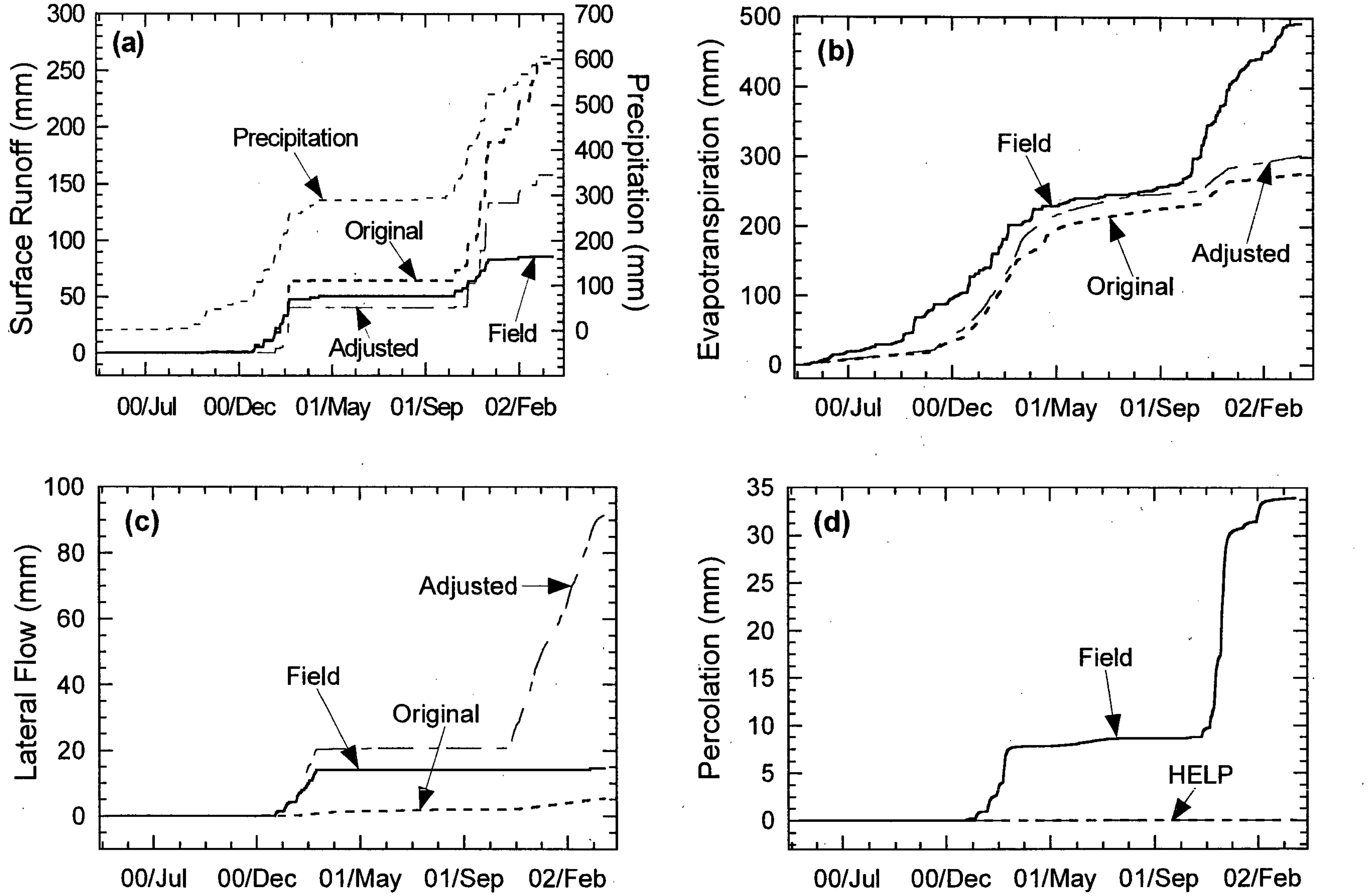


Fig. 5.26. Comparison of Water Balance Data for the Marina Site (Composite Cover) to Predictions Made with HELP: (a) Surface Runoff, (b) Evapotranspiration, (c) Lateral Flow, and (d) Percolation.

soil water storage capacity of the vegetative layer was exceeded. The saturated hydraulic conductivity of lower portion of vegetative layer is 4.5×10^{-6} cm/s, which corresponds to 0.4 mm/day under unit-gradient conditions.

The field data show that soil water storage increases during the fall, reaching a maximum in the winter, and decreasing to the wilting point in the summer (Fig. 5.27). A similar trend is evident in soil water storage predicted by HELP. However, HELP over-predicts soil water storage by 40 mm each winter, and predicts an increase in soil water storage slightly earlier than measured.

During each winter, HELP predicted the soil water storage to reach saturation (Fig. 5.27). During the same periods, HELP under-predicted soil water removal by evapotranspiration (Fig. 5.26b), especially in Winter 2002. The under-prediction of evapotranspiration is likely due to an under-estimate of the maximum LAI [a maximum LAI of 1.5 was used], and the absence of lateral flow in the field. The latter makes more water available for evapotranspiration.

Percolation was measured from the composite cover during each winter, of which 78% occurred during Winter 2002. HELP did not predict any percolation during the entire monitoring period, despite predicting an average head of 236 mm on the geomembrane. The initial simulation was conducted with a hole frequency of 50 holes/ha. An additional simulation was conducted with an increased hole frequency (150 holes/ha). However, even with a greater number of defects, HELP still did not yield any percolation.

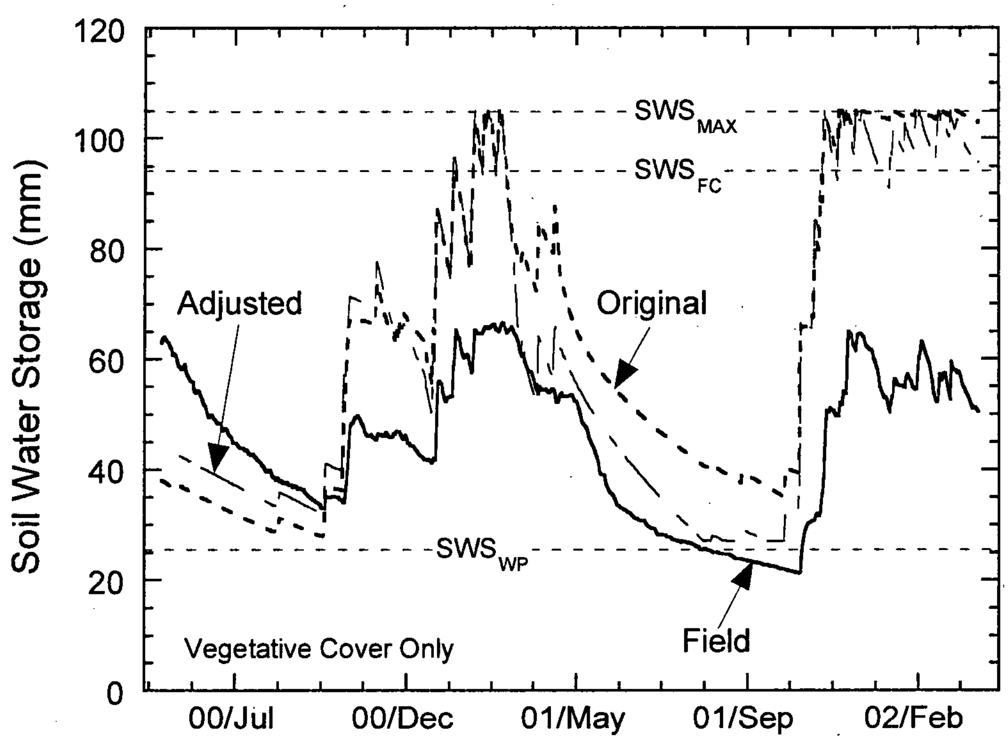


Fig. 5.27. Comparison of Soil Water Storage at the Marina Site (Composite Cover) and Predictions Made with HELP.

5.5.2.5 Albany Site

The measured water balance and predictions made with HELP and UNSAT-H for the compacted clay cover at the Albany site are shown in Figs. 5.28 and 5.29. To predict surface runoff better, the saturated hydraulic conductivity of the topsoil layer (150 mm) was set at 2.8×10^{-4} cm/s, and the runoff curve number was reduced from 90.9 to 82.3.

Both models grossly over-predicted surface runoff, despite an attempt to increase infiltration (see Section 5.5). HELP over-predicted surface runoff by 470.5 mm, and UNSAT-H over-predicted surface runoff by 188.2 mm. HELP and UNSAT-H were able to predict the occurrences of surface runoff well, but over-predicted the amount of surface runoff.

The field data show that the soil water storage rapidly fluctuates during the entire monitoring period, which is caused by intense rain events that are typical at Albany, and high evaporation rates. HELP and UNSAT-H predicted a similar trend as measured in the field (Fig. 5.29), but under-predicted the peak soil water storage during the summer. HELP typically over-predicted the soil water storage of the topsoil layer by 15 mm, and frequently predicted that the topsoil layer was saturated. UNSAT-H typically under-predicted the soil water storage of the entire cover profile by 20 mm. For the topsoil layer, HELP predicted the soil water storage would approach the wilting point shortly after each rain event.

The over-predictions of soil water storage are due to the inability of the models to account for preferential flow, which is also evident in under-predictions of percolation (approximately 543 mm) by HELP and UNSAT-H. Preferential flow paths in the

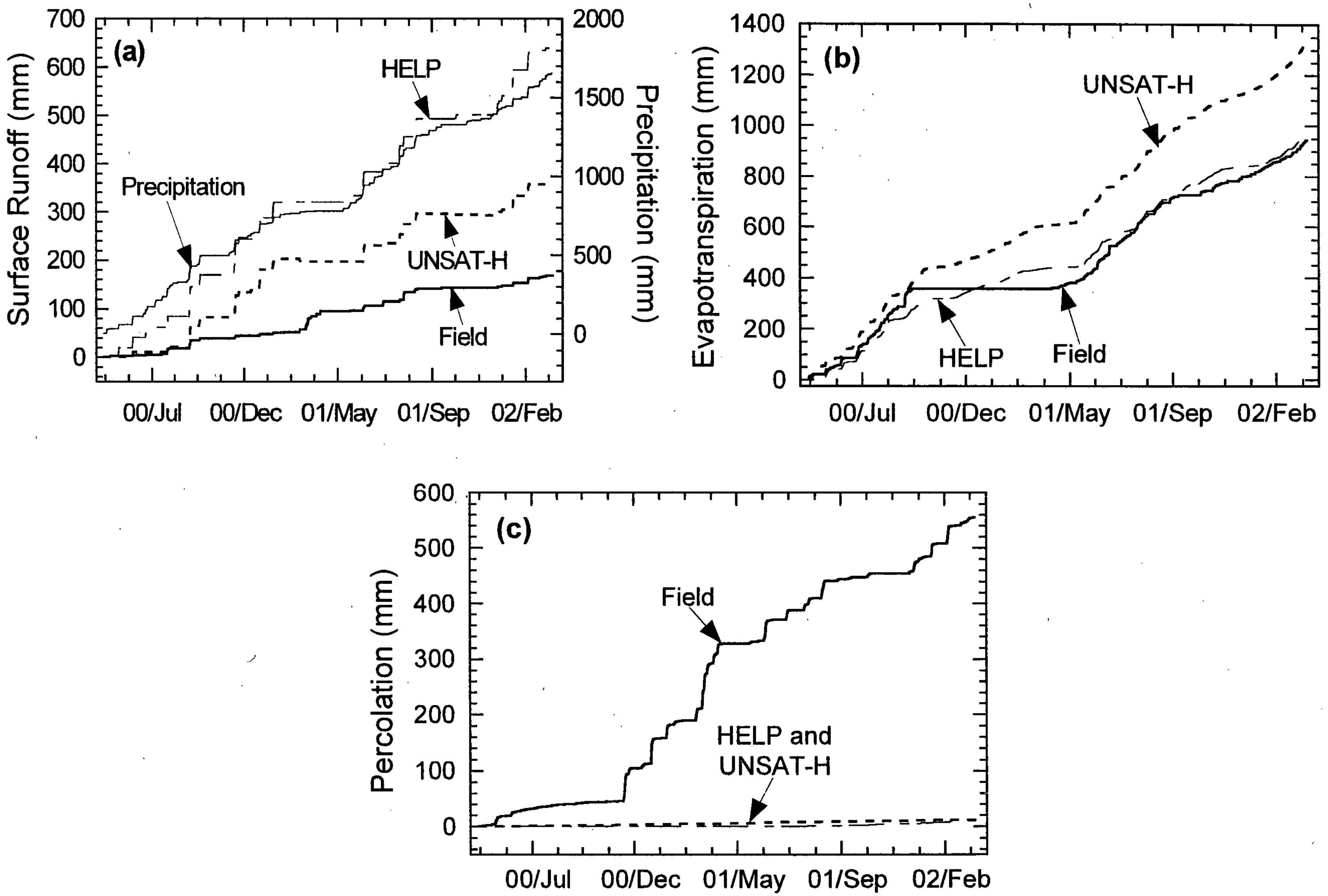


Fig. 5.28. Comparison of Water Balance for the Albany Site (Compacted Clay Cover) to Predictions Made with UNSAT-H and HELP: (a) Surface Runoff, (b) Evapotranspiration, and (c) Percolation.

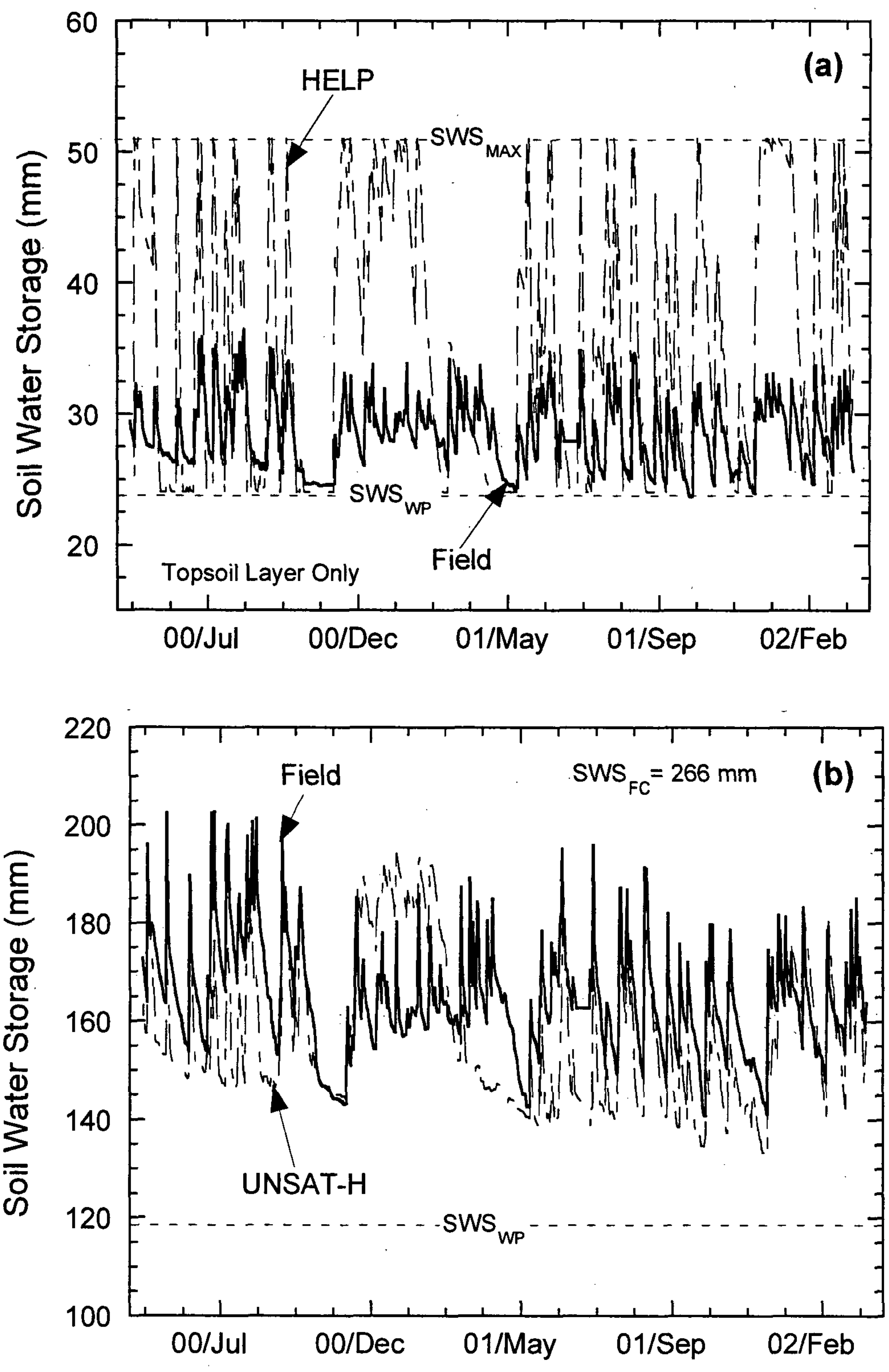


Fig. 5.29. Comparison of Soil Water Storage for the at Albany Site (Compacted Clay Cover) to Predictions Made with (a) HELP and (b) UNSAT-H.

compacted clay barrier (see Section 4.7.3) led to the high percolation rate in the field

5.5.2.6 Omaha Site

The measured water balance and predictions by HELP for the composite cover at the Omaha site are shown in Fig. 5.30. To predict surface runoff better, the saturated hydraulic conductivity of the surface layer (150 mm) was set at 2.8×10^{-4} cm/s.

HELP over-predicted surface runoff by 20 mm, but predicted occurrences of surface runoff accurately. The majority of the over-prediction occurred after May 2001, when HELP over-predicted surface runoff by 14 mm. Closer agreement might have been obtained if the runoff curve number was decreased over time, to reflect establishment of the vegetative cover.

HELP under-predicted lateral flow by 27 mm, most likely due to a low saturated hydraulic conductivity assigned for the vegetative layer (6.9×10^{-7} cm/s). HELP predicted slow progression of the wetting front through the vegetative layer, which caused the soil water storage to increase more than occurred in the field (Fig. 5.31). During two weeks in May 2001, HELP predicted the soil water storage of the vegetative layer to be exceeded, but did not predict lateral drainage. HELP either predicted water to be quickly removed by evapotranspiration, or to flow through the geomembrane. No drainage composite was installed above the geomembrane at Omaha. Instead the vegetative cover was designated as the lateral drainage layer. Thus, lateral drainage to the collection sump was likely delayed by the low saturated hydraulic conductivity of the vegetative layer.

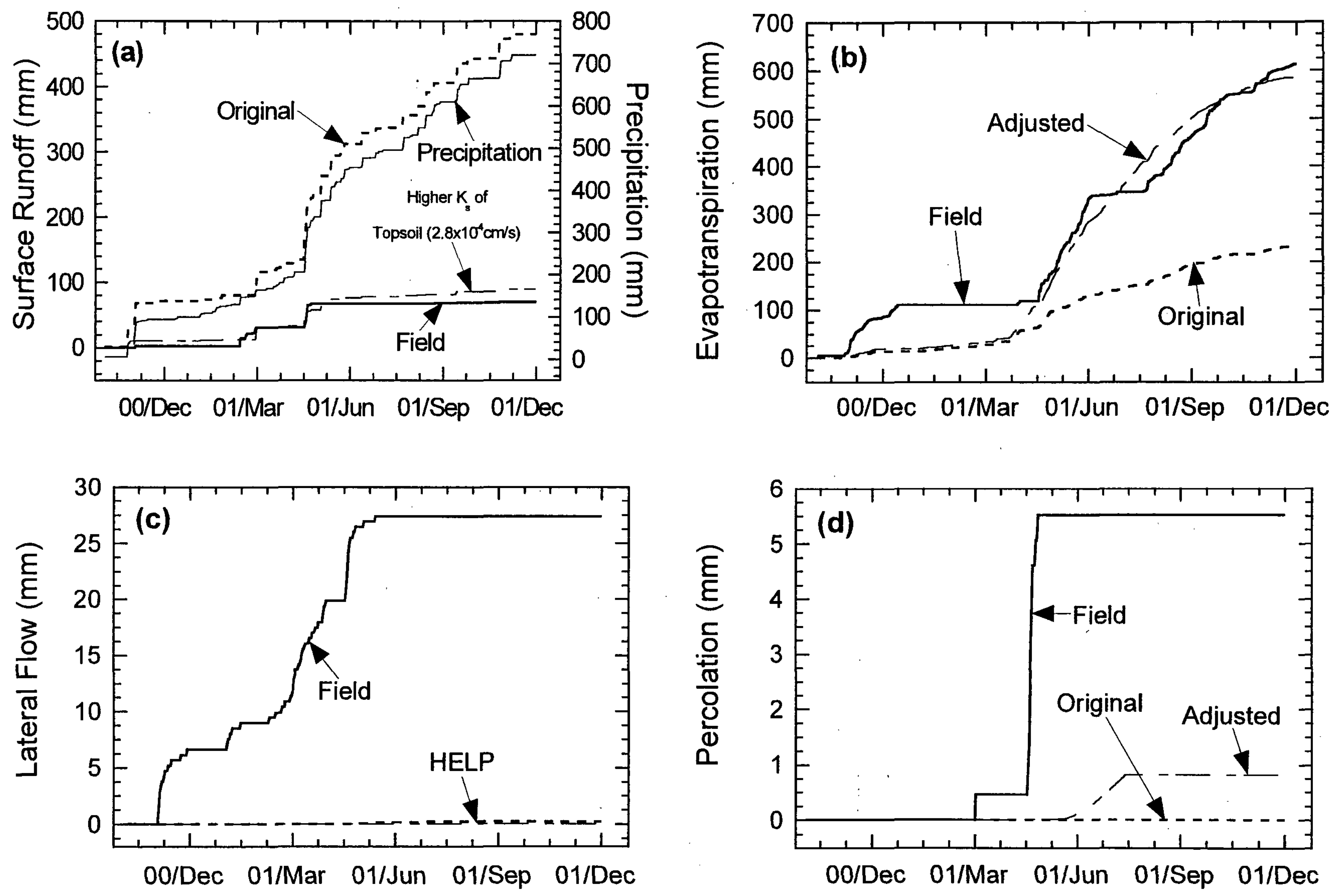


Fig. 5.30. Comparison of Water Balance Data for the Omaha Site (Composite Cover) to Predictions Made with HELP: (a) Surface Runoff, (b) Evapotranspiration, (c) Lateral Flow, and (d) Percolation.

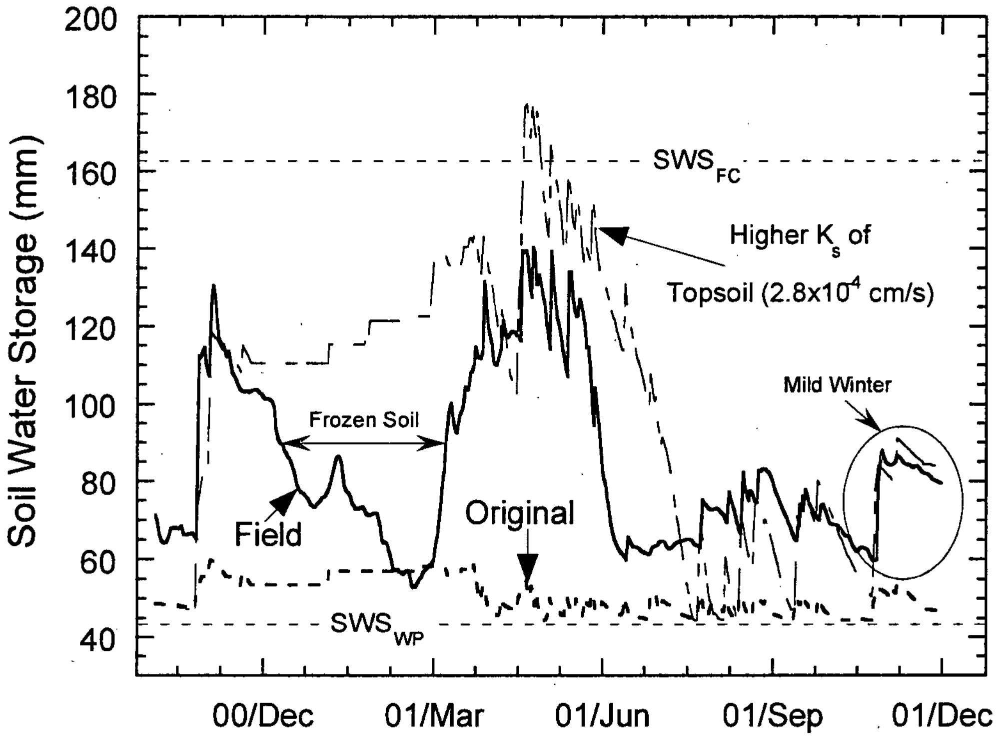


Fig. 5.31. Comparison of Soil Water Storage at the Omaha Site (Composite Cover) and Predictions Made with HELP.

The field data show that soil water storage increased significantly during times of intense rain in November 2000, and May 2001 (Fig. 5.31). The reduction in soil water storage during Winter 2001 is likely an artifact of soil freezing, which is reported as decrease in water content by the WCR probes installed in the cover. During Summer 2001, soil water storage decreases rapidly due to high evapotranspiration and percolation. HELP predicted a similar trend in soil water storage, but over-predicted soil water storage during Winter and Spring 2001, and slightly under-predicted soil water storage in Fall 2001.

During Spring 2001, HELP over-predicted soil water storage by 33 mm, and predicted the capacity of the vegetative layer to be exceeded. In June 2001, HELP predicted soil water storage to rapidly decrease, but under-predicted the minimum soil water storage by approximately 20 mm. HELP predicted that the soil water storage to reach the wilting point in the Summer 2001. During Fall 2001, HELP closely predicted the trend in soil water storage, but slightly under-predicted the storage during breaks in precipitation events. This may be due to an over-estimate of the maximum LAI.

HELP under-predicted percolation by 4.7 mm. Percolation was transmitted through the composite cover during two separate events in March and May 2001. In contrast, HELP did not predict percolation to begin until the beginning of June 2001.

5.6 PARAMETRIC STUDY

A parametric study was conducted using HELP and UNSAT-H to gain a better understanding of how varying the model inputs would affect the model predictions. One parameter was varied at a time, while all other parameters remained constant.

The parametric study was performed using only one year of data rather than the entire monitoring period.

5.6.1 Surface Runoff Curve Number in HELP

The surface runoff curve number was adjusted for three test sections. Two are located in a humid climate (Albany), and one in an arid climate (Helena). Water balance predictions for these simulations are in Tables 5.13-5.15.

Surface runoff was insensitive to the curve number for the conventional cover at Albany (Table 5.13) and the alternative cover at Helena (Table 5.15). Helena does not receive the intense rain events like Albany, and therefore little surface runoff is generated unless a surface runoff curve number close to 100 (impermeable) is used.

For the conventional cover at Albany, the hydraulic conductivity of the barrier layer below the topsoil layer controls the infiltration rate. Decreasing the surface curve number increases the amount of infiltration into the topsoil layer. However, the conventional cover does not have enough storage capacity above the barrier layer, and water is not able to drain through the barrier faster than water is being applied. Therefore, additional water is routed to surface runoff. For the alternative cover at Albany, surface runoff is more sensitive to the curve number, because the more permeable storage layers can accept and retain more water (Table 5.14).

5.6.2 Saturated Hydraulic Conductivity of Barrier Layer in HELP

The saturated hydraulic conductivity of the barrier layer for the conventional cover at Albany was varied between 7.3×10^{-5} cm/s and 1.0×10^{-8} cm/s (Table 5.16). The water balance quantities were insensitive to the saturated hydraulic conductivity of the barrier layer until the saturated hydraulic conductivity was increased to 1.0×10^{-6} cm/s

Table 5.13. Water Balance Quantities Predicted by HELP for Compacted Clay Cover at Albany Site[a] for Various Surface Runoff Curve Numbers (CN). Percentage of Precipitation in Parentheses.

Curve Number	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
80.6	472 (57.0%)	191 (23.2%)	0	7
82.3	477 (58.0%)	186 (22.6%)	0	7
90.9	469 (57.0%)	193 (23.5%)	0	8
94.4	441 (53.6%)	220 (26.7%)	0	9

[a] Simulation Period is from January 1 to December 31, 2001. Precipitation was 670 mm during this period. Surface Layer $K_s = 1.3 \times 10^{-4}$ cm/s.

Table 5.14. Water Balance Quantities Predicted by HELP for ECap Cover at Albany Site[b] for Various Surface Runoff Curve Numbers (CN). Percentage of Precipitation in Parentheses.

Curve Number	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
80.6	664 (80.1%)	38 (4.6%)	0.23 (0.03%)	121
82.3	664 (80.1%)	45 (5.5%)	0.22 (0.03%)	114
90.9	655 (79.6%)	109 (13.2%)	0.34 (0.04%)	59

[b] Simulation Period is from January 1 to December 31, 2001. Precipitation was 823 mm during this period. Surface Layer $K_s = 1.9 \times 10^{-7}$ cm/s.

Table 5.15. Water Balance Quantities Predicted by HELP for Alternative Cover at Helena Site[a] for Various Surface Runoff Curve Numbers (CN). Percentage of Precipitation in Parentheses.

Curve Number	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
70.7	134.6 (92.5%)	4.3 (3.0%)	0.0	6.6
80.6	134.6 (92.5%)	4.3 (3.0%)	0.0	6.6
90.9	132.7 (91.2%)	4.2 (2.9%)	0.0	8.6
91.1	133.2 (91.6%)	4.7 (3.2%)	0.0	7.6
94.1	133.7 (91.9%)	5.8 (4.0%)	0.0	6.0
97.1	133.6 (91.8%)	12.6 (8.7%)	0.0	-0.7

[a] Simulation Period is from January 1 to December 31, 2000. Precipitation was 145.5 mm during this period. Surface Layer $K_s = 5.0\times10^{-7}$ cm/s

Table 5.16. Water Balance Quantities Predicted by HELP for Compacted Clay Cover at Albany Site[a] for Various Saturated Hydraulic Conductivities of the Barrier Layer. Percentage of Precipitation in Parentheses.

Saturated Hydraulic Conductivity (cm/s)	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
7.3×10^{-5}	350 (42.5%)	45 (5.5%)	288 (35.0%)	-13
1.0×10^{-6}	442 (54.7%)	184 (22.4%)	58 (7.0%)	-14
1.0×10^{-7}	444 (54.0%)	233 (28.3%)	7 (0.9%)	-14
7.3×10^{-8} (Measured in Laboratory)	455 (55.3%)	226 (27.5%)	3 (0.4%)	-14
1.0×10^{-8}	461 (56.0%)	230 (28.0%)	0 (0.0%)	-21

[a]Simulation Period is from January 1, 2001 to December 31, 2001. Precipitation was 670 mm during this period.

(nearly two orders of magnitude higher than saturated hydraulic conductivity at time of construction). When the saturated hydraulic conductivity was increased from 7.3×10^{-8} cm/s (measured immediately after construction) to 7.3×10^{-5} cm/s, surface runoff decreased from 27.5% to 5.5% of precipitation, evapotranspiration decreased slightly from 55.3% to 42.5% of precipitation, and percolation increased from 0% to 35% of precipitation

Using a low saturated hydraulic conductivity resulted in large predictions of surface runoff. The infiltration rate into the cover is based on the hydraulic properties (e.g., saturated hydraulic conductivity, soil water storage capacity, initial water content) of the topsoil layer, and the hydraulic properties of the underlying layers. As the water content of the topsoil layer approached saturation, the infiltration rate decreased to the saturated hydraulic conductivity of the underlying barrier layer.

Flow through the barrier layer in the field was dominated by preferential flow caused by desiccation cracking, rather than conventional porous media flow. To match the percolation transmitted from the compacted clay cover at Albany (298 mm), the saturated hydraulic conductivity of the barrier layer had to be increased significantly to 7.3×10^{-5} cm/s, which is 1000 times higher than the saturated hydraulic conductivity at time of construction. This hydraulic conductivity is comparable to hydraulic conductivities for desiccated moderate to highly plastic compacted clays reported by Albrecht and Benson (2001).

5.6.3 Geomembrane Properties in HELP

The number of defects and the placement condition for the geomembrane were varied for the composite covers at Omaha (Table 5.17) and Marina (Table 5.18). Two

Table 5.17. Effect of Placement Condition and Hole Frequency for Geomembrane on Predictions Made with HELP[a] for Composite Covers at Omaha.

Surface Layer K_s	Parameter		Lateral Flow (mm)	Leakage Thu Barrier Layer (mm)	Percolation (mm)
	Placement Condition	Hole Frequency (holes/ha)			
As-Built	1	(50)	0.00	0.00	0.00
	2	(50)	0.00	0.00	0.00
	3	(50)	0.00	0.00	0.00
	4	(50)	0.00	0.00	0.00
	5	(50)	0.00	0.00	0.00
	(2)	1	0.00	0.00	0.00
	(2)	50	0.00	0.00	0.00
	(2)	100	0.00	0.00	0.00
Increased	1[b]	(50)	6.58	0.00	1.5
	2[b]	(50)	7.53	0.19	1.35
	3[b]	(50)	7.14	0.69	0.95
	4[b]	(50)	6.70	3.53	0.16
	5[b]	(50)	0.25	21.6	0.57
	(2)	1[b]	7.92	0.02	1.49
	(2)	50[b]	7.14	0.69	0.95
	(2)	100[b]	6.6	0.02	0.59

[a]Simulation period is from January 1, 2001 to December 31, 2001.
[b]Increased K_s of topsoil layer to 1.5×10^{-4} cm/s, and K_s of the vegetative layer to 7.0×10^{-5} cm/s. Reduced runoff curve number to 84.3.

Table 5.18. Effect of Placement Condition and Hole Frequency for Geomembrane on Predictions Made with HELP[a] for Composite Cover at Marina.

Parameter		Lateral Flow (mm)	Leakage Thru Geomembrane (mm)	Percolation (mm)
Placement Condition	Hole Frequency (holes/ha)			
1	(50)	2.60	0.55	0.00
2	(50)	2.60	0.55	0.00
3	(50)	2.60	0.55	0.00
4	(50)	2.60	0.55	0.00
5	(50)	2.10	6.10	0.00
(3)	1	2.60	0.01	0.00
(3)	50	2.60	0.10	0.00
(3)	100	2.60	0.20	0.00

[a]Simulation period is from January 1, 2001 to December 31, 2001.

sets of simulations were conducted for Omaha. One set simulated the profile as it was constructed. The other set simulated the composite barrier with an increased saturated hydraulic conductivity of the topsoil and vegetative layers (above geomembrane), and a reduced runoff curve number to increase the head on the geomembrane. A drainage layer was not included in the composite covers at Omaha and Marina. Thus, the vegetative layer was designated as a lateral drainage layer. According to Schroeder et al. (1994), a lateral drainage layer is modeled in the same manner as a vertical percolation layer, except saturated lateral drainage is allowed.

There was no change in percolation when the placement condition and defect frequency was varied for the composite barrier at Omaha. Each simulation yielded 0 mm of percolation, because no water reached the geomembrane due to the low saturated hydraulic conductivity of the soil layer (7.0×10^{-7} cm/s) above the geomembrane. Therefore, to increase the potential for HELP to predict percolation, an additional simulation was conducted with increased saturated hydraulic conductivities of the topsoil and vegetative layers, and a reduced runoff curve number. In contrast to what was expected, percolation decreased as the quality of placement was reduced, and as the defect frequency was increased. For several of the simulations, the predicted leakage through the barrier layer was less than the predicted percolation, which is not logical.

For the composite barrier at Marina, HELP predicted 0 mm of percolation for each simulation using the as-constructed hydraulic properties as input. Leakage through the geomembrane did increase slightly when placement condition 5 (worse case: bad contact) was simulated, and also when the hole frequency was increased.

5.6.4 Maximum Leaf Area Index (LAI)

The maximum LAI was adjusted for HELP and UNSAT-H to evaluate its effect on the water balance. Simulations were conducted at a humid site (ECap at Albany), a semi-arid site (thick monolithic barrier at Sacramento), and an arid site (alternative cover at Helena).

For HELP, increasing the maximum LAI caused an increase in evapotranspiration, a decrease in surface runoff and percolation, and a reduction in soil water storage (see Tables 5.19-5.21). However, the magnitude of these changes depended on the climate.

Evapotranspiration increased only 2% of precipitation at Helena (arid site) when the LAI was increased from 0.5 to 5.0, as opposed to 23.5% at Albany (humid site) and 34.1% at Kiefer (semi-arid). Helena was least sensitive because potential evapotranspiration is lower at Helena than at Sacramento, and Helena does not have the available water that exists at Albany.

LAI had a greater effect on surface runoff for Albany than the other sites. HELP predicted surface runoff would decrease approximately 22% of precipitation at Albany (Table 5.19), 2% of precipitation at Sacramento (Table 5.20), and less than 1% of precipitation at Helena (Table 5.21). As described in Section 5.5, HELP sheds more precipitation as surface runoff at Albany because the soil water storage capacity of the surface layer is quickly exceeded during intense rain events. When the LAI was increased at Albany, the vegetation was more capable of removing water, providing more void space for water retention in the surface layer.

Table 5.19. Water Balance Quantities Predicted by HELP for ECap Cover at Albany Site[a] (Humid) for Various Maximum LAI. Percentage of Precipitation in Parentheses.

LAI	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
0.5	515 (62.6%)	307 (37.3%)	0.0 (0.0%)	0.4
1.0	585 (69.2%)	260 (31.5%)	0.0 (0.0%)	-21.9
2.0	695 (80.0%)	174 (21.1%)	0.0 (0.0%)	-46.4
3.0	738 (82.8%)	152 (18.5%)	0.0 (0.0%)	-67.8
4.0	766 (85.1%)	134 (16.3%)	0.0 (0.0%)	-77.4
5.0	778 (86.1%)	125 (15.2%)	0.0 (0.0%)	-80.7

[a] Simulation Period is from January 1 to December 31, 2001. Precipitation was 823 mm during this period.

Table 5.20. Water Balance Quantities Predicted by HELP for Thick Monolithic Barrier Cover at Sacramento Site[a] (Semi-Arid) for Various Maximum LAI. Percentage of Precipitation in Parentheses.

LAI	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
0.5	290 (49.5%)	96 (16.4%)	0.76 (0.13%)	201 (34.4%)
1.0	367 (62.5%)	90 (15.3%)	0.57 (0.10%)	129 (22.0%)
2.0	472 (80.4%)	86 (14.7%)	0.51 (0.09%)	29 (4.9%)
3.0	496 (84.5%)	84 (14.3%)	0.45 (0.08%)	6 (1.0%)
4.0	489 (83.3%)	87 (14.8%)	0.25 (0.04%)	10 (1.7%)
5.0	491 (83.6%)	86 (14.7%)	0.22 (0.04%)	10 (1.7%)

[a] Simulation Period is from January 1 to December 31, 2000. Precipitation was 587 mm during this period.

Table 5.21. Water Balance Quantities Predicted by HELP for Alternative Cover at Helena Site[a] (Arid) for Various Maximum LAI. Percentage of Precipitation in Parentheses.

LAI	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
0.1	128.0 (88.9%)	6.2 (4.3%)	0.0 (0.0%)	5.9 (4.1%)
0.5	134.7 (93.1%)	6.2 (4.3%)	0.0 (0.0%)	3.3 (2.3%)
5.0	136.7 (95.1%)	5.2 (3.6%)	0.0 (0.0%)	2.3 (1.6%)

[a] Simulation Period is from January 1 to December 31, 2000. Precipitation was 144 mm during this period.

Soil water storage in all three covers decreased as the LAI increased. At Albany, HELP was able to remove more water from the soil profile than was added by precipitation (Table 5.19). At Sacramento, soil water storage decreased significantly (nearly 33%) when the LAI was increased from 0.5 to 5.0 (Table 5.20). However, even when the LAI was large, HELP predicted that the vegetation on the thick monolithic barrier at Sacramento would not remove more soil water than added by precipitation, despite using an LAI of 5.0. At Helena, soil water storage decreased slightly (2.5%) when the LAI was increased from 0.5 to 5.0.

HELP only predicted percolation for the Sacramento site. The percolation rate decreased approximately 0.5 mm/yr (0.1% of precipitation) when the LAI was increased from 0.5 to 5.0. Even with an LAI of 5.0, HELP still predicted percolation would occur, because soil water at deeper depths could not be extracted from the thick (2450 mm) cover.

For UNSAT-H, varying the maximum LAI from 0.5 to 4.5 resulted in a trend similar to that found with HELP for the Sacramento site, but not for the Helena site (Tables 5.22 and 5.23). UNSAT-H predicted evapotranspiration at Helena to decrease slightly as the LAI increased (Table 5.23), despite more soil water being removed from the cover. The reduction in evapotranspiration is apparently due to a slight increase in the predicted surface runoff. Increasing the LAI increased the potential transpiration demand, but less water was available for evapotranspiration.

At Sacramento, UNSAT-H predicted evapotranspiration to increase by nearly 86 mm (4% of precipitation) when the LAI was increased from 0.5 to 4.5. By increasing the LAI, UNSAT-H predicted significantly more soil water removal, which resulted in less percolation. Surface runoff was not affected by an increase in LAI.

Table 5.22. Water Balance Quantities Predicted by UNSAT-H for Thin Monolithic Barrier Cover at Sacramento Site[a] for Various Maximum LAI. Percentage of Precipitation in Parentheses.

LAI	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
0.5	342.6 (93.6%)	0.4 (0.1%)	22.6 (6.3%)	-8.7
1.6	395.1 (97.0%)	0.3 (0.1%)	12.8 (3.6%)	-50.9
2.5	415.6 (97.2%)	0.2 (0.1%)	9.7 (2.7%)	-68.7
4.5	428.8 (97.6%)	0.2 (0.1%)	8.1 (2.3%)	-80.2

[a] Simulation Period is from July 29, 2000 to July 28, 2001. Precipitation was 356.6 mm during this period.

Table 5.23. Water Balance Quantities Predicted by UNSAT-H for Alternative Cover at Helena Site[a] (Arid) for Various Maximum LAI. Percentage of Precipitation in Parentheses.

LAI	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change Storage (mm)
0.5	227.5 (88.9%)	23.5 (10.1%)	0.0	-17.5
1.5	231.4 (88.0%)	28.0 (12.0%)	0.0	-25.7
4.5	231.3 (87.3%)	29.7 (12.7%)	0.0	-27.3

[a] Simulation Period is from October 19, 2000 to October 18, 2001. Precipitation was 233.7 mm during this period.

5.6.5 Growing Season in HELP

The growing season dates chosen for HELP were adjusted for the Sacramento (Table 5.24) and Helena (Table 5.25) sites. Adjusting the germination and harvest dates changes the number of days during which transpiration occurs. This may become critical at some sites based on the timing of the rainy season and the spring thaw.

At Sacramento, evapotranspiration decreased slightly as the number of growing days was reduced. For example, evapotranspiration decreased 2% of precipitation when the number of growing days was reduced by 30 days (from a germination date of 275 to 245). Significant evapotranspiration did not occur during this period because only 6 mm of precipitation was received at the site. However, evapotranspiration was reduced by 38% when the harvest date was under-estimated, which reduced the number of growing days by 133 days.

At Helena, evapotranspiration was significantly less sensitive to varying the germination and harvest dates. There was negligible change in evapotranspiration when the growing season was reduced by 50 days (from a germination date of 158 to 108). During this period, only 19 mm of precipitation fell, which was easily removed from the soil once the vegetation germinated.

Surface runoff was not sensitive to varying the growing season dates at either site.

Percolation was only predicted for the Sacramento site, and the amount of percolation at Sacramento was insensitive to the germination dates. When the harvest date was under-estimated, percolation increased by only approximately 3.6 mm. However, the soil water storage increased substantially. Therefore, large percolation rates may have been predicted had additional years been simulated. This scenario

Table 5.24. Water Balance Quantities Predicted by HELP for Thick Monolithic Barrier Cover at Sacramento Site[a] (Semi-Arid) for Various Growing Season Dates Percentage of Precipitation in Parentheses.

Germination Julian Date (Date)	Number of Growing Days	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
275 (10/2)	273	466.9 (79.5%)	84.5 (14.4%)	0.08 (0.01%)	35.4 (6.0%)
265 (9/22)	283	461.9 (78.7%)	87.9 (15.0%)	0.05 (0.01%)	37.1 (6.3%)
255 (9/12)	293	469.8 (80.0%)	87.3 (14.9%)	0.13 (0.02%)	29.7 (5.1%)
245 (9/2)	*303*	*478.0 (81.4%)*	*86.0 (14.7%)*	*0.09 (0.02%)*	*22.4 (3.8%)*
235 (8/23)	313	492.9 (84.0%)	85.6 (14.6%)	0.11 (0.02%)	8.3 (1.4%)
225 (8/13)	323	517.7 (85.8%)	85.5 (14.6%)	0.18 (0.03%)	-16.4
Germinate = 245 Harvest = 50 (2/19)	170	269.0 (45.8%)	90.5 (15.4%)	3.7 (0.63%)	223.7 (38.1%)

[a] Simulation Period is from January 1, 2000 to December 31, 2000. Precipitation was 587 mm during this period. Typical growing season for Kiefer site is 245 to 183 (Julian Day).

Table 5.25. Water Balance Quantities Predicted by HELP for Alternative Cover at Helena Site[a] (Arid) for Various Growing Season Dates. Percentage of Precipitation in Parentheses.

Germination Julian Day (Date)	Number of Growing Days	Evapotranspiration (mm)	Surface Runoff (mm)	Percolation (mm)	Change in Storage (mm)
105 (4/15)	158	134.6 (93.5%)	5.7 (4.0%)	0.0 (0.0%)	3.9 (2.7%)
115 (4/25)	148	130.6 (90.7%)	5.9 (4.1%)	0.0 (0.0%)	7.9 (5.5%)
125 (5/5)	138	133.3 (92.6%)	6.0 (4.2%)	0.0 (0.0%)	4.9 (3.4%)
135 (5/15)	*128*	*133.7 (92.9%)*	*5.8 (4.0%)*	*0.0 (0.0%)*	*4.7 (3.3%)*
145 (5/25)	118	135.8 (94.3%)	6.2 (4.3%)	0.0 (0.0%)	2.2 (1.5%)
155 (6/4)	108	135.0 (93.8%)	6.2 (4.3%)	0.0 (0.0%)	2.8 (1.9%)
Germinate = 135 Harvest = 291 (10/18)	156	135.9 (94.4%)	5.8 (4.0%)	0.0 (0.0%)	2.5 (1.7%)

[a] Simulation Period is from January 1, 2000 to December 31, 2000. Precipitation was 144 mm during this period. Typical growing season for Helena site is 135 to 263 (Julian Day).

occurred in the field. Vegetation at the Sacramento site ceased transpiring prior to the expected harvest date, resulting in more water remaining in the cover at the end of the summer than had been anticipated. During the following year, the soil water storage capacity of the cover was exceeded following the on-set of the rainy season, and the percolation rate increased.

Soil water storage decreased more at the Sacramento site than at the Helena site as the number of growing days was increased. Increasing the growing season at the Sacramento site by 40 d caused the soil water storage to decrease 27.1 mm (4.6% of precipitation). In contrast, the same change caused a decrease in soil water storage of only 0.7 mm at Helena (1.2% of precipitation).

In general, the water balance is not affected significantly by varying the growing season, as long as reasonable germination and harvest dates are chosen. For arid and semi-arid sites in warm climates (that are characterized as having hot summers and wet winters), the growing season should at least include the rainy season during which transpiration will occur at its maximum rate. Transpiration will also occur for a period after the rainy season as the plants scavenge for water, but during this period transpiration may be a smaller fraction of evapotranspiration. For sites in cooler climates, the spring thaw and first killing frost are adequate estimates for the start and end of the growing season.

SECTION SIX
SUMMARY AND CONCLUSIONS

This report describes the measured and predicted hydrology of twenty-one large-scale test sections simulating landfill final covers. The test sections are being monitored as part of the USEPA's Alternative Cover Assessment Program (ACAP). Data collected through April 2002 are included in this report. The predictions were made with two common models (HELP and UNSAT-H) using on-site meteorological and hydrological data for input. Comparisons between the predictions and the field data were made to assess the accuracy of the models. The following sections describe the salient aspects of the field data, and key findings of the comparison between the field data and model predictions.

6.1 SUMMARY OF FIELD PERCOLATION RATES

6.1.1 Percolation from Alternative Covers

A summary of percolation rates from the alternative covers is in Table 6.1. The alternative covers in arid and semi-arid climates transmitted significantly less percolation than the alternative covers in humid climates, with the exception of the thin monolithic barrier at Sacramento. At the arid and semi-arid sites, the percolation rate was generally less than 1 mm/yr (except for the test sections in Sacramento). In contrast, percolation rates exceeding 30 mm/yr were measured at the humid sites. The relatively high percolation rates at the humid sites may diminish over time as the vegetation at these sites matures, and more effectively removes water stored in the cover.

Table 6.1. Summary of Percolation Data: Alternative Covers.

Climate	Site	Annual Precipitation (mm)	Cover Type	Percolation (mm/yr)
Arid and Semi-Arid	Altamont, CA	358	Monolithic Barrier	1.0
	Sacramento, CA	434	"Thin" Monolithic Barrier (1070 mm)	48.4
			"Thick" Monolithic Barrier (2450 mm)	3.1
	Helena, MT	289	Capillary Barrier	0.0
	Polson, MT	380	Capillary Barrier	0.4
	Boardman, OR	225	"Thin" Monolithic Barrier (1220 mm)	0.0
			"Thick" Monolithic Barrier (1840 mm)	0.0
Humid	Marina, CA	466	Monolithic Barrier	61.8
	Albany, GA	1263	Monolithic Barrier (ECap)	91.3
	Cedar Rapids, IA	915	Monolithic Barrier (ECap)	143.1
	Omaha, NE	760	"Thin" Capillary Barrier (760 mm)	62.9
			"Thick" Capillary Barrier (1060 mm)	36.8

At sites where snow occurred, there was a delayed response in runoff and infiltration because the snow was stored on the surface. When the snow cover melted, a significant amount of water infiltrated the cover. Much of this infiltration became percolation, because removal of soil water by evapotranspiration was minimal during and soon after the snowmelt. Thus, accounting for storage of snowmelt is a key factor that must be considered when designing alternative covers in seasonal climates.

The data from Sacramento illustrate the importance of long-term records when evaluating the efficacy of final covers. During the first growing season, the vegetation at Sacramento was very effective at removing stored water from the cover, leaving an empty reservoir for soil water storage the following winter. In contrast, the vegetation was ineffective at removing water during the second growing season, resulting in limited capacity to retain water during the subsequent winter. As a result, the storage capacity of both covers was exceeding during the winter, and appreciable amounts of percolation were transmitted. Future monitoring will show whether this behavior persists.

6.1.2 Percolation from Conventional Covers

A summary of percolation rates from the conventional covers is in Table 6.2. Percolation rates less than 1 mm/yr were transmitted from the conventional covers at arid and semi-arid sites. At humid sites, the percolation rates ranged between 0.9 to 18.1 mm/yr for the composite cover and 15.5 to 280 mm/yr for compacted clay covers.

Table 6.2. Summary of Percolation Rates: Conventional Covers.

Climate	Site	Annual Precipitation (mm)	Cover Type	Percolation (mm/yr)
Arid and Semi-Arid	Altamont, CA	358	Composite Barrier	0.0
	Polson, MT	380	Composite Barrier	0.2
	Boardman, OR	225	Composite Barrier	0.0
Humid	Marina, CA	466	Composite Barrier	18.1
	Albany, GA	1263	Compacted Clay Barrier	280.4
	Cedar Rapids, IA	915	Compacted Clay Barrier	15.5
			Composite Barrier	0.9
	Omaha, NE	760	Composite Barrier	3.7

The percolation rate for the composite barrier at Marina, CA (18.1 mm/yr) was higher than anticipated during design. The composite barrier at Marina, CA was constructed without a drainage layer above the geomembrane, and without adequate protection of the geomembrane against puncture. The vegetative layer, which was placed directly above the geomembrane, was constructed with waste soil from nearby construction projects that contained concrete rubble and wire. Despite the potential for puncturing of the geomembrane by debris in the waste soil, no protection layer was provided on top of the geomembrane at the direction of the site owner. If a drainage composite had been used and a protection layer had been provided (both of which are typical in practice and were recommended by the ACAP investigators), percolation transmitted from the cover would have been significantly lower.

The data from the conventional cover at Albany, GA show that percolation from compacted clay covers is particularly sensitive to desiccation cracking of the clay. The cover with a compacted clay barrier transmitted over 550 mm of percolation during the two-year monitoring period, even though the storage capacity of the cover was never exceeded.

6.2 MODEL PREDICTIONS

The modeling effort was not intended to calibrate HELP and UNSAT-H using the field data collected by ACAP, but rather to determine the accuracy of the models when well-defined parameters were used as input. Nevertheless, certain input parameters were adjusted in an attempt to match the field conditions after the outcomes of initial simulations were determined to be unsatisfactory.

6.2.1 Surface Runoff

Surface runoff was found to be very sensitive to the hydraulic properties of the surface layer. Gross over-predictions of runoff were obtained when the hydraulic properties measured in the laboratory immediately after construction were used as input. Therefore, another set of simulations was conducted where the surface layer of was assigned higher saturated hydraulic conductivity. The purpose of these simulations was to account for pedogenesis that likely occurred after construction due to factors such as desiccation, freeze-thaw cycling, and biota intrusion. Increasing the saturated hydraulic conductivity resulted in more reasonable predictions of runoff for both models. After this change was made, HELP predicted runoff more accurately than UNSAT-H, even though the same hydraulic properties were used for both models.

Both models had difficulty accurately predicting surface runoff at sites that received intense rainfall (e.g., Albany, GA; Sacramento, CA) and have a soil layer with low saturated hydraulic conductivity beneath the surface layer. For these covers, the only way to match the surface runoff measured in the field was to increase the saturated hydraulic conductivity of the underlying soil layer.

6.2.2 Percolation in Alternative Covers

Neither HELP of UNSAT-H predicted percolation from the alternative covers accurately, and no general bias in the models (i.e., over-prediction or under-prediction of percolation) was apparent. Both models captured the seasonal changes in percolation. The seasonal changes in soil water storage and evapotranspiration, both of which strongly influence percolation, were also captured. However, nuances in the field data (e.g., elevated soil water storage or lower than expected evapotranspiration) were not captured by the models, and these nuances typically controlled the percolation rate. Preferential flow also appears to affect the percolation rate at some sites. Currently, preferential flow cannot be predicted reliably with conventional models.

Accurate predictions of percolation rate are tied to the predictions of soil water storage and evapotranspiration. Both of these water balance components are strongly influenced by the hydraulic properties of the covers soils and the properties of the vegetation. Thus, properties representative of the field condition are necessary to predict the water balance of alternative covers accurately. Additional characterization of soil and vegetation properties will be emphasized in future efforts by the ACAP investigators.

6.2.3 Lateral Flow and Percolation from Conventional Covers

HELP was used to model the composite barriers, whereas both HELP and UNSAT-H were used to model the compacted clay barrier at Albany, GA. HELP predicted percolation record for composite covers constructed in arid and semi-arid climates accurately, but under-predicted percolation rates for composite covers in humid climates. For most of the composite covers, HELP over-predicted lateral flow.

HELP and UNSAT-H significantly over-predicted surface runoff from the compacted clay barrier at Albany, GA despite efforts to increase infiltration into the cover by increasing the saturated hydraulic conductivity of the topsoil layer, and decreasing the runoff curve number. Also, HELP and UNSAT-H did not predict percolation from the compacted clay barrier at Albany accurately, because neither model accounts for preferential flow.

6.3 PRACTICAL IMPLICATIONS

Analysis of the field data collected to date indicates that alternative covers generally are effective in limiting percolation to small amounts (< 1 mm/yr) in semi-arid and arid areas provided the cover is designed for adequate storage capacity and is seeded with vegetation that can effectively remove stored water. The effectiveness of alternative covers in humid climates is not yet clear. Higher than anticipated percolation rates have been recorded to date, but lower rates are anticipated in the future as the vegetation matures.

The data from test sections simulating conventional covers indicate that composite barriers are very effective in limiting percolation in all climates (< 1 mm/yr in semi-arid and arid climates, and < 5 mm/yr in humid climates) provided that the cover is designed and constructed properly. Protecting the geomembrane is a key factor. Methods or materials that damage the geomembrane during construction will lead to higher than anticipated percolation rates. The data also show that covers relying on a compacted clay barrier (i.e., no geomembrane) as the primary impedance to flow may become ineffective even after a short service life. Cracking of the clay must be prevented for covers relying on a clay barrier to be effective.

Predicting the hydrology of covers (conventional and alternative) is challenging, even with an abundance of data describing the properties of the cover materials. Predictions made with current models represent seasonal trends well, but have limited accuracy. At present, predictions made with current models can only be considered estimates of field performance. Field performance testing, using methods such as those employed by ACAP, is the best technique currently available to characterize the hydrology of covers

These inferences are predicated on the relatively short data record that has been collected. The unexpected conditions observed at some sites (e.g., Sacramento) are indicative of the need for a long-term record if a reliable understanding of the hydrology of final covers is to be attained.

SECTION SEVEN
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APPENDIX 1
CORRECTIONS TO ET CALCULATIONS

Evapotranspiration (ET) was calculated on a daily basis by using Eq. 2 (Section 5), where P is precipitation, P_r is percolation, R_o is runoff, L_o is lateral flow, and ΔS is change in soil water storage. Because ET is computed as a residual quantity, it includes the errors inherent in each of the water balance quantities being measured. In addition, the ET equation does not account for the dynamic effects in the system on a small time scale. For example, daily ET may be over-estimated at times due to a delay in response between percolation and precipitation events (See Fig. A1a).

Also, ET may be over-estimated at times when there is an artificial decrease in soil water storage, which is caused be temperatures effects on the WCR probes (see Fig. A1b). Kim (2002) indicates that there can be a 6% error in volumetric water content due to temperature effects alone. Campbell Scientific, Inc. (CSI), manufacturer of WCR probes (CS615), recommends applying a correction for temperature to the soil specific calibration equation (that relates volumetric water content and CS615 output). When frozen ground conditions exist, the WCR measurements only reflect the unfrozen water content rather than the true volume of water in the soil.

To remove the artificial increase in ET (followed by a decrease), cumulative ET was re-calculated on a daily basis by assigning the "minimum" value of ET between the existing day and the last day of data An example of this computation is shown in Fig. A2.

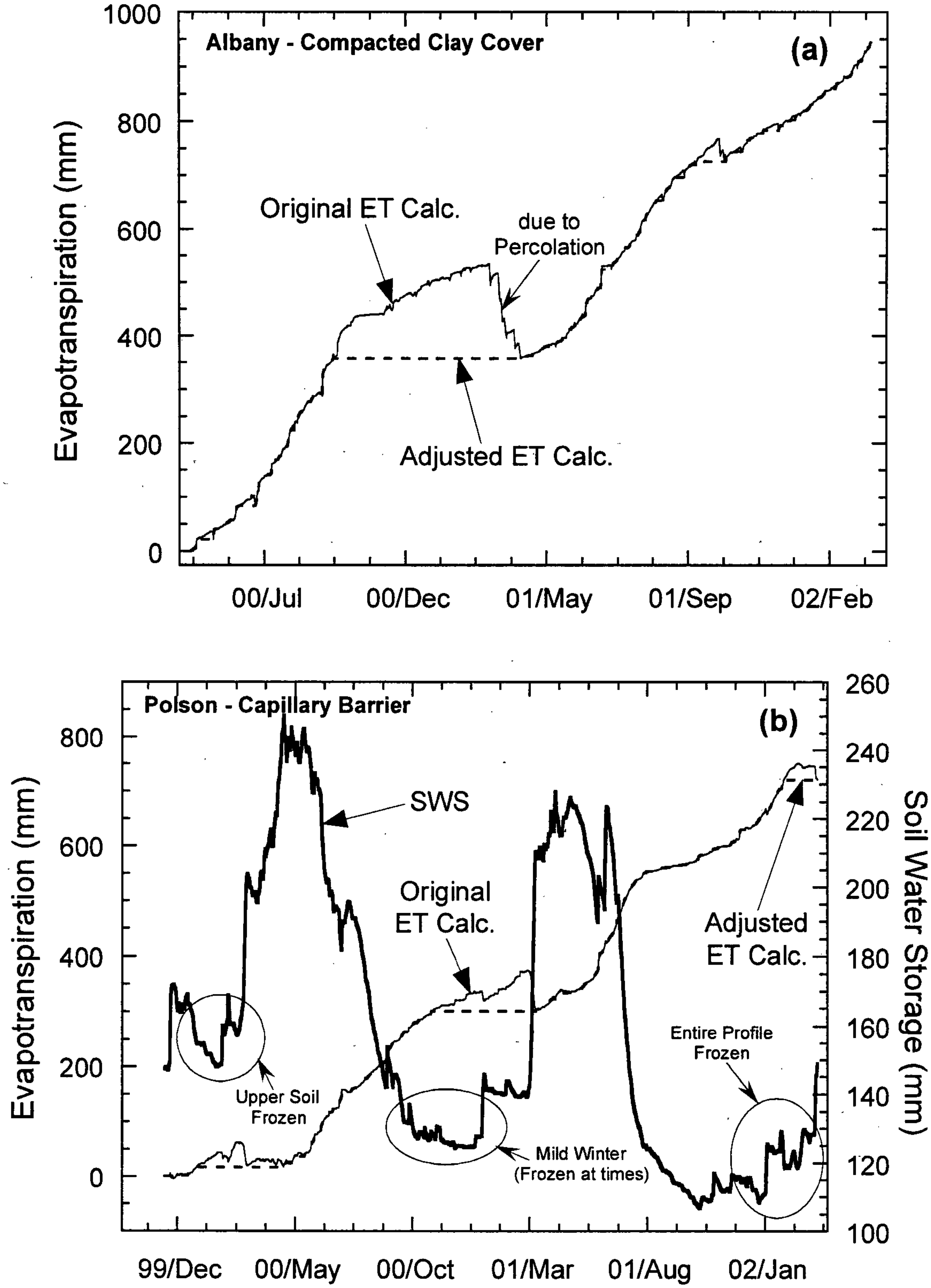

Fig. A1. Effects on Daily Evapotranspiration Calculation Due to (a) Delay in Percolation and (b) WCR Sensitivity to Temperature.

Daily						
Date	Cum. Precip. (mm)	SWS (mm)	Perc Cum. Flush (mm)	SRO Cum. Flush (mm)	Cum. ET (mm)	Cum. ET (mm) "adjusted"
11/19/1999	0	147.24	0	0	0.00	0.00
11/20/1999	0.254	147.69	0	0	0.00	0.00
11/21/1999	0.254	147.45	0	0	0.05	0.00
11/22/1999	0.254	146.99	0	0	0.51	0.00
11/23/1999	0.254	146.83	0	0	0.67	0.00
11/24/1999	0.254	147.29	0	0	0.21	0.00
11/25/1999	1.524	148.98	0	0	0.00	0.00
11/26/1999	18.542	160.85	0	0	4.93	0.00
11/27/1999	19.304	168.93	0	0	0.00	0.00
11/28/1999	19.812	171.34	0	0	0.00	0.00
11/29/1999	19.812	171.34	0	0	0.00	0.00
11/30/1999	20.066	171.62	0	0	0.00	0.00
12/1/1999	20.066	171.00	0	0	0.00	0.00
12/2/1999	20.066	170.52	0	0	0.00	0.00
12/3/1999	20.066	169.63	0	0	0.00	0.00
12/4/1999	20.066	166.61	0	0	0.70	0.70
12/5/1999	20.066	164.13	0	0	3.18	0.99
12/6/1999	20.066	165.77	0	0	1.54	0.99
12/7/1999	20.066	166.32	0	0	0.99	0.99
12/8/1999	20.066	164.59	0	0	2.72	1.04
12/9/1999	20.066	163.62	0	0	3.69	1.04
12/10/1999	20.32	163.66	0	0	3.91	1.04
12/11/1999	20.32	163.83	0	0	3.73	1.04
12/12/1999	20.32	166.07	0	0	1.50	1.04
12/13/1999	20.32	166.02	0	0	1.55	1.04
12/14/1999	20.32	164.58	0	0	2.99	1.04
12/15/1999	20.828	165.11	0	0	2.96	1.04
12/16/1999	21.844	168.05	0	0	1.04	1.04
12/17/1999	22.098	167.71	0	0	1.63	1.46
12/18/1999	23.114	168.90	0	0	1.46	1.46

Fig. A2. Example of Water Balance Computation for the Alternative Cover at the Polson Site.

APPENDIX 2
LAI GRAPHS FOR ACAP SITES

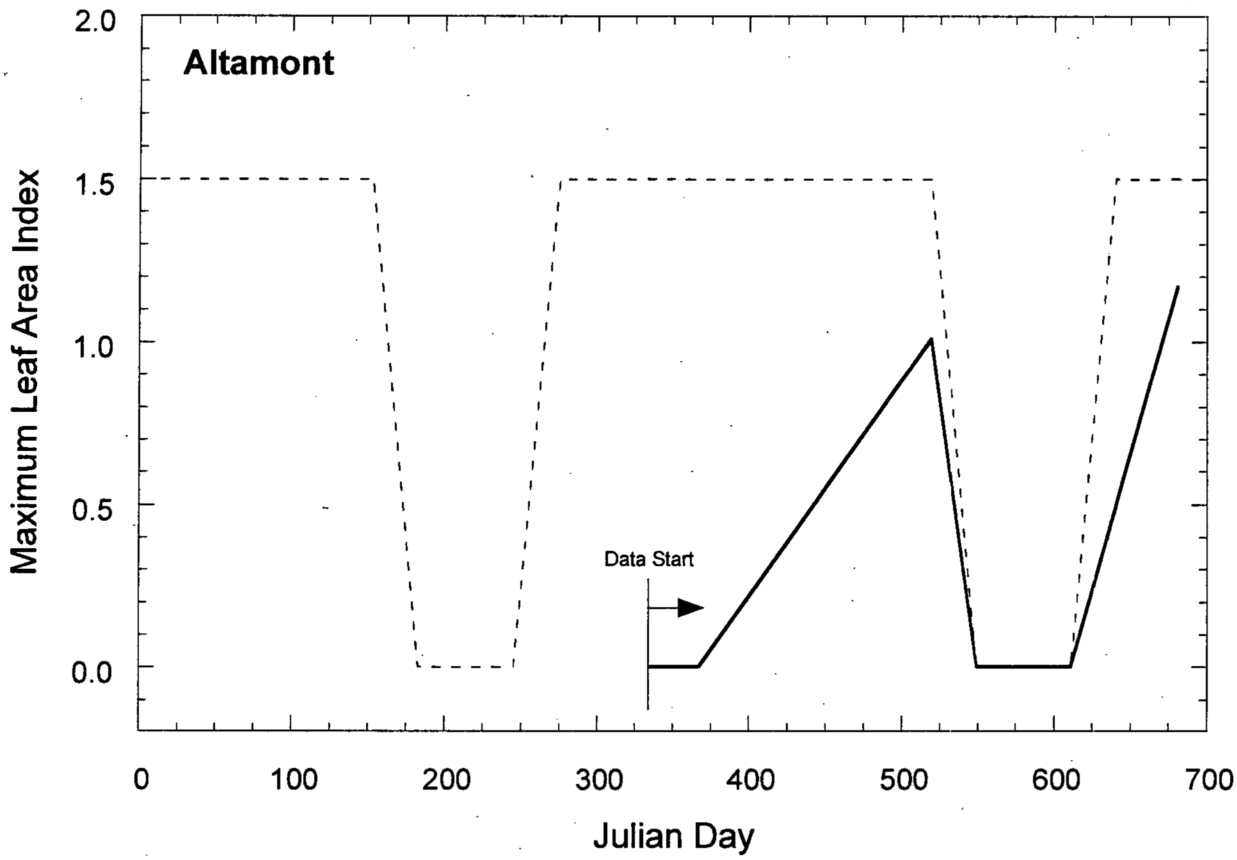

Fig. A3. LAI Plot for Altamont Site.

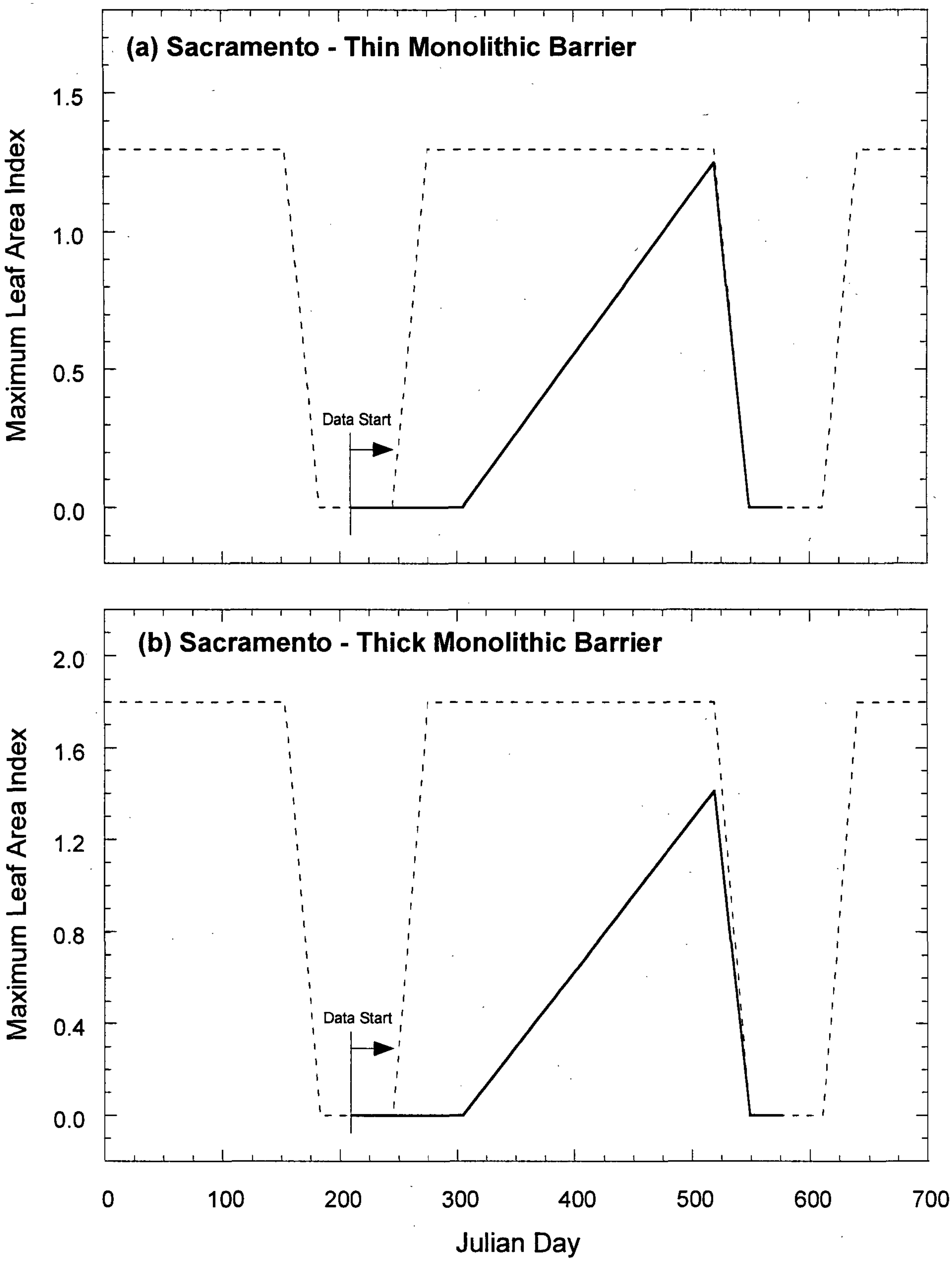

Fig. A4. LAI Plot for Sacramento Site: (a) Thin Barrier and (b) Thick Barrier.

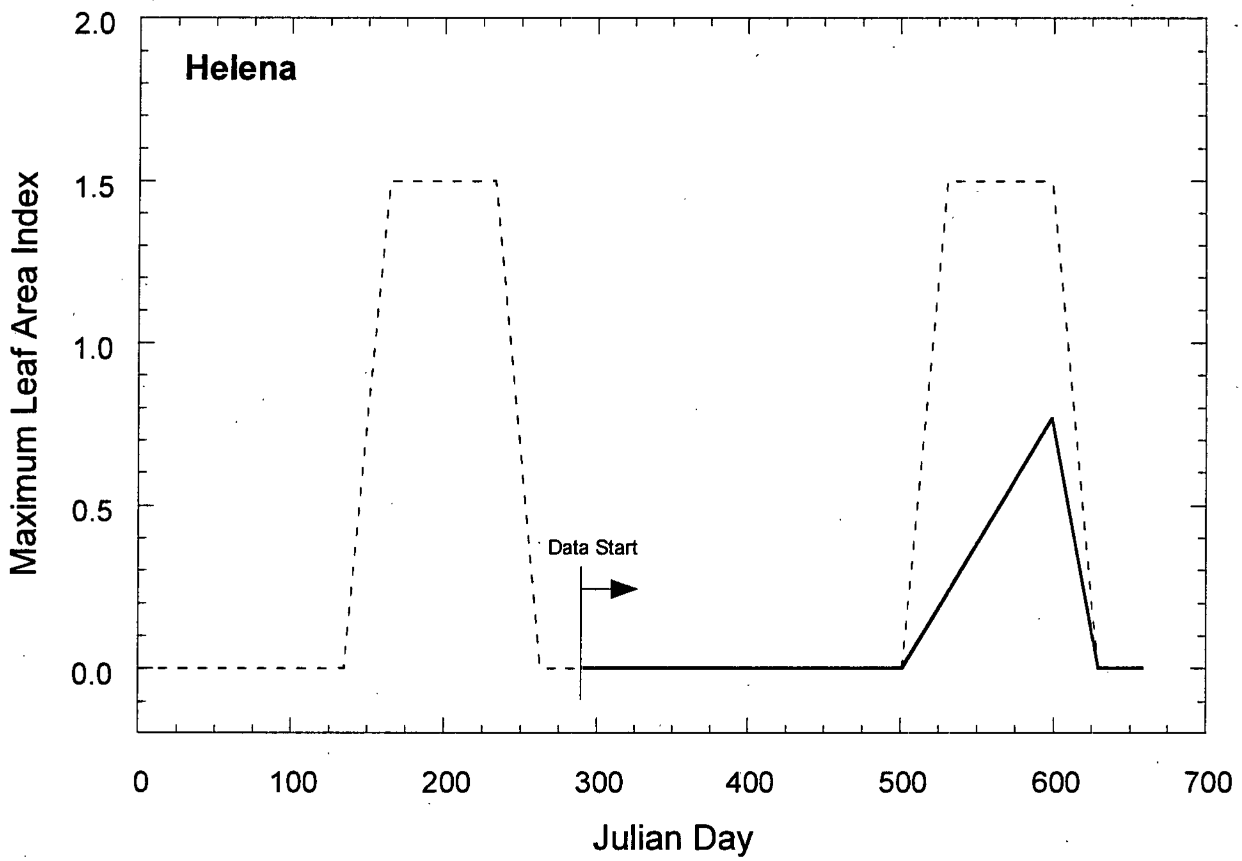

Fig. A5. LAI Plot for Helena Site.

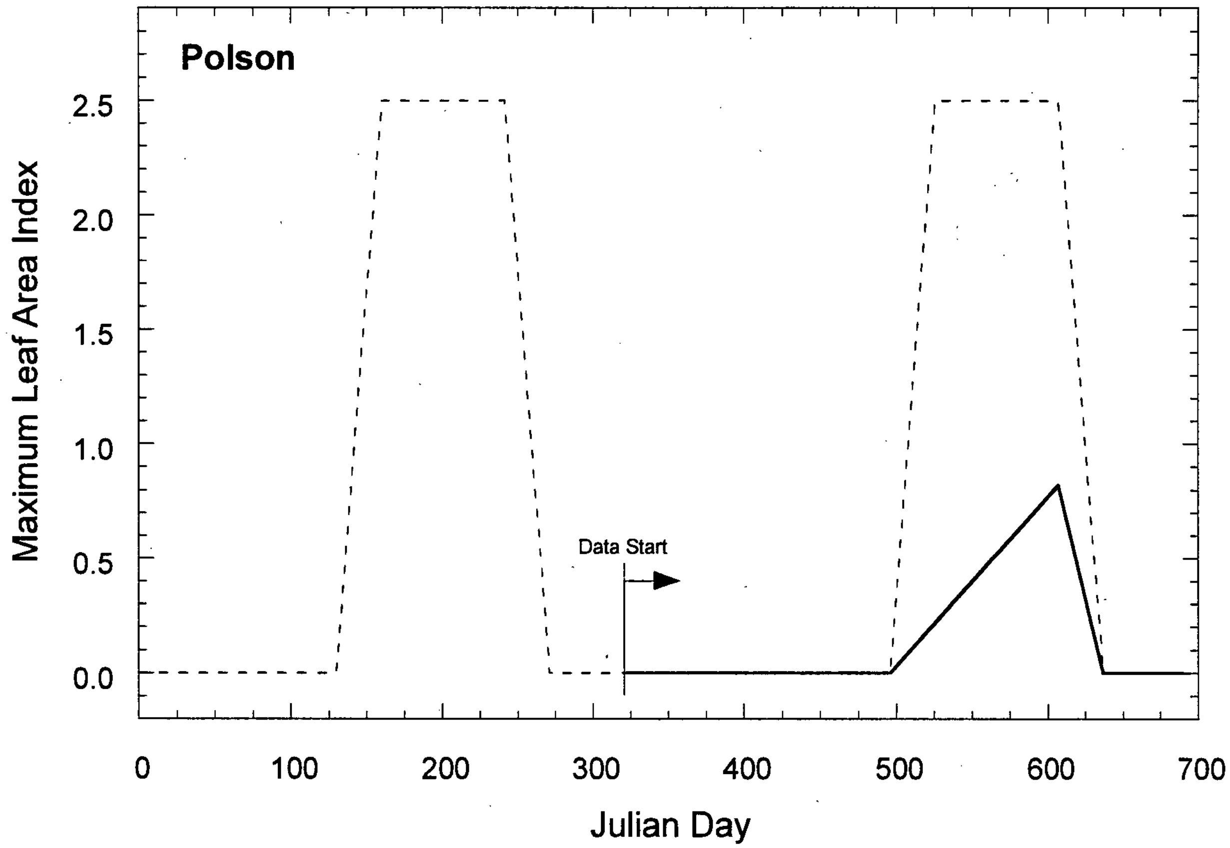

Fig. A6. LAI Plot for Polson Site.

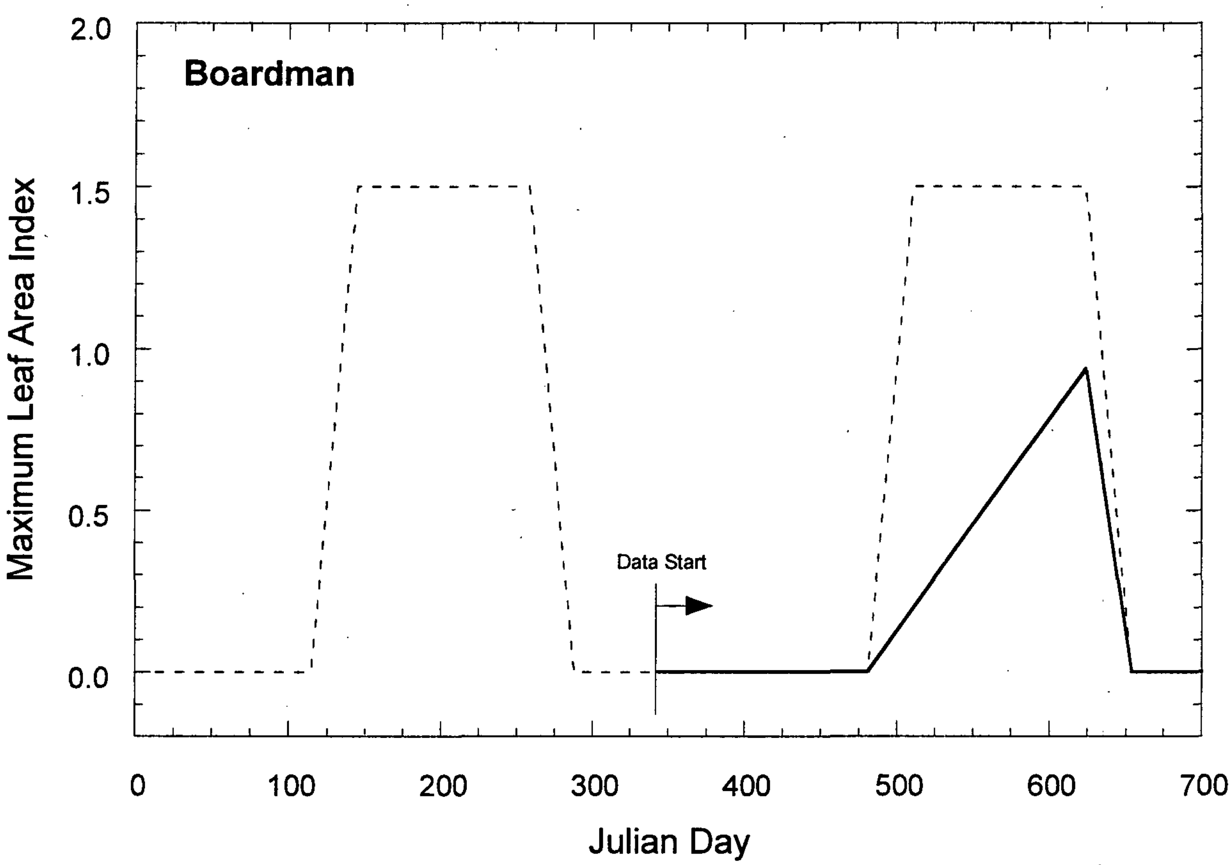

Fig.A7. LAI Plot for Boardman Site.

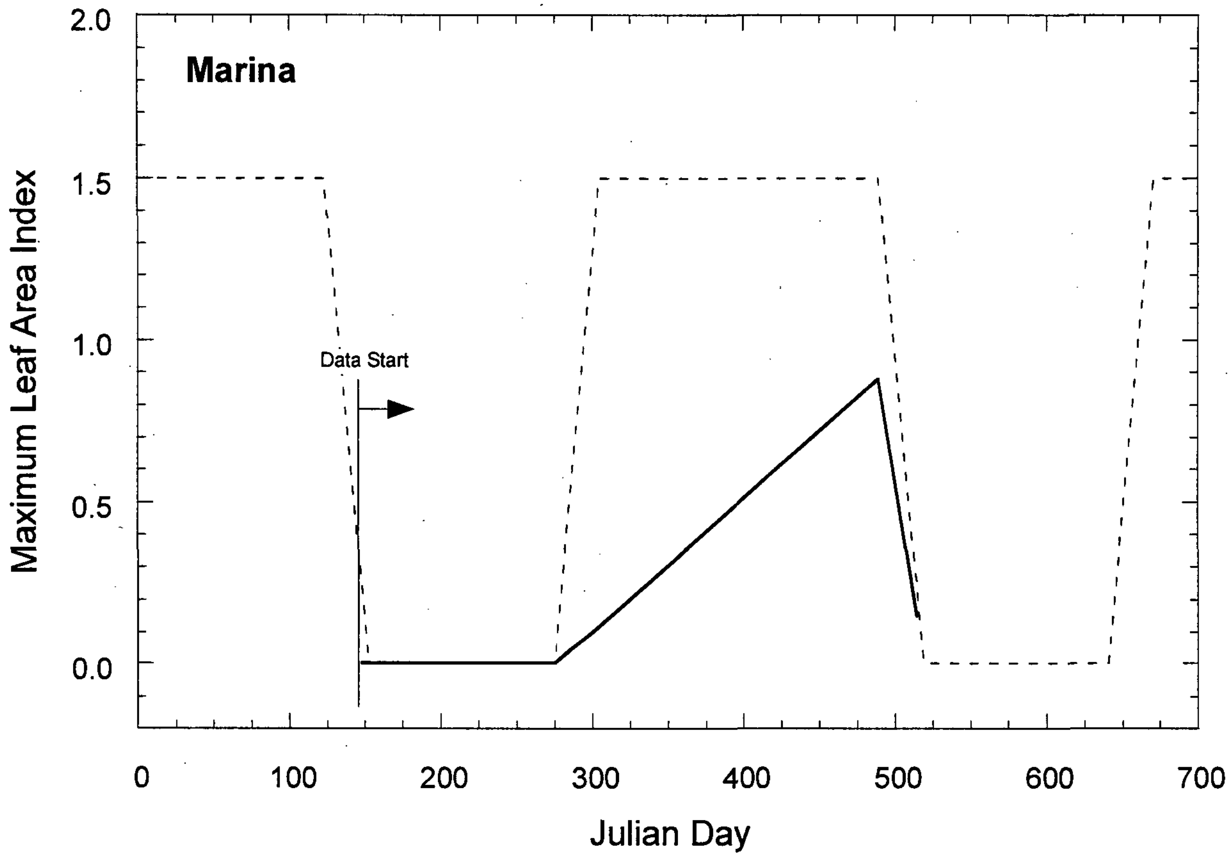

Fig. A8. LAI Plot for Marina Site.

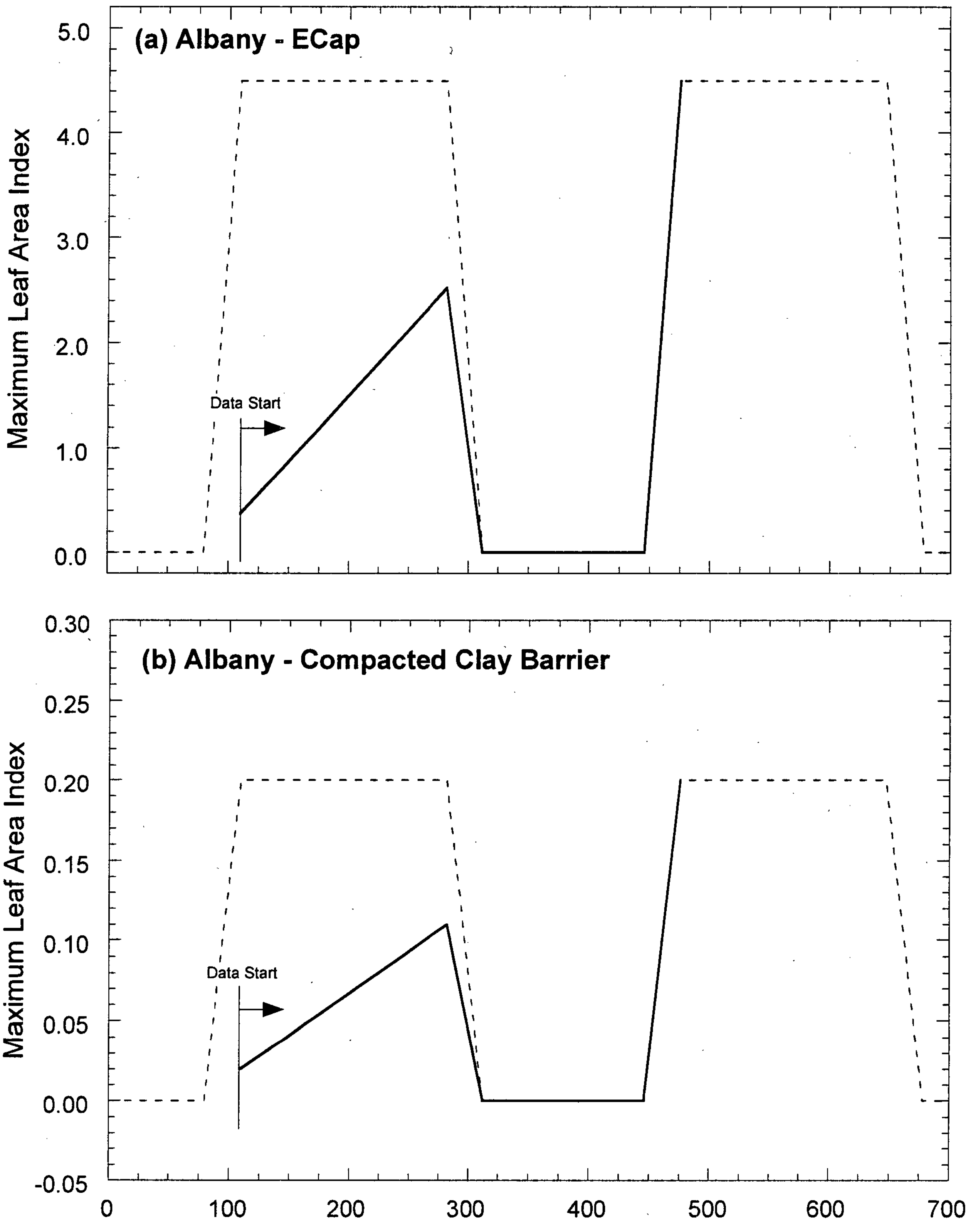

Fig. A9. LAI Plot for Albany Site: (a) ECap and (b) Compacted Clay Barrier.

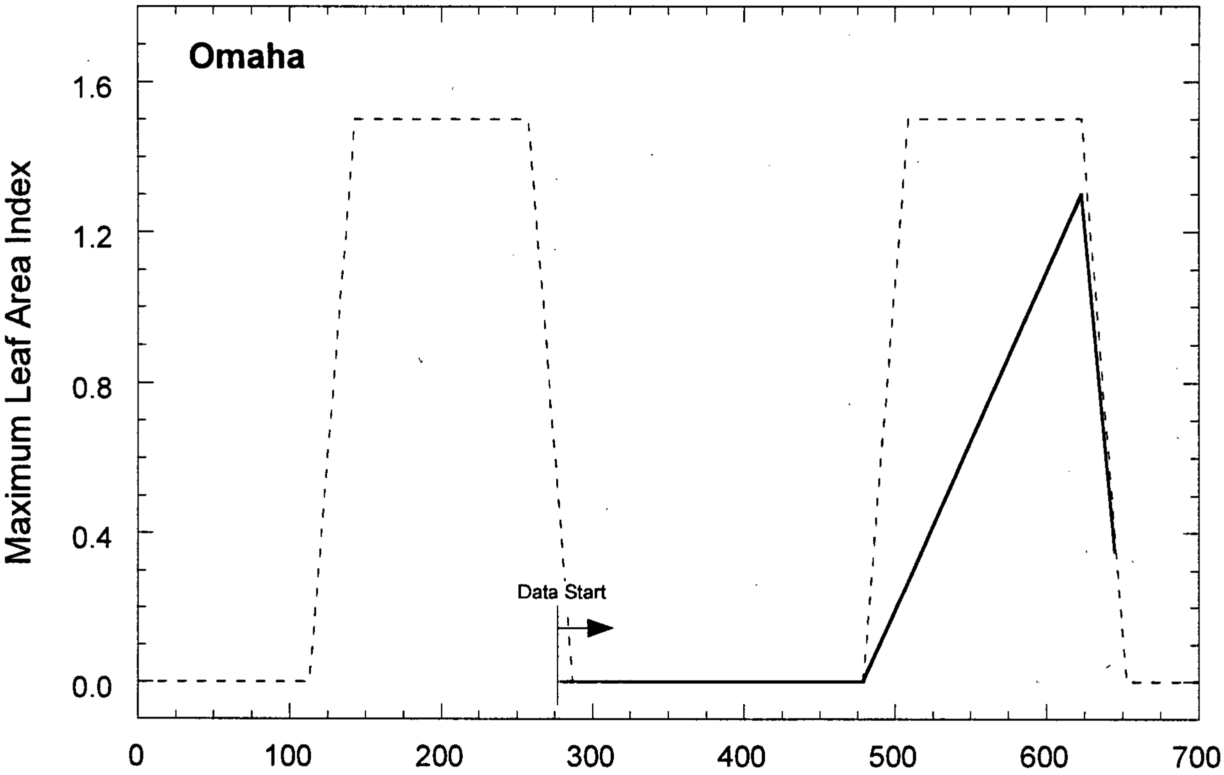

Fig. A10. LAI Plot for Omaha Site.

APPENDIX 3
FACTORS AFFECTING SURFACE RUNOFF IN FIELD

Surface runoff from the ACAP test sections ranged between 0 and 14% of precipitation (see Table A1) There are several factors that influence surface runoff, such as rainfall intensity, slope, frozen ground conditions, and the surface layer physical and hydraulic properties. Factors that may have affected surface runoff at each ACAP site are summarized in Table A1.

Table A1. Summary of Surface Runoff Data from ACAP Study.

Climate	Site	Cover Type	Slope (%)	Tilling	Frozen Ground	Surface Runoff (% of Precip.)
Cool Semi-Arid	Boardman	"Thin" Monolithic	25	-	-	0.0
Cool Semi-Arid	Boardman	"Thick" Monolithic Barrier	25	-	-	0.0
Cool Semi-Arid	Boardman	Composite Barrier	25	-	-	0.0
Sub Humid	Marina	Monolithic Barrier	25	√ *	-	0.0
Humid Subtropical	Albany	Monolithic Barrier	5	√ *	-	0.1
Cool Humid	Cedar Rapids	Compacted Clay Barrier	5	-	√	1.9
Cool Semi-Arid	Polson	Composite Barrier	5	-	√	2.3
Cool Humid	Cedar Rapids	Composite Barrier	5	-	√	2.8
Arid to Semi-Arid	Altamont	Composite Barrier	5	-	-	3.0
Cool Semi-Arid	Polson	Capillary Barrier	5	-	√	3.1
Cool Humid	Cedar Rapids	Monolithic Barrier	5	√	√	3.5
Cool Humid	Omaha	"Thick" Capillary Barrier	25	-	√	5.0
Arid to Semi-Arid	Altamont	Monolithic Barrier	5	-	-	5.4
Semi-Arid	Sacramento	"Thick" Monolithic Barrier	5	-	-	5.9
Cool Humid	Omaha	Composite Barrier	25	-	√	6.3
Cool Humid	Omaha	"Thin" Capillary Barrier	25	-	√	6.6
Cool Semi-Arid	Helena	Capillary Barrier	5	-	√	7.4
Humid Subtropical	Albany	Compacted Clay Barrier	5	-	-	10.4
Semi-Arid	Sacremento	"Thin" Monolithic Barrier	5	-	-	10.5
Sub Humid	Marina	Composite Barrier	25	-	-	14.2

*Includes trenching to plant trees.

APPENDIX 4
WATER BALANCE GRAPHS OF ORIGINAL UNSAT-H SIMULATIONS

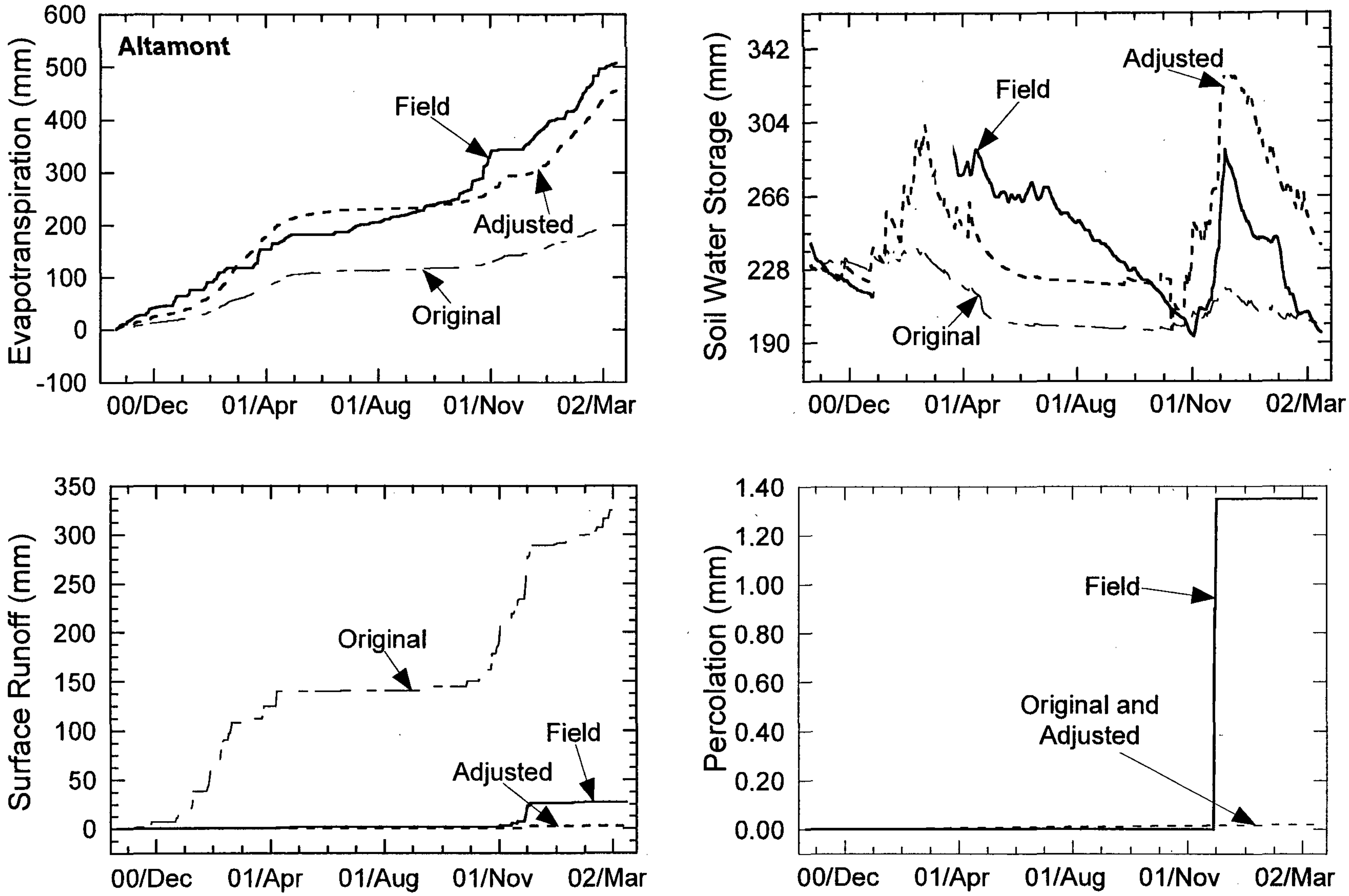

Fig. A11. UNSAT-H Comparison to Field Data at the Altamont Site.

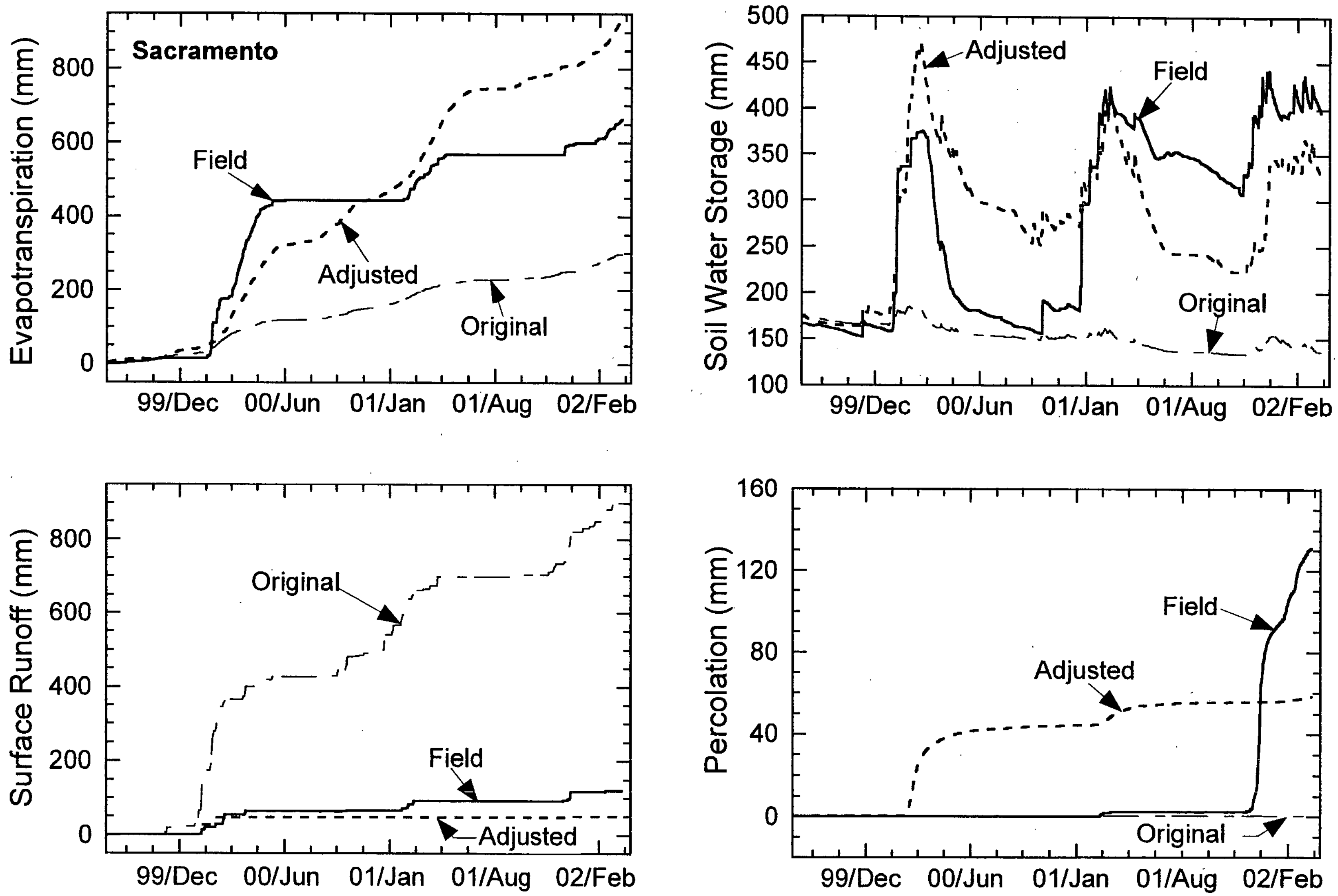

Fig. A12. UNSAT-H Comparison to Field Data for Thin Monolithic Barrier at the Sacramento Site.

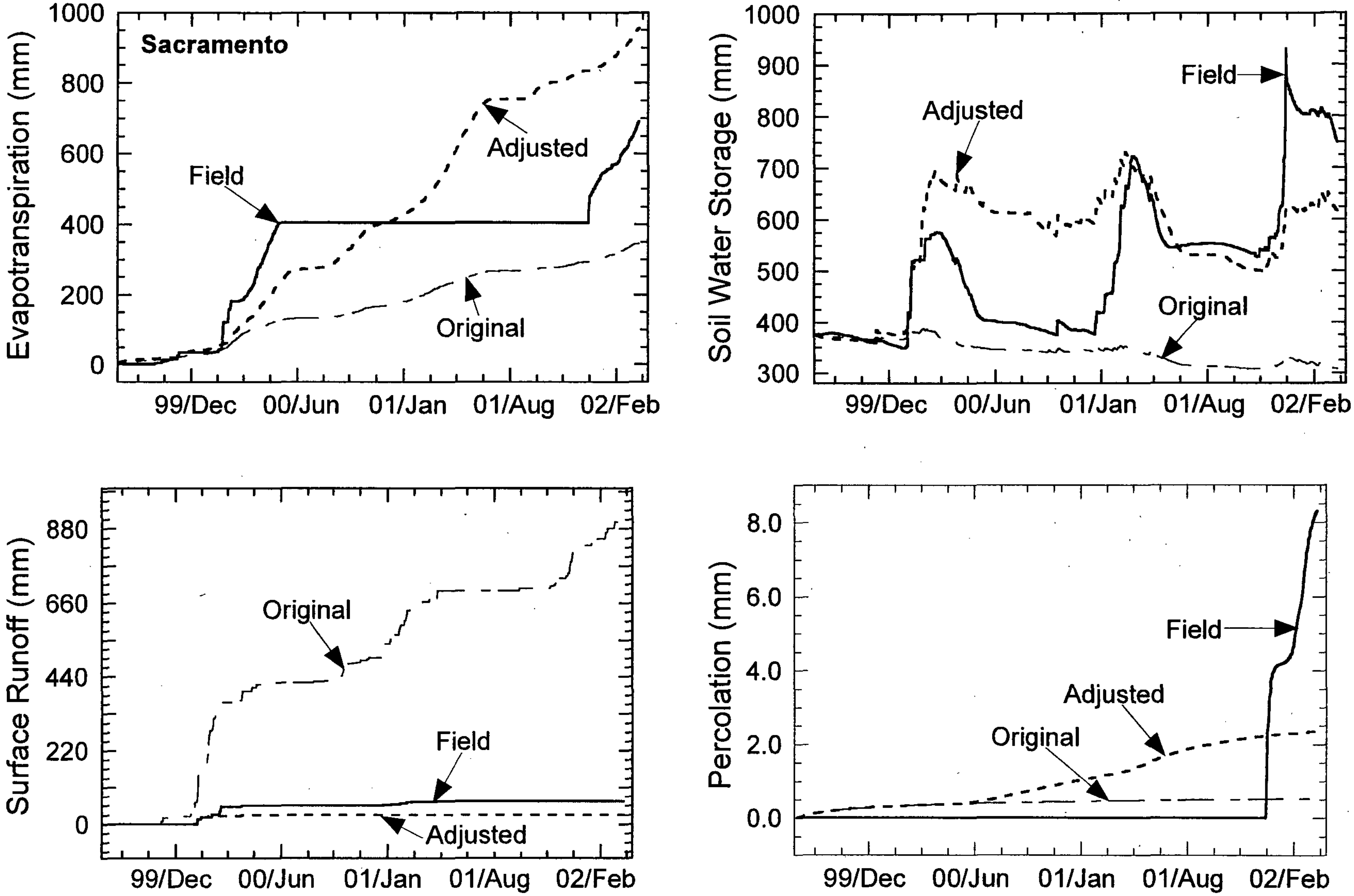

Fig. A13. UNSAT-H Comparison to Field Data for Thick Monolithic Barrier at the Sacramento Site.

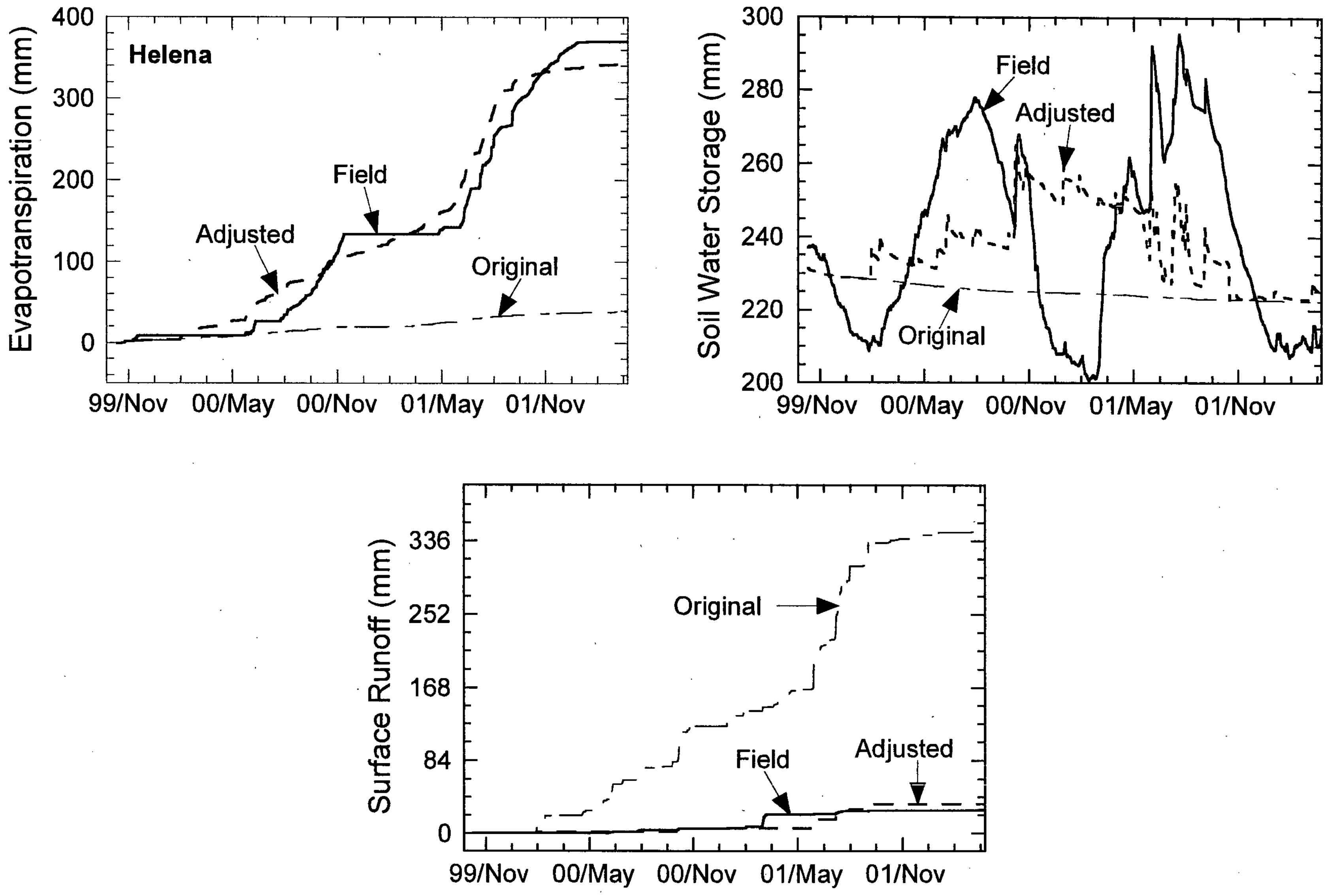

Fig. A14. UNSAT-H Comparison to Field Data at the Helena Site.

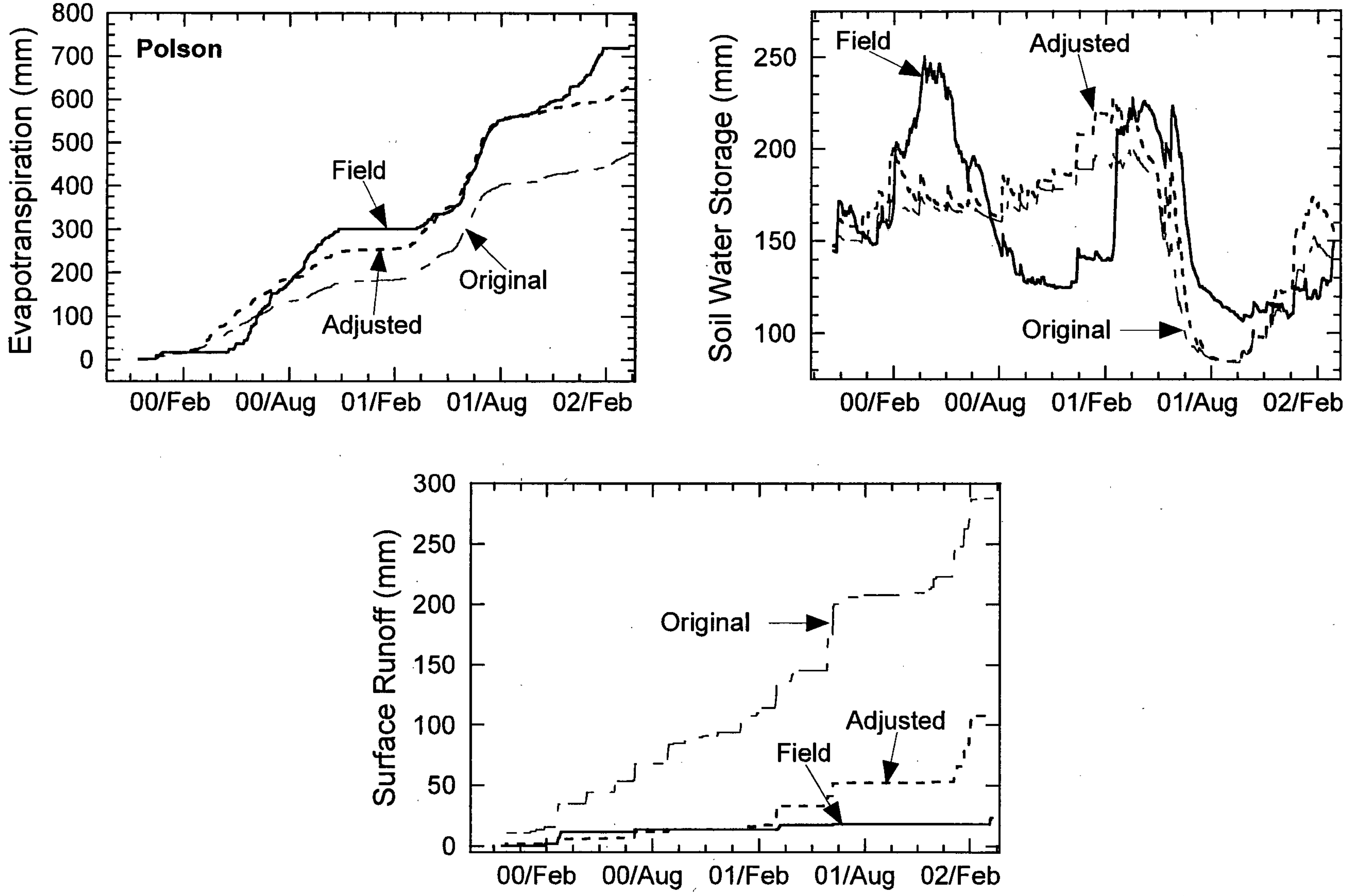

Fig. A15. UNSAT-H Comparison to Field Data at the Polson Site.

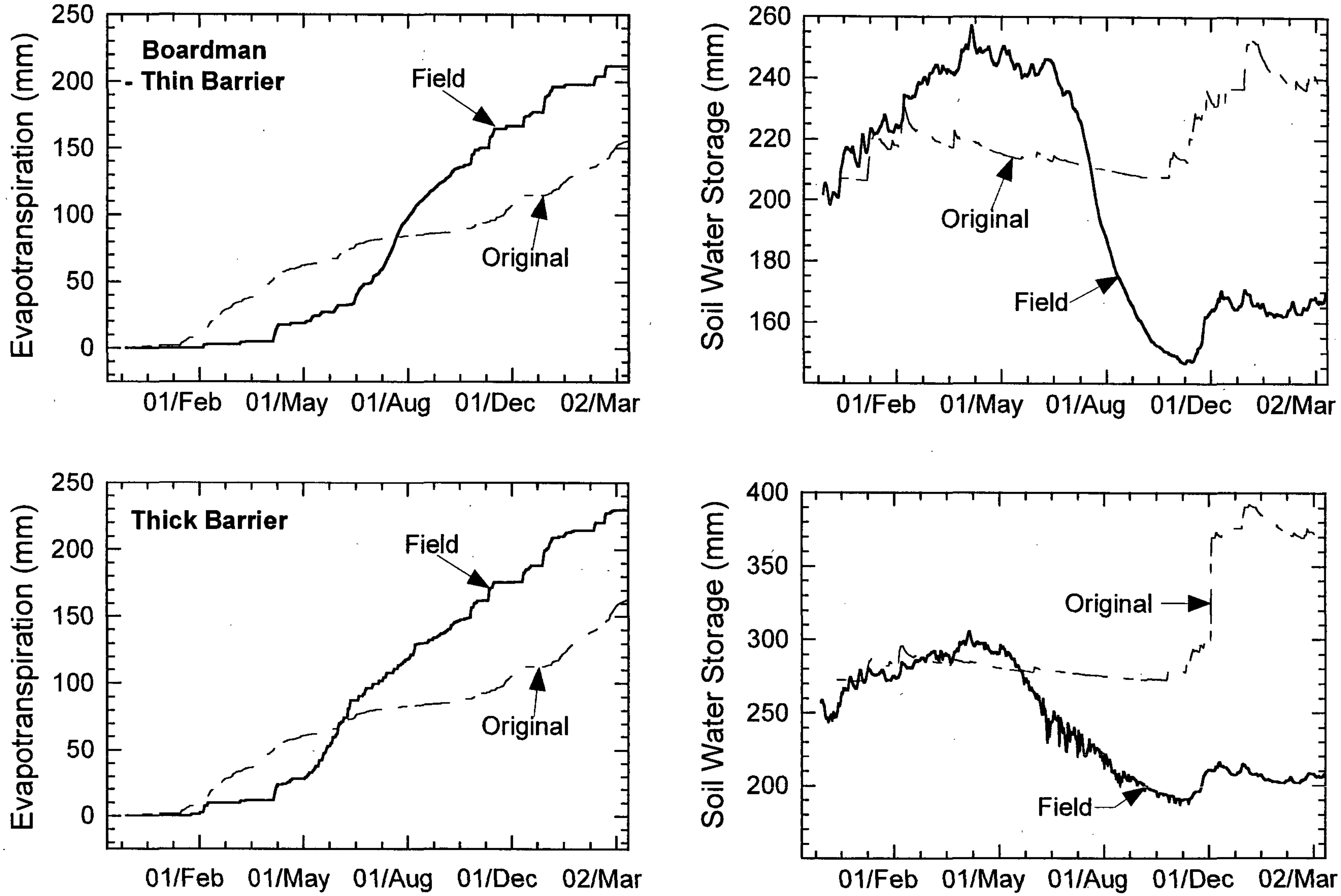

Fig. A16. UNSAT-H Comparison to Field Data at the Boardman Site.

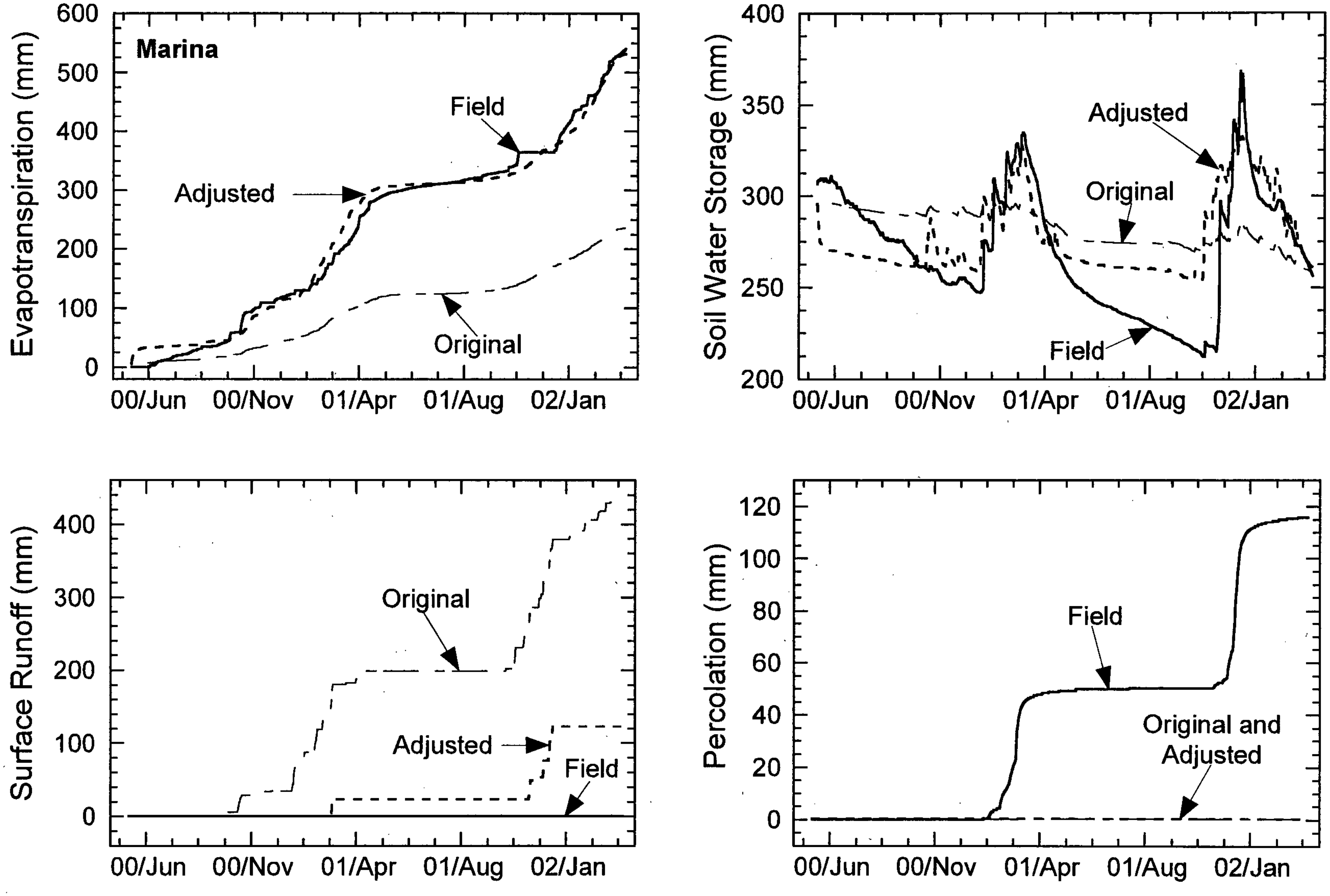

Fig. A17. UNSAT-H Comparison to Field Data at the Marina Site.

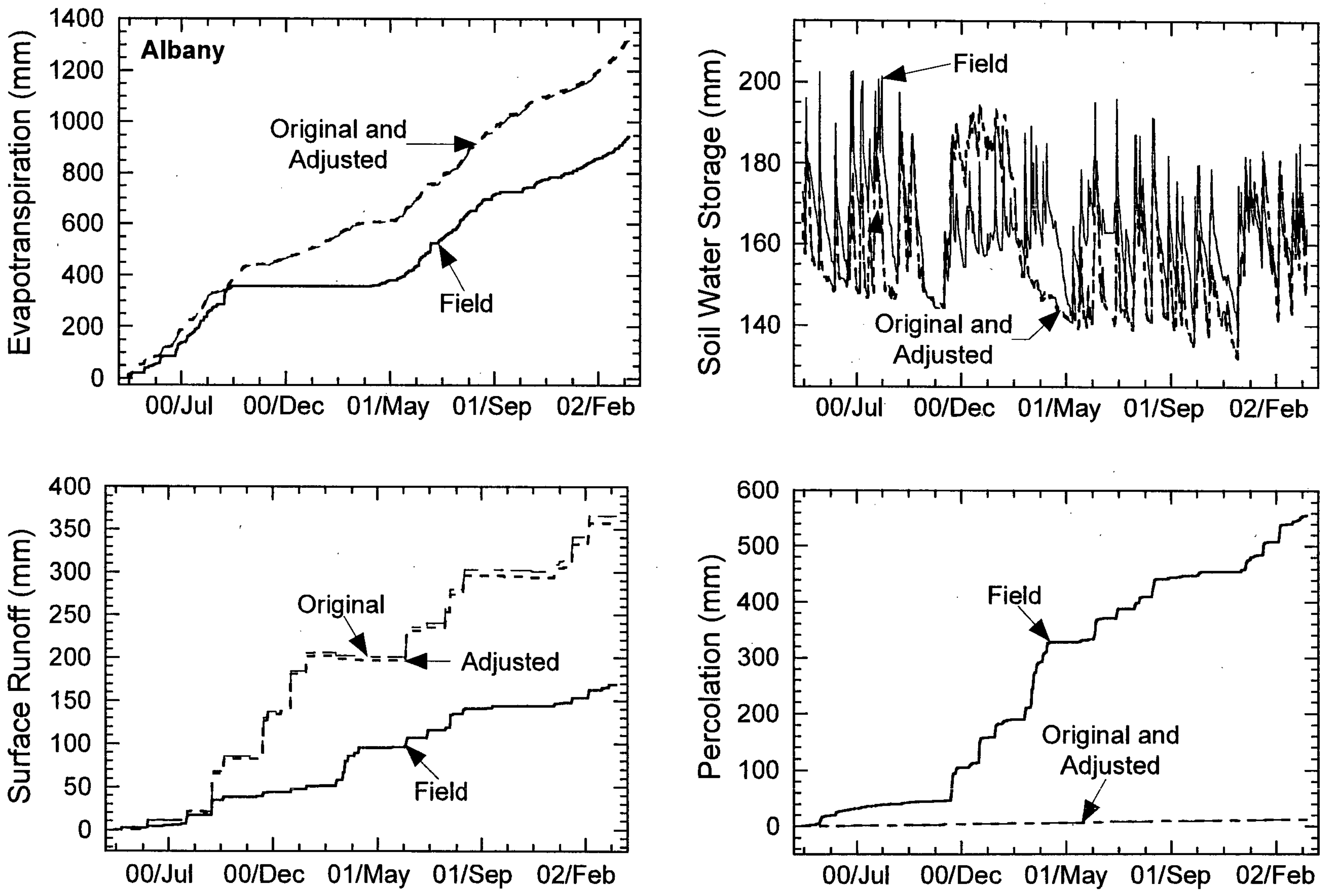

Fig. A18. UNSAT-H Comparison to Field Data for the Compacted Clay Cover at the Albany Site.

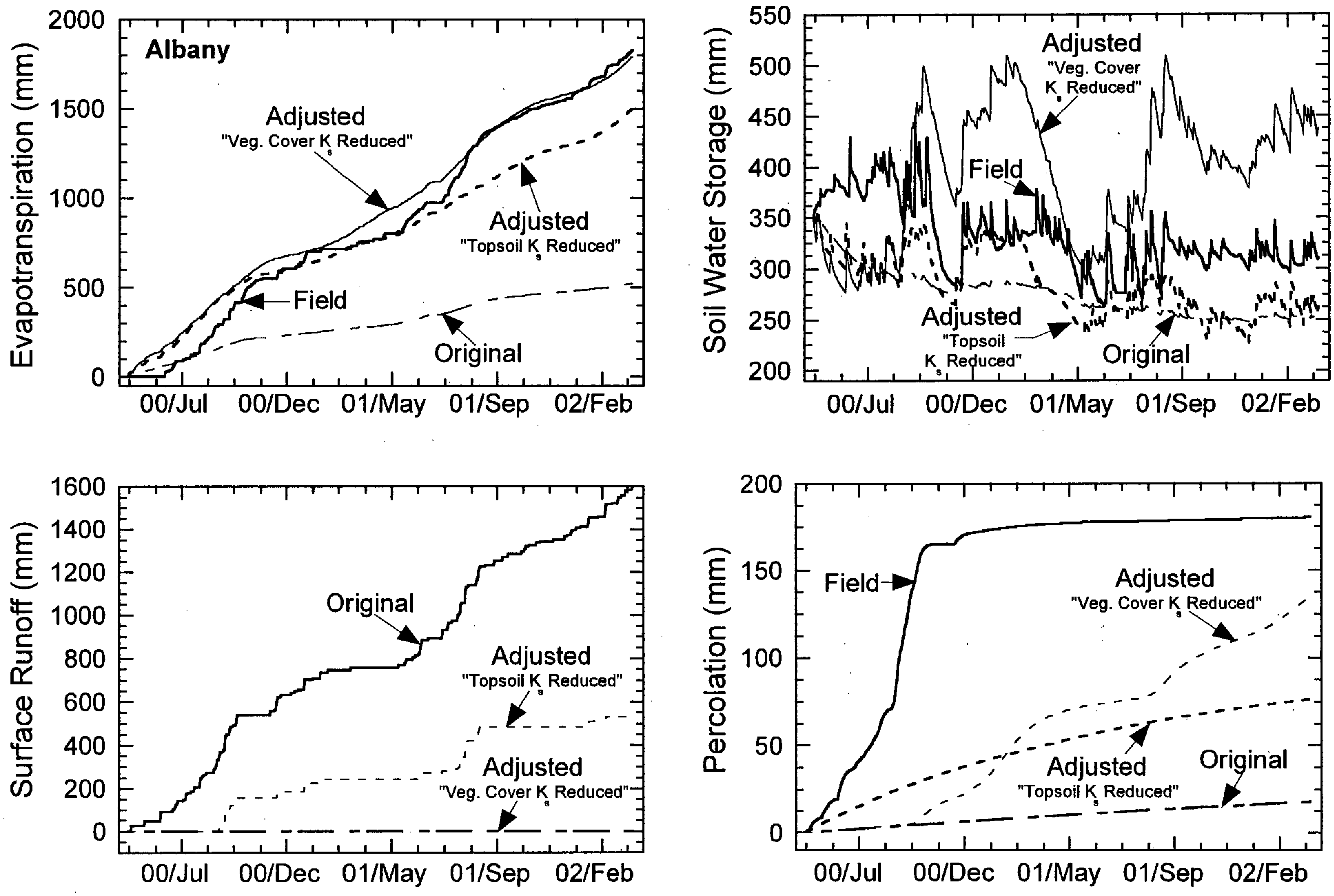

Fig. A19. UNSAT-H Comparison to Field Data for the ECap at the Albany Site.

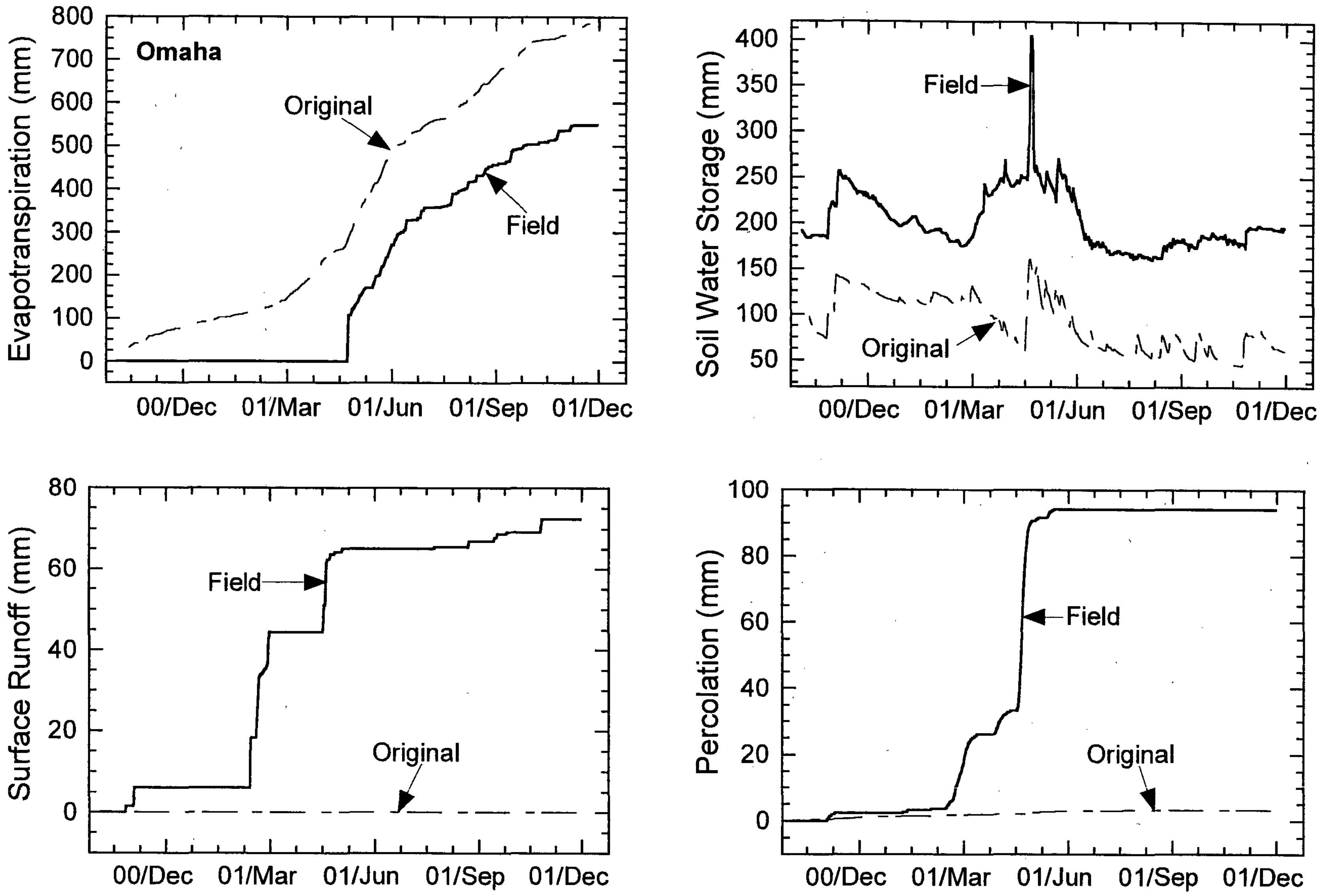

Fig. A20. UNSAT-H Comparison to Field Data for the Thin Monolithic Barrier at the Omaha Site.

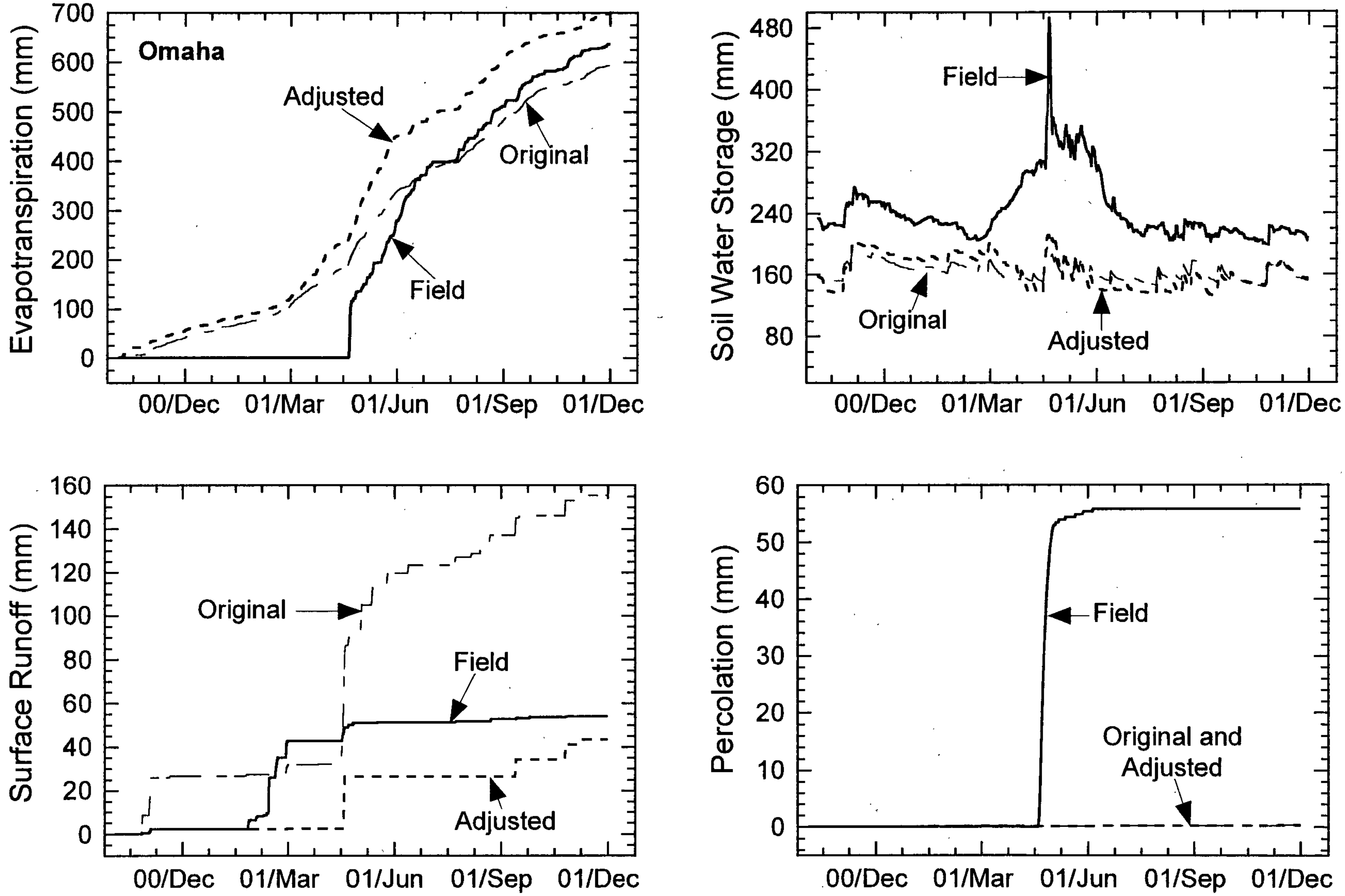

Fig. A21. UNSAT-H Comparison to Field Data for the Thick Monolithic Barrier at the Omaha Site.

APPENDIX 5
WATER BALANCE GRAPHS OF ORIGINAL HELP SIMULATIONS

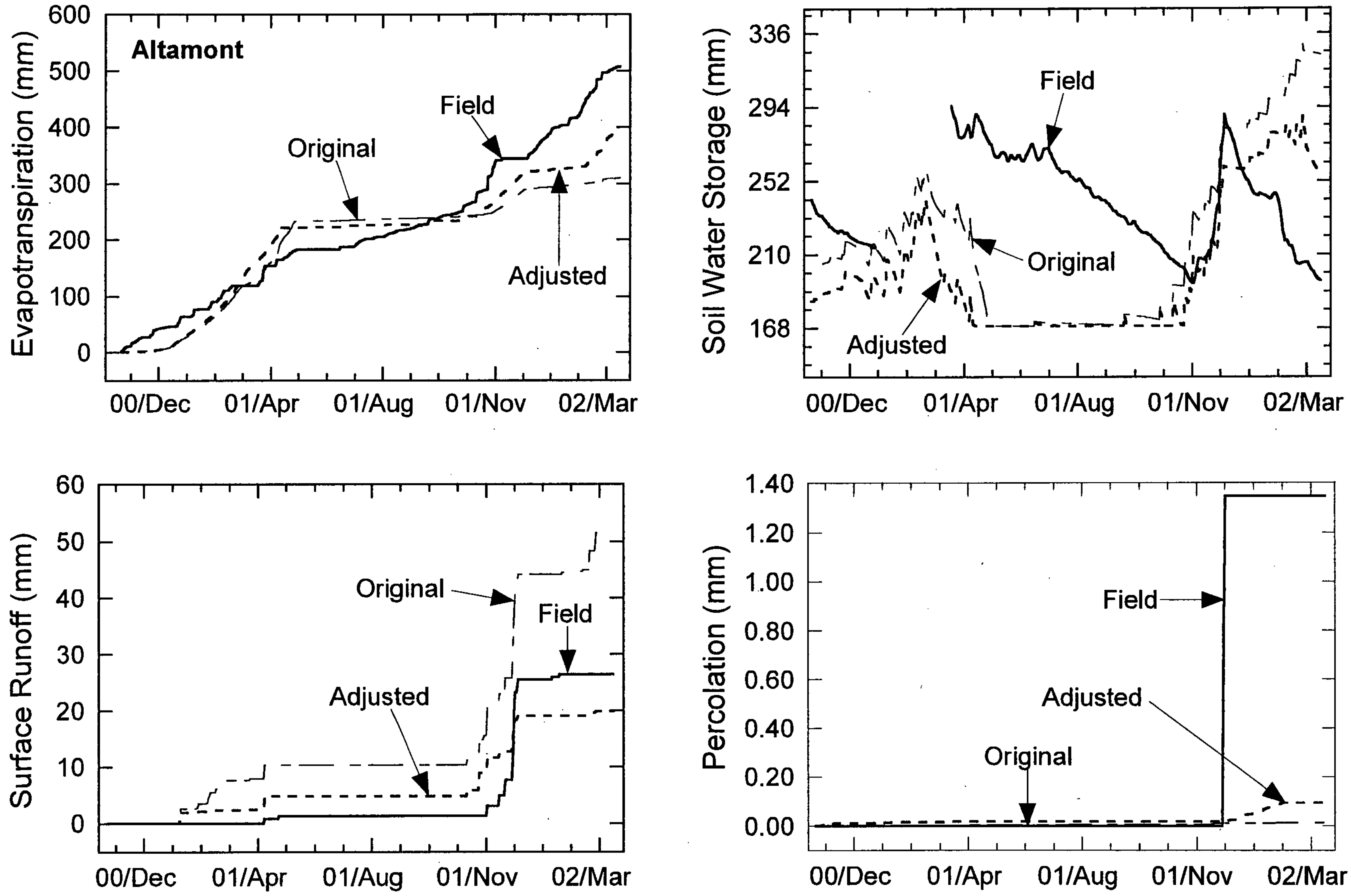

Fig. A22. HELP Comparison to Field Data for the Alternative Cover at the Altamont Site.

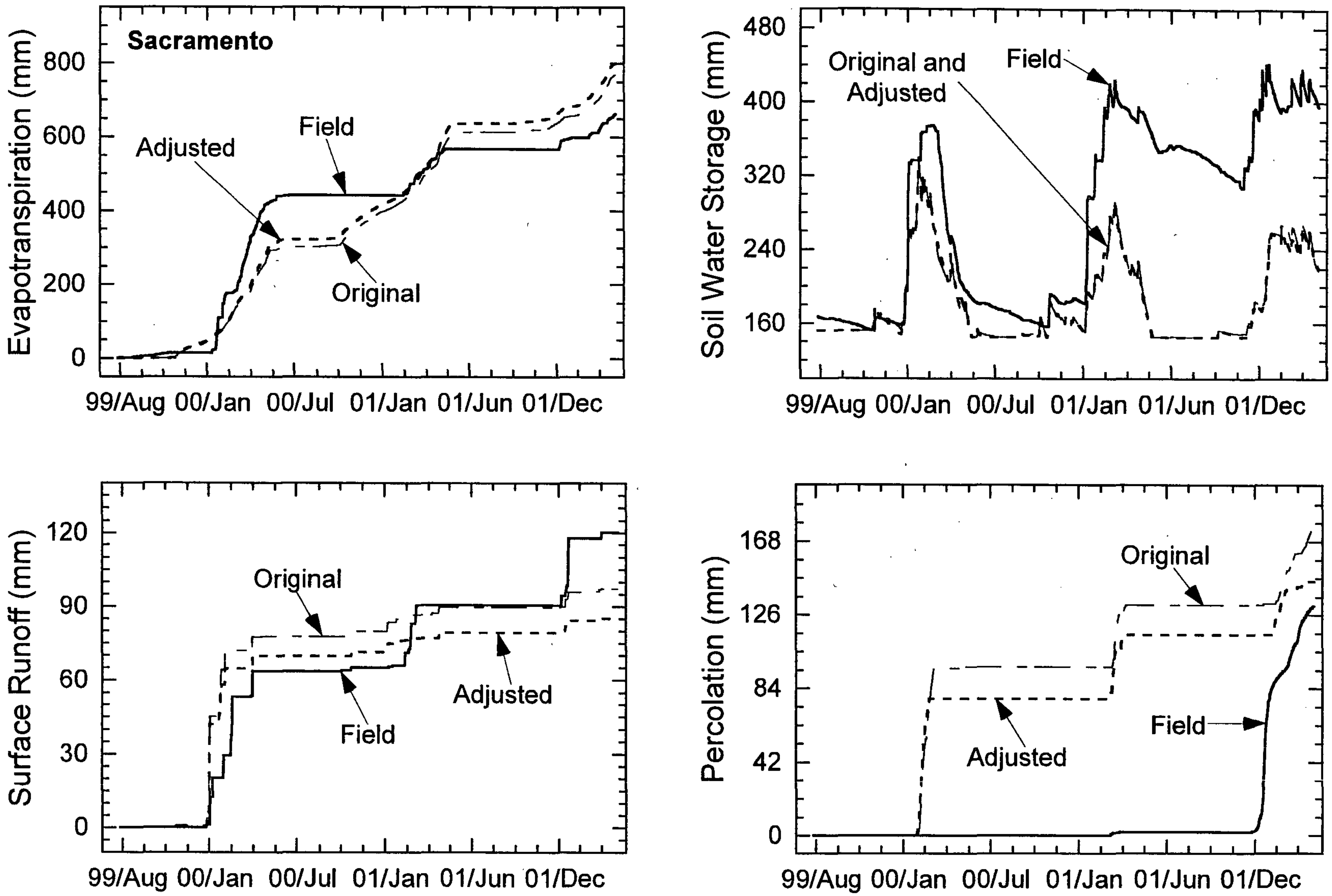

Fig. A23. HELP Comparison to Field Data for the Thin Monolithic Barrier at the Sacramento Site.

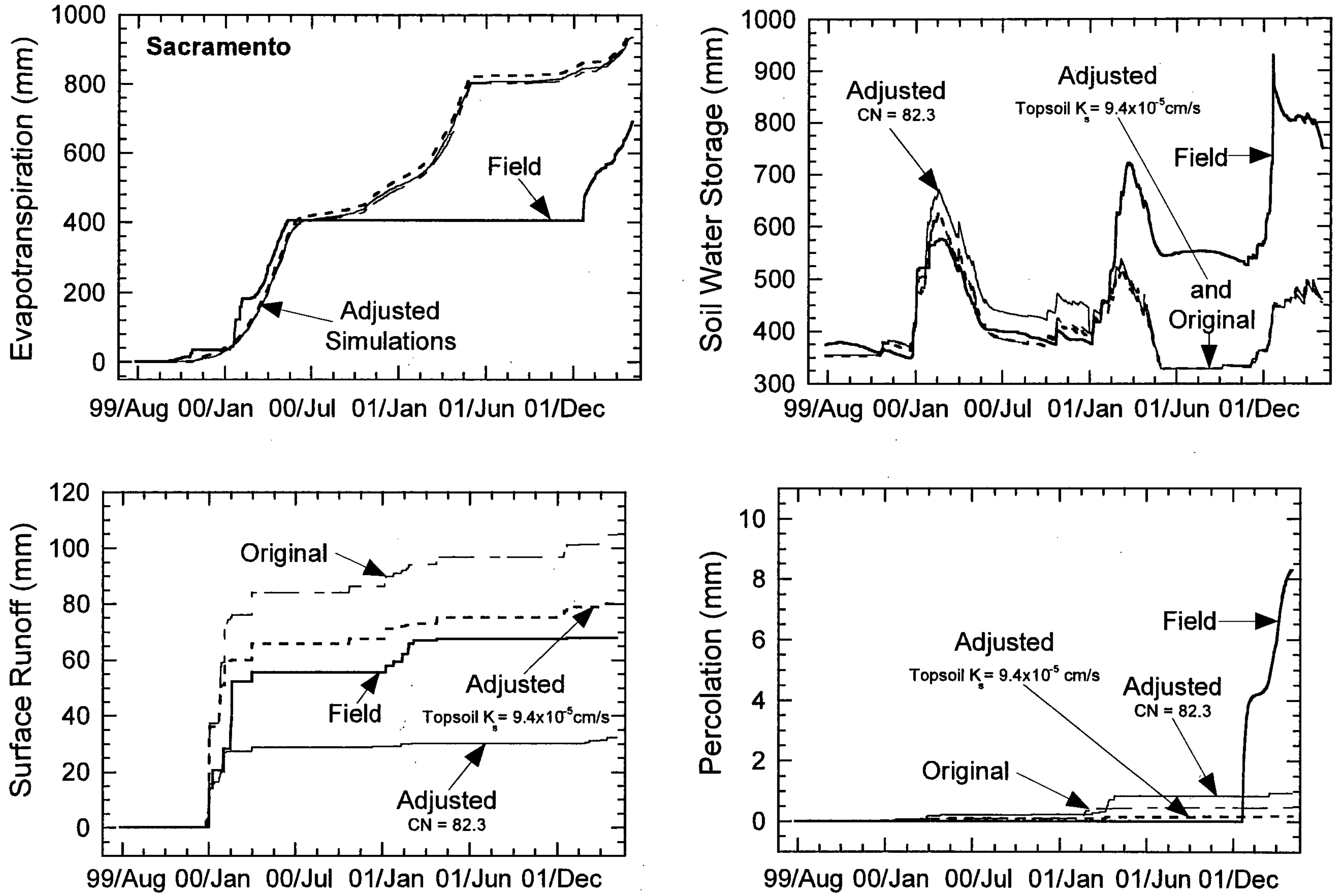

Fig. A24. HELP Comparison to Field Data for the Thick Monolithic Barrier at the Sacramento Site.

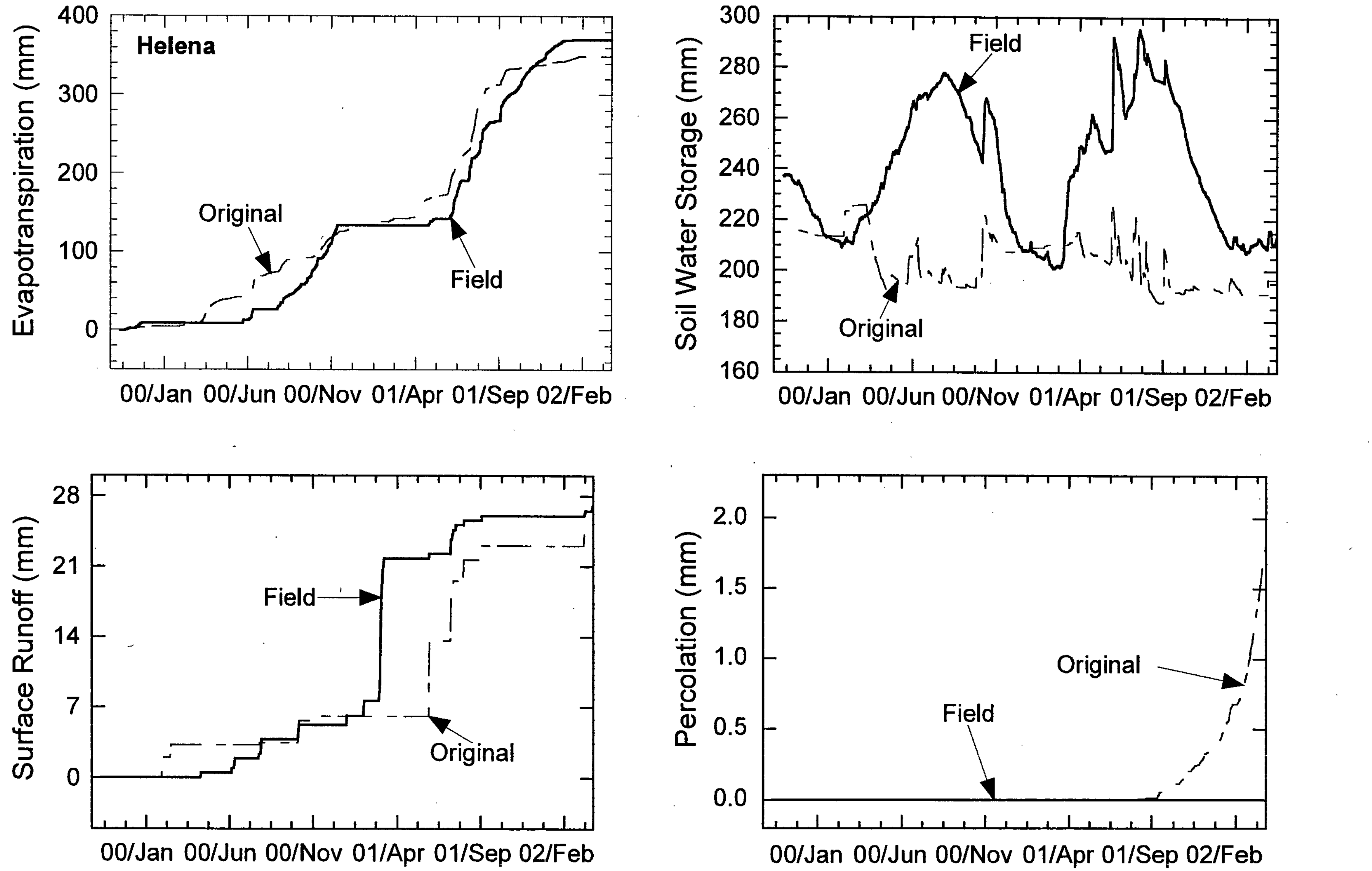

Fig. A25. HELP Comparison to Field Data for the Alternative Cover at the Helena Site.

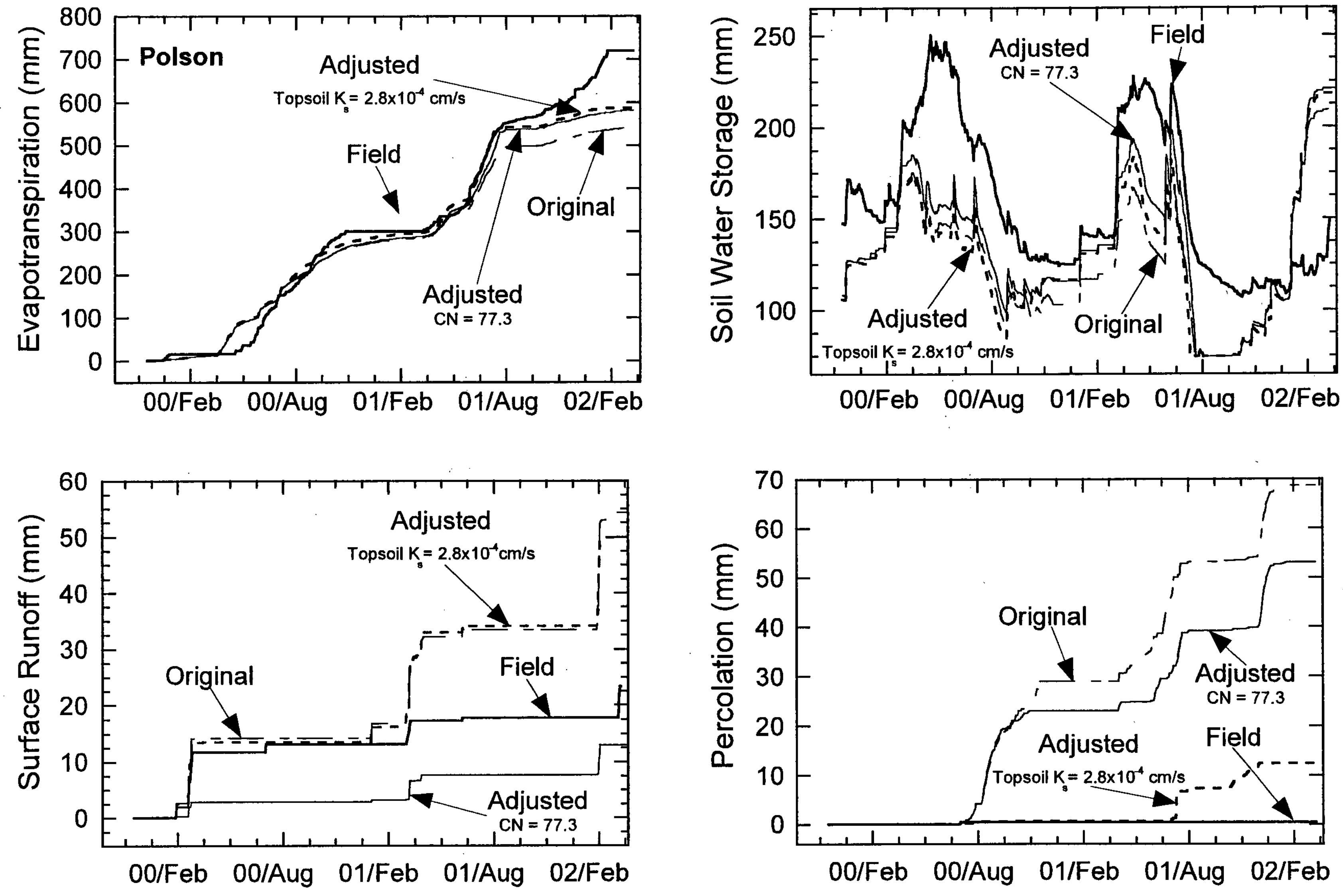

Fig. A26. HELP Comparison to Field Data for the Alternative Cover at the Polson Site.

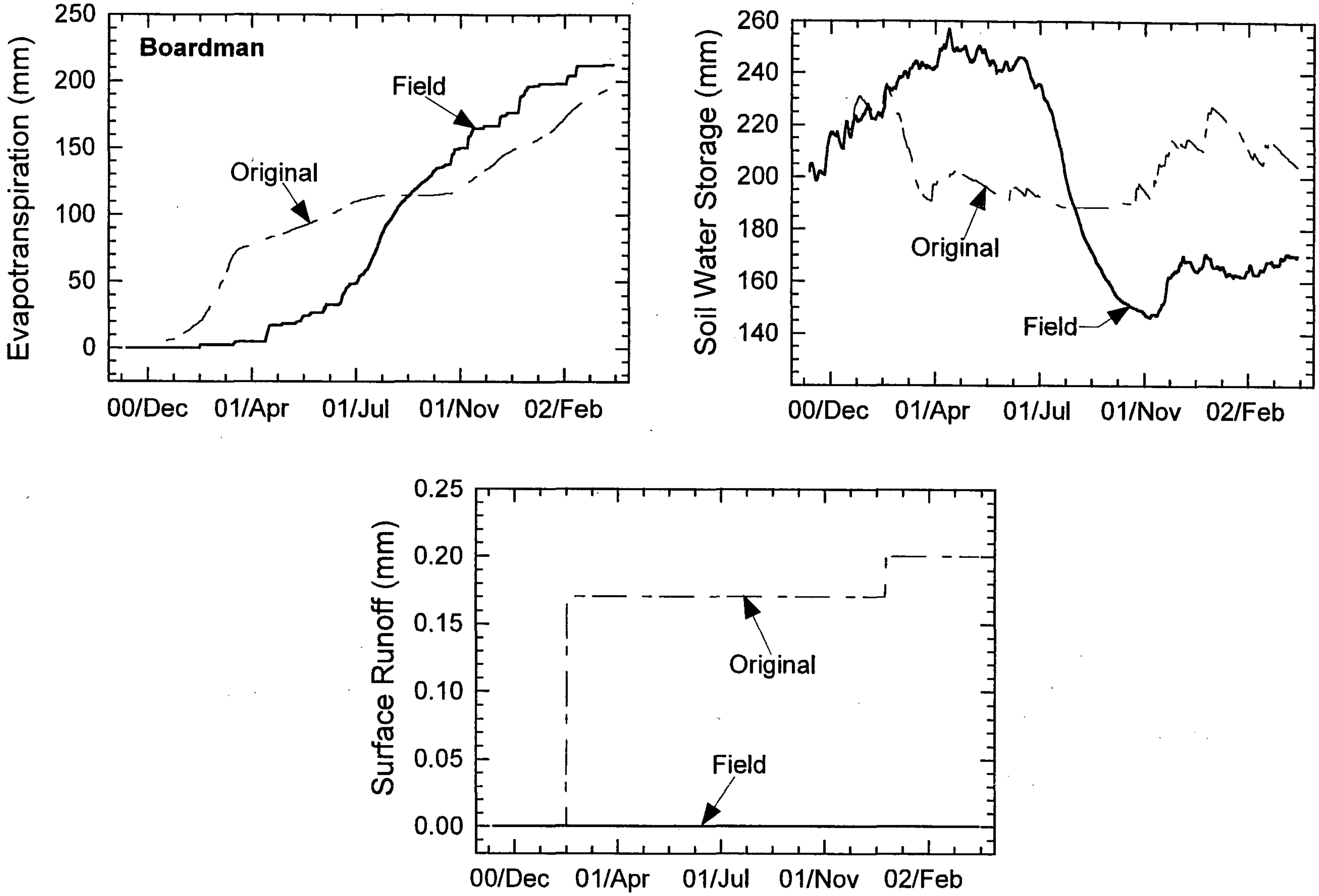

Fig. A27. HELP Comparison to Field Data for the Thin Monolithic Barrier at the Boardman Site.

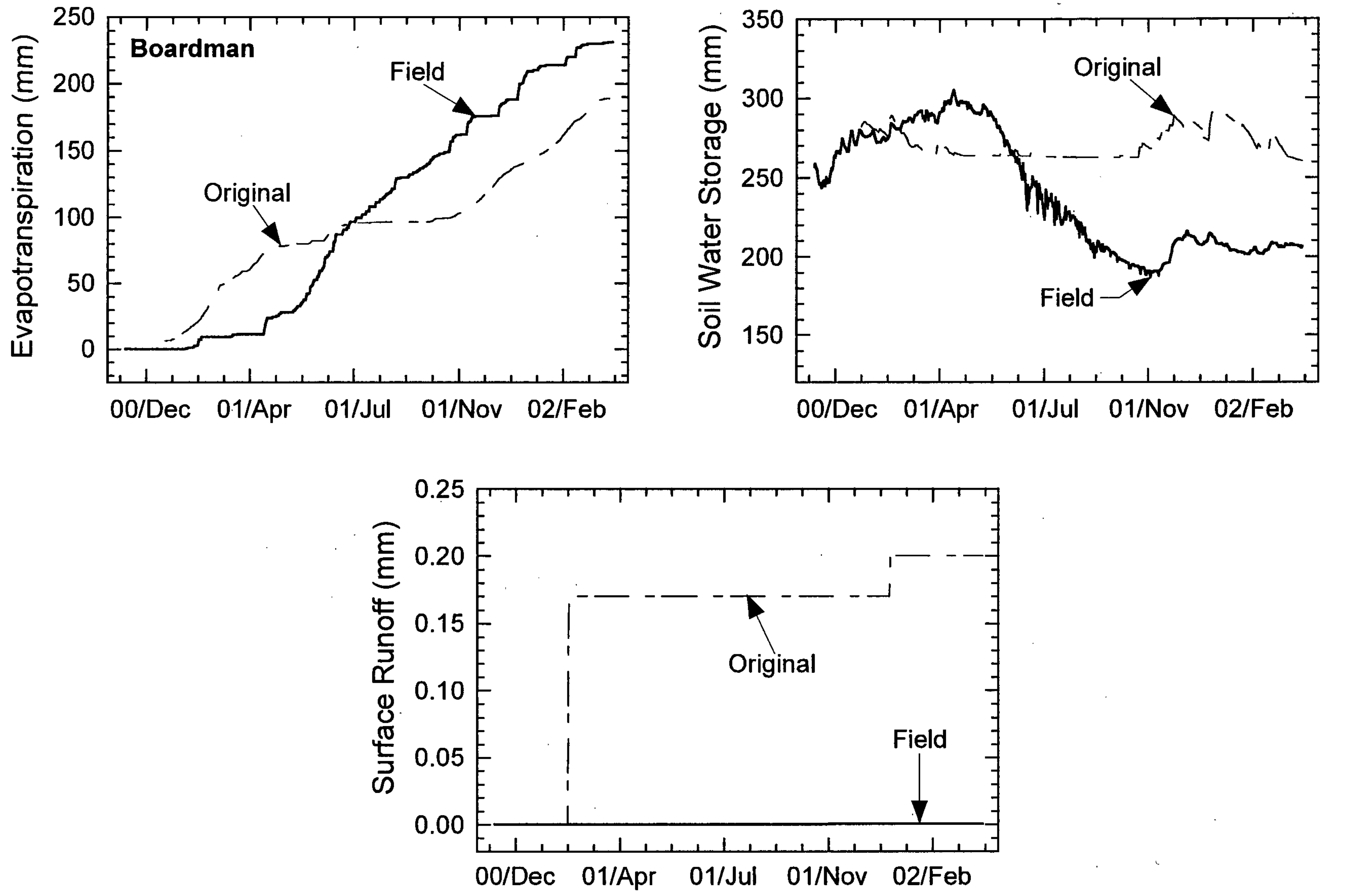

Fig. A28. HELP Comparison to Field Data for the Thick Monolithic Barrier at the Boardman Site.

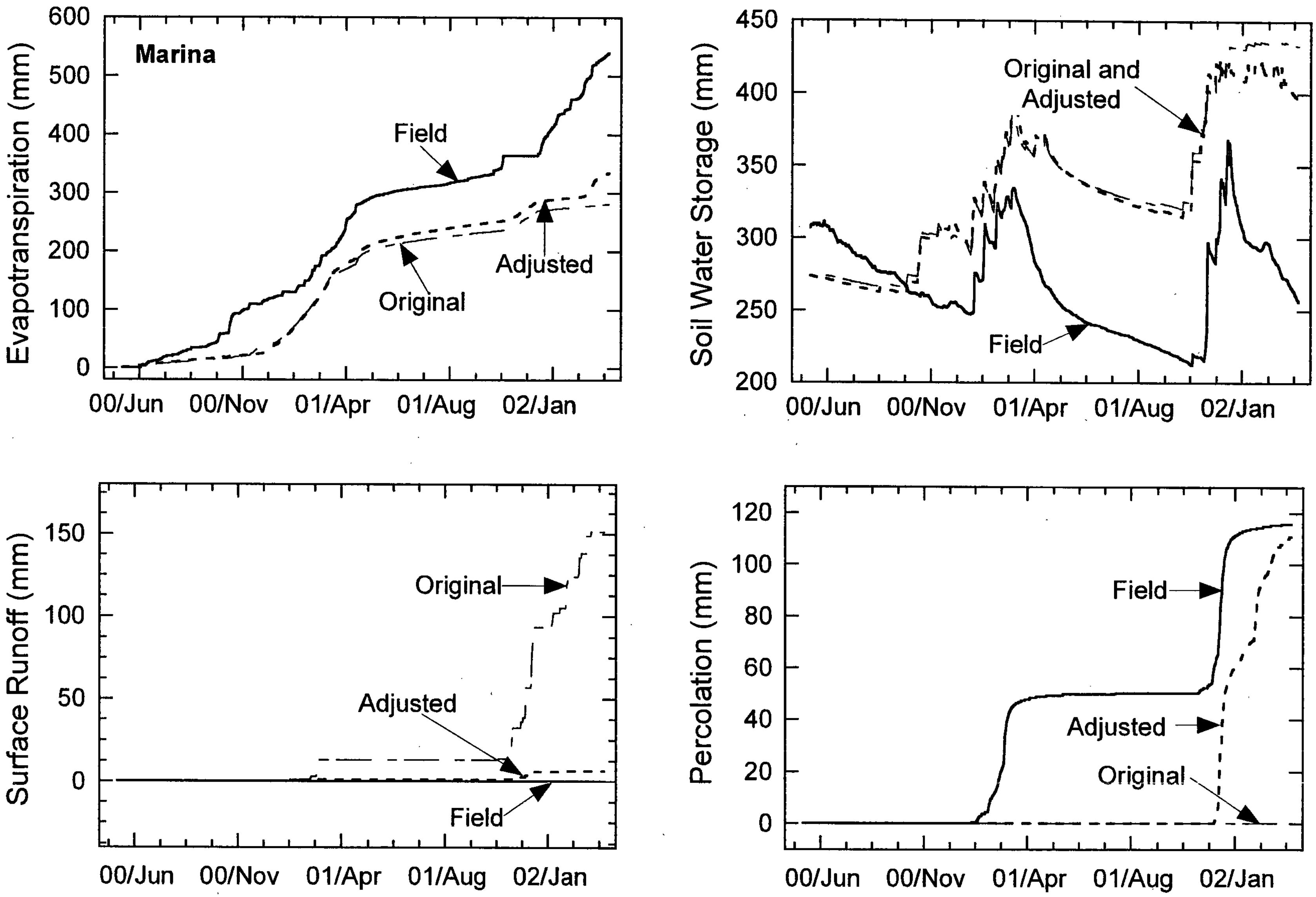

Fig. A29. HELP Comparison to Field Data for the Alternative Cover at the Marina Site.

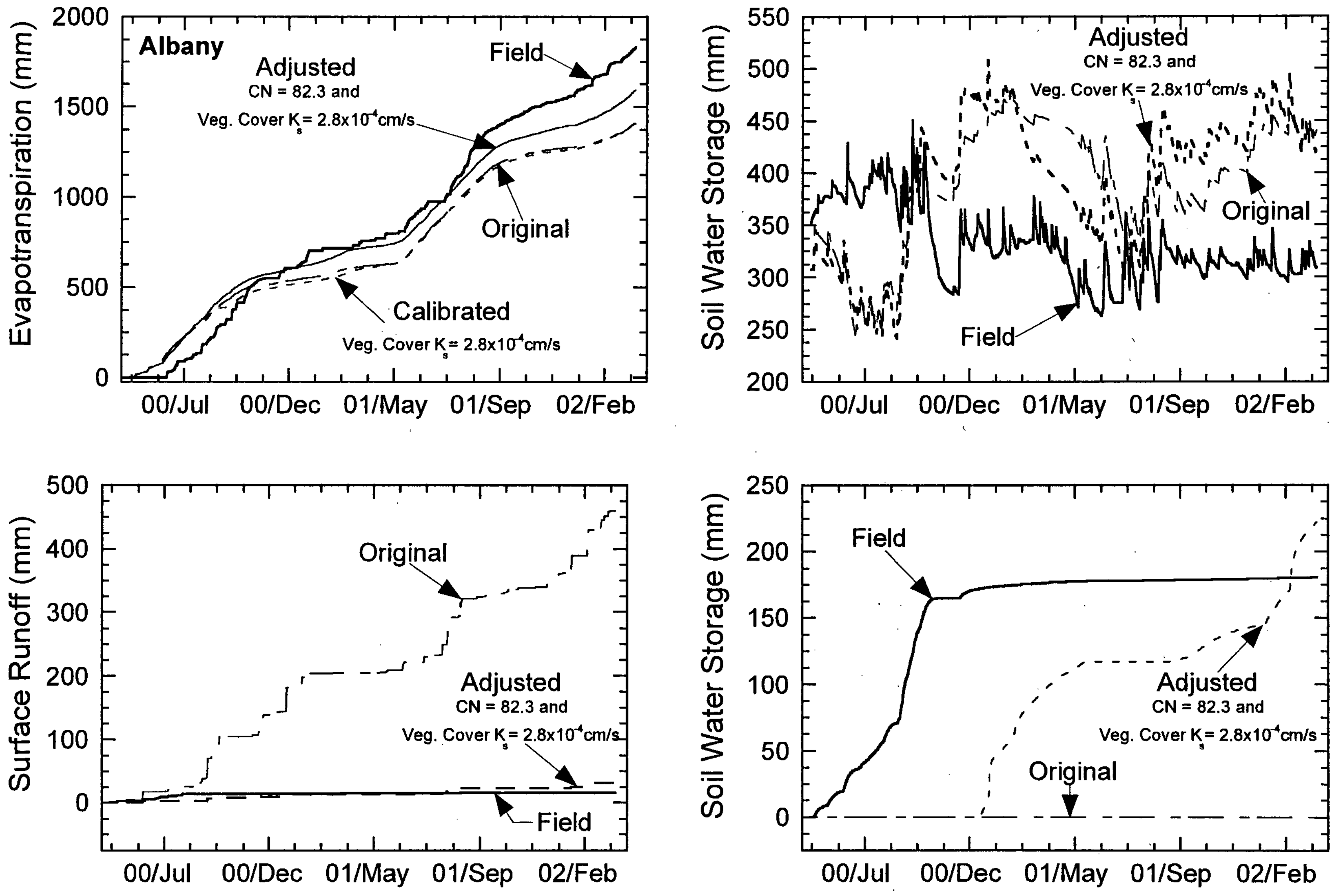

Fig. A30. HELP Comparison to Field Data for the Alternative Cover at the Albany Site.

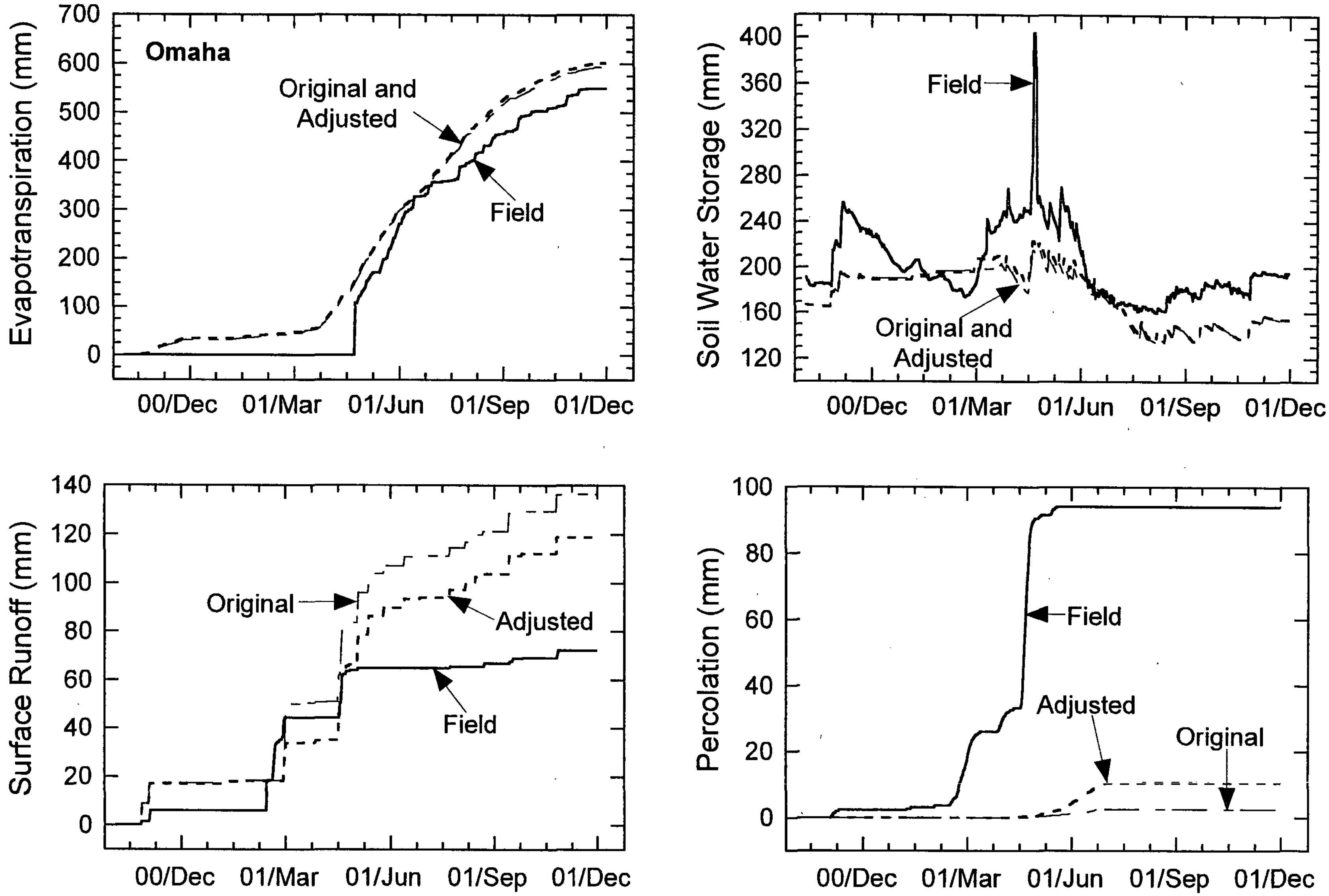

Fig. A31. HELP Comparison to Field Data for the Thin Capillary Barrier at the Omaha Site.

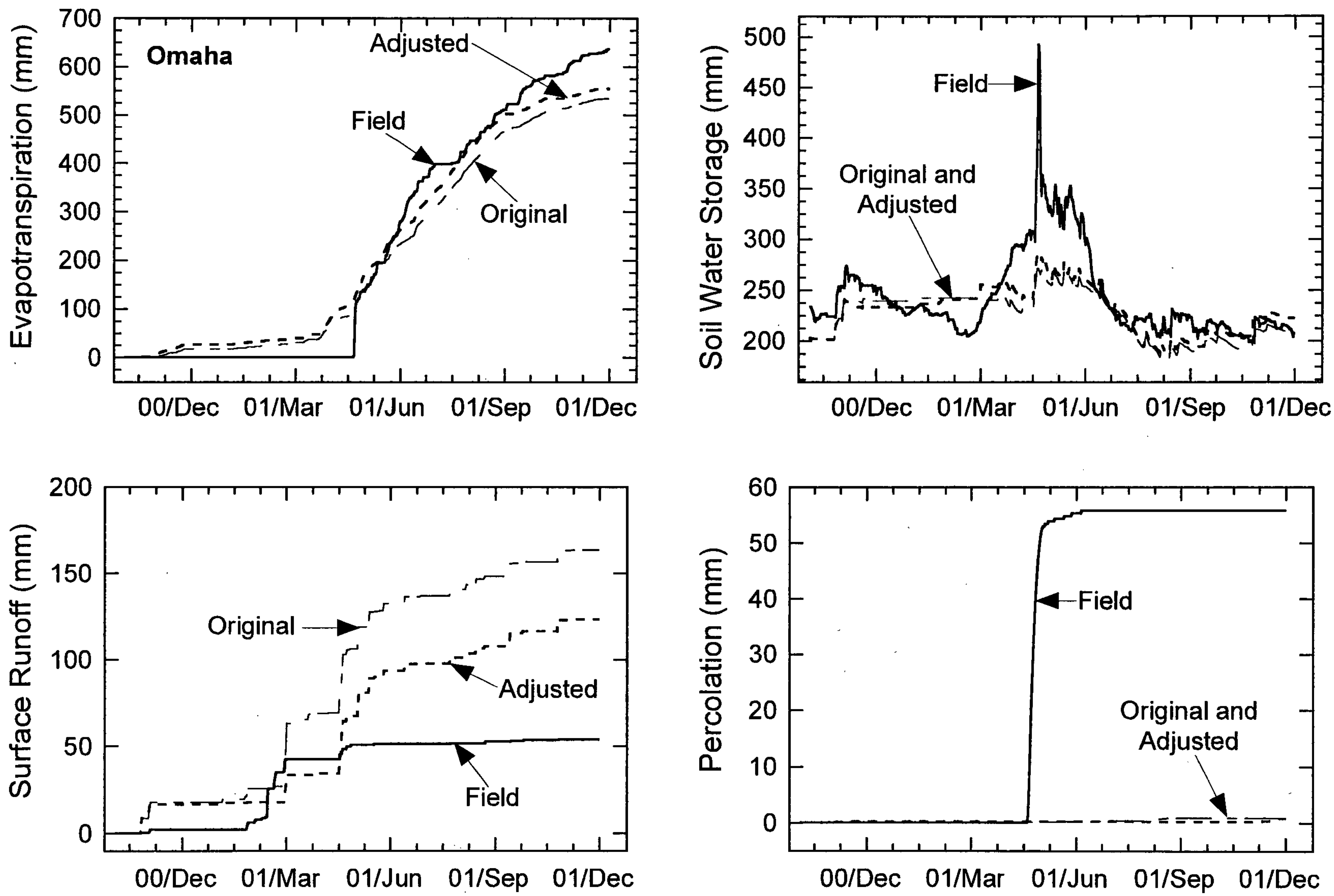

Fig. A32. HELP Comparison to Field Data for the Thick Capillary Barrier at the Omaha Site.