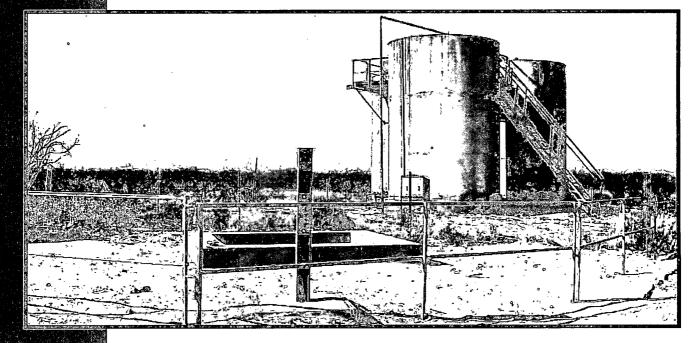
AP. 50



March 13, 2007



AT 5



Final Site Investigation Report & Abatement Completion Report: Zachary Hinton EOL Junction Box

RECEIVED

APR - 3 2007 Environmental Bureau Oil Conservation Division

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

March 15, 2007

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

RECEIVED

APR - 3 2007 Environmental Bureau Oil Conservation Division

RE: Zachary Hinton EOL Junction Box Final Site Investigation and Abatement Completion Report, NMOCD #: AP-50

Dear Mr. Price:

On behalf of Rice Operating Company, we are pleased to submit the Final Site Investigation and Abatement Completion Report for the above-referenced site. This report fulfills the obligations of ROC presented in the Stage 1 & 2 Abatement Plan of October, 2005, verbally approved by NMOCD in March, 2006. The signed Junction Box Closure Report is attached. We are pleased to report that the chloride concentration in samples from the on-site monitoring well has returned to background levels. We conclude that the residual chloride in the vadose zone poses no threat to human health or the environment. We recommend filling the excavation with soil capable of sustaining vegetation and plugging the monitoring well.

Please contact us with any comments or questions regarding our recommended closure protocol for this site.

Sincerely, R.T. Hicks Consultants, Ltd.

Conditt T.H.J

Randall Hicks Principal

CC: NMOCD Hobbs office, Rice Operating Company

RECEIVED

RICE OPERATING COMPANY

JUNCTION BOX CLOSURE REPORT

APP - 3 2007

Environmental Bureau Oil Conservation Division

				BOX LOCAT	ION					
SWD SYSTEM	JUNCTION	UNIT	SECTION	TOWNSHIP	RANGE	COUNTY	BOX DI	MENSIONS	- FEET	
00.	Zachary Hinton	- O	12	225	37E	Lea	Length	Width	Depth	
BD	EOL		12	220	2/5	LCA	6	5	6	
LAND TYPE: B	STA	TE	FEE LAND	OWNER			• · · · · · · · · · · · · · · · · · · ·	an a		 ,
Depth to Grour	idwater	56	feet	NMOCD	SITE ASSI	ESSMENT I	RANKING S	CORE:	10	
Date Started	2/6/20	01	_ Date Co	mpleted	1/24/2007	NMOC	CD Witness	n and a second	nö	
Soil Excavated	0	cubic y	ards Ex	cavation Le	ngth0	Width	0	Depth	0	fe
	0 on of Remedial			ffsite Facility			~~ .	rade Work Pl	<i>.</i> .	
eneral Descriptions was instanting was was instanting was was instanting was instanting the second		Action: a. 2002.	This junction	n box was delin	eated accordi	ng the the Jun	- iction Box Upg	rade Work Pl	an. One	······································
eneral Description	on of Remedial statled on site in Fe	Action: a. 2002.	This junction	n box was delin	eated accordi	ng the the Jun	nction Box Upg	rade Work Pl x site and is i	an. One ncluded	, 500
eneral Descriptions was instanting was was instanting was was instanting was instanting the second	on of Remedial statled on site in Fe	Action: a. 2002.	This junction	n box was delin	eated accordi	ng the the Jun	- iction Box Upg	rade Work Pl x site and is i	an. One ncluded	500
eneral Description whomy wat was in farch 2007 "Final S httis form.	on of Remedial stated on site in Fe site Investigation R	Action: a. 2002: eport & Abate	This junction	n box was delin	eated accordi Hicks reques	ng the the Jun as closure of t en	his junction ba	rade Work Pl x site and is i ure letter from	an. One ncluded n Hicks (Dec	50
eneral Descriptions wat was interested to the second secon	on of Remedial stated on site in Fe site Investigation R	Action: a. 2002: eport & Abate HAT THE I	This junction ement Comple INFORMAT KNO	n box was delin ntion Report" by	eated accordi	ng the the Jun Its closure of the Internet of the second s	his junction ba	rade Work Pl x site and is i ure letter from fE BEST O	an. One ncluded n Hicks (Dec	200

RECEIVED

APR - 3 2007 Environmental Bureau Oil Conservation Division

Final Site Investigation Report & Abatement Completion Report: Zachary Hinton EOL Junction Box (O-12) Sec. 12, T22S-R37E NMOCD case #: AP-50

Sector of the

And the state

TRAFTIC

Same and the

and the fait

Satan Radian

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

TABLE OF CONTENTS

132. W

Sales and

Contraction of

State . Au

NERSON IN

State of the second

新設設

1. A. S. S. S.

1. C. B. S.

State:

1.122 - AL

She Links

LARX OF

Particular.

のないで

S. States

No. of Concession, No. of Conces

1.0 Executive Summary 4
2.0 Chronology 5
3.0 Background
4.0 Geology and Hydrogeology7
5.0 MODFLOW Simulation
6.0 Closure of the Excavation
7.0 Quality Assurance and Quality Control Protocols
8.0 Conclusions and Recommendations
Plates
Tables
Tables Appendix A: Previous Reports
Appendix A:
Appendix A: Previous Reports Appendix B:
Appendix A: Previous Reports Appendix B: Relevant Correspondence Appendix C:

Appendix E: Quality Assurance Protocols

1.0 EXECUTIVE SUMMARY

This final Site Investigation and Abatement Completion Report presents the results of the characterization activities performed by R.T. Hicks Consultants (Hicks Consultants) and the characterization and site closure activities performed by Rice Operating Company (ROC) at the Zachary Hinton EOL Junction Box site. This report fulfills the obligations of ROC presented in the Stage 1 & 2 Abatement Plan of October, 2005, verbally approved by NMOCD in March, 2006. Based on field data, laboratory results, and predictive modeling, the selected remedy for the site involved placing clean fill within the excavation and placing about 3 feet of topsoil and over the site installed with a slight crown to promote surface runoff, then seeding the site with native vegetation. Using highly conservative input data, a MODFLOW transport module of this scenario predicts that resulting ground water chloride concentrations due to migration of residual chloride to ground water will be less than 70 ppm above background concentrations after five years.

Ground water monitoring data confirm that the HYDRUS-1D predictions are conservative in that they over estimate the impact of residual chloride transport to ground water. After two years of ground water monitoring, chloride concentrations in ground water beneath the site have returned to ambient conditions (300–400 ppm).

Background conditions at the site have been confirmed through chemical analysis of several surrounding wells and consultation of local ground water research. Ground water quality at the site (MW-1) has returned to background conditions. We do not believe that additional ground water monitoring is necessary. Based on our physical findings, the findings of the MODFLOW simulations (see Appendix C), and the documentation that the site is backfilled and re-seeded, we conclude that this remedy is protective of ground water quality, human health, and the environment. On behalf of ROC, we repectfully request that NMOCD close the regulatory file.

CHARLES .

20.294

の時間

Sharks

2.0 CHRONOLOGY OF EVENTS

Party P

A Carlos

100

S. Section

Sec. 1

Parties of the second

200

Same a

Contraction of

the second

ALC: NO.

Sec.

Strain P

The Disclosure Report prepared by Rice Operating Company (ROC) in January 21, 2003 (see Appendix A), summarizes the initial activities at the site. On August 21, 2003, NMOCD approved the Hicks Consultants workplan dated July 2, 2003, for the site (see Appendix B). Since the initial upgrade of the end-of-line box and installation of the monitoring well in 2002, ROC has overseen nearly four years of ground water sampling. In October, 2005, Hicks Consultants submitted a Stage 1 & 2 Abatement plan for the site, which NMOCD verbally approved after public notice on March 30, 2006. In October, 2006, Hicks Consultants constructed and ran a MODFLOW model to predict the fate and transport of chloride at the Zachary Hinton EOL Junction Box site. Table A, below, summarizes the chronology of events at the site.

Table A. Chronology of Events at the Zachary Hinton EOL Box

Date	Event
February 6, 2002	ROC upgrades EOL junction box and characterizes upper vadose zone
February 28, 2002	ROC installs monitoring well adjacent to EOL junction box
March 12, 2002	ROC notifies NMOCD of groundwater impact
April, 2002, to June, 2003	ROC conducts four quarters of ground water monitoring to confirm initial results and collect data in preparation for a corrective action plan
July 2, 2003	Hicks Consultants submits a work plan to NMOCD for approval
August 21, 2003	NMOCD approves the workplan, including collection of ground water quality data from nearby supply wells and HYDRUS-1D simulation modeling
January 30, 2004	Hicks Consultants submits a Corrective Action Plan for NMOCD approval
December 3, 2004	NMOCD requests additional information
December 8, 2004	Hicks Consultants provides requested information
May 5, 2005	NMOCD orders ROC to submit an Abatement Plan pursuant to Rule 19
June 29, 2005	Hicks Consultants requests reconsideration of Abatement Plan Requirement
July 13, 2005	NMOCD reiterates Abatement Plan Requirement
October 12, 2005	Hicks Consultants submits a Stage 1 & 2 Abatement Plan
December 28, 2005	NMOCD approves public notice
January 11, 2006	ROC sends public notice to appropriate landowners
January 18, 2006	Public notice published in Albuquerque Journal and Hobbs News Sun
February 10, 2006	ROC mails proof of public notice publication to NMOCD
March 30, 2006	NMOCD verbally approves the Stage 1 & 2 Abatement Plan and public notice
October 6, 2006	Hicks Consultants runs a MODFLOW model for the site
November, 2006	ROC backfills excavation with clean, imported fill and installs a new junction box at the site
January, 2007	ROC re-seeds the site

3.0 BACKGROUND

"Alere

S. S. W.

\$ 3.3.5

1.343

14.73

3.1 SITE LOCATION AND LAND USE

The Zachary Hinton EOL Junction Box is located about 2.5 miles southeast of the intersection of State Routes 18 and 8/176, near Eunice, New Mexico. Plate 1 shows the location of the site. The general area of the site is used for grazing and production.

3.2 SUMMARY OF DATA PREVIOUSLY SUBMITTED TO NMOCD

- 1. In early 2002, ROC upgraded the junction box, characterized the upper vadose zone, and installed a monitoring well about 20 feet down gradient from the former box.
- 2. Chloride concentrations in the vadose zone exceeded 1,000 ppm from 5 feet below ground surface to ground water.
- 3. The first ground water sample from the monitoring well exhibited a chloride concentration of 1,000 ppm.
- 4. Sampling of nearby supply wells demonstrates that the ambient chloride concentration in ground water is 300-400 ppm near the site.
- Nine months of quarterly monitoring after installation of the monitoring well, chloride concentrations in samples from the monitoring well returned to the regional background concentration, 300–400 ppm.

Previous submissions to NMOCD that provide additional detail regarding these data are presented in Appendix A.

4.0 GEOLOGY & HYDROGEOLOGY

and a

18 E. A

Sec.

がた

5.2498

The Ogallala Formation is present throughout much of the area and is underlain by the Dockum Group red-beds. Along Monument Draw, erosion has stripped the Ogallala and deposition of alluvium over the red-beds has created a separate aquifer that is hydraulically connected to the Ogallala in many locations (see Nicholson and Clebsch, 1961).

The Zachary Hinton EOL Junction Box is in the middle of the alluvium within Monument Draw. The Dockum Group red beds are an aquiclude below the Ogallala and alluvial aquifers. In the area of the Zachary Hinton EOL junction box, the red bed elevation contours define a paleo-valley just west of and subparallel to Monument Draw. The elevation of the red-bed surface exerts controls on ground water flow. Where this surface is higher than the water table elevation, it obviously creates a barrier to flow. Where the red-bed surface is an expression of a paleovalley, such as our area of interest, ground water may be directed toward the axis of this subsurface feature and the saturated thickness of the aquifer can increase as a result.

Plate 2 is the ground water map of southern Lea County (Nicholson and Clebsch, 1961). The water table elevation mimics the red-bed elevation. At the Zachary Hinton EOL junction box site, ground water flows south, parallel to Monument Draw. Nicholson and Clebsch (1961) conclude that "The bulk of the water [in the sediments along Monument Draw and under the Eunice Plain] is derived by underground flow from the Laguna Valley [Monument] area." The red-bed surface map and the water table map support this hypothesis.

Although Nicholson and Clebsch note that the quality of the City of Eunice water supply wells is about 100 mg/L chloride (locations of the wells noted in Nicholson and Clebsch are noted on Plate 3 with sample dates from the late 1950s), a more detailed investigation of ground water quality in the area near the Zachary Hinton EOL site shows higher background levels. Plate 3 shows the locations of wells with past water quality found by Nicholson and Clebsch and present water quality data collected since 2003. Table 2 (below) presents the results for chloride.

Well Name	Sample Date	Chloride (mg/L)
22S.37E.24.133B	9/8/1958	580
22S.37E.01.P.444	9/8/1958	320
Windmill	12/18/2003	460
Peters Well West	11/7/2003	200
Peters Well East	11/7/2003	438
Jct. E-15 MW #1	10/26/2006	396
Jct J-26 MW #1	10/23/2006	193
Jct. Zachary Hinton (O-12)	8/10/2005	361
Jct. I-27	12/2/2002	266

1. Tol.

16252

ALC: NO

A MAR

ar se

¥8.,4

Sec. 25

Sec. Sec.

- Albian

Sur and

a. mar

Table 2: Chloride Data for Wells Surrounding Zachary Hinton Site (see Plate 3)

Using Nicholson and Clebsch (1961) data, we estimate the saturated thickness of the alluvium in our area of interest is approximately 25–75 feet (2.6–22 meters). As shown on Plate 2, the hydraulic gradient in our area of interest is about 0.004. From these data and information provided in Freeze and Cherry (1979), we calculate the rate of ground water flow as 0.14 m/d.

Surface water in the area is ephemeral and flows in Monument Draw occur only after large precipitation events. We found no evidence to suggest that the release from the junction box affected Monument Draw in any manner; therefore, this document does not provide information on surface water hydrogeology.

5.0 MODFLOW SIMULATION

1

12. M. 2.

1. 2.8.

2867

3.60 als

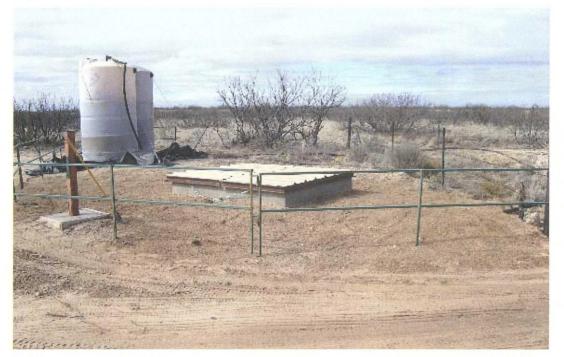
As proposed in the Stage 1 & 2 Abatement Plan of the October 12, 2005, Hicks Consultants used MODFLOW and its contaminant transport module to predict the fate and transport of the historic impact to ground water quality evidenced by the first sample analysis. Appendix C presents a thorough explanation of the model design, inputs and results. The predictive modeling tested the hypothesis that natural dilution and dispersion effectively mitigated any past impact to ground water quality at the site and down-gradient from the site.

\The model predicts that natural dilution and dispersion rapidly reduce chloride concentrations in ground water after the cessation of recharge (i.e. intermittent brine releases from the EOL Junction Box).

6.0 Closure of the Excavation

In early November 2006, ROC imported twenty-four yards of clean soil and backfilled the hole at the site according to our proposal. A new junction box was built in the original location. The surrounding area was re-seeded with a mixture of native grasses and plants that will re-vegetate the area at a natural rate. Figure 1 shows the site after the excavation was filled, the box was replaced, and the site was re-seeded.

Figure 1: Zachary Hinton Site After Box Replacement Filling, and Re-Seeding



7.0 QUALITY ASSURANCE/QUALITY CONTROL PROTOCOLS

Sampling and analytical procedures were performed in accordance with Title 20 NMAC 6.3107.B and Section 103 of the Water Quality Standards for Interstate and Intrastate Streams in New Mexico (20 NMAC 6.1). Specific quality procedures for obtaining ground water samples are included in Appendix E.

Same all

Section 1

pursel.

an and

1. 2 m

N. W.

F 2039

and the

1.00

125

1.64.12

A. (26)

6.0 1.62

1.1.2.2.5

S. Condick

No.

8.0 CONCLUSIONS AND RECOMMENDATIONS

1.2.2

がほう

ななど

S. ALL CH

the states

金石等

A. 18.8.

S TOPE S

1. 181

1.5.16

di 260

of Prairie

Berg

s lingte war

3203

146225

N. VIN

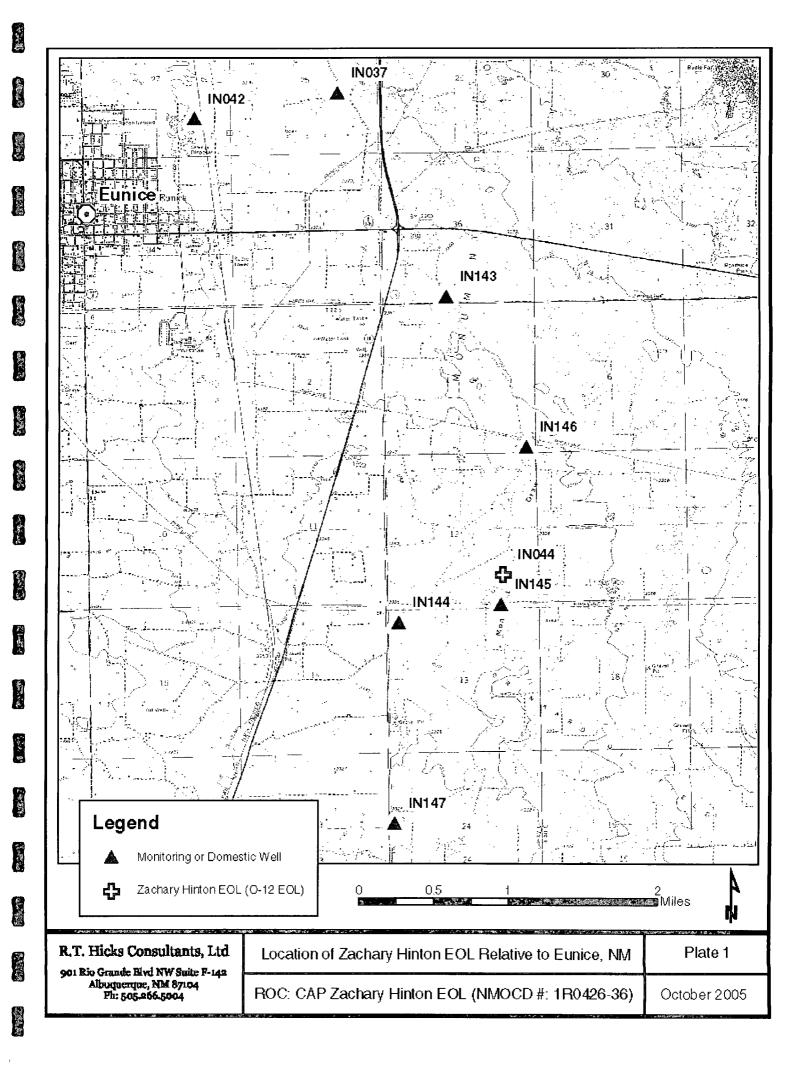
Natural dilution and dispersion have restored ground water quality down-gradient from the release site as well as at the release site. Additional monitoring of the existing well provides no value as ground water quality has returned to background conditions. The ground surface is now restored and re-seeded. On behalf of ROC, we respectfully request closure of the Rule 19 regulatory file associated with this site.

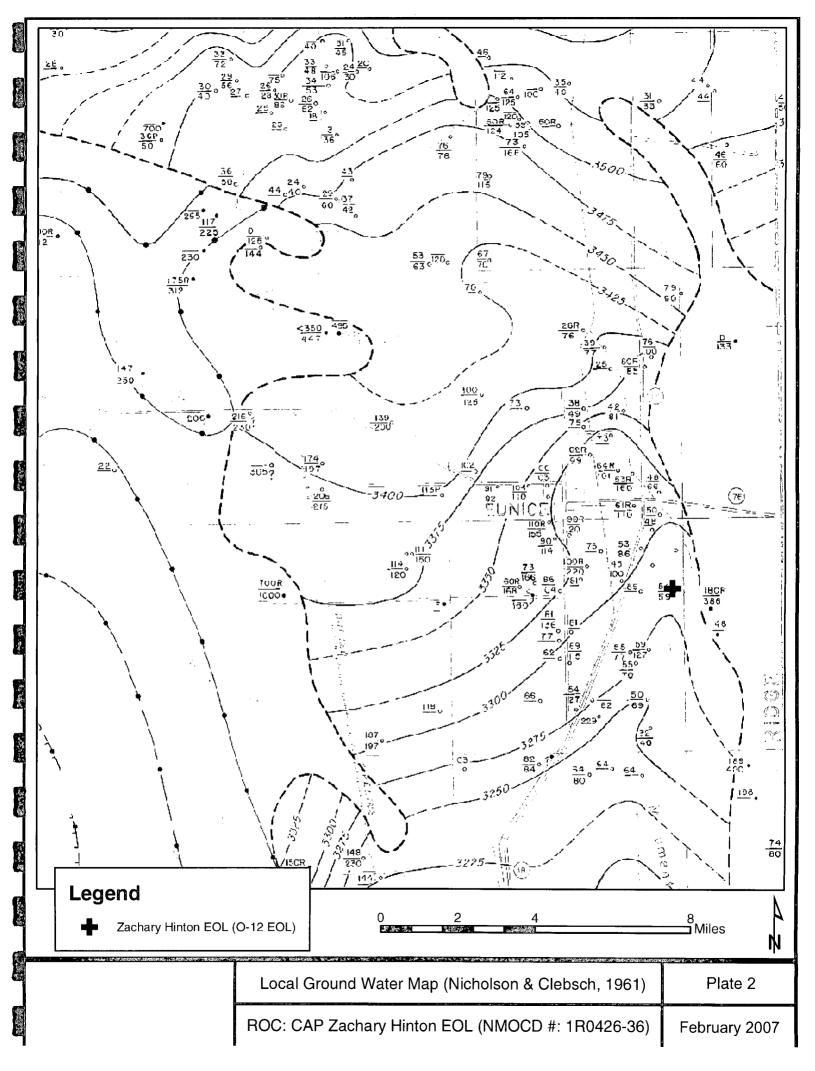
Plates

Station of

R.T. Hicks Consultants, Ltd.

901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104





EXPLANATION

F = Flowing 150 R = Reported p - Water level measured while pumping Wiles well 0 = Dry ? - Uncerninty as to uquifer Upper tigure is wealt to water; lower wa More than frome is depth of well. Open aircles < + Less then ure wells simished in Tertiory or Quaternary maks; solid pirsles are (See habits 6 and 7 for deto ien well dato.) weils finished in Triuswic 19045 -3500-* Approximate position of boundary Water-table or piezomatric contour or Woter table contour in Tertiony or octween Triassic ronks and cuturoted when body in Triccals uquifers Quaternury rocks Tersiony and Quaternary rocks Durined where interrod or uncertoin. Dashed where inferred or uncertain Servour unceval 100 feet. Datam Contour interval 25 feet. Datum mean sea level mene seu level Legend to Nicholson & Clebsch (1961) Ground Water Map Plate 2 R.T. Hicks Consultants, Ltd Supplemental Legend to Ground Water Map Supplemental 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104

ROC: CAP Zachary Hinton EOL (NMOCD #: 1R0426-36)

February 2007

Ph: 505.266.5004

1. 18 A

記書語言語

御御教

A CONTRACTOR

1680 A.S.

A TOP SHOW

138.28G

Sec. No.

1975 C. S. M.

States.

Service Service

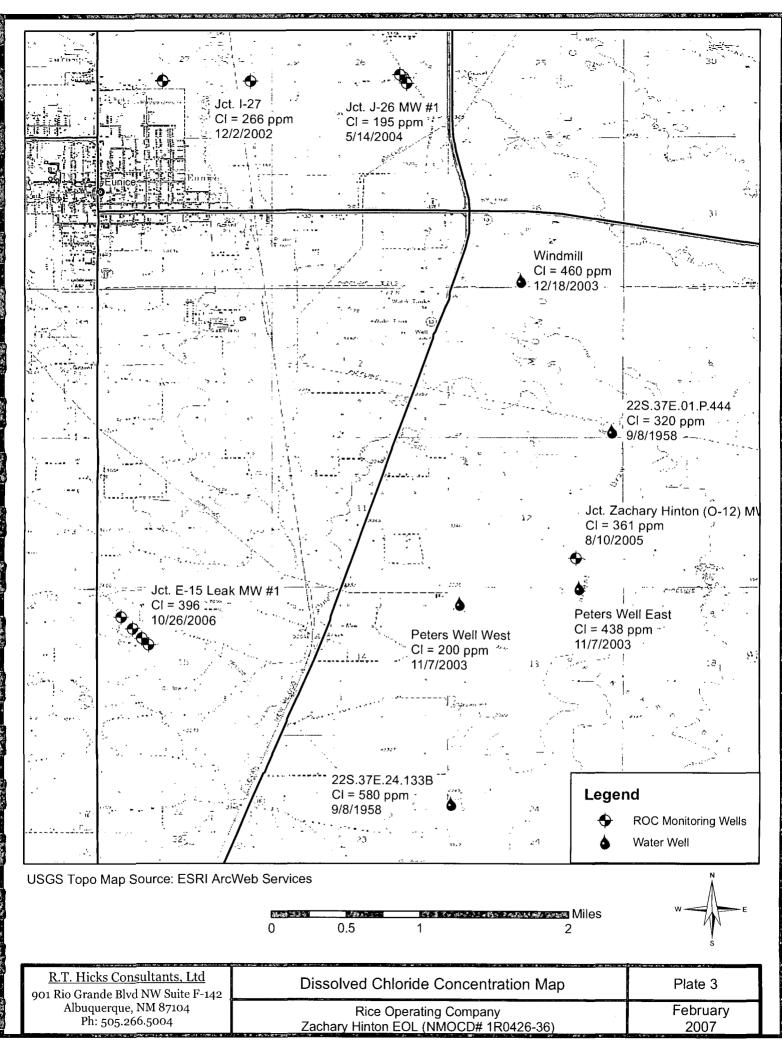
Sec. of Sec.

ない

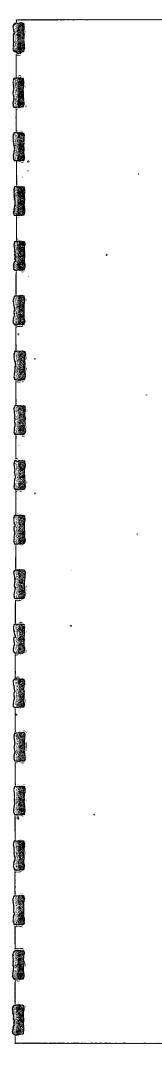
PC. 2 2400

Sector Sector

あるの時間



and the second se



Tables

R.T. Hicks Consultants, Ltd. 901 Bio Grande Blvd. NW. Suite F-142

901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

TABLE I

1. N. W.

S STATES

State St

Strates and

ALL BALLY

18. 19.5

e v Vac

W.A.N.

States

18. Call

STATES

12.000

Service March

AL LAKE

の時に

Salar Salar

ACCESS OF

-(A-4-8)

Comparison of physical and chemical data from Texas, New Mexico, and Australia

	Precipitation (mm yr ⁴)	Water table deptli (m)	Geomorphic setting	Soil texture	Maximum chloride +y/m³)	Moisture flux (mm·yr*)
Texas ^a						
(Hueco Bolson)	280 (arid)	150	* Ephemeral stream	Clay to muddy- sandy-gravel	άζησ	0.01 to 0.7
			intersticam	Clay to muddy- sandy-gravel	6300	0.03 to 0.27
New Mexicobe	444 or 385	30	Playa		≤ 100	2.8-12.4*
(Fastern)	(semiarid)		Sand hills		≤ 300	13-430
(Central)	220 (anid)	5	Pleistocene	Sandy Ioam to	60 to 2720	1-3
24 km N of Sceptrode			alluvium	leamy sand		
(3*) (3*°)		100	Hobseene terrace	sand		1-3
40 km NE of	220 tarid)	100		Sandy foam to	680	0.1
Las Cruces ^t -				Sandy clay loam		
South Australia 100 km NE of	300 (anid)	28-40	Undisturbed calcrete		75(<i>n</i>)	0.1-0.17
Adelaide ⁽			1° sinkhole		<u>22508</u>	0,07-0,00
			2º sinkhole		30	≥ 60
			Vegetated		20000	0,06
			dunes Cleared dunes			13
			citaneo ounes			1.1
Western Australia 40 km N of Perth*	8(9) (humid)	90	Dunes	sand	250-500	50-115

This paper: "Phillips and Stone, 1985, "Stone (1920): "Maniek et al., 1987, Phillips et al., 1988; "Phillips et al., 1984; "Allison et al., 1985; #Sharma and Hughes, 1985.

	M	AP		Nom	regetat	ed San	d	Nı		nated T iable S		illy	Vegu	tated !	Sand			ted Tex jable So		
			R	echarge	:			Rech	arge				Rech	arge		Rech	arge			
Region	Total	CV	Total	CV	RP	AE	PETZAE	Total	R/P	AE	Ro	48	Total	R/P	AET	Total	R/P	AET	R_{O}	- 48
I	224	0.35	51	0.22	23	173	12.1	19	9	205	0	0.0	2	1	222	0.2	0,1	224	0	-0.1
2	380	0.35	137	0.20	36	243	8,9	80	21	286	14	0.0	34	9	346	11.1	2.9	356	14	0.7
3	380	0.35	137	0.20	36	243	8.9	56	15	316	7	-0.1	11	3	369	1.5	0.4	375	4	-0.0
4	474	0.23	180	0.24	38	294	ő.9	19	4	366	90	-0.4	33	7	441	0.8	0.2	390	85	-0.9
5	497	0.21	174	0,16	35	323	6.5	16	3	286	195	-1.0	29	6	468	0.4	0.1	312	186	ند ا
6	620	0.23	269	0,19	43	351	6,1	88	14	364	168	-0.4	80	13	540	5.6	0,9	435	180	-0.8
7	671	0.24	338	0.19	50	334	5.4	191	29	454	25	0,0	115	17	556	33.8	5.0	610	27	-0.1
8	810	0.21	406	0.20	50	403	4.3	98	12	586	125	0.0	95	12	715	10.1	1.3	619	181	-0.8
Ģ	855	0.22	432	0.18	51	423	4.3	193	23	587	74	0.0	106	12	749	29.0	3.4	727	-99	-0,4
10	855	0.22	432	0.18	51	423	4.3	146	17	663	46	0.0	83	10	772	4.7	0,6	792	59	
11	855	0.22	432	0.18	51	423	4.3	193	23	639	24	0.0	111	13	744	35.1	4.1	795	25	-0.2
12	933	0.23	507	0.22	54	427	3,9	91	10	423	419	-0.2	285	31	648	25.7	2.8	520	388	0.]
13	1184	0.22	709	0.18	-60	475	2.9	230	19	619	335	-0.2	369	31	815	117.7	9.9	748	319	-0.2

Reason and charge in source to for indicesting and vegetaria indicating simulated 30 year mean annual recharge: R/P, recharge to precipitation ratio; AE, actual evaporation; AET, actual evapotranspiration; ΔS , charge in water storage; R_{O} , runoff,

Appendix A Previous Reports

* Jak 10-1

R.T. Hicks Consultants, Ltd.

901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

R. T. HICKS CONSULTANTS, LTD.

10.101

an tak

Caller of

and the second

d when the

a subserve

Constrainty

133.6

Co-Plan

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

Appendices Associated with Previously Submitted Reports are Available on the Attached CD

RICE OPERATING COMPANY

B. Star

and the second

the state of

Station of the second

1200

and the

Fight of

ALL DA

THE REAL PROPERTY.

Sector Sector

a to a state

- Salary

Sec.

Series.

JUNCTION BOX CLOSURE REPORT

SWD SYSTEM	JUNCTION	UNIT	SECTION	TOWNSHIP	RANGE	COUNTY	BOX DI	IMENSIONS	S - FEET	٦
							Length	Width	Depth	-
BD	Zachary Hinton EOL	0	12	22S	37E	Lea	6	5	6	
LAND TYPE: E	BLMST/	ATE	FEE LAND	OWNER	Tom Ker	inann	OTHER			
Depth to Grour	ndwater	56	feet	NMOCD	SITE ASSE	ESSMENT F	RANKING S	CORE:	10	
Date Started	2/6/20	01	Date Co	mpleted	1/24/2007	NMOC	D Witness		no	
Soil Excavated _.	0	cubic ya	rds Exc	cavation Le	ength <u>0</u>	Width	0	Depth	0	fe
Soil Disposed	0	cubic va	rds Of	fsite Facilitv	'n	12	Location		n/a	
neral Descriptic	on of Remedial	Action:				ing the the Jur				
neral Descriptic	on of Remedial stalled on site in F	Action: eb. 2002.	This junction	box was delin	neated accord	ing the the Jur	nction Box Up	ograde Work	Plan. One	
neral Descriptic itoring well was ins arch 2007 "Final S	on of Remedial stalled on site in F	Action: eb. 2002.	This junction	box was delin	neated accord	ing the the Jur	nction Box Up	bgrade Work	Plan. One	. 200
neral Description itoring well was instance arch 2007 "Final S this form.	on of Remedial stalled on site in F	Action: eb. 2002. eport & Abate	This junction	box was delin	by Hicks reque	ing the the Jur ests closure of encl	nction Box Up this junction osures: Closu	box site and	Plan. One is included	. 200
neral Description itoring well was instance arch 2007 "Final S this form.	on of Remedial stalled on site in F ite Investigation R	Action: eb. 2002. eport & Abate	This junction ement Comple	box was delin	IS TRUE A	ing the the Jur ests closure of encl	this junction	box site and ure letter from	Plan. One is included n Hicks (Dec	. 200

R. T. HICKS CONSULTANTS, LTD.

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

February 12, 2007

Wayne Price Oil Conservation Division 1220 S. St. Francis Drive Santa Fe, NM 87505

RE: 2006 Annual Ground Water Monitoring Report Jct. Zachary Hinton (O-12), Sec 12, T22S, R37E, Unit "O" NMOCD Case #: AP-50

Dear Mr. Wayne Price:

R.T. Hicks Consultants, Ltd is pleased to submit the 2006 Annual Ground Water Monitoring Report for the Jct. Zachary Hinton (O-12) site located in the BD Salt Water Disposal System (SWD). This report consists of the following sections:

- 1. A table summarizing all laboratory results, depth to ground water and other pertinent data associated with ground water sampling at the site, including this past year.
- 2. Graphs showing chemical concentration vs. time for chloride and TDS.
- 3. Laboratory data sheets associated with the routine sampling for 2006.

The Final Closure Report will be submitted to NMOCD by February 26, 2007. Per agreement with NMOCD, the monitoring well at the site will be sampled twice a year, during the first and third quarters of the year.

Thank you for your consideration of this annual summary information. The attached CD contains an electronic copy of the annual report. If you have any questions, please contact us at 505-266-5004, or Kristin Farris Pope at ROC, 505-393-9174.

Sincerely, R.T. Hicks Consultants, Ltd.

Randall T. Hicks Principal

100

Copy: Hobbs NMOCD office; Rice Operating Company

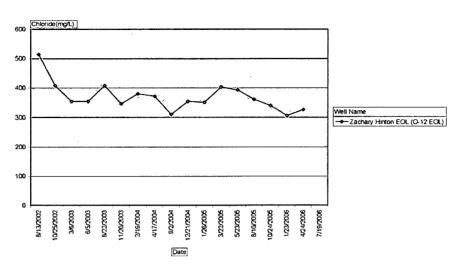
Model Data Data </th <th>Zachary</th> <th>Jct. Zachary Hinton (0-12)</th> <th>-12)</th> <th></th> <th>Table 1</th> <th>: chemist</th> <th>Table 1: chemistry over time</th> <th>ıe</th> <th></th> <th></th> <th></th>	Zachary	Jct. Zachary Hinton (0-12)	-12)		Table 1	: chemist	Table 1: chemistry over time	ıe			
0112/02 510 114 266 1460 6001 <th< th=""><th>l Name</th><th>Date</th><th>DTW (ft)</th><th>Chloride (mg/L)</th><th>Sulfate (mg/L)</th><th>TDS (mg/L)</th><th>Benzene (ug/L)</th><th>Toluene (ug/L)</th><th>EthylBenzene (ug/L)</th><th>Total Xylenes (ug/L)</th><th>Comments</th></th<>	l Name	Date	DTW (ft)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)	Benzene (ug/L)	Toluene (ug/L)	EthylBenzene (ug/L)	Total Xylenes (ug/L)	Comments
10725002 614 68 20 720 700 700 700 700 362703 5617 34 37 1160 6001 6001 6001 6001 6001 952003 560 34 327 1140 6001 6001 6001 6001 952003 560 346 327 1360 6001 6001 6001 6001 11720403 560 360 360 360 6001 6001 6001 6001 11720403 560 370 327 6021 6021 6001 6001 1172040 560 370 327 6021 6021 6001 6001 1172040 560 360 360 6001 6001 6001 6001 1172040 560 360 3601 6001 6001 6001 6001 11720400 560 360 3601 6001 6001 6001	W-01	8/13/2002	56.10	514	256	1450	<0.001	<0.001	<0.001	<0.001	red & silty
36200607364377160<001<001<001<00166700560364225140<001	MW-01	10/25/2002	56.14	408	240	1290	<0.001	<0.001	<0.001	<0.001	
65003600342214040014001400140018220036004037139400140014001400111/2003600346346346347400140014001400121/2004559340347347402400140014001400121/2004550310320347349400140014001400121/2004550340347349340400140014001400121/2004550340340340340400140014001400121/2005550354354357327400140014001400121/200555035035035035035035035021/20055503503503503503003001300121/20055503503503503503003001300121/200555035035035035030013001300131/200555035035035035030013001300131/200555035035035030030013001300131/200555035035035035030013001300131/200555035035035030030013001	MW-01	3/6/2003	56.07	354	377	1160	<0.001	<0.001	<0.001	<0.001	
822003 560 48 37 150 400 400 400 11/20206 840 346 56 170 601 6001 6001 6001 219/2044 565 327 326 173 6022 6001 6001 6001 219/2044 566 372 252 189 702 602 6001 217/2046 569 372 252 189 601 6001 6001 6001 212/2046 569 361 260 190 601 6001 601 601 212/2046 569 361 260 2601 6001 6001 6001 212/2046 569 361 270 6011 6011 6011 6011 212/2046 569 369 2601 6011 6011 6011 6011 212/2046 569 369 2601 6021 6021 6021 6021	MW-01	6/5/2003	56.00	354	252	1140	<0.001	<0.001	<0.001	<0.001	
1120200 560 36 15 170 600 600 600 219204 556 32 22 130 502 602 600 600 417204 556 312 22 1190 600 600 600 600 92204 550 310 25 1190 6001 6001 6001 6001 1221204 550 310 25 150 601 6001 6001 6001 1221204 550 351 25 150 600 6001 6001 6001 1221205 550 351 25 150 6001 6001 6001 6001 1221205 550 351 252 150 6001 6001 6001 6001 1221205 550 351 252 150 6001 6001 6001 601 1221205 550 350 252 150 6001	MW-01	8/22/2003	56.00	408	327	1350	<0.001	<0.001	<0.001	<0.001	
219204 569 30 97 129 002 002 002 000 417204 569 312 259 199 001 001 001 001 922044 569 310 259 196 700 6001 6001 6001 12212044 559 351 256 150 601 6001 6001 6001 1252055 554 351 250 150 601 6001 6001 6001 1262056 554 351 226 150 6001 6001 6001 6001 1262056 554 351 226 150 6001 6001 6001 6001 1262056 552 351 226 150 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001 <td< td=""><td>MW-01</td><td>11/20/2003</td><td>56.00</td><td>346</td><td>256</td><td>1170</td><td><0.001</td><td><0.001</td><td><0.001</td><td><0.001</td><td></td></td<>	MW-01	11/20/2003	56.00	346	256	1170	<0.001	<0.001	<0.001	<0.001	
41/12004 56 56 372 120 6001	AW-01	2/19/2004	56.59	380	67	1297	<0.002	<0.002	<0.002	<0.006	
y22004 560 310 258 160 6001 6001 6001 6001 6001 12671204 559 34 261 270 6001 6001 6001 6001 1267205 554 31 226 110 6001 6001 6001 6001 3727005 554 33 226 110 6001 6001 6001 6001 3727005 554 33 226 1100 6001 6001 6001 6001 3727005 554 364 120 0201 6001 6001 6001 1024206 554 369 120 120 6001 6001 6001 6001 1024206 557 369 170 6001 6001 6001 6001 6001 1234206 557 369 170 6001 6001 6001 6001 6001 6001 6001 6001 6001 6001	AW -01	4/17/2004	55.65	372	252	1190	<0.001	<0.001	<0.001	<0.001	
1/2/1/204 5.9 3.4 2.6 3.7 6.001 6.001 6.001 6.001 6.001 1/26/205 5.94 35 2 1.5 2 0.01 6.001 6.001 6.001 6.001 3/2/2005 5.80 403 222 1270 7.001 6.001 6.001 6.001 6.001 3/2/2005 5.84 393 226 170 7.001 6.001 6.001 6.001 8/10/2015 5.82 361 272 1200 7.010 6.001 6.001 6.001 1/2/2015 5.81 361 120 1201 6.001 6.001 6.001 6.001 1/2/2016 5.71 361 1200 6.001 6.001 6.001 6.001 6.001 1/2/2016 5.71 361 6.001 6.001 6.001 6.001 6.001 6.001 1/2/2016 5.71 362 170 6.001 6.001 6.001	AW-01	9/2/2004	56.00	310	258	1160	<0.001	<0.001	<0.001	<0.001	lt. brown; cloudy
1/26/205 55.94 31 226 150 6.001 6.001 6.001 6.001 6.001 3/2/2005 55.80 43 222 170 2001 6.001 6.001 6.001 6.001 5/2/2005 55.84 333 226 170 6.001 6.001 6.001 6.001 6.001 8/10/2005 55.82 361 227 1200 6.001 6.001 6.001 6.001 6.001 10/24/2005 55.10 340 177 1240 6.001 6.001 6.001 6.001 6.001 10/24/2005 55.10 340 177 1240 6.001 6.001 6.001 6.001 10/24/2005 55.70 369 164 170 6.001 6.001 6.001 6.001 11/27/2005 55.70 369 169 170 6.001 6.001 6.001 6.001 11/27/2005 55.70 369 169 6.001 <td< td=""><td>AW-01</td><td>12/21/2004</td><td>55.90</td><td>354</td><td>261</td><td>2370</td><td><0.001</td><td><0.001</td><td><0.001</td><td><0.001</td><td>tan, silty</td></td<>	AW-01	12/21/2004	55.90	354	261	2370	<0.001	<0.001	<0.001	<0.001	tan, silty
J22/2065 55.80 403 202 1270 6.001 6.001 6.001 6.001 6.001 5/23/2005 55.84 393 226 1190 6.001 6.001 6.001 6.001 8/10/2005 55.82 361 227 1200 6.001 6.001 6.001 6.001 10/24/2005 55.10 340 177 1240 6.001 6.001 6.001 6.001 1/24/2005 55.75 306 184 170 6.001 6.001 6.001 6.001 1/24/2005 55.75 306 184 170 6.001 6.001 6.001 6.001 1/24/2005 55.75 306 184 170 6.001 6.001 6.001 6.001 6.001 1/24/2005 55.70 326 167 190 6.001 6.001 6.001 6.001 1/31/2006 55.70 326 167 6.001 6.001 6.001 6.001 <	/W-01	1/26/2005	55.94	351	226	1150	<0.001	<0.001	<0.001	<0.001	
5/23/2005 5.84 33 226 1190 <0.01 <0.01 <0.01 <0.01 <0.01 8/10/2005 55.82 361 27 1200 <0.01	1W-01	3/22/2005	55.80	403	202	1270	<0.001	<0.001	<0.001	<0.001	clear; no odor
8/10/2005 55.82 361 227 1200 <0.01 <0.01 <0.01 <0.01 <0.01 10/24/2005 55.10 340 177 1240 <0.01	4W-01	5/23/2005	55.84	393	226	1190	<0.001	<0.001	<0.001	<0.001	
10/24/2005 55.10 340 174 1240 <0.001 <0.001 <0.001 <0.001 1/23/2006 55.75 306 184 1170 <0.001	1W-01	8/10/2005	55.82	361	227	1200	<0.001	<0.001	<0.001	<0.001	
1/23/2006 55.75 306 184 1170 <0.001 <0.001 <0.001 4/24/2006 55.70 326 167 1190 <0.001	1W-01	10/24/2005	55.10	340	177	1240	<0.001	<0.001	<0.001	<0.001	clear; no odor
4/24/2006 55.70 326 167 1190 <0.001	1W-01	1/23/2006	55.75	306	184	1170	<0.001	<0.001	<0.001	<0.001	
7/19/2006	W-01	4/24/2006	55.70	326	167	1190	<0.001	<0.001	<0.001	<0.001	
	IW-01	7/19/2006	55.68	1							

Monday, February 05, 2007

Ground Water Quality at Zachary Hinton

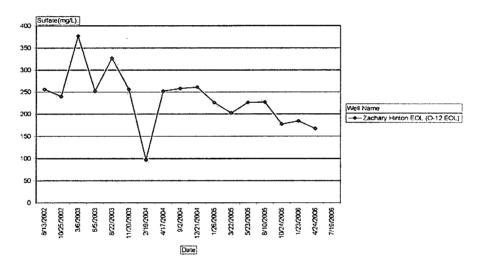
Site Name Zachary Hinton EOL (O-12 EOL)

Chloride Over Time



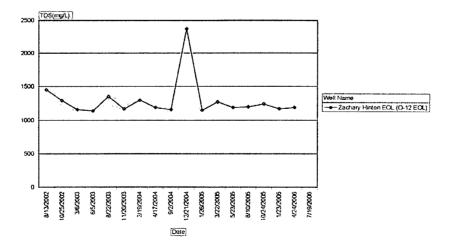
Site Name Zachary Hinton EOL (O-12 EOL)

Sulfate Over Time



Site Name Zachary Hinton EOL (O-12 EOL)





and a stand

あるない

Sec.

a state

Analy .

1. N. 1. 1.

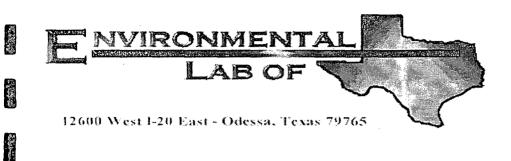
* * * * * * *

in Barris

an march by

r. A. Ko

5. Mar 1



Analytical Report

Prepared for: Kristin Farris-Pope Rice Operating Co. 122 W. Taylor Hobbs, NM 88240

Project: BD Zachary Hinton Project Number: None Given Location: Lea County

Lab Order Number: 6A25021

Report Date: 02/01/06

And and

W HERE

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240	Project: BD Zachar Project Number: None Give Project Manager: Kristin Far	n	1	Fax: (505) 397-1471 Reported: 02/01/06 11:42
	ANALYTICAL REPORT FOR SA	MPLES		
Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Monitor Well #1	6A25021-01	Water	01/23/06 09:45	01/25/06 13:2
		-		

AND SE

調査部

27.742

An Their

にいた

Pley and

Encontra

1. 3 4 C

TO XALL

South State

See and

334 to

- & A. S. "01

1. A.W.

R. E. B. Car

Acres

WE TEL

学学る

Page 1 of 10

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

Project: BD Zachary Hinton	Fax: (505) 397-1471
Project Number: None Given	Reported:
Project Manager: Kristin Farris-Pope	02/01/06 11:42
	Project Number: None Given

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method .	Notes
Monitor Well #1 (6A25021-01) Water									
Benzene	ND	0.00100	mg/L	1	EA62618	01/26/06	01/27/06	EPA 8021B	
Toluene	ND	0.00100					- H	"	
Ethylbenzene	ND	0.00100	**	"		н	"		
Xylene (p/m)	ND	0.00100				н	"	"	
Xylene (o)	ND	0.00100	<i>n</i>	"					
Surrogate: a,a,a-Trifluorotoluene		95.2 %	80-12)	"	"	"	"	
Surrogate: 4-Bromofluorobenzene		89.2 %	80-12)	"	"	"	"	

Environmental Lab of Texas

and and

1999 W.

at the second

S.Bas.ut

S. 8. 9.

March .

44.52 m

State of

1.1

2000

State of the

2.1996

200

100

Second R.

ないます

a hana

\$ 2.2 M

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas. Rice Operating Co. 122 W. Taylor Hobbs NM, 88240

Project:BD Zachary HintonProject Number:None GivenProject Manager:Kristin Farris-Pope

Fax: (505) 397-1471

Reported: 02/01/06 11:42

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 (6A25021-01) Water			-					,	
Total Alkalinity	172	2.00	mg/L	1	EA62406	01/26/06	01/26/06	EPA 310.1M	
Chloride	. 306	10.0	"	20	EA63004	01/30/06	01/30/06	EPA 300.0	
Total Dissolved Solids	1170	5.00	0	1	EA63003	01/26/06	01/27/06	EPA 160.1	
Sulfate	184	10.0	"	20	EA63004	01/30/06	01/30/06	EPA 300.0	

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 3 of 10

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

ALCON BUT

and the

S. Kere

1. C. P.

340 TO

9913. VA

24.4.5

1. S. R. S. W.

State State

Sec. 1

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

Sale Bar

States and

STRATES

10.000

1. C. C.

1. 2. 2 B

1887 - 1895

Station.

9. No

1. A. S. A.

de de la

王明金

Sec.

No.2

an an In

Project: BD Zachary Hinton Project Number: None Given Project Manager: Kristin Farris-Pope Fax: (505) 397-1471

Reported: 02/01/06 11:42

Total Metals by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (6A25021-01) Water				-					
Calcium	93.8	0.100	mg/L	10	EA62615	01/26/06	01/26/06	EPA 6010B	
Magnesium	44.4	0.0100				"	н		
Potassium	8.85	0.500		"		*	н		
Sodium	208	0.500	н.	50	"	**	н	n	

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 4 of 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		Fax: (505) 397-147 Reported: 02/01/06 11:42								
	0	rganics by Environm								
Analyte	Result	Reporting	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EA62618 - EPA 5030C (GC)	·····	<u>-</u> .					• • • • •			
Blank (EA62618-BLK1)	<u></u>	····		Prepared: 0)1/26/06 A	nalvzed: 01	/27/06			<u> </u>
3enzene	ND	0.00100	mg/L							
Foluene	ND	0.00100	"							
Ethylbenzene	ND	0.00100	л							
Xyiene (p/m)	ND	0.00100								
Xyłene (o)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	38.5		• ug/l	40.0		96.2	80-120			
Surrogate: 4-Bromofluorobenzene	42.4		, "	40.0		106	80-120			
LCS (EA62618-BS1)				Prepared: 0)1/26/06 A	nalvzed: 01	/27/06			
Benzene	0.0566	0.00100	mg/L	0.0500		113	80-120			
Foluene	0.0557	0.00100	"	0.0500		111	80-120			
Ethylbenzene	0.0547	0.00100	и	0.0500		109	80-120			
Xylene (p/m)	0.102	0.00100		0.100		102	80-120			
Xylene (o)	0.0538	0.00100		0.0500		108	80-120			
Surrogate: a, a, a-Trifluorotoluene	41.2		ug/l	40.0		103	80-120			
Surrogate: 4-Bromofluorobenzene	32.8		"	40.0		82.0	80-120		-	
Calibration Check (EA62618-CCV1)				Prepared: 0)1/26/06 A	nalyzed: 01	/28/06			
Benzene	51.3		ug/l	50.0		103	80-120			
Foluene	52.5			50.0		105	80-120			
Ethylbenzene	54.5			50.0		109	80-120			
Xylene (p/m)	101		n	100		101	80-120			
Xylene (o)	55.6			50.0		111	80-120			
Surrogate: a,a,a-Trifluorotoluene	34.3		"	40.0		85.8	80-120			
Surrogate: 4-Bromofluorobenzene	39.5		"	40.0		98.8	80-120			
Matrix Spike (EA62618-MS1)	Sou	rce: 6A24010-	01	Prepared: 0)1/26/06 A	nalyzed: 01	/27/06			
Benzene	0.0559	0.00100	mg/L	0.0500	ND	112	80-120			
foluene	0.0548	0.00100		0.0500	ND	110	80-120			
Ethylbenzene	0.0515	0.00100		0.0500	ND	103	80-120			
Sylene (p/m)	0.0835	0.00100	"	0.100	ND	83.5	80-120			
Xylene (0)	0.0512	0.00100	n	0.0500	ND	102	80-120			
Surrogate: a,a,a-Trifluorotoluene	37.5		ug/l	40.0		93.8	80-120			
Surrogate: 4-Bromofluorobenzene	34.3		<i>n</i> ~	40.0		85.8	80-120			

No. of the local division of the local divis

業業業業

1000

No.

3. F. & S

States and

102.34

の言葉

Carl Street

Market

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

Page 5 of 10

..

Rice Operating Co.	Project: BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	Reported:
Hobbs NM, 88240	Project Manager: Kristin Farris-Pope	02/01/06 11:42

Organics by GC - Quality Control

Environmental Lab of Texas

		Reporting		Spike	Source		%REC		RPD	
Analyte	Result	Linit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes

Batch EA62618 - EPA 5030C (GC)

1.4.20

NAVAR.

S. A. State

1983

A THE

議院

and an

43 c' 62

1. 2 M. Day

が認め

S. A. A.

Matrix Spike Dup (EA62618-MSD1)	Sou	rce: 6A24010-	-01	Prepared: 0	1/26/06 A	nalyzed: 0	1/28/06			
Benzene	0.0482	0.00100	mg/L	0.0500	ND	96.4	80-120	15.0	20	
Tohiene	0.0484	0.00100		0.0500	ND	.96.8	80-120	12.8	20	
Ethylbenzene	0.0456	0.00100		0.0500	ND	91.2	80-120	12.2	20	
Xylene (p/m)	0.0841	0.00100	"	0.100	ND	84.1	80-120	0.716	20	
Xylene (6)	0.0448	0.00100		0.0500	ND	89.6	80-120	12.9	20	
Surrogate: a,a,a-Trifluorotoluene	33.0		ug/l	40.0		82.5	80-120			
Surrogate: 4-Bromofluorobenzene	32.4	•	"	40.0		81.0	80-120			

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Rice Operating Co.	Project: BD Zachary Hinton										
122 W. Taylor			Reported:								
Hobbs NM, 88240		Project Nu Project Mar		istin Farris-Pop	pe				02/01/0		
General	Chemistry Para	-				ls - Qua	lity Cont	trol		-	
· · · · · · · · · · · · · · · · · · ·		Environm	iental I	Lab of Texa	as						
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes	
Batch EA62406 - General Preparatio	n (WetChem)			-							
Blank (EA62406-BLK1)		Prepared &	Analyzed:	01/26/06							
Total Alkalinity	ND	2.00	mg/L								
LCS (EA62406-BS1)				Prepared & Analyzed: 01/26/06							
Bicarbonate Alkalinity	220		mg/L	200		110	85-115				
Duplicate (EA62406-DUP1)	Sour	·ce: 6A19005-	01	Prepared & Analyzed: 01/26/06							
Total Alkalinity	258	2.00	mg/L	-	256			0.778	20		
Reference (EA62406-SRM1)				Prepared &	Analyzed:	01/26/06					
Total Alkalinity	97.0		mg/L	100		97.0	90-110 .				
Batch EA63003 - General Preparatio	on (WetChem)										
Blank (EA63003-BLK1)				Prepared: 01	/26/06 A	nalyzed: 01	/27/06	-			
Total Dissolved Solids	ND	5.00	mg/L								
Duplicate (EA63003-DUP1)	Sour	-ce: 6A25018-	01	Prepared: 01	/26/06 A	nalyzed: 01	/27/06			· -	
Total Dissolved Solids	- 2020	5.00	mg/L		2080			2.93	5		
Batch EA63004 - General Preparatio	on (WetChem)										
Blank (EA63004-BLK1)				Prepared &	Analyzed:	01/30/06					
Sulfate	ND	0,500	mg/L	· · · ·							
Chloride	ND	0.500	"				•				
LCS (EA63004-BS1)	<i>.</i>		·	Prepared &	Analyzed:	01/30/06					
Sulfate	9.61	0,500	mg/L	. 10.0		96.1	80-120				
			. <u>L</u> .								

Environmental Lab of Texas

Conserved Served Ser

ALC: NO

。如何是你

語を行

-Sana

Sec. 1

Street.

A PARA

P. P. B.

Carles and

and the second

Street and

いたの

のないの

and the second

The results in this report apply to the samples analyzed in accordance with the samples. received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 7 of 10

Rice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number:	None Given	Reported:
Hobbs NM, 88240	Project Manager:	Kristin Farris-Pope	02/01/06 11:42

General Chemistry Parameters by EPA / Standard Methods - Quality Control

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Spike	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EA63004 - General Preparation (V	VetChem)							-		_
Calibration Check (EA63004-CCV1)				Prepared &	Analyzed:	01/30/06				
Sulfate	9.82		mg/L	10.0		98.2	80-120			
Chloride -	8.64		"	10.0		86.4	80-120			
Duplicate (EA63004-DUP1)	Sour	rce: 6A25018-	01	Prepared &	Analyzed:	01/30/06				
Sulfate	84.4	25.0	mg/L		88.2			4.40	20	
Chloride	879	25.0	<i>n</i>		886			0,793	20	

Environmental Lab of Texas

and and an

Sec. 1

調測

のため

Pestoria.

S. Branking

ACT THE

Same and

S. S. Barris

A STANS

PE-SEA

States.

and the set

Tathestant.

S. S. S.

a states

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

ないない

ALC: N

のなる

記録が

Sec. Sec.

10 a 10

Section In

- A alalo

W. Ball

P. Quantan

10.00

S. Martine

Station for

ung Co. /lor _ 88240 Project: BD Zachary Hinton Project Number: None Given Project Manager: Kristin Farris-Pope

Total Metals by EPA / Standard Methods - Quality Control

Environmental Lab of Texas

		Reporting		Spike	Source		%REC		RPD	
Analyte	Result	Limit	`Units	Level	Result	%REC	Limits	RPD	Limit	Notes
Batch EA62615 - 6010B/No Digestion										
Blank (EA62615-BLK1)				Prepared &	Analyzed:	01/26/06				
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	н							
Sodium	ND	0.0100	P							
Calibration Check (EA62615-CCV1)				Prepared &	Anałyzed:	01/26/06				
Calcium	2.12		mg/L	2.00		106	85-115			
Magnesium	1.99			2.00		99.5	85-115			
Potassium	1.88		*1	2.00		94.0	85-115			
Sodium	1.94		"	2.00		97.0	85-115			
Duplicate (EA62615-DUP1)	Sou	rce: 6A19005-	01	Prepared &	Analyzed:	01/26/06				
Calcium	224	0,500	mg/L		222			0.897	20	
Magnesium	115	0.0500	*		120			4.26	20	
Potassium	14.6	0.500	"		15.2		-	4.03	20	
Sodium	306	0.500	н		313			2.26	20	

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

R	ice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
1:	22 W. Taylor	Project Number:	None Given	Reported:
н	lobbs NM, 88240	Project Manager:	Kristin Farris-Pope	02/01/06 11:42

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:

18. E.

ALC: UNK

きた

Sal and

12.1012

Raland Khuts

2/1/2006

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.

Date:

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

The results in this report apply to the sumples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

Page 10 of 10

NALON		1		ļ	}				I	TAT brebnet2	×												
							lacesta.			RUSH TAT (Pre-Schedule)						 		 -		S			
					1				•							 	_	 	z z	ГЛ Q			
																 			\sim $^{\circ}$	not fr			
-										sbilo3 beviossi0 letoT	×	\square						 	S. Cooler	40			
										M.O.R.M.						 			19	2			
		U					۲.			RCI									ct?	เต			
	EST	Project Name: BD Zachary Hinton	1	Lea County			Analyze For	×		91EX 80518/2030	\times								Sampla Containers Intact? Labels on container? Custody Seals: Containers Temperature Upon Receipt	Laboratory Comments:			
	CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST	av		Ö			Analy			celikstovime2						 	1		Sampla Containers Ir Labels on container? Custody Seals Cont Temperature Upon R	ome			
-26	IS RI	ach		ea					<u> </u>	Metals: As Ag Ba Cd Cr Pb Hg Se Volatike						 		 	tonte Loon Seals ure l	° 2			
	r As	02								SAR / ESP / CEC						 		 	pla C Is on ody 5 perat	oratic			
	ANA	ы Ш	4£ 1	ğ	i ¥			TOTAL:	\vdash	Anions (CI, SO4, CO3, HCO3)	×								Sam _abe Cust	abc			
3	QN	Nam	Project#:	Project Loc:	но Но Н					Cations (Ca, Mg, Va, K)	×					\vdash							
<i>6</i> 9	A Cl	ject	Рго	<u>oje</u>					9	TPH: 418.1 8015M 1005 100			-							Time		Ly inte	
	COF	Pro		a.			-	-		Other (specify):									ε			2	
	r RE								Matrix	Ins						 		 	8			ي	
	(ao,	ı	i	1	ł	1	1	-	Σ	spuls	×					 			wd	Date		Date Z.S-t	
	เกรา		ļ							Ofher (Specify) Water				-		 _		 	Sec			Date 01-2.5-06	
	GF C				ľ					None (1) 1 Liter HDPE								 	<u>Ø</u> ric				
	NIR	Í							đive	ros⁼h									(s)				ı
	CH					471			Preservative	HOPN									an				ł
122						397-147			Ъ.	HCI (Z) 40 ml glass viels	2								mfr				
					l	33				^c onh						 			ත්			5	<
						(505)				10e				-				 	E O			3	
		1			ĺ	2		T		No. of Containers	3					 			Ľ, Č		1	لح	í
		E				Fax No:				bekqme2 emiT	9:45								kpriceswd@valornet.com & mfranks@riceswd.com			men	
		alornet.com			ſ	R	t	\uparrow)		6					 			swd@			iloT:	1
								Y		belqme2 steQ	1/23/2006								kprice	Received by:		Received by ELOT	-
A MARINE	() cm	kpriceswd@v			0	31-931										 					1:25	Time Rec	
	Of TOXAS hone: 432-583-1800 Fax: 432-563-1713		ompany	eet	oo 8824	(505) 6		HINS											RESULT		1 2	<u>≓</u>	
ŝint ante	Lab of Texas Phone: 432-563-1800 Fax: 432-563-1713	Project Manager: Kristin Farris Pope	Company Name RICE Operating Company	Company Address: 122 W. Taylor Street	city/state/Zip: Hobbs, New Mexico 88240	Telephone No: (505) 393-9174	tourolo: 6	Email: 10241116(@Valutific.colli		FIELD CODE									PLEASE Email RESULTS TO:	Date	1/34	Date	:
the second		stin Fa	CE Op	2 W. T	bbs, N	25) 393 Zanne				Ë	eli #1								LEASE	$\left \right\rangle$	$\left\{ \right\}$		
	Q D	iger: <u>Kri</u>	ame RI(ess: <u>12</u> .	Zip: <u>Ho</u>	No: (5(Monitor Well #1								۵ ۲		Tit -		
	8111116 10 East 5 79765	ject Mana	mpany N.	any Addr	City/State/	Telephone No: (505) 393-9174		Ξ		(fine				144			i antis		tions:	$\left \right $	2 C		I
	Environmental 12600 west 1-20 East Odessa, Texas 79765	Pro	ů	Comp	5	T mea				A (lab use only)									Special Instructions:	Relinquist pod by	Rozanne Johnson	Relinquished by.	
6	HT ÇQ									<u>1 </u>	1						1. N 1. N 1. N		้ที่	<u>J</u>	18	- B - - - - - - - - - - - - - - - - - -	
Trank.							۰.				· .		÷. •		÷.	÷			• .			~	

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

Contraction of the local division of the loc	Olient	Rice Op.
a Wind and	Date/Time:	1/25/06 13:25
5.5	Order #:	6A75021
ジャー	Initials:	Cle

Sample Receipt Checklist

Temperature of container/cooler?	Yes No	-2.5 CI
Shipping container/cooler in good condition?	Xas No	
Custody Seals intact on shipping container/cooler?	Kas No	Not present
Custody Seals intact on sample bottles?	Xes No	Not present ()
Chain of custody present?	XES NO 1	
Sample Instructions complete on Chain of Custody?	Yes No 1	
Chain of Custody signed when relinquished and received?	Kas No I	
Chain of custody agrees with sample label(s)	X=5 NO	
Container labels legible and intact?	KES NO	
Sample Matrix and properties same as on chain of custody?	Xes No	1
Samoles in proper container/bottle?	Va No I	, [
Samples properly preserved?	X= No	
Sample bottles intact?	Σ≠≫s No	I
Preservations documented on Chain of Custody?	Xes No	
Containers documented on Chain of Custody?	I Cas I No I	1
Sufficient sample amount for indicated test?	YES NO 1	
All samples received within sufficient hold time?	YES NO !	
VOC samples have zero headspace?	X32 No	Not Applicable

Other observations:

are differing

教授記録

AC LOUGH

States?

The state

144

States,

のない

Sec. 2

	,	
· · ·	t	
	•	i

Variance Documentation:

Contact Person:	_ Date/Time:	Contacted by:	
Regarding:			

Corrective Action Taken:



South States

1. S. L. L.

A.R. OKAZ

Sugar Si

· ""你了了。"

ab Steel

Service .

Mar Barry

1.25

A grant

ちまた

1. Mar.

Spin Jon

- ALCON

A.C.M.

Analytical Report

Prepared for: Kristin Farris-Pope Rice Operating Co. 122 W. Taylor Hobbs, NM 88240

Project: BD Zachary Hinton Project Number: None Given Location: Lea County

Lab Order Number: 6D27011

Report Date: 05/04/06

R	ice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
12	22 W. Taylor	Project Number:	None Given	Reported:
• н	obbs NM, 88240	Project Manager:	Kristin Farris-Pope	05/04/06 14:09

ANALYTICAL REPORT FOR SAMPLES

10.0

ALC: NO.

Sec. Sec.

. Salata

Sandy Arts

States and

Sec. 1

Sarah Ca

Lange.

Tanka I

N. 26. 21.

and the

12 . Lat. 24

* 12 2 A 20

and the second

्रक्षेत्र्यं हो। २:

1 Public Call

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Monitor Well #1	6D27011-01	Water	04/24/06 09:30	04/27/06 10:30

Page 1 of 10

Rice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number:	None Given	Reported:
Hobbs NM, 88240	Project Manager:	Kristin Farris-Pope	05/04/06 14:09

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (6D27011-01) Water									
Benzene	ND	0.00100	mg/L	1	ED62807	04/28/06	04/30/06	EPA 8021B	
Toluene	ND	0.00100	н		и	и	"	я	
Ethylbenzene	ND	0.00100			0				
Xylene (p/m)	ND	0.00100		"		· "	"		
Xylene (o)	ND	0.00100			"	н	н		
Surrogate: a,a,a-Trifluorotoluene		102 %	80-12)	"	"	. "	. "	
Surrogate: 4-Bromofluorobenzene		103 %	80-12)	"	"	"	"	

Environmental Lab of Texas

S. Satha

the for least sta

and an inter

ate control to

ومريط والعار

S BAREAR S

dia year dan e

. 20. C. See

10-COP-01

- 15103 - 1

Carles and a second

1.00120020

States in

San Star

法规律法

TOC: W

State State

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Rice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number:	None Given	Reported:
Hobbs NM, 88240	Project Manager:	Kristin Farris-Pope	05/04/06 14:09

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 (6D27011-01) Water									
Total Alkalinity	184	2.00	mg/L	I	EE60301	05/03/06	05/03/06	EPA 310.1M	
Chloride	326	5.00		10	EE60116	05/01/06	05/01/06	EPA 300.0	
Total Dissolved Solids	1190	5.00	"	i	EE60115	04/27/06	04/28/06	EPA 160,1	
Sulfate	167	5.00		10	EE60116	05/01/06	05/01/06	EPA 300.0	

Environmental Lab of Texas

AL COMPANY

3.8.44F

STATE OF

2. 88. 64

10.00

24227

不学

FR. South

ALL DAY

Sec. Martin

2.55% "

ALCOLOGICAN

e de arte

1. an 895 27 5

र्वीक्षेत्र गर्न्छ वन्त

A REMER ADD ADD

調査の

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

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

at here a

100

2. Carloger

antes the Sec.

N. Charles

4, 'the price of the

Pringhang, Shar

T PUS EL O

Sarah .

Bell and

A. C. C.

の時間

Project: BD Zachary Hinton Project Number: None Given Project Manager: Kristin Farris-Pope

Fax: (505) 397-1471

Reported: 05/04/06 14:09

Total Metals by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (6D27011-01) Water									
Calcium	85.0	0.100	mg/L	10	ED62719	04/27/06	04/27/06	EPA 6010B	
Magnesium	43.4	0.0100		н	IT	*	н		
Potassium	9.70	0.500					н		
Sodium	238	0.500	"	50		"	12	"	

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240		Project Nu	mber: No	D Zachary Hin one Given istin Farris-P					Fax: (505) Repor 05/04/06	ted:
	0	rganics by Environm		-						
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch ED62807 - EPA 5030C (GC)										
Blank (ED62807-BLK1)				Prepared: ()4/28/06 A	Analyzed: 04	4/30/06			
Benzene	ND	0.00100	mg/L							
Toluene	ND	0.00100								
Ethylbenzene	ND	0.00100								
Xylene (p/m)	ND	0.00100	"							
Xylene (0)	ND	0.00100	"							
Surrogate: a,a,a-Trifluorotoluene	42.7		ug:1	40.0		107	80-120			
Surrogate: 4-Bromofluorobenzene	42.2		"	40.0		106	80-120			
LCS (ED62807-BS1)				Prepared: 0)4/28/06 A	Analyzed: 04	4/30/06			
Benzene	0.0599	0.00100	mg/L	0.0500		120	80-120			
Toluene	0.0580	0.00100		0.0500		116	80-120			
Ethylbenzene	0.0551	0.00100	"	0.0500		110	80-120			
Xylene (p/m)	0.120	0.00100		0.100		120	80-120			
Xylene (o)	0.0596	0.00100		0.0500		119	80-120			
Surrogaté: a,a,a-Trifluorotoluene	43.0		ug/l	40.0		108	80-120			
Surrogate: 4-Bromofluorobenzene	42.2		"	40.0		106	80-120			
Calibration Check (ED62807-CCV1)				Prepared: 0)4/28/06 A	analyzed: 05	5/01/06			
Benzene	\$5.0		ug/l	50.0		110	80-120		````	
Toluene	53.0		н	50.0		106	80-120			
Ethylbenzene	55.9		"	50.0		112	80-120			
Xylene (p/m)	110		"	100		110	80-120			
Xylene (o)	\$5.9		P	50.0		112	80-120			
Surrogate: a,a,a-Trifluorotoluene	39.0		11	40.0		97.5	80-120			
Surrogate: 4-Bromofluorobenzene	39.1		"	40.0		97.8	80-120	1		
Matrix Spike (ED62807-MS1)	Sou	rce: 6D27008-	01	Prepared: 0)4/28/06 A	analyzed: 05	5/01/06			
Benzene	0.0576	0.00100	mg/L	0.0500	ND	115	80-120			
Foluene	0.0568	0.00100	*	0.0500	ND	114	80-120			
Ethylbenzene	0.0587	0.00100	н	0.0500	ND	117	80-120			
Xylene (p/m)	0.120	0.00100	**	0.100	ND	120	80-120			
Xylene (o)	0.0600	0.00100	"	0.0500	ND	120	80-120			
Surrogate: a,a,a-Trifluorotoluene	41.7		ug/l	40.0		104	80-120			
Surrogate: 4-Bromofluorobenzene	47.5		"	40.0		119	80-120			

のないのない

tations.

Section of the sectio

A Start Bar

など、語言

新聞第3

-theory in

S. LAND

Sec. Bar

1

1000

Lin stan

a the state

The second

17. F. B. B.

Same and the second sec

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 5 of 10

Rice Operating Co.	Project: BD Zachary	y Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	n	Reported:
Hobbs NM, 88240	Project Manager: Kristin Farr	ris-Pope	05/04/06 14:09

Organics by GC - Quality Control

Environmental Lab of Texas

······································										
		Reporting		Spike	Source		%REC		RPD	
Analyte	Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes

Batch ED62807 - EPA 5030C (GC)

the same

Service Service

Sarah Sarah

State State

34 B 334

h was the

LP CEAN

たちの

Series S

NA SIN

S. S. Sand

the second

L.S. Malla

No.

Matrix Spike Dup (ED62807-MSD1)	Sou	rce: 6D27008-	01	Prepared: 04	4/28/06 Ai	nalyzed: 0	5/01/06		
Benzene	0.0597	0.00100	mg/L	0.0500	ND	119	80-120	3.42	20
Toluene	0.0579	0.00100	"	0.0500	ND	116	80-120	1.74	20
Ethylbenzene	0.0585	0.00100	"	0.0500	ND	117	80-120	0,00	20
Xylene (p/m)	0.120	0.00100	н	0.100	ND	120	80-120	0,00	20
Xylene (0)	0.0598	0.00100	и	0.0500	ND	120	80-120	0.00	20
Surrogate: a,a,a-Trifluorotoluene	+3.5		ug/l	40.0		109	80-120		
Surrogate: 4-Bromofluorobenzene	. 46.4		"	40.0		116	80-120		

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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 Nu	mber: No	D Zachary Hir one Given ristin Farris-Pe					Fax: (505) Repo 05/04/0	rted:
General C	hemistry Para	ameters by Environm				ls - Qua	lity Con	trol		
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EE60115 - General Preparation (WetChem)									
Blank (EE60115-BLK1)				Prepared: 0)4/27/06 Ai	nalyzed: 04	/28/06			
Total Dissolved Solids	ND	5.00	mg/L					····-		
Duplicate (EE60115-DUP1)	Sou	гсе: 6D27015-	-01	Prepared: 0)4/27/06 Ai	nalyzed: 04	/28/06			
Total Dissolved Solids	3020	5.00	mg/L	··	3040			0.660	5	
Batch EE60116 - General Preparation (WetChem)	,								
Blank (EE60116-BLK1)		<u>//</u>		Prepared &	Analyzed	05/01/06				
Chloride	ND	0.500	mg/L		<u></u>					
Sulfate	ND	0.500	"							
LCS (EE60116-BS1)				Prepared &	: Analyzed:	05/01/06				
Sulfate	9.47	0.500	mg/L	10.0		94.7	80-120			
Chloride	.9.71	0.500	n	10.0		97. J	80-120			
Calibration Check (EE60116-CCV1)				Prepared &	Analyzed:	05/01/06				
Chloride	9.86		mg/L	10.0	- <u> </u>	98.6	80-120			
Sulfate	8.11		n	10.0		81.1	80-120			
Duplicate (EE60116-DUP1)	Sou	rce: 6D27008-	01	Prepared &	Analyzed:	05/01/06				
Sulfate	80.0	2.50	mg/L		79.2			1.01	20	
Chloride	49.3	2.50			49.0			0.610	20	
Batch EE60301 - General Preparation (WetChem)									
Blank (EE60301-BLK1)				Prepared &	Analyzed	05/03/06		<u> </u>		
Total Alkalinity	ND	2.00	mg/L		Andrew Constant					

Environmental Lab of Texas

South State

Constant of

NA CRA

"Beege

and the second

State?

CALL PAR

and the second

Walter Ta

the same

Ser and an

25 . 130 . 25

E.S.C.M.

Street Street

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 7 of 10

F	Rice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
1	22 W. Taylor	Project Number:	None Given	Reported:
ŀ	lobbs NM, 88240	Project Manager:	Kristin Farris-Pope	. 05/04/06 14:09

General Chemistry Parameters by EPA / Standard Methods - Quality Control

Environmental Lab of Texas

		Reporting		Spike	Source		%REC		RPD	
Analyte	Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes
Batch EE60301 - General Preparatio	n (WetChem)									
LCS (EE60301-BS1)				Prepared &	Analyzed:	05/03/06				
Bicarbonate Alkalinity	214		mg/L	200		107	85-115			
Duplicate (EE60301-DUP1)	Sourc	e: 6D26006-	01	Prepared &	Analyzed:	05/03/06				
Total Alkalinity	29.0	2.00	mg/L		28.0			3.51	20	
Reference (EE60301-SRM1)				Prepared &	Analyzed:	05/03/06				
Total Alkalinity	.96.0		mg/L	100		96.0	90-110			

.

Street as

States -

Sec. Sec.

and the states

-0440-42

- Contraction

Sugar

S. Jakaba S

Same and

action of the second

Sector 1

A. R. S. A.

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

Total Metals by EPA / Standard Methods - Quality Control

		Environm	iental l	Lab of Tey	kas					
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch ED62719 - 6010B/No Digestion										
Blank (ED62719-BLK1)				Prepared &	Analyzed:	04/27/06				
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	н	,						
Potassium	ND	0.0500								
Sodium	ND	0.0100	n							
Calibration Check (ED62719-CCV1)				Prepared &	Analyzed:	04/27/06				
Calcium	2.08		mg/L				85-115		,	
Magnesium	2.16						85-115			
Potassium	1.94		"				85-115			
Sodium	1.96						85-115			
Duplicate (ED62719-DUP1)	Sou	rce: 6D26006-	01	Prepared &	Analyzed:	04/27/06				
Calcium	0.0366	0.0100	mg/L		0.0367			0.273	20	

ND

0.275

12.1

ND

0.275

13.0

0.00100

0.0500

0.100

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

20

20

20

0.00

7.17

Contraction of the

ALCORAL!

Magnesium

Potassium

Sodium

Sec. 1991

A DATE

100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100

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

Reported: 05/04/06 14:09

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:

1.1

and an and

Raland Kitut

5/4/2006

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.

Date:

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

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 10 of 10

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Environmental Labor Environmental Labor Environmental Labor Environmental Labor Statusticana Immunication Immunication Immunication			1	1		. 1	l				TAT biebneid	X	1							r - 1		- Berlin Fra	য় হাজ প		
Image: Name Contract (Contraction) Image: Name Contract (Contraction) Name Contract (Contraction) Image: Name Contract (Name Image: Name Contract (Name Image: Name Contract (Name Image: N)											+												
Internal Lab of Texas Cuara of Exprove RECEDB ANALVASIS RELUES Internal Lab of Texas Cuara of Exprove RECEDB ANALVASIS RELUES Internal Lab of Texas Cuara of Exprove RECEDB ANALVASIS RELUES Internal Lab of Texas Cuara of Exprove RECEDB ANALVASIS RELUES Internal Lab of Texas Relative Lab of Texas Internal Lab of Texas Lab of Texas <th>am</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>m</th> <th></th>	a m								m																
Image: Tenane: Calandor Labor Calandor Custoroly recoma ato Audy tos Recours State: Previe: State: Proprietic: Editory Hitlen Interest State: Proprietic: Editory Hitlen Proprinte:												<u> </u>						-+				ŹŻ			
Internal Lab of Texas Internal Lab of Texas Internation of Texas Interna				1		.]													<u></u>		-	₽ V			
Image: Final of Texas Cuantor of texas Image: Prover 42240-110 Cuantor 122000 recommon Annucless recuests Image: Prover 42240-110 Prover 42240-110 Image: Prover 42240-110 Prover 4220-110 Image: Prover 4200-114/1 Prover 4200-114/1 Image: Prover 4200-114/1 Prover 4200-114/1 Image: Prover 4200-114/1 Prover 4200-114/1 Image: Prover 400-100-114/1 Prover 400-100-114/1 Image: Pro										······································	sbiloz bevloseiü isloj	l ×									[
Image: Final of Texas Cuantor of texas Image: Prover 42240-110 Cuantor 122000 recommon Annucless recuests Image: Prover 42240-110 Prover 42240-110 Image: Prover 42240-110 Prover 4220-110 Image: Prover 4200-114/1 Prover 4200-114/1 Image: Prover 4200-114/1 Prover 4200-114/1 Image: Prover 4200-114/1 Prover 4200-114/1 Image: Prover 400-100-114/1 Prover 400-100-114/1 Image: Pro				Í							.M.A.O.	1									_	P			
Immerial Lab of Texas Main method Main method<			ទ						5		JOL	4										eipt:			
Immerial Lab of Texas Main method Main method<		1s	Ē		In t					×	BTEX 60216/5030	×										eter ~ tere	ents		
Immerial Lab of Texas Main method Main method<	1000	ane	2 Z		ğ				ualy.		səlitejoviməs	;										ners pon	Ê		
Immerical Lab Of Texas Main methods Mai		REC	acha						 ≺	+												ntain contra sals: re.U	្ល		
Immental Lab of Texas Main Provide Action Main Provide Action Program Provide Action Bits Provide Action Program Provide Action Program Provide Action Program Provide Action Bits Provide Action Program Provide Action Prog		SIS	20		ات									<u> </u>								on on vite	ğ		
Immental Lab Of Texas Main Mark Main Mark <th></th> <th>ALY</th> <th>Ш</th> <th></th> <th></th> <th><u> </u></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>\vdash</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>mple bels stod mpe</th> <th>por</th> <th></th> <th></th>		ALY	Ш			<u> </u>							\vdash									mple bels stod mpe	por		
Immerital Lab of Texas CHAIN OF Texas Immerital Lab of Texas Phone: 435841400 Immerital Lab of Texas Phone: 40006 Immerital Lab of Texas State Stampled Immerital Lab Fax No. (505) 337-1471 State Stampled Fax No. (505) 337-1471 State		AN	алпе	ct #	, jo	ő				ſĔ <u>├</u>												Se O Se	<u></u>	<u></u>	
Immerital Lab of Texas CHAIN OF Texas Immerital Lab of Texas Phone: 435841400 Immerital Lab of Texas Phone: 40006 Immerital Lab of Texas State Stampled Immerital Lab Fax No. (505) 337-1471 State Stampled Fax No. (505) 337-1471 State		DNP	et N	roje	lect																		e 、		8
Immerital Lab of Texas CHAIN OF Texas Immerital Lab of Texas Phone: 435841400 Immerital Lab of Texas Phone: 40006 Immerital Lab of Texas State Stampled Immerital Lab Fax No. (505) 337-1471 State Stampled Fax No. (505) 337-1471 State		, D	70 je c	<u>م</u>	Proj					┶╋╌	a de la companya de l	-	┝──┥						171.yu - 4] [-	
Immental Lab of Texas Mountal Lab of Texas ast Phone: 423-661-003 pay Name RICE Operating Company Phone: 423-661-003 any Name RICE Operating Company Klemaper Kitstin Farris Pope Appropriate any Name RICE Operating Company Monton Address: 122 W Taylor Street Phone: 505) 393-9174 Farance Reamine Street Printing Stream of Company Address: 122 W Taylor Street Phone No: 505) 393-9174 France: 205) 393-9174 France: Reamine Stream of Company Andress: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Anno: 1005 (65) 631-3310 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Ano: 1424/2006 Pane No. of Contany Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1		00	ã									┼	\vdash		-	┝							\vdash	1	\leq
Immental Lab of Texas Mountal Lab of Texas ast Phone: 423-661-003 pay Name RICE Operating Company Phone: 423-661-003 any Name RICE Operating Company Klemaper Kitstin Farris Pope Appropriate any Name RICE Operating Company Monton Address: 122 W Taylor Street Phone: 505) 393-9174 Farance Reamine Street Printing Stream of Company Address: 122 W Taylor Street Phone No: 505) 393-9174 France: 205) 393-9174 France: Reamine Stream of Company Andress: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Anno: 1005 (65) 631-3310 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Ano: 1424/2006 Pane No. of Contany Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1		Y RE								(afri)	10S	}	$\left - \right $									B	1.3	<u>.</u> 🖗	2
Immental Lab of Texas Mountal Lab of Texas ast Phone: 423-661-003 pay Name RICE Operating Company Phone: 423-661-003 any Name RICE Operating Company Klemaper Kitstin Farris Pope Appropriate any Name RICE Operating Company Monton Address: 122 W Taylor Street Phone: 505) 393-9174 Farance Reamine Street Printing Stream of Company Address: 122 W Taylor Street Phone No: 505) 393-9174 France: 205) 393-9174 France: Reamine Stream of Company Andress: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Anno: 1005 (65) 631-3310 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Ano: 1424/2006 Pane No. of Contany Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1	10 M	GO,	ļ	1		ļ	. 1		J I			1~	┝╌┤		┝╌┤							J.C	Date	Date	2
Immental Lab of Texas Mountal Lab of Texas ast Phone: 423-661-003 pay Name RICE Operating Company Phone: 423-661-003 any Name RICE Operating Company Klemaper Kitstin Farris Pope Appropriate any Name RICE Operating Company Monton Address: 122 W Taylor Street Phone: 505) 393-9174 Farance Reamine Street Printing Stream of Company Address: 122 W Taylor Street Phone No: 505) 393-9174 France: 205) 393-9174 France: Reamine Stream of Company Andress: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Anno: 1005 (65) 631-3310 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Ano: 1424/2006 Pane No. of Contany Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1		UST								-	a a survey and a survey of the	+		_				-	PCDy age and			SWC.		\$ <u></u> []∶	10
Immental Lab of Texas Mountal Lab of Texas ast Phone: 423-661-003 pay Name RICE Operating Company Phone: 423-661-003 any Name RICE Operating Company Klemaper Kitstin Farris Pope Appropriate any Name RICE Operating Company Monton Address: 122 W Taylor Street Phone: 505) 393-9174 Farance Reamine Street Printing Stream of Company Address: 122 W Taylor Street Phone No: 505) 393-9174 France: 205) 393-9174 France: Reamine Stream of Company Andress: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Anno: 1005 (65) 631-3310 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Ano: 1424/2006 Pane No. of Contany Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1		л С	1						[1												292			
Immental Lab of Texas Mountal Lab of Texas ast Phone: 423-661-003 pay Name RICE Operating Company Phone: 423-661-003 any Name RICE Operating Company Klemaper Kitstin Farris Pope Appropriate any Name RICE Operating Company Monton Address: 122 W Taylor Street Phone: 505) 393-9174 Farance Reamine Street Printing Stream of Company Address: 122 W Taylor Street Phone No: 505) 393-9174 France: 205) 393-9174 France: Reamine Stream of Company Andress: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Anno: 1005 (65) 631-3310 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Ano: 1424/2006 Pane No. of Contany Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1	1	N C	Í	{			1			evi		┢──						{			{	Dri	{		
Immental Lab of Texas Mountal Lab of Texas ast Phone: 423-661-003 pay Name RICE Operating Company Phone: 423-661-003 any Name RICE Operating Company Klemaper Kitstin Farris Pope Appropriate any Name RICE Operating Company Monton Address: 122 W Taylor Street Phone: 505) 393-9174 Farance Reamine Street Printing Stream of Company Address: 122 W Taylor Street Phone No: 505) 393-9174 France: 205) 393-9174 France: Reamine Stream of Company Andress: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Premain: 122 W Taylor Street Anno: 1005 (65) 631-3310 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Anno: 1205 (205) 397-14 France Reamine Stream of Company Ano: 1424/2006 Pane No. of Contany Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1424/2006 Ano: 1	and a	СНА					71			ave.	HOPN										{	(3)(1.2	
Image: Phone: 422-563-1800 Bast Phone: 432-563-1713 Attenage: Kristin Farris Pope kpope@rice Pany Name RICE Operating Company Pan vane RICE Operating Company Vadress: 122 W. Taylor Street Wisterzin: Hobbs, New Mexico 88240 Piphone No: (505) 393-9174 Signature: Rozanne Johnson (505) 631-9310 Email: (702anne@valornet.com Monitor Well #1 4/2 Monitor Well #1 4/2 Monitor Well #1 1/2 PLEASE Email RESULTS TO: Jane Monitor Well #1 0							4	,		rest	HCI (2) 40 ml glass vials	2										anla			
Image: Phone: 422-563-1800 Bast Phone: 432-563-1713 Attenage: Kristin Farris Pope kpope@rice Pany Name RICE Operating Company Pan vane RICE Operating Company Vadress: 122 W. Taylor Street Wisterzin: Hobbs, New Mexico 88240 Piphone No: (505) 393-9174 Signature: Rozanne Johnson (505) 631-9310 Email: (702anne@valornet.com Monitor Well #1 4/2 Monitor Well #1 4/2 Monitor Well #1 1/2 PLEASE Email RESULTS TO: Jane Monitor Well #1 0						•	67					1										nfr			
Image: Phone: 422-563-1800 Bast Phone: 432-563-1713 Attenage: Kristin Farris Pope kpope@rice Pany Name RICE Operating Company Pan vane RICE Operating Company Vadress: 122 W. Taylor Street Wisterzin: Hobbs, New Mexico 88240 Piphone No: (505) 393-9174 Signature: Rozanne Johnson (505) 631-9310 Email: (702anne@valornet.com Monitor Well #1 4/2 Monitor Well #1 4/2 Monitor Well #1 1/2 PLEASE Email RESULTS TO: Jane Monitor Well #1 0				÷							69	×										లే			$\sum_{i=1}^{n}$
Image: Phone: 422-563-1800 Bast Phone: 432-563-1713 Attenage: Kristin Farris Pope kpope@rice Pany Name RICE Operating Company Pan vane RICE Operating Company Vadress: 122 W. Taylor Street Wisterzin: Hobbs, New Mexico 88240 Piphone No: (505) 393-9174 Signature: Rozanne Johnson (505) 631-9310 Email: (702anne@valornet.com Monitor Well #1 4/2 Monitor Well #1 4/2 Monitor Well #1 1/2 PLEASE Email RESULTS TO: Jane Monitor Well #1 0				-			20			b _{en}	No. of Containers	0							(Versee)			Ē	1 2		20
Image: Phone: 422-563-1800 Bast Phone: 422-563-1800 Partis Pope kpope@rice Pay Name RICE Operating Company Vadress: 122 W. Taylor Street Visute/zip: Hobbs, New Mexico 88240 Visute/zip: 122 W. Taylor Street Visute/zip: Field Signature: Rozanne Johnson (505) 631-9310 Email: Forzanne@valornet.com Monitor Well #1 4/2 Monitor Well #1 4/2 Monitor Well #1 1/2 Monitor Well #1 1/2 Monitor Well #1 1/2 Monitor Well #1 1/2	GR					-	<u>ر</u> د			ł			$\left - \right $								\neg	00	00		3
Image: Phone: 422-563-1800 Bast Phone: 422-563-1800 Partis Pope kpope@rice Pay Name RICE Operating Company Vadress: 122 W. Taylor Street Visute/zip: Hobbs, New Mexico 88240 Visute/zip: 122 W. Taylor Street Visute/zip: Field Signature: Rozanne Johnson (505) 631-9310 Email: Forzanne@valornet.com Monitor Well #1 4/2 Monitor Well #1 4/2 Monitor Well #1 1/2 Monitor Well #1 1/2 Monitor Well #1 1/2 Monitor Well #1 1/2							ŇX				5	0										κά	a mar	\mathcal{A}	\leq
Image: Phone: 422-563-1800 Bast Phone: 422-563-1800 Partis Pope kpope@rice Pay Name RICE Operating Company Vadress: 122 W. Taylor Street Visute/zip: Hobbs, New Mexico 88240 Visute/zip: 122 W. Taylor Street Visute/zip: Field Signature: Rozanne Johnson (505) 631-9310 Email: Forzanne@valornet.com Monitor Well #1 4/2 Monitor Well #1 4/2 Monitor Well #1 1/2 Monitor Well #1 1/2 Monitor Well #1 1/2 Monitor Well #1 1/2	S.E7						Ľ	~			Time Sampled	6:3										sa		120	SI.
Image: File ast Phone: 432-653-1713 ast Phone: 432-653-1713 pany Name RICE Operating Company phone No: [505] 393-9174 signature: Rozanne Ophnson Signature: Rozanne@valonnet.com file Annio file Annio <th>(11)</th> <th></th> <th>_</th> <th></th> <th></th> <th></th> <th></th> <th>$\left(\right)$</th> <th>A.</th> <th></th> <th></th> <th> .</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>1</th> <th></th> <th></th> <th><u>Øric</u></th> <th>0</th> <th>2</th> <th>Q.</th>	(11)		_					$\left(\right)$	A.			.							1			<u>Øric</u>	0	2	Q.
Image: File ast Phone: 432-653-1713 ast Phone: 432-653-1713 pany Name RICE Operating Company phone No: [505] 393-9174 signature: Rozanne Ophnson Signature: Rozanne@valonnet.com file Annio	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	•	ő					/			· · · · · · · · · · · · · · · · · · ·											<u>e</u>	× ×	50	S
Image: File ast Phone: 432-653-1713 ast Phone: 432-653-1713 pany Name RICE Operating Company phone No: [505] 393-9174 signature: Rozanne Ophnson Signature: Rozanne@valonnet.com file Annio	a		- <u>p</u>			ļ		\sim		\mathcal{L}								1				doc	15-2		
Immental Lab of Tex ast Phone: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone:	.		MS:							$\langle \rangle$	Date Sampled	4/2										кр Кр	ed ba		\sim
Immental Lab of Tex Phone: 432-563- 9765 Fax: 432-563- 9765 Fax: 432-563- 9810 Name RICE Operating Compe Pany Name RICE Operating Compe Phone No: (505) 393-9174 9700 Signature: Rozanne Johnson (50 Signature: Rozanne Johnson (50 Signature: Rozanne Johnson (50 Phone No: (505) 393-9174 Phone Phone No: (505) 9174 Phone No: (505) 9174 Phone Phone			<u>.</u>	· [<u> </u>			20	2			4/2										ö	sceiv	sceiv	
Immental Lab of Tex Phone: 432-563- 9765 Fax: 432-563- 9765 Fax: 432-563- 9810 Name RICE Operating Compe Pany Name RICE Operating Compe Phone No: (505) 393-9174 9700 Signature: Rozanne Johnson (50 Signature: Rozanne Johnson (50 Signature: Rozanne Johnson (50 Phone No: (505) 393-9174 Phone Phone No: (505) 9174 Phone No: (505) 9174 Phone Phone			Õ					-93		\Rightarrow								{				⊢ ທ	<u>R</u>		
Immental Lab of Tex ast Phone: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone:		(h)	ğ					5		$\left \right\rangle$	the .									Ì		Ë	• <i>⊆</i>		\odot
Immental Lab of Tex ast Phone: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone: 432:563- Fax: 432:563- Phone:		1213	ğ	Ē		540		0 0	ĺ	`												5	Ę 2	Ξ.	21
Thental sast arest arest arest arest arest arest arest areat signature: Roz Signature: Roz Signature: Roz Email: <u>Foz</u> Email: <u>Foz</u> areat areat		× 55		e Qu		88		505		5												ű		\$	2
Thental sast arest arest arest arest arest arest arest areat signature: Roz Signature: Roz Signature: Roz Email: <u>Foz</u> Email: <u>Foz</u> areat areat		32.5	e	b	ee	8		c	c at														9		108
Imental East artes artes artes pany name RIC pany name RIC y Address: 122 Signature: R02 Signature: R02 Signature: R02 Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u>		Maaa Maaa 44	8) D	둸	VeX	4	SO	, i									ļ				, Č	Date	Date	1
Imental East artes artes artes pany name RIC pany name RIC y Address: 122 Signature: R02 Signature: R02 Signature: R02 Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u> Email: <u>F02</u>		hon Fax	ŝ	atir	힌	N N	11	ohr								-		}		1		ш Ш	4/2	: :	7
Thental the trip of tr		<u></u>	ar	Der	Tay	Nei	5-6	٩	é													AS		1	
Thental the trip of tr			LL L	õ	2 Z	ъ,	36	iuu			<u>۳</u>											Ш			21
VITONTRON VITONTRON Ivest I-20 East sa, Texas 79765 Project Manager: KI Company Address: 12 Company Addres	D.Y.	्रम्प् द्रम्प	isti	U U	2	g	62	oza	727			/ell				ļ	ļ					ር			<u>z</u>
In the set of the set	_	497 1995 1997	죄	æ	2	쾨	छ	Ř	2			21 1]							200	
Ray Ny Project Mani Ny Fromany N Project Mani Company Addi Company A		6	nger.	ame	655	/Zip:	No:	ture	naíl [.]		-	2 nitc										1		11	
Interventional and the second			វិនរាa	ΝŃ	Vddr	tate	anor	gnat	ů.	í		Ĭ					<u> </u>							$\langle \rangle$	X
Randol Aliantic Alian		1979 7976	sct N	npar	ny A	hyiS	leph	ır Siç			[[]] [] [] [] [] [] [] [] []											;sin	1 1 1	4	X
sa, Tey West A VII Instrumente Sa Con F,	12.00	O 1-20	roje	Соп	mpa	õ	Te.	nple			Lo e		圆									veti	N.		10
		text Text	σ		COI			Sar			1 O	5									셁	nstr	(F) X	ed b	3
🗖 🗖 💥 👘 The Net State of the State of th		O W Sa,										3											欖灯	infsh	the
	16										A CO											bec	憲令	eling	J.
		0										للاث	<u>1997</u>	<u>- 22</u>	8.0	<u></u>	256	531	267	< 3	e p	u;		<u> fl</u> ∝	î^

A COMPANY OF

Environmental La				
Variance / Corrective Action F	Report	– Sa	mple Log-In	
nt <u>Rice Op.</u>				
ATTIME: 4/24/020 10:30		-		
$==== \frac{602701}{1000}$				
als:				
Sample Receipt	Chackli	ct		
Derature of container/cooler?	Yes I	No I	2.0 C I	1
ncing container/cooler in good condition?	JES	NIO		, , , , , , , , , , , , , , , , , , ,
ady Seals intact on shipping container/cooler?	Per I	Na	Not present	
cdy Seals intact on sample bottles?	Les	No	Not present	
in of custody present?	125	No		ļ -
Tole Instructions complete on Chain of Custody? In of Custody signed when relinquished and received?	- Es	No No	·····	-
in of custody agrees with sample label(s)		No I		 -
tainer labels ledible and intact?	YES	No		
tole Matrix and properties same as on chain of custody?	Yes	NO		
tolas in procer container/bottle?	1 65	NO		Ì
ncies proderly preserved?	- A	1 No		
nople bottles intact?		I NO		1
servations documented on Chain of Custody? Itainers documented on Chain of Custody?	-0-	No		+
ficient sample amount for indicated test?		I No I I No I		
samples received within sufficient hold time?		NO I	······	
C complex have zero headspace?	1 YE	No	Net Acclicable	
Variance Docur entact Person: Date/Time:	nentatio	on:	Contracted by:	
Date/Time:Date/Time:	/ _	<u> </u>	Contacted by:	
arrective Action Taken:				
	· · ·			
· · · · · · · · · · · · · · · · · · ·	····			
· · · · · · · · · · · · · · · · · · ·				
		with Brighten		
387				· · · · · · · · · · · · · · · · · · ·

Name States

MULLING INC. MULLING TRACEANALYSIS, INC. MULLING

6701 Aberdeen Avenue, Suite 9 155 McCutcheon, Suite H Lubbock, Texas 79424 800•378•1296 El Paso, Texas 79932 888•588•3443 E-Mail lab@traceanalysis.com 806 • 794 • 1296 FAX 806 • 794 • 1298 915 • 585 • 3443 FAX 915 • 585 • 4944

Analytical and Quality Control Report

Kristen Farris-Pope Rice Operating Company 122 W Taylor Street Hobbs, NM, 88240

6 934 6

1. 3451 . 2451 San 2. 10000

A LAND A

ALCONTRACTOR

Project Location:Lea County,NMProject Name:BD Zachary HintonProject Number:BD Zachary Hinton

Report Date: August 9, 2006

Work Order: 6072143

Enclosed are the Analytical Report and Quality Control Report for the following sample(s) submitted to TraceAnalysis, Inc.

			Date	Time	Date
Sample	Description	Matrix	Taken	Taken	Received
96140	Monitor Well #1	water	2006-07-19	12:55	2006-07-21

These results represent only the samples received in the laboratory. The Quality Control Report is generated on a batch basis. All information contained in this report is for the analytical batch(es) in which your sample(s) were analyzed.

This report consists of a total of 10 pages and shall not be reproduced except in its entirety, without written approval of TraceAnalysis, Inc.

Michael ale

Dr. Blair Leftwich, Director

Report Date: August 9, 2006 BD Zachary Hinton

The supervised of the supervis

A. 1998 A. 1998 A.

and the second

5. 5. 5 X

1.7.7.86.20

6 95. AV19

The state of the state

a and a second secon

1.1

A Star and

The second

5. 22.00 S.

Analytical Report

Sample: 96140 - Monitor Well #1

Analysis:AlkalinityQC.Batch:28340Prep Batch:24777		Analytical Method: Date Analyzed: Sample Preparation:	SM 2320B 2006-07-26 2006-07-25	Prep Method: Analyzed By: Prepared By:	
×		RL			
Parameter	Flag	Result	Units	Dilution	RL
Hydroxide Alkalinity	·	<1.00	mg/L as CaCo3	1	1.00
Carbonate Alkalinity		<1.00	mg/L as CaCo3	1	1.00
Bicarbonate Alkalinity		188	mg/L as CaCo3	1	4.00
Total Alkalinity		188	mg/L as CaCo3	1	4.00

Sample: 96140 - Monitor Well #1

Analysis:	BTEX	Analytical Method:	S 8021B	Prep Method:	S 5030B
QC Batch:	28277	Date Analyzed:	2006-07-24	Analyzed By:	MT
Prep Batch:	24759	Sample Preparation:	2006-07-24	Prepared By:	MT
		RL			

Parameter	Flag	Resi	ult	Units	Γ	Dilution	RL
Benzene		< 0.0010	00	mg/L		1	0.00100
Toluene		< 0.0010	00	mg/L		1	0.00100
Ethylbenzene		< 0.0010	00	mg/L		1	0.00100
Xylene		< 0.0010	00	mg/L		1	0.00100
					Spike	Percent	Recovery
Surrogate	Flag	Result	Units	Dilution	Amount	Recovery	Limits
Trifluorotoluene (TFT)		0.0961	mg/L	1	0.100	96	66.2 - 127.7
4-Bromofluorobenzene (4-BFB	B) ¹	0.0585	mg/L	1	0.100	58	70.6 - 129.2

Sample: 96140 - Monitor Well #1

Analysis: Cations QC Batch: 28356 Prep Batch: 24749		Analytical Method: Date Analyzed: Sample Preparation:	S 6010B 2006-07-26 2006-07-24	Prep Method: Analyzed By: Prepared By:	
		RL			
Parameter	Flag	Result	Units	Dilution	RL
Dissolved Calcium	· · · · · · · · · · · · · · · · · · ·	98.2	mg/L	<u>l</u>	0.500
Dissolved Potassium		12.8	mg/L	1	1.00
Dissolved Magnesium		49.3	mg/L	1	1.00
Dissolved Sodium		230	mg/L	10	1.00

Sample: 96140 - Monitor Well #1

Analysis:	lon Chromatography	Analytical Method:	E 300.0	Prep Method:	N/A
QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	Sample Preparation:	2006-08-02	Prepared By:	WB

¹BFB surrogate recovery outside normal limits. ICV/CCV and TFT surrogate recovery show the method to be in control.

Parameter Flag Chloride Sulfate		RL Result 375					
Chloride							
		375		Jnits	Di	lution	R
Sullate				ng/L		50	0.50
		234	r	ng/L		50	0.50
Sample: 96140 - Monitor Well #	#1						
Analysis: TDS		Analytical Meth	nod: SM 2	540C		Prep N	1ethod: N/2
QC Batch: 28406		Date Analyzed:		-07-27		-	zed By: SM
Prep Batch: 24850	,	Sample Prepara		-07-26			ed By: SN
		RL		÷			
Parameter	Flag	Result		Units		Dilution	R
Total Dissolved Solids		1318	3	mg/L		2	10.0
Method Blank (1) QC Batch: QC Batch: 28277	: 28277	Date Analyze QC Preparatic				Analyz Prepar	-
Method Blank (1) QC Batch: QC Batch: 28277	: 28277	Date Analyze	on: 2006-07				-
Method Blank (1) QC Batch: QC Batch: 28277 Prep Batch: 24759		Date Analyze	on: 2006-07 MDL		Unit	Prepar	ed By: M
Method Blank (1) QC Batch: QC Batch: 28277 Prep Batch: 24759 Parameter	: 28277 Flag	Date Analyze QC Preparatic	on: 2006-07		Unii mg/	Prepar	ed By: M ^r
Method Blank (1) QC Batch: QC Batch: 28277 Prep Batch: 24759 Parameter Benzene		Date Analyze QC Preparatio	on: 2006-07 MDL Result			Prepar ts L	ed By: M ^r
Method Blank (1) QC Batch: QC Batch: 28277 Prep Batch: 24759 Parameter Benzene Toluene Ethylbenzene		Date Analyze QC Preparatio	MDL Result <0.000255 <0.000210 <0.000317		mg/ mg/ mg/	Prepar ts L L L	ed By: M [*]
Method Blank (1) QC Batch: QC Batch: 28277 Prep Batch: 24759 Parameter Benzene Toluene Ethylbenzene		Date Analyze QC Preparatio	MDL Result <0.000255 <0.000210		mg/ mg/	Prepar ts L L L	ed By: M [*]
Method Blank (1) QC Batch: QC Batch: 28277 Prep Batch: 24759 Parameter Benzene Toluene Ethylbenzene Xylene	Flag	Date Analyze QC Preparatic	MDL Result <0.000255 <0.000210 <0.000317 <0.000603	7-24	mg/ mg/ mg/ Spike	Prepar ts L L L L Percent	ed By: M RL 0.00 0.00 0.00 0.00 0.00 Recover
Method Blank (1) QC Batch: QC Batch: 28277		Date Analyze QC Preparatic « « « « « « « « « « « « « « « « « « «	MDL Result <0.000255 <0.000210 <0.000317 <0.000603		mg/ mg/ mg/	Prepar ts L L L L	ed By: MT RL 0.00 0.00 0.00 0.00

Flag	Result	Units	KL
	< 1.00	mg/L as CaCo3	1
	<1.00	mg/L as CaCo3	I
	<4.00	mg/L as CaCo3	4
	<4.00	mg/L as CaCo3	4
	r lag	<1.00 <1.00 <4.00	<1.00 mg/L as CaCo3 <1.00

Method Blank (1) QC Batch: 28356

QC Batch:	28356	Date Analyzed:	2006-07-26	Analyzed By:	TP
Prep Batch:	24749	QC Preparation:	2006-07-24	Prepared By:	TS

and a Cire

A DATE AND

Anna Tarras Marina Anna Anna Anna Anna Anna

AL AL STREET

A ANALAS

A Not

And States

Constant.

100 miles

and B. S. I

Aller M. H.

ALL AND ALL

the state of the s

t in The Oak

A. A. M.

9-14 N. 1

Constant of the

State of the

Alfan in Mail

Section Providence

Starter 1

10 - 10 - 0 -

L States

T. Share's

2.1.2

The state of

1.2.4.2.382

R. NER.

5 20.0° 192

and the second

1.8 3 miles

		MDL		
Parameter	Flag	Result	Units	RL
Dissolved Calcium		0.132	mg/L	0.5
Dissolved Potassium		1.08	mg/L	1
Dissolved Magnesium		< 0.704	mg/L	1
Dissolved Sodium		0.836	mg/L	1

Method Blank (1) QC Batch: 28406

QC Batch: 28406 Prep Batch: 24850		nalyzed: 2006-07-27 paration: 2006-07-26		Analyzed By: S Prepared By: S	
		MDL			
Parameter	Flag	Result	Units		RL
Total Dissolved Solids		<5.000	mg/L		10

Method Blank (1) QC Batch: 28782

QC Batch:2Prep Batch:2		Date Analyzed: 2006-08-02 QC Preparation: 2006-08-02		alyzed By: WB pared By: WB
		MDL		
Parameter	Flag	Result	Units	RL
Chloride		<0.0181	mg/L	0.5
Sulfate		< 0.0485	mg/L	0.5

Duplicates (1)

QC Batch:	28340	Date Analyzed:	2006-07-26	Analyzed By:	LJ
Prep Batch:	24777	QC Preparation:	2006-07-25	Prepared By:	LJ

Param	Duplicate Result	Sample Result	Units	Dilution	RPD	RPD Limit
Hydroxide Alkalinity	<1.00	<1.00	mg/L as CaCo3	1	0	20
Carbonate Alkalinity	<1.00	<1.00	mg/L as CaCo3	1	0	20
Bicarbonate Alkalinity	110	108	mg/L as CaCo3	1	2	12.6
Total Alkalinity	110	108	mg/L as CaCo3	1	2	11.5

Duplicates (1)

QC Batch: 28406 Prep Batch: 24850		Analyzed: 2006 reparation: 2006		Analyzed I Prepared E	•	
Param	Duplicate Result	Sample Result	Units	Dilution	RPD	RPD Limit
Total Dissolved Solids	768.0	928.0	mg/L	2	19	17.2

Laboratory Control Spike (LCS-1)

A Standar

11.62

and the second

a.a.

10. 10 A 1940

Salar Ar

10. 10 AN

AL 24 24

14 - C - Val

to failed on the

に通る時間

A. B. Bank

APRA STATE

1000

QC Batch: 28277 Prep Batch: 24759		Date Analyzed: QC Preparation:			Analyzed By: Prepared By:	MT MT	
	LCS			Spike	Matrix		Rec.
Param	Resul	t Units	Dil.	Amount	Result	Rec.	Limit
Benzene	0.109	mg/L	1	0.1	0	109	
Toluene	0.108	8 mg/L	1	0.1	0	108	
Ethylbenzene	0.109) mg/L	1	0.1	0	109	
Xylene	0.322	2 mg/L	1	0.3	0	107.333	

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	LCSD			Spike	Matrix		Rec.		RPD
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Benzene	0.104	mg/L	1	0.1	0	109		4.7	20
Toluene	0.103	mg/L	1	0.1	0	108		4.7	20
Ethylbenzene	0.101	mg/L	1	0.1	0	109		7.6	20
Xylene	0.306	mg/L	1	0.3	0	107.333		5.1	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	LCS	LCSD			Spike	LCS	LCSD	Rec.
Surrogate	Result	Result	Units	Dil.	Amount	Rec.	Rec.	Limit
Trifluorotoluene (TFT)	0.101	0.101	mg/L	1	0.100	101	101	81.8 - 114
4-Bromofluorobenzene (4-BFB)	0.112	0.111	mg/L	1	0.100	112	111	72.7 - 116

Laboratory Control Spike (LCS-1)

C Batch: 28356 ep Batch: 24749		2006-07-26 2006-07-24		Analyzed By Prepared By:			
ram	LCS Result	Units	Dil.	Spike Amount	Matrix Result	Rec.	Rec. Limit

Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Dissolved Calcium	51.7	mg/L	1	50	0	103.4	
Dissolved Potassium	50.8	mg/L	1	50	0	101.6	
Dissolved Magnesium	51.5	mg/L	1.	50	0	103	
Dissolved Sodium	50.5	mg/L	1	50	0	101	

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	LCSD			Spike	Matrix		Rec.		RPD
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Dissolved Calcium	51.7	mg/L	1	50	0	103.4		0	20
Dissolved Potassium	49.3	mg/L	1	50	0	101.6		3	20
Dissolved Magnesium	49.8	mg/L	1	50	0	103		3.4	20
Dissolved Sodium	48.6	mg/L	1	50	0	101		3.8	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Laboratory Control Spike (LCS-1)

QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	QC Preparation:	2006-08-02	Prepared By:	WB

Report Date: August 9, 2006	Work Order: 6072143	
BD Zachary Hinton	BD Zachary Hinton	

	LCS			Spike	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Chloride	12.2	mg/L	1	12.5	0	97.6	
Sulfate	12.5	mg/L	1	12.5	0	100	

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Param	LCSD Result	Units	Dil.	Spike Amount	Matrix Result	Rec.	Rec. Limit	RPD	RPD Limit
Chloride	12.2	mg/L	<u></u>	12.5	0	97.6		0.8	20
Sulfate	12.3	mg/L	1	12.5	0	100		0.0	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Matrix Spike (MS-1) Spiked Sample: 96149

A STATE OF STATE

A CALL A

A Not C

State of the second

and the Pileton

4 States

A. 11 (A. 13)

C. Said

And And And

Ald States

and the second

QC Batch:	28277	Date Analyzed:	2006-07-24	Analyzed By:	MT
Prep Batch:	24759	QC Preparation:	2006-07-24	Prepared By:	MT

	MS			Spike	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Benzene	0.107	mg/L	1	0.100	< 0.000255	107	70.9 - 126
Toluene	0.105	mg/L	1	0.100	< 0.000210	105	70.8 - 125
Ethylbenzene	0.106	mg/L	1	0.100	< 0.000317	106	74.8 - 125
Xylene	0.311	mg/L	1	0.300	< 0.000603	104	75.7 - 126

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

		MSD			Spike	Matrix		Rec.		RPD
Param		Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Benzene	2	NA	mg/L	1	0.100	< 0.000255	0	70.9 - 126	200	20
Toluene	3	NA	mg/L	1	0.100	< 0.000210	0	70.8 - 125	200	20
Ethylbenzene	4	NA	mg/L	1	0.100	< 0.000317	0	74.8 - 125	200	20
Xylene	5	NA	mg/L	1	0.300	< 0.000603	0	75.7 - 126	200	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

		MS	MSD			Spike	MS	MSD	Rec.
Surrogate		Result	Result	Units	Dil.	Amount	Rec.	Rec.	Limit
Trifluorotoluene (TFT)	6	0.101	NA	mg/L	1	0.1	101	0	73.6 - 121
4-Bromofluorobenzene (4-BFB)	7	0.110	NA	mg/L	1	0.1	110	0	81.8 - 114

Matrix Spike (MS-1) Spiked Sample: 96124

QC Batch:	28356	Date Analyzed:	2006-07-26	Analyzed By:	TP
Prep Batch:	24749	QC Preparation:	2006-07-24	Prepared By:	TS

²RPD is out of range because a matrix spike duplicate was not prepared.

³RPD is out of range because a matrix spike duplicate was not prepared.

⁴RPD is out of range because a matrix spike duplicate was not prepared. ⁵RPD is out of range because a matrix spike duplicate was not prepared.

⁶RPD is out of range because a matrix spike duplicate was not prepared.

⁷RPD is out of range because a matrix spike duplicate was not prepared.

Automore an

An Cherry of a

a Provident

A BULLER

1. S. W. S.

The second second

Same strengt

PRANS BASE

A RAN A

a national a

8. XT. 78. W

22.00

0.0%-0

	MS			Spike	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Dissolved Calcium	416	mg/L	1	50.0	361	110	68.4 - 138
Dissolved Potassium	73.8	mg/L	1	50.0	22	104	82 - 129
Dissolved Magnesium	208	mg/L	1	50.0	147	122	61.2 - 135
Dissolved Sodium	633	mg/L	1	50.0	578	110	81.8 - 125

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	MSD			Spike	Matrix		Rec.		RPD
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Dissolved Calcium	406	mg/L	1	50.0	361	90	68.4 - 138	2	20
Dissolved Potassium	81.3	mg/L	1	50.0	22	119	82 - 129	10	20
Dissolved Magnesium	194	mg/L	1	50.0	147	94	61.2 - 135	7	20
Dissolved Sodium	637	mg/L	1	50.0	578	118	81.8 - 125	1	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Matrix Spike (MS-1) Spiked Sample: 96141

QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	QC Preparation:	2006-08-02	Prepared By:	WB ·

	MS			Spike	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Chloride	2210	mg/L	100	12.5	988	98	25.4 - 171
Sulfate	1580	mg/L	100	12.5	298	102	0 - 677

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Param	MSD Result	Units	Dil.	Spike	Matrix Result	Rec.	Rec. Limit	RPD	RPD Limit
Chloride	2200	mg/L	<u> </u>	Amount 12.5	<u>988</u>	97	25.4 - 171	0	20
Sulfate	1550	mg/L	100	12.5	298	100	0 - 677	2	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Standard (ICV-1)

QC Batch: 282	.77		Date Analy	zed: 2006-07-	24	Ana	lyzed By: MT
			ICVs	lCVs	lCVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Benzene		mg/L	0.100	0.104	104	85 - 115	2006-07-24
Toluene		mg/L	0.100	0.104	104	85 - 115	2006-07-24
Ethylbenzene		mg/L	0.100	0.104	104	85 - 115	2006-07-24
Xylene		mg/L	0.300	0.314	105	85 - 115	2006-07-24

Standard (CCV-1)

QC Batch: 28277

Date Analyzed: 2006-07-24

Analyzed By: MT

Report Date: August 9 BD Zachary Hinton	9, 2006	· 		rder: 6072143 chary Hinton			Number: 8 of 1 Lea County,NI
			CCVs	CCVs	CCVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Benzene	_	mg/L	0.100	0.107	107	85 - 115	2006-07-2
Toluene		mg/L	0.100	0.105	105	85 - 115	2006-07-2
Ethylbenzene		mg/L	0.100	0.106	106	85 - 115	2006-07-2
Xylene		mg/L	0.300	0.311	104	85 - 115	2006-07-2
Standard (ICV-1)							
QC Batch: 28340			Date Analyzed:	2006-07-26		Ana	alyzed By: L.
,			ICVs	ICVs	ICVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Total Alkalinity		mg/L as CaCo2	-	240	96	90 - 110	2006-07-2
Standard (CCV-1) QC Batch: 28340			Date Analyzed:	2006-07-26		Ana	alyzed By: L
			CCVs	CCVs	CCVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Total Alkalinity		mg/L as CaCo3	3 250	240	96	90 - 110	2006-07-2
Standard (ICV-1)							
QC Batch: 28356			Date Analyzed:	2006-07-26		Ana	lyzed By: TI
			lCVs	ICVs	ICVs	Percent	
			True	Found	Percent	Recovery	Date
Param		Flag Units	Conc.	Conc.	Recovery	Limits	Analyzed
Dissolved Calcium		mg/L	50.0	50.7	101	90 - 110	2006-07-2
Dissolved Potassium		mg/L	50.0	52.0	104	90 - 110	2006-07-2
Dissolved Magnesium		mg/L	50.0	49.6	99	90 - 110	2006-07-2
Dissolved Sodium		mg/L	50.0	50.9	102	90 - 110	2006-07-2
Standard (CCV-1)							
QC Batch: 28356			Date Analyzed:	2006-07-26		Ana	lyzed By: TI
			CCVs	CCVs	CCVs	Percent	_
D			True	Found	Percent	Recovery	Date
Param		Flag Units	Conc.	Conc.	Recovery	Limits	Analyzed
Dissolved Calcium		mg/L	50.0	51.2	102	90 - 110	2006-07-2
Dissolved Potassium		mg/L	50.0	54.6	109	90 - 110	2006-07-2
Dissolved Magnesium		mg/L mg/L	50.0 50.0	50.0 53.2	100 106	90 - 110 90 - 110	2006-07-2
Dissolved Sodium							2006-07-2

ana na an

Sandara da

e 46, 67, 65

1001, 0.3 , 1

Aberta at a

A Sector A

A STREET

The first state

A DESCRIPTION

1 - 1 - 1 1 - 1 - 1

100 1121

Contraction of the

4. B. 6302 -

18.08.00 V

Report Date: August 9, 20 BD Zachary Hinton		Work C BD Za	Page Number: 9 of 1 Lea County,NN				
Standard (ICV-1)							
QC Batch: 28406		Dat	e Analyzed:	2006-07-2	7	Ana	lyzed By: SM
			ICVs	ICVs	ICVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Total Dissolved Solids		mg/L	1000	1056	106	90 - 110	2006-07-2
Standard (CCV-1)							
QC Batch: 28406		Dat	e Analyzed:	2006-07-2	7	Ana	lyzed By: SN
			CCVs	CCVs	CCVs	Percent	
			True	Found	Percent	Recovery	Date
						•	
Param	Flag	Units			Recoverv	Limits	Analyzed
Total Dissolved Solids	Flag	Units mg/L	Conc. 1000	Conc. 1075	Recovery 108	Limits 90 - 110	
Param Total Dissolved Solids Standard (ICV-1) QC Batch: 28782	Flag	mg/L	Conc.	Conc. 1075	108	90 - 110	2006-07-2
Total Dissolved Solids Standard (ICV-1)	Flag	mg/L	Conc. 1000 e Analyzed:	Conc. 1075	108	90 - 110	2006-07-2
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782		mg/L Dat	Conc. 1000 e Analyzed: J F	Conc. 1075 2006-08-02 CVs 'ound	108 2 ICVs Percent	90 - 110 Anal Percent Recovery	2006-07-2 yzed By: WE Date
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag	Units	mg/L Dat ICVs True Conc	Conc. 1000 e Analyzed: F	Conc. 1075 2006-08-02 CVs Found Conc.	108 ICVs Percent Recovery	90 - 110 Anal Percent Recovery Limits	2006-07-2 yzed By: WF Date Analyzed
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride	Units mg/L	mg/L Dat ICVs True Conc 12.5	Conc. 1000 e Analyzed: F	Conc. 1075 2006-08-02 CVs Yound Conc. 12.4	ICVs Percent Recovery 99	90 - 110 Anal Percent Recovery Limits 90 - 110	2006-07-2 yzed By: WF Date Analyzec 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782	Units	mg/L Dat ICVs True Conc	Conc. 1000 e Analyzed: F	Conc. 1075 2006-08-02 CVs Found Conc.	108 ICVs Percent Recovery	90 - 110 Anal Percent Recovery Limits	2006-07-2 yzed By: WE Date Analyzed 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride	Units mg/L	mg/L Dat ICVs True Conc 12.5	Conc. 1000 e Analyzed: F	Conc. 1075 2006-08-02 CVs Yound Conc. 12.4	ICVs Percent Recovery 99	90 - 110 Anal Percent Recovery Limits 90 - 110	2006-07-2 yzed By: WE Date Analyzed 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1)	Units mg/L	mg/L Dat ICVs True Conc 12.5 12.5	Conc. 1000 e Analyzed: F	Conc. 1075 2006-08-02 CVs Yound Conc. 12.4 12.7	ICVs Percent Recovery 99 102	90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110	2006-07-2 yzed By: WE Date Analyzed 2006-08-0 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate	Units mg/L	mg/L Dat ICVs True Conc 12.5 12.5	Conc. 1000 e Analyzed: F C	Conc. 1075 2006-08-02 CVs Yound Conc. 12.4 12.7	ICVs Percent Recovery 99 102	90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110	2006-07-2 yzed By: WE Date Analyzed 2006-08-0 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782	Units mg/L mg/L	mg/L Dat ICVs True Conc 12.5 12.5 Dat CCVs True	Conc. 1000 e Analyzed: F C e Analyzed: s C F	Conc. 1075 2006-08-02 CVs Jound Conc. 12.4 12.7 2006-08-02 CCVs Jound	ICVs Percent Recovery 99 102 CCVs Percent	90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 Anal Percent Recovery	Date Analyzed 2006-08-0 2006-08-0 yzed By: WE Date
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782 Param Flag Flag Standard (CCV-1) Param Flag Param Flag Flag Chard (CCV-1) Param Flag	Units mg/L mg/L Units	mg/L Dat ICVs True Conc 12.5 12.5 Dat CCVs True Conc	Conc. 1000 e Analyzed: F C e Analyzed: s C F C C C C C C C C C C C C C	Conc. 1075 2006-08-02 CVs Cound Conc. 12.4 12.7 2006-08-02 CCVs Cound Conc.	108 ICVs Percent Recovery 99 102 CCVs Percent Recovery	90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 Anal Percent Recovery Limits	2006-07-2 yzed By: WE Date Analyzed 2006-08-0 2006-08-0 2006-08-0 yzed By: WE Date Analyzed
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782	Units mg/L mg/L	mg/L Dat ICVs True Conc 12.5 12.5 Dat CCVs True	Conc. 1000 e Analyzed: F C e Analyzed: s C F C	Conc. 1075 2006-08-02 CVs Jound Conc. 12.4 12.7 2006-08-02 CCVs Jound	ICVs Percent Recovery 99 102 CCVs Percent	90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 Anal Percent Recovery	2006-07-2 yzed By: WE Date Analyzed 2006-08-0 2006-08-0 yzed By: WE Date

8. 58.

AL AND AL

a Alana a

an a le version de la version

No. of the local division of the local divis

20.02

1. a. X.

Concent.

12 . 3 . A.

A CONTRACT

A. A. C. M. P.

Contra -

1995 J. W. W.

24.15

X74.9

1. 1. L.

Constraints and

Work Order: 6072143 BD Zachary Hinton

The Party

a strange

Acres and

A STATE OF STATE

A AN TANK

10. 20 CA

ALC: NO PERSONNAL PROPERTY OF

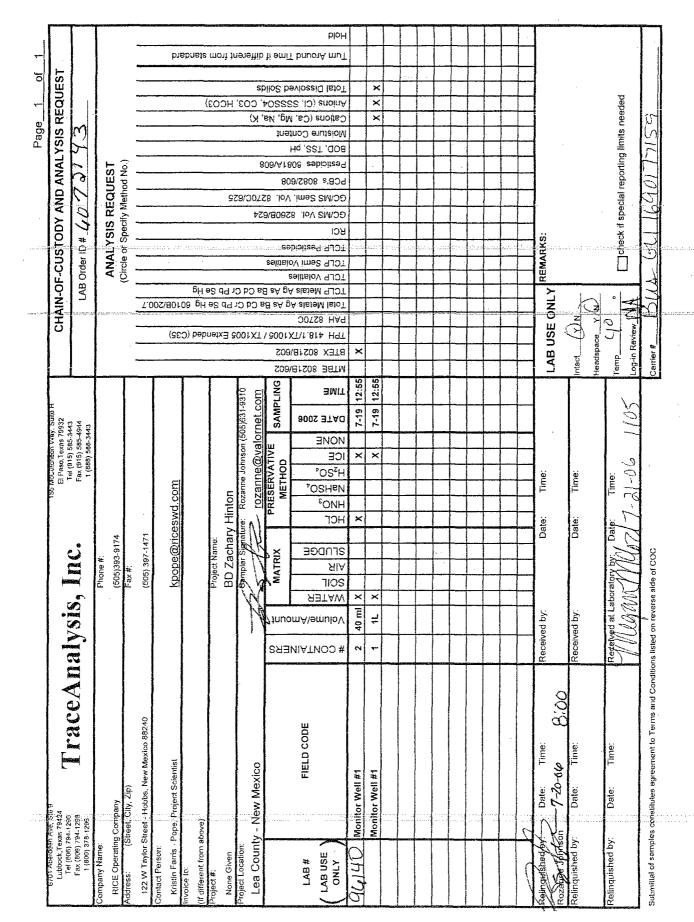
A REAL

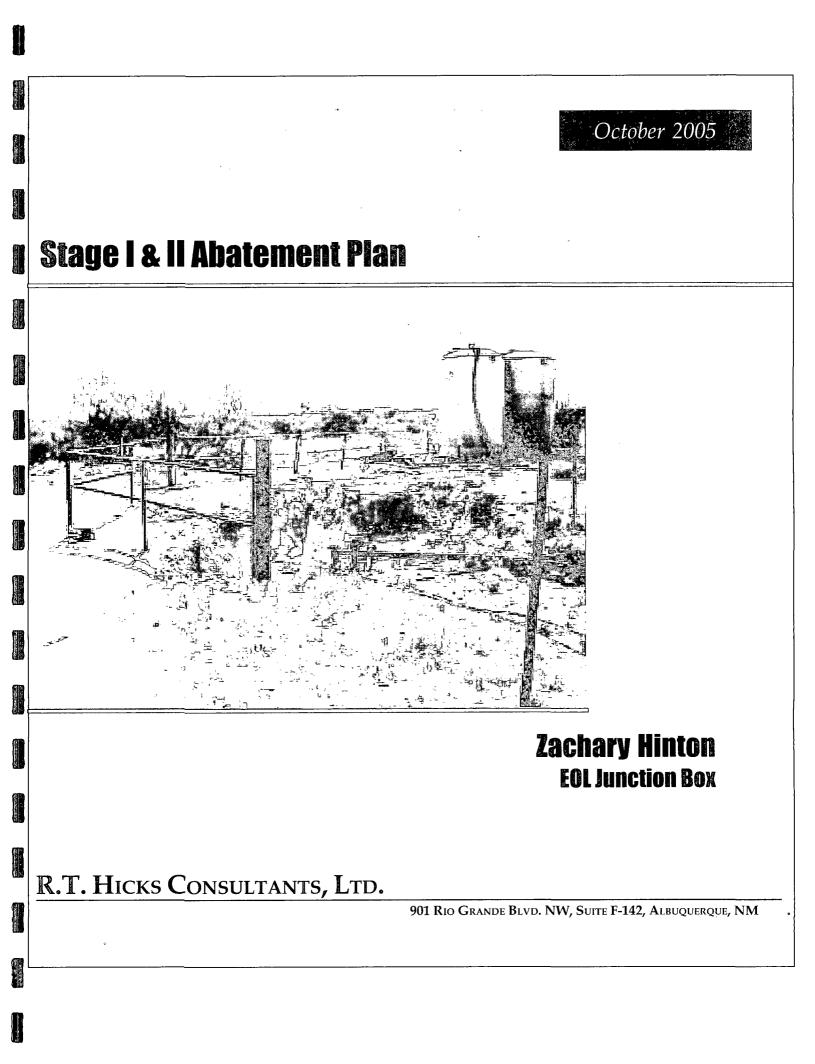
10. Walt

Acres 1. Carlo

ALC: NOT A

1. 2. A. W.





R.T. HICKS CONSULTANTS, LTD.

1.0 EXECUTIVE SUMMARY

This report presents the results of the characterization activities performed by R.T. Hicks Consultants (Hicks Consultants) and Rice Operating Company (ROC) at the Zachary Hinton EOL Junction Box site. Based on field data, laboratory results, and predictive modeling, the selected remedy for the site involves placing clean fill within the excavation and placing about 3-feet of topsoil and over the site installed with a slight crown to promote surface runoff, then seeding the site with native vegetation. Using highly conservative input data, HYDRUS-1D modeling of this scenario predicts that resulting ground water chloride concentrations due to migration of residual chloride to ground water are less than 70 ppm above background concentrations (assumed as 100 ppm) after five years.

Ground water monitoring data confirm that the HYDRUS-1D predictions are conservative in that they over estimate the impact of residual chloride transport to ground water. After two years of ground water monitoring, chloride concentrations in ground water beneath the site have returned to ambient conditions (300-400 ppm).

We propose to employ MODFLOW and its contaminant transport module to predict the fate and transport of the historic impact to ground water quality evidenced by the first sample analysis. We hypothesize that the simulation modeling will show that natural dilution and dispersion has effectively mitigated any past impact to ground water quality.

This remedy is protective of ground water quality, human health, and the environment. We recommend that NMOCD close the regulatory file after completion of surface restoration and proposed modeling and forego regulation of this site under Rule 19.

STARE I & IN ABATEMENT PLAN -October 12, 2005

NN - Zachary Minton EQL Innetion Box (8-12)

Page 1 OCD Case # 1R0426-36

2.0 DATA SUMMARY & CONCLUSIONS

2.1 DATA SUMMARY

- 1. In early 2002, ROC upgraded the junction box, characterized the upper vadose zone, and installed a monitoring well about 20 feet down gradient from the former box.
- 2. Chloride concentrations in the vadose zone exceed 1,000 ppm from 5 feet below ground surface to ground water.
- 3. The first ground water sample from the monitoring well exhibited a chloride concentration of 1,000 ppm.
- 4. Sampling of nearby supply wells demonstrates that the ambi ent chloride concentration in ground water is 300-400 ppm at the site.
- 5. Nine months of quarterly monitoring after installation of the monitoring well, chloride concentrations in samples from the monitoring well returned to the regional background concentration, 300-400 ppm.

2.2 CONCLUSIONS

- 1. The chemical data, the sandy lithology of the vadose zone, the lack of hydrocarbons in soil, and the water production history of the site support a conclusion that periodic small releases of produced water moved vertically from the junction box to ground water without horizontal dispersion.
- 2. The nature of the release and the site investigation results support a conclusion that the magnitude and extent of the release is sufficiently defined to permit design of a remedy.
- 3. In the past, leakage from the site caused a highly localized zone of ground water impairment.
- 4. Due to the nature of the release, the cross-gradient (east-west) extent of the historic impairment of ground water is probably less than 40 feet.
- 5. Although a single monitoring well cannot define the down gradient (north-south) extent of chloride in ground water caused by past releases, the Second Law of Thermodynamics supports a conclusion that natural dispersion and dilution will cause chloride to reach background concentrations after a relatively short down gradient transport distance.
- 6. Ground water data from nearby wells and data from the Zachary Hinton EOL site monitoring wells support the conclusion that 2004-2005 ground water samples from the Zachary Hinton EOL monitoring well are at background concentrations

STAGE I.e. N ABATEMENT PLAN - Zachary Ninton EEL Inactien Box (0-12) October 12, 2005 Page 2 OCD Case # 1R0426-36 and therefore do not now exceed the state ground water standards for chloride and TDS.

- 7. Other than TDS and chloride, no other constituents of concern exceed the New Mexico numerical ground water standards in the area near the site.
- 8. The HYDRUS-1D simulation that considers re-vegetation of the site provides an accurate representation of the current condition and agrees with site ground water data.

2.3 PROPOSED REMEDY

We recommend restoring the ground surface in the excavation using soil that will permit re-vegetation. Because the water quality at the site has returned to background conditions, we recommend plugging and abandonment of the existing monitoring well and closure of the regulatory file for this site, pending documentation of appropriate surface reclamation and presentation of the proposed saturated zone modeling experiment.

STAGELE, HABATEMENT PLAN-October 12, 2005

Tachary Binton EGL Junction Box (6-12)

Page 3 CCD Case # 1R0426-36

3.0 STAGE 1 ABATEMENT PLAN

ROC characterized the uppermost vadose zone during the junction box upgrade program. The results of this characterization are included in the disclosure report (Appendix A). ROC obtained samples of the deep vadose zone using an air-rotary technique and split spoon sampling. This delineation program adequately defines site conditions, and provide the data necessary to select and design an effective abatement option for the vadose zone (see Rule 19.15.1.19.E.3).

ROC characterized the saturated zone through more than three years of ground water monitoring. Hicks Consultants and ROC augmented this ground water quality database by collecting samples from nearby wells and by researching historic ground water quality data. The ground water delineation program adequately defines site conditions, and provides the data necessary to select and design an effective abatement option for the saturated zone (see Rule 19.15.1.19.E.3).

The following sections of this report present the results of the characterization programs.

3.1 CHRONOLOGY OF EVENTS

The disclosure report prepared by Rice Operating Company (ROC) in January 21, 2003 (Appendix A) summarizes the initial activities at the site. NMOCD approved the Hicks Consultants July 2, 2003 work plan for the site on August 21, 2003 (see Appendix B). Since the initial upgrade of the end-of-line box and installation of the monitoring well in 2002, ROC has overseen nearly four years of ground water sampling. Table 1 summarizes the chronology of events.

3.2 SITE LOCATION AND LAND USE

The Zachary Hinton EOL Junction Box is located about 2.5 miles southeast of the intersection of State Routes 18 and 8/176, near Eunice, New Mexico. Plate 1 shows the location of the site relative to Eunice, New Mexico. The general area of the site is employed for grazing and oil production. Plate 2 is a 2004 image showing the site, nearby oil wells and other development on this rangeland.

3.3 GEOLOGY & HYDROGEOLOGY

3.3.1 Regional & Site Hydrogeology

Plate 3 presents a geologic map of southern Lea County. This map shows the Ogallala Formation is present throughout much of the area and is underlain by the Dockum Group redbeds (the Dockum Group is mapped as T (r) cu on Plate 3). Along Monument Draw, erosion has

STAGELS. U ABATEMENT PLAN - Zechery Minton EOL Innction Box 10-121 October 12, 2005 Page 4 OCD Case # 1R0426-36

R.T. HICKS CONSULTANTS, LTD.

 Table 1. Chronology of Events at the Zachary Hinton EOL Box

·····	ROC upperedge EOL impetion how and characterized upper				
February 6, 2002	ROC upgrades EOL junction box and characterizes upper vadose zone				
February 28, 2002	ROC installs monitoring well adjacent to EOL junction box				
March 12, 2002	ROC notifies NMOCD of groundwater impact				
April 2002 to June 2003	ROC conducts four quarters of ground water monitoring to confirm initial result and collect data in preparation for a corrective action plan				
July 2, 2003	Hicks Consultants submits a corrective action workplan to NMOCD for review				
August 21, 2003	NMOCD approves the workplan, which includes collection of ground water quality data from nearby supply wells and HYDRUS-1D simulation modeling				
January 30, 2004	Hicks Consultants submits a Corrective Action Plan for NMOCD Review				
December 3, 2004	NMOCD requests additional information				
December 8, 2004	Hicks Consultants provides requested information				
May 5, 2005	NMOCD orders ROC to submit an Abatement Plan pursuant to Rule 19				
June 29, 2005	Hicks Consultants requests reconsideration of Abatement Plan Requirement				
July 13, 2005	NMOCD re-iterates Abatement Plan Requirement				

stripped the Ogallala and deposition of alluvium over the redbeds has created a separate aquifer that is hydraulically connected to the Ogallala in many locations (see Nicholsen and Clebsch, 1961).

Plate 4 displays the portion of the geologic map of southern Lea County southeast of Eunice, New Mexico (Nicholsen and Clebsch, 1961). The Ogallala Formation underlies the City of Eunice and the eastern boundary of Plate 4. Quaternary erosion and deposition removed the Ogallala and deposited alluvium within the central part of Plate 4, which effectively outlines the active channel of Monument Draw. The Zachary Hinton EOL junction box is plotted on Plate 4 and is in the middle of the alluvium within Monument Draw.

Plate 4 also shows the elevation of the top of the red-bed surface. The Dockum Group red beds are an aquiclude below the Ogallala and allu-

STAGEL & HABATEMENT PLAN - Zuchary Nintes EOL function Box (0-12) October 12, 2005 Page 5 OCD Case # 1R0426-36

R.T. HICKS CONSULTANTS, LTD.

vial aquifers. In the area of the Zachary Hinton EOL junction box, the red bed elevation contours define a paleo-valley just west of and subparallel to Monument Draw. The elevation of the red-bed surface exerts controls on ground water flow. Where this surface is higher than the water table elevation, it obviously creates a barrier to flow. Where the red-bed surface is an expression of a paleo-valley, such as our area of interest, ground water may be directed toward the axis of this subsurface feature and the saturated thickness of the aquifer can increase as a result.

Plate 5 is the ground water map of southern Lea County (Nicholsen and Clebsch, 1961) covering the same area as Plate 4. This plate shows that the water table elevation mimics the red-bed elevation. At the Zachary Hinton EOL junction box site, ground water flows south, parallel to Monument Draw. Nicholsen and Clebsch (1961) conclude that "The bulk of the water [in the sediments along Monument Draw and under the Eunice Plain] is derived by underground flow from the Laguna Valley [Monument] area." The red-bed surface map and the water table map support this hypothesis.

Although the quality of the City of Eunice water supply wells is about 100 mg/L chloride (see Nicholson and Clebsch, 1961), a more detailed investigation of the area near the Zachary Hinton EOL site shows higher background levels. Plate 6 shows the locations of wells with past and present water quality data and Table 2 (attached) presents the results for chloride. A later section of this report discusses the local ground water chemistry.

By comparing the data from Nicholsen and Clebsch (1961) presented in Plates 4 and 5 of this report, one can estimate the saturated thickness of the alluvium in our area of interest is approximately 25-75 feet (2.6-22 meters). As shown on Plate 5, the hydraulic gradient in our area of interest is about 0.004.

Freeze and Cherry (1979) present a chart that compares hydraulic conductivity values to grain size and employing this chart for the unconsolidated sand in the uppermost saturated zone (50-60 feet below ground surface) yeilds a hydraulic conductivity value of 10^{-4} m/s. The resultant transmissivity of the unit is 1.5×10^{-3} m/s. The storativity (specific yield or porosity for this unconsolidated water table aquifer) of this sand should be about 0.25. From these data we calculate the rate of ground water flow as 0.14 m/d.

Surface water in the area is ephemeral and flows in Monument Draw occur only after large precipitation events. We found no evidence to

STAGE 1 & HABATEMENT PLAN - Zachazy Winton EOL function Box (0-12) October 12, 2005

Page 6 OCD Case # 1R0426-36 suggest that the release from the junction box affected Monument Draw in any manner. Therefore, this document does not provide information on surface water hydrogeology.

3.4 WATER WELL INVENTORY

Appendix D presents the locations and other data of wells within the Office of the State Engineer database for the area within 1-mile of the Zachary Hinton EOL junction box site and the adjacent area. To this table we have added several wells discovered by field reconnaissance.

A later section of this report presents data to show that no existing supply wells are threatened by the release from the Zachary Hinton EOL junction box.

3.5 SUBSURFACE SOILS MONITORING PROGRAM

3.5.1 Results

The soil boring (Plate 7 and Appendix E) and backhoe excavation data (Appendix A) demonstrate that the vadose zone is sand and does not contain the caliche horizons that are common to the Ogallala Formation. This vadose zone profile is typical of the Quaternary Alluvium and is consistent with the geologic mapping presented in Plate 4.

0

0

10

20

40

50

60

70

Depth feet 30 2000

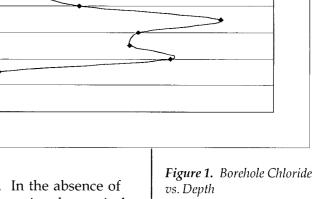
The investigations did not detect evidence of regulated petroleum hydrocarbons in the vadose zone. Because regulated hydrocarbons were not present, further inquiry with respect to hydrocarbons is not warrented. In borehole samples, chemical data show concentrations of chloride greater than 200 ppm from 11 feet below ground surface to 50 feet below ground surface (Figure 1). The chloride concentrations greater than 1,000 ppm prompted ROC to complete a monitoring well at this site.

3.5.2 Nature of the Release

Appendix C presents our conceptual model of produced water releases from

junction boxes, such as the Zachary Hinton EOL site. In the absence of crude within the pores of the vadose zone at the release site, the vertical flow of produced water is less restricted. At this site, we believe that episodic releases of produced water entered the vadose zone and migrated vertically.

STAGE I & II ABATEMENT PLAN -Zachary Hinton EOL Junction Box (0-12) October 12, 2005



Chloride ppm

6000

8000

10000

4000

Chloride concentrations in excess of 1,000 ppm from below the junction box to ground water suggest that past releases from the junction box created saturated conditions in the vadose zone. Additionally, the geometry of the chloride v. depth profile of the boring may cause one to hypothesize that chloride concentration peaks at 20, 35 and 50 feet below ground surface represent three separate release events. However, without definitive grain size or moisture content analyses, these types of hypotheses are not always correct. A fine-grained horizon (such as a caliche) will have materially higher chloride concentrations than a sand horizon that immediately overlies the fine-grained horizon due to the higher moisture content.

We believe that the large difference between chloride values from 0-30 feet versus the higher values observed below 30 feet suggest that releases from the Zachary Hinton EOL junction box decreased significantly about 15-20 years ago. We base this hypothesis on measurements of chloride migration in the vadose zone of 1 to 3 feet per year at a site near Lovington, New Mexico. We also believe that the chloride concentrations from 0-30 feet suggest that some leakage continued at the site until ROC replaced the box in 2003.

3.5.3 Extent & Magnitude of Brine in the Vadose Zone

The chemical data, the sandy lithology of the vadose zone and the lack of hydrocarbons in the release allow us to conclude that produced water moved vertically from the junction box to ground water. Therefore the vertical extent of the release in the vadose zone is the entire 50-60 foot thick column. The horizontal extent of the release to the vadose zone is defined by the footprint of the former junction box. We believe that produced water moved vertically without the horizontal dispersion because the absence of fine-grained caliche horizons or clay layers in the vadose zone permits one-dimensional vertical flow. We also conclude that the chloride concentration data of the borehole adequately define the magnitude of the release to the vadose zone.

3.6 GROUND WATER QUALITY MONITORING PROGRAM

3.6.1 Results

As stated above, ROC found no hydrocarbons in soil and have not detected hydrocarbons in ground water.

Figure 2 presents ground water quality data from the monitoring well that is located within 20 feet of the former Zachary Hinton EOL junction box. Chloride concentrations were about 1,000 mg/L in early 2002, soon after replacement of the junction box. The concentration of chloride declined significantly after the first sampling event then continued

STREEL: HABATIMENT FLAN - Zochary Minton Edit Subotion Bert 15-121 -October 12, 2005 Page 8 OCD Case # 1R0426-36

BD jct. O-12 (Zachary Hinton) Monitor Well

1600

1400

1200

1000 [mg/L]

800

600

400 200

31512002

to decline until June 2003. Since mid summer of 2003, chloride concentrations remained stable (less than 500 mg/L). With the exception of an anomalous analysis tied to documented laboratory errors in December 2004, TDS concentrations have followed the trend established by the chloride ion. Note that the scale of Figure 2 eliminates plotting of this anomalous data point and permits one to observe the parallel trends of chloride and TDS.

As part of our evaluation of water quality in the area, we examined the past and current ground water quality of nearby water supply wells. Plate 6 shows the

locations of nearby wells that have historical water quality data and presents the chloride concentration in ground water for each of these wells.

West of Monument Draw, the data show the chloride concentration in the City of Eunice wells and the Peters West well are below Water Quality Control Commission numerical standards for ground water. Wells within or near Monument Draw, however, generally exceed the numerical standards. The difference between the water quality west of Monument Draw and the water quality within and near the Draw has been evident since the 1950s when Nicholson and Clebsch sampled the water of the area (Table 2).

Up gradient (north) from the Zachary Hinton EOL site, chloride concentration in the Active Windmill of Section 36 is 460 ppm. Like the Zachary Hinton EOL site, this well lies within Monument Draw. The chloride in this active windmill is consistent with the chloride concentrations observed in wells 22.37.1.440 and 22.37.24.133b (average of 422 and 675 ppm respectively) in the 1950s, both of which are located within Monument Draw. The Peters East well, which lies within Monument Draw and is down gradient of the Zachary Hinton EOL site, exhibits a chloride concentration of 438 ppm. As stated above the recent chloride concentrations in the Zachary Hinton EOL monitoring well are less than 400 ppm. This measurable difference in chemistry between the Zachary Hinton Site and the Peters East well could be due to the effect of higher quality ground water flowing into the Monument Draw area from the west (e.g. 200 ppm chloride in the Peters West well), or the difference may be due to normal variance associated with sampling and analysis. From these data we can conclude that 2004-2005 ground water samples

STAGE I & II ABATEMENT PLAN -Zachary Ninton EOL Junction Box (0-12) October 12, 2005

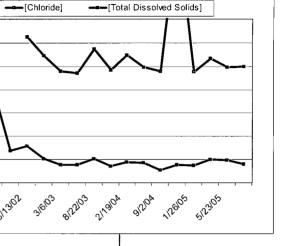


Figure 2. Chloride and TDS in site monitor well over time.

from the Zachary Hinton EOL monitoring well are at background concentrations and therefore do not now exceed the state ground water standards for chloride and TDS.

3.6.2 Other Constituents of Concern

The laboratory did not detect any regulated petroleum hydrocarbons in ground water. Sulfate concentrations in ground water are below New Mexico numerical standards. The evidence allows us to conclude that only chloride and total dissolved solids exceed the numerical ground water standards.

3.6.3 Extent and Magnitude of TDS and Chloride in Ground Water As suggested above, we conclude that the horizontal extent of the near surface release was confined to the size of the junction box itself and produced water flowed vertically through the vadose zone without material lateral dispersion to ground water. Therefore, the monitoring well, which is located about 20 feet down gradient from the former junction box, provides representative ground water chemistry data for the aquifer immediately below the release. These data show chloride concentrations of 1,000 mg/L several months after replacement of the junction box and a 6-month decline in chloride concentrations after the source of leakage ceased (i.e. replacement of the junction box).

Earlier sections of this report also provide evidence that saturated flow existed from the base of the junction box to ground water until the box was replaced in 2002. Because saturated flow continued until 2002 and the highest chloride concentrations are deep in the vadose zone, we can also conclude that the 1,000 mg/L chloride concentration of the initial ground water sample represents a reasonable estimate of the maximum chloride concentration in ground water caused by the release. A later section of this report suggests a maximum chloride concentration in ground water of less than 2,000 mg/L may have occurred in the past. Today concentrations of chloride in down gradient ground water are unlikely to be greater than 1,000 mg/L because of dispersion and dilution with transport would reduce chloride concentration.

Although we can definitively state that the water quality at the site currently meets state standards (i.e. background or existing water quality), one well cannot define the full extent of any impairment caused by the past leakage from the site. We can conclude, however, that the cross-gradient (east-west) extent of chloride concentrations exceeding background levels may be about twice the cross-gradient dimension of the junction box, or about 40 feet. We propose to test this hypothesis with the ground water modeling exercise proposed as part of the Stage 2 Abatement Plan: Saturated Zone.

STAGE I & HAGATEMENT PLAN - Zechary Hinton EOL Junction Box (0-12) October 12, 2005 Page 10 OCD Case # 1R0426-36

ι

A single monitoring well cannot define the down gradient (north-south) extent of chloride in ground water caused by past releases. We believe that natural dispersion and dilution will cause chloride to reach background concentrations after a relatively short down gradient transport distance. We propose to test this hypothesis with the ground water modeling proposed as part of the Stage 2 Abatement Plan: Saturated Zone.

語のであ

STE CON

1. 1. 1.

at Bridge

24.28 A

12 ADA

A.C.M

100 and 100

10.00

12 Sec. 97

S. E. S.

STAGE (& H ABATEMENT PLAH - Zechery Kinton EOL Junction Box (0-12)

Page 11 OCD Case # 1R0426-36

4.0 STAGE 2 ABATEMENT PLAN: VADOSE ZONE

We used the numerical model HYDRUS-1D to simulate the transport of residual chloride from the surface through the vadose zone to ground water. We used the predicted flux of chloride to ground water from HYDRUS-1D as input into a simple ground water mixing-model to evaluate the impact on ground water quality. As Hendickx and others (2005) describe in *Modeling Study of Prodiced Water Release Scenarios*, this modeling effort requires 10 input parameters. Section 3.0 of Hendrickx and others describes the modeling approach.

4.1 DATA EMPLOYED FOR THE ZACHARY HINTON SITE

Table 3. Input parameters inHYDRUS model

For some input parameters we employed regional data or values based upon professional judgment (see Table 3). For most of the input data to our simulations, we relied upon site data collected by Rice Operating Company. Our field inspection of the site and our evaluation of the data allow us to conclude that the site data used in our simulations reflect the conditions at the site.

Plate 7 shows the soil profile texture and thickness of the vadose zone at the site (input parameters # 1 and #2 of Table 3). We input the soil texture into HYDRUS-1D and allowed the model's library to generate the hydraulic properties. We then used these hydraulic properties in simulations of these scenarios.

October 12, 2005

D. (
Parameter	Values	Source of Data
1. Depth to Ground Water (feet)	56	Site Data
2. Vadose Zone Texture (see Plate 7)	Attached well log	Site Data
3. Dispersion Length (cm)	100	Professional Judgment
4. Water Content θg (%)	High θg	
	Layer 1: 10%	Estimated from
	Layer 2: 30%	HYDRUS simulations
	Layer 3: 25%	
5. Vadose Zone Chloride Distribution (gr/kg)	Soil boring, Plate 7	ROC data from Disclosure Report
6. Length of release perpendicular to ground water flow (feet)	20	Field measurements
7. Climate Index	Pearl, NM station (Hobbs area)	NOAA data
8. Background Ground Water Chloride (mg/L)	100	Samples from nearby wells
9. Ground Water Flux (cm/day)	0.014	Calculated from regional hydrological data
10. Aquifer Thickness (feet)	35	Nicholson & Clebsh (1961) and OSE data

STAGE (& HABATEMENT PLAN - Zachary Ninton EOL Junction Box (0-12)

Based upon our experience, we employed a dispersion length of 100 cm (input #3). The selected dispersion length is 7% of the total length of the HYDRUS-1D model (55 feet). Many researchers suggest that a dispersion length that is 7-10% of the total model length provides reasonable results for simulation experiments.

We used the soil moisture content (input # 4) presented in Table 3 from HYDRUS-1D simulations. Because we did not have site-specific soil moisture data, we assumed a "dry" soil profile then used the climate data to add moisture to the profile via precipitation over 100 years. We found that initial soil moisture in the profile changed over this 100-year period, responding to the climatic conditions. Therefore, we ran the simulations under both "wet" and "dry" conditions as determined by the 100-year simulation experiment. As Table 3 shows, we elected to employ the "wet" conditions in our simulations because leakage from the junction box over the past years has created "wet" conditions within the profile.

Plate 7 shows the measured soil chloride concentration per unit weight of soil. We converted these values to concentrations per liter of soil water (input #5) by using the equations in Hendrickx and others (2005). The length of the release (input #6) was measured in the field.

The daily climate data available from the Pearl weather station near the Hobbs Airport served as input for all climate indices required by HYDRUS-1D (input #7). We simulated 10 years after the release with average precipitation 36 cm/year.

For the input parameter #8, background ground water chloride concentration, we used 100 mg/L based upon data from the City of Eunice. We used data for the Ogallala Aquifer as described in Nicholsen and Clebsch, (1961) as input to the mixing model (input #9, ground water flux; input #10, aquifer thickness).

We also used data from the BD Zachary Hinton site monitor well to verify the predictions of the HYDRUS-1D model and the mixing model.

4.2 SETUP OF SIMULATIONS

Scenario 1: Current Conditions

The current condition scenario evaluates the potential of the chloride mass in the vadose zone to materially impair ground water quality at the site in the absence of any action by Rice Operating Company and in the absence of any natural restoration (e.g. re-establishing vegetation). As described in Hendickx and others (2005), the distribution of the mass of chloride in the vadose zone (input #5) is the most important input pa-

STAGE (& N ABATEMENT PLAN - Zachary Hinton EOL Junction Bex (0-12) October 12, 2005 Page 13 OCD Case # 1R0426-36

rameter for prediction of chloride concentrations in ground water. For this and all simulations, we assumed the chloride concentrations shown in Plate 7 existed in the profile at time zero. At time zero, we also assume that man-made leakage of produced water has ceased and the chloride concentration in the monitoring well is equal to background (100 mg/L). While the first and second assumptions are acceptable, the assumption that the chloride concentration in the monitoring well is equal to background is false. We make this last assumption as a matter of convenience to simplify our model and we explain the effect of this simplification in our discussion of the results of the simulations.

The chloride concentration of soil water $Cl^{soil water}$ (mg/liter) depends on the gravimetric chloride content of moist soil $Cl_g^{moist soil}$ (mg/kg of moist soil), the bulk density of the soil D_{soil}^{dry} (kg/m³), and the volumetric water content of the soil e_v (m³/m³) input #4. To convert the chloride concentration in the soil to chloride concentration in soil water (see Hendrickx and others, 2005), we used a soil density of 1,858 kg/cubic meter and the soil moisture content in Table 3.

We entered the chloride concentration of soil water in the soil profile in HYDRUS and ran the simulation for 10 years with total precipitation and evaporation from the soil. Vegetation was assumed to not be present to enhance water transfer from soil to the atmosphere. We calibrated the results from the model with the chloride data from a monitoring well located 20 feet down gradient from the center of the spill.

Scenario 2: Reduce Infiltration

To minimize the potential for any leaching of residual chloride from the vadose zone, we assumed a surface remedy that would reduce infiltration of precipitation. To simulate such a remedy, we simply reduced the precipitation by assuming that heavy rains (that cause the majority of the infiltration) ran off after 1.5 cm fell. This simulation predicts the effect of (a) sloping the site to cause runoff of the larger precipitation events and/or (b) placement of a graded compacted layer at the surface to minimize infiltration, facilitate runoff and prevent ponding of precipitation. All other input parameters are the same as Scenario 1.

Scenario 3: Vegetation

This scenario consists of placing 30 cm of silt loam and reseeding with pasture. The transpiration is zero during the winter months but soil evaporation takes place. During the growing season, evapotranspiration is greatest. All other input parameters are the same as Scenario 1.

STAGE (a. II ABATEMENT PLAN - Zachary Ninton E&L Junction Box (8-12) October 12, 2005 Page 14 OCD Case # 1R0426-35

Scenario 4: A Silt Clay Below the Top Soil

In this scenario we placed 60 cm of a silt clay below the topsoil under the same conditions of Scenario 3. Placing the clay below the top soil minimizes infiltration into the deeper profile and provides a place for the infiltration of winter precipitation to reside until the plants take it up in the following spring and summer. All other input parameters are the same as Scenario 1.

4.3 SIMULATION RESULTS AND DISCUSSION

Figure 3 shows the response of Scenario 1 in a monitoring well located

20 feet from the center of the spill at the release site. The simulation shows chloride concentration increasing to a maximum of 1,652 ppm in year 1.7. As stated in the previous section, in this and other simulations, when man-made leakage ceased, the chloride concentrations in the vadose zone are equal to that represented in Plate 7 and Figure 1. To simplify our modeling experiment, we assumed that the chloride concentration in the monitoring well at time zero in Figure 3 is equal to background (100 mg/L). Therefore, the initial increase in chloride concentration from background (100 mg/L) to a maximum (1,652 in this)simulation) is the model's response to the

downward movement of the initial distribution of chloride in the profile. Because the well was installed after replacement of the junction box and cessation of periodic leakage, we cannot know the chloride concentration at the monitoring well during past man-made leakage events. We hypothesize, however, that chloride concentration in ground water would be 1,652 mg/L or more during the time that the junction box periodically released produced water. Chloride concentrations in the monitoring well might remain at or above the 1,652 mg/L during the years of periodic discharges from the former junction box, as chloride migrated from the ground surface to ground water via saturated flow. After replacement of the junction box, water additions to the soil profile cease and the soil profile would drain. During the drainage of the soil profile, chloride concentrations in the monitoring well would decrease as saturated flow ceased and slower, unsaturated flow conditions occurred in the profile.

Figure 4 modifies the HYDRUS-1D output to better represent the conditions described above. In this Figure, time X represents background conditions, before any leakage from the junction box. As periodic leak-

STAGE I & M ADSTEMENT PLAN - Zachary Ninton EOL function Box (0-12) October 12, 2005

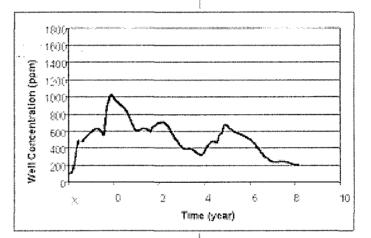


Figure 3. Chloride concentration in the monitoring well for the current conditions scenario. (Scenario 1)

age occurs, chloride concentration in ground water rises and chloride is distributed throughout the unsaturated zone. We believe that the maximum chloride concentration in ground water in Figure 4 (1,652 mg/L) is approximately what we would have observed during the period of leakage from the junction box if the monitoring well had been installed. After upgrade of the junction box (here noted as approximately time zero), chloride concentrations decline as discussed above and as shown in Figure 4. About five years after upgrade of the junction box under the Current Condition Scenario, ground water chloride approaches the background concentration assumed in the model (100 mg/L).

Figure 5 shows the results of our simulations of Scenario 2 with the same modified time line as in Figure 3. Reducing infiltration of precipitation creates a maximum concentration 1,048 mg/L marked approximately as year 0 to show when junction box upgrade occured. Reducing infiltra-

tion slows the drainage of vadose zone water relative to the current condition scenario. Therefore, water and chloride enter the ground water more slowly in this scenario as compared to the no action scenario. In other words, the chloride flux (mass/time) into ground water is lower in scenario 2 than in scenario 1. The ground water flux and aquifer thickness, however, remain the same in both scenarios. The lower chloride flux into ground water results in a lower maximum concentration observed in the monitoring well. This lower flux also results in a longer time of predicted non-compliance at the monitoring well.

About six years after upgrade of the junction box, the majority of the chloride has drained from the vadose zone and concentrations in the well declines to the standard of 250 mg/L. We did not simulate the length of time necessary for ground water to reach background conditions under this scenario.

STAGE Le, II ABATEMENT PLAN - Zachary Hinton EOL Function Box (0-12) October 12, 2005

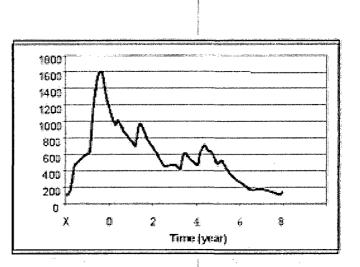


Figure 4. Modification of HYDRUS-1D simulation results to illustrate a more realistic time scale for Scenario 1.

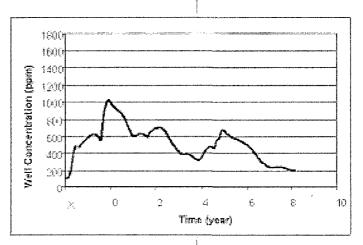


Figure 5. Modification of HYDRUS-1D simulation results to show a more realistic time scale for chloride concentration in the monitoring well for the scenario reducing the infiltration. (Scenario 2)

> Page 16 OCD Case # 1R0426-36

Figure 6 shows the results of the Scenario 3, which assumes further reduction of infiltration due to evapotranspiration as a result of plant cover. The maximum chloride concentration in the well is 693 mg/L (or about 600 mg/L above the assumed background concentration of 100 mg/L) at approximately zero time on the modified scale. As discussed previously, the time of maximum chloride concentration is the time when the junction box is upgraded. The chloride concentration declines to the standard of 250 mg/L in year 2.11. However, we predict an increase in ground water chloride

concentrations to 323 mg/L in year 6.5 followed by a decrease to the standard by year 7.5. This increase at year 6.5 is probably due to increased infiltration associated with the El Niño weather pattern. Because most the chloride has drained from the profile by year 6.5, we conclude that any additional increase in ground water chloride concentration (perhaps at year 14) would not exceed the ground water standard of 250 mg/L.

The concentrations in the root zone in Scenario 3 are quite high as result of capillary rise that accumulates the salts at the top of the profile. Concentrations of 4,000 mg/L will prevent the grass of developing unless chloride moves deeper into the subsurface due to a soil flushing program or natural rainfall.

Figure 7 shows the result of Scenario 4 with the modified time scale. The maximum concentration in the well is 604 mg/L in year 0. It declines to 250 ppm in year 1.75. The concentrations in the

root zone are about 1,300 mg/L, suitable for vegetation. By year 8, background conditions exist in the monitoring well.

Figure 2 of this report is reproduced in Plate 8 with the HYDRUS-1D simulation for Scenario 3 to permit comparison. The monitoring well data show chloride concentrations declining from 1,000 mg/L to 400 mg/L over a nine-month period. Obviously, these data do not correlate with the model predictions of Scenario 1, current conditions. Instead,

STAGE I & III ABATEMENT PLAN - Zachary Hinton EOL Junction Box (0-12) October 12, 2005

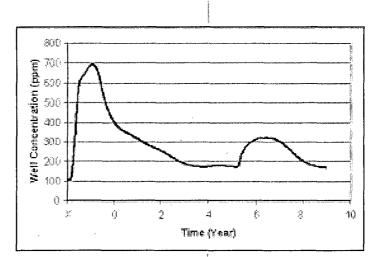


Figure 6. Modification of HYDRUS-1D simulation results to illustrate a more realistic time scale, chloride concentration in the well for the vegetation scenario. (Scenario 3)

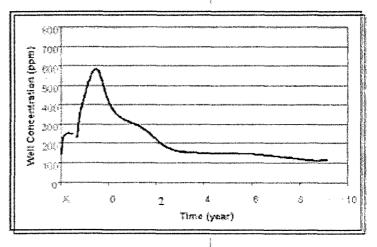


Figure 7. Modification of HYDRUS-1D simulation results showing a more realistic time scale of chloride concentration in the well for the scenario with vegetation and a silt clay layer below the topsoil. (Scenario 4).

> Page 17 OCD Case # 1R0426-36

the field data are more similar to the predictions of Scenario 3, where infiltration into the vadose zone is relatively low due to evapotranspiration associated with vegetation. What is most striking about the field data and the predictions of Scenario 3 is that both show a maximum chloride concentration of 600 mg/L above background at time zero. The field data and the HYDRUS-1D prediction also show relatively good agreement with respect to the time required for ground water to re-equilibrate with background water quality conditions. The simulation predicts that chloride will be less than 200 mg/L after about 2.5 years. The ground water data show that the monitoring well is at background

chloride concentrations (between 350 and 400 mg/L) after about 1.5 years from cessation of saturated or "wet" conditions.

The similarity shown in Plate 10 should not be surprising if one visits the site. Vegetation does exist around the area of the suspected release (Figure 8). We believe the current flux of chloride from the vadose zone to ground water is approximately the same as that simulated in Scenario 3. We can also conclude from Figure 8 that the chloride concentration in the root zone is low enough to support vegetation. The current condition scenario, which does not provide for evapotranspiration or any reduced infiltration, obviously overestimates the impact of the chloride load to ground water quality.



4.4 CONCLUSION AND RECOMMENDED ACTION: VADOSE ZONE

The HYDRUS-1D simulations for the Zachary Hinton site provide reasonably good, albeit conservative, predictions of chloride concentrations in ground water for the various scenarios. The simulation showed that about two years after the upgrade of the junction box and cessation of accidental and periodic water leakage, HYDRUS-1D predicts that chloride concentrations in the ground water monitoring well are at background correlations. The field data correlate well with early time predictions of Scenario 3, reduced flux due to vegetation. We conclude Scenario 3 predicts higher chloride concentrations than observed.

We conclude that the background chloride concentration in ground water at the Zachary Hinton EOL site is about 350-400 mg/L. We base this conclusion on historical and recent water quality analyses from the area. Natural restoration has mitigated the transient impact of past

STAGE I & II ABATEMENT PLAN - Zachary Hinton EOL Junction Box (0-12) October 12, 2005 *Figure 8.* Vegetation at the site.

Page 18 OCD Case # 1R0426-36 leakage from the site.

a that

5. Sept. 3.6

Alexa his

A South Sol

314 - 25

Sec. 1

and the second

ALC: NO

11

の

We recommend restoring the ground surface in the excavation using soil that will permit re-vegetation. Because the water quality at the site has returned to background conditions, we recommend plugging and abandonment of the existing monitoring well and closure of the regulatory file for this site, pending documentation of appropriate surface reclamation.

STAGE 1 & II ABATEMENT PLAN -October 12, 2005

Zachary Hinton EOL Junctics Box (0-12)

Page 19 OCD Case # 1R0426-36

5.0 STAGE 2 ABATEMENT PLAN: SATURATED ZONE

and the

The monitoring well at the Zachary Hinton EOL Junction Box site does not exceed New Mexico ground water standards because ambient (background) concentrations are equal or greater than those currently observed. Therefore, there exists no zone of ground water impairment to define. Additional monitoring wells at the site are not warranted.

We propose to employ MODFLOW and its contaminant transport module to predict the fate and transport of the historic impact to ground water quality evidenced by the first sample analysis. We hypothesize that the simulation modeling will show that natural dilution and dispersion has effectively mitigated any past impact to ground water quality.

STAGELS HABATIMENT MAN-October 12, 2305

LAN - - Dischary Hinton EOL Junctics Box (0-12)

Page 20 OCD Case # 1R0425-36

PLATES

•

4. E. 4. E.

AVE AND

and the se

- 4 1 1 K g.

State .

Land Martin

1. 7 10.00

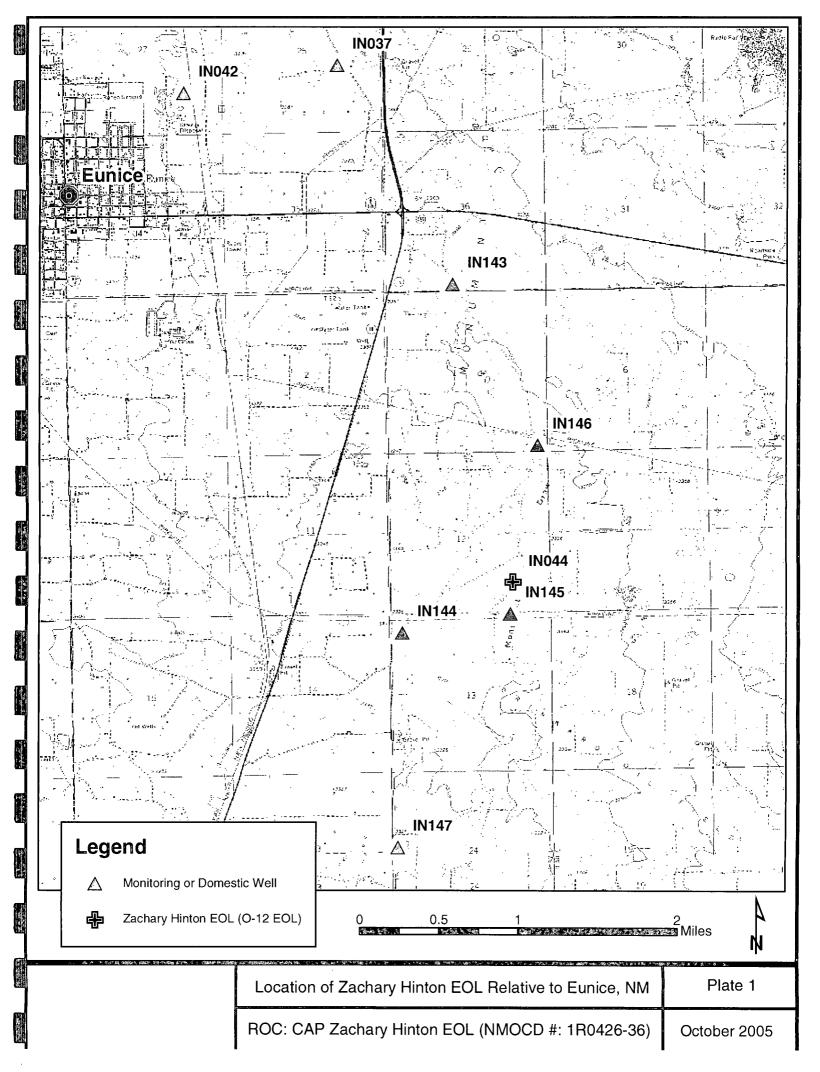
No. and

1000

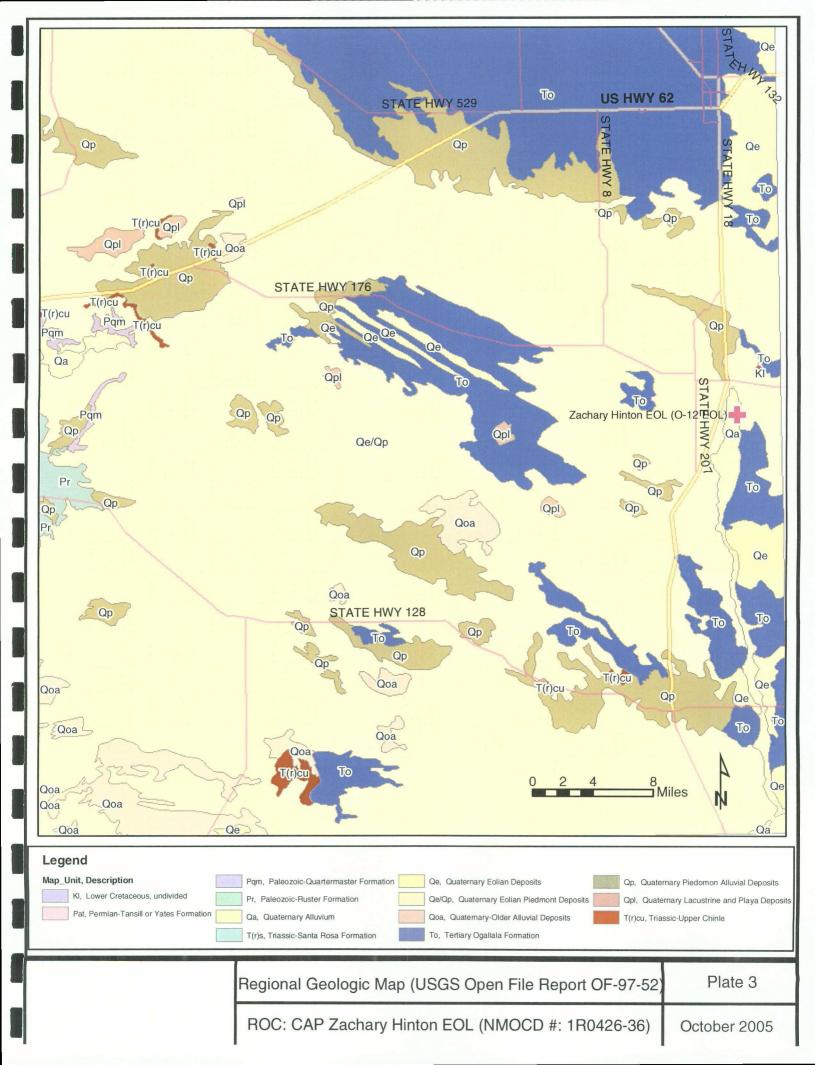
1. Fel.

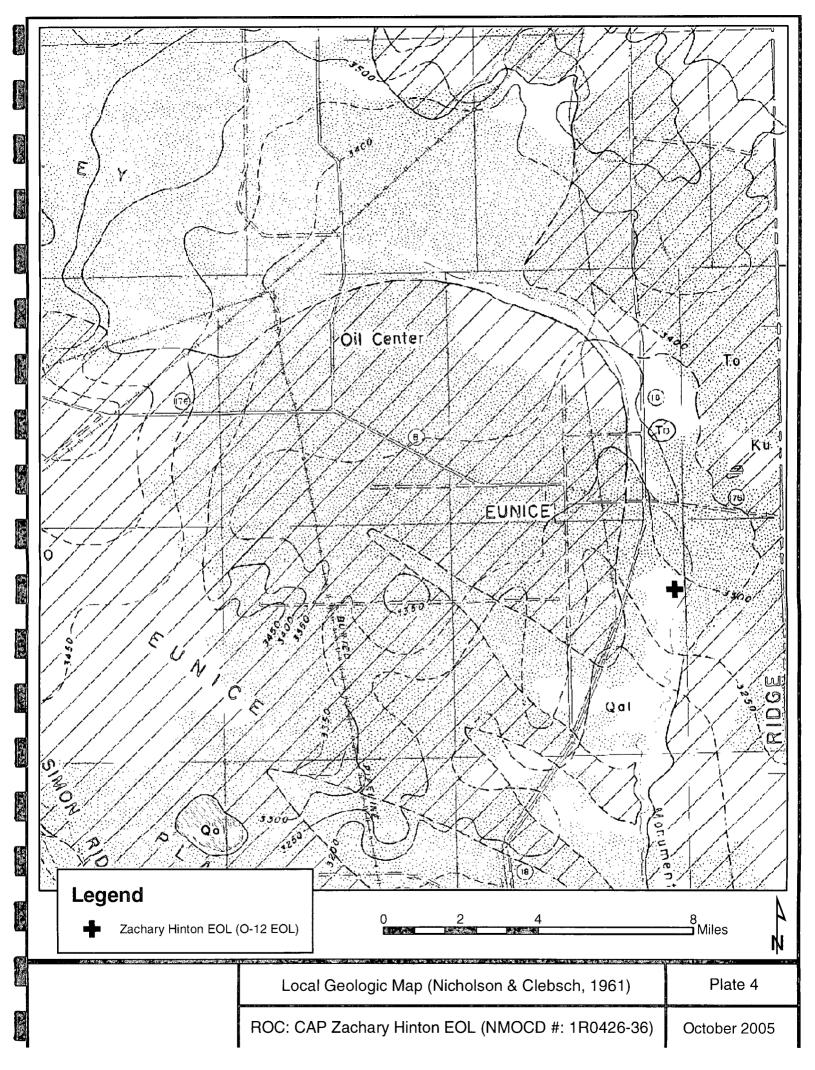
and the first

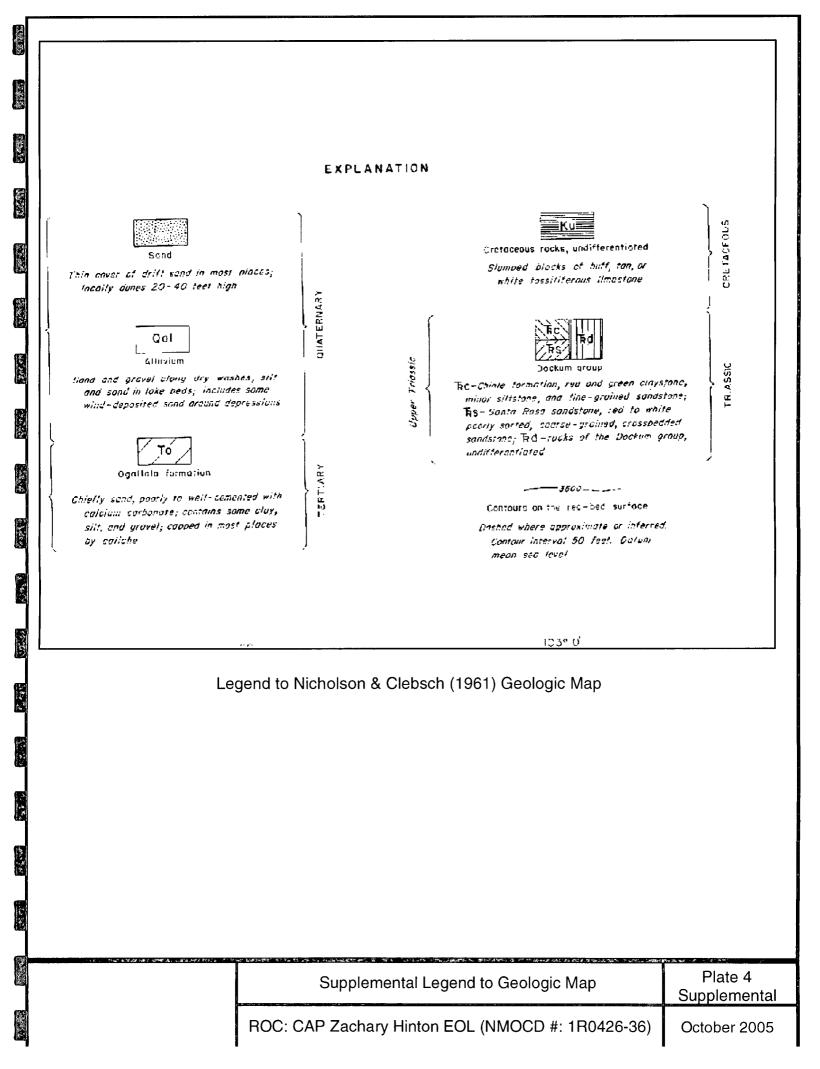
1.00 S. 100

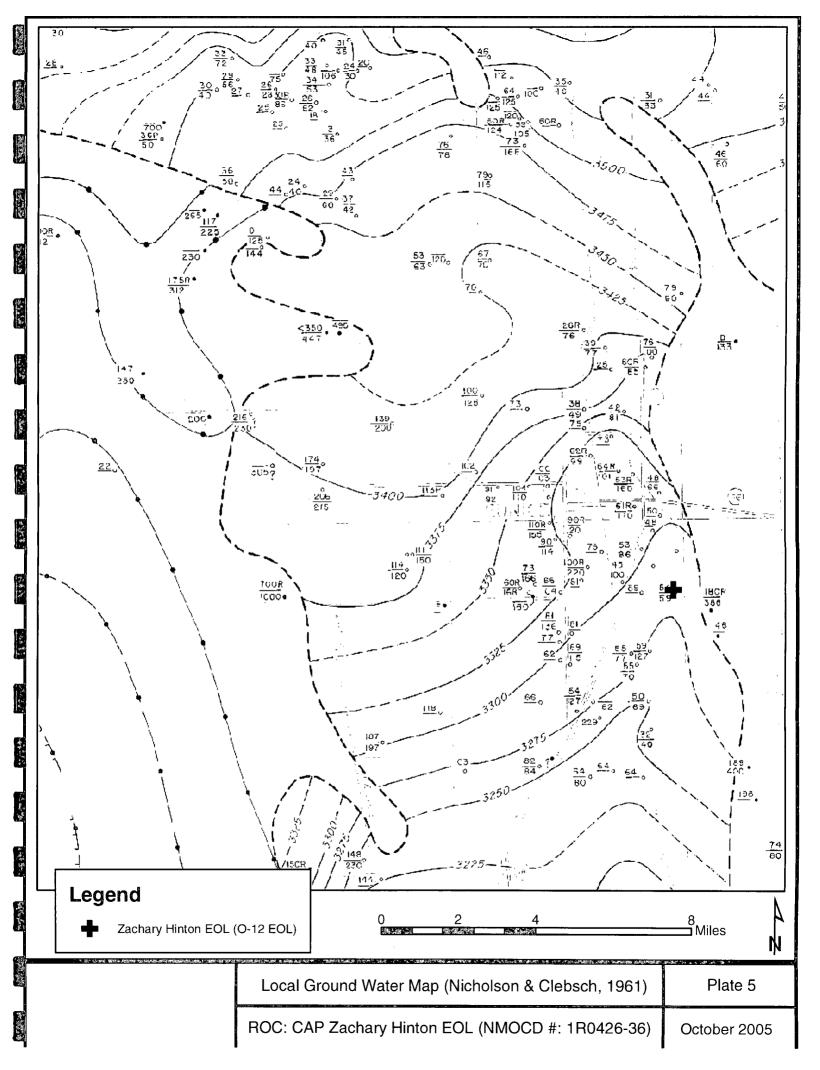


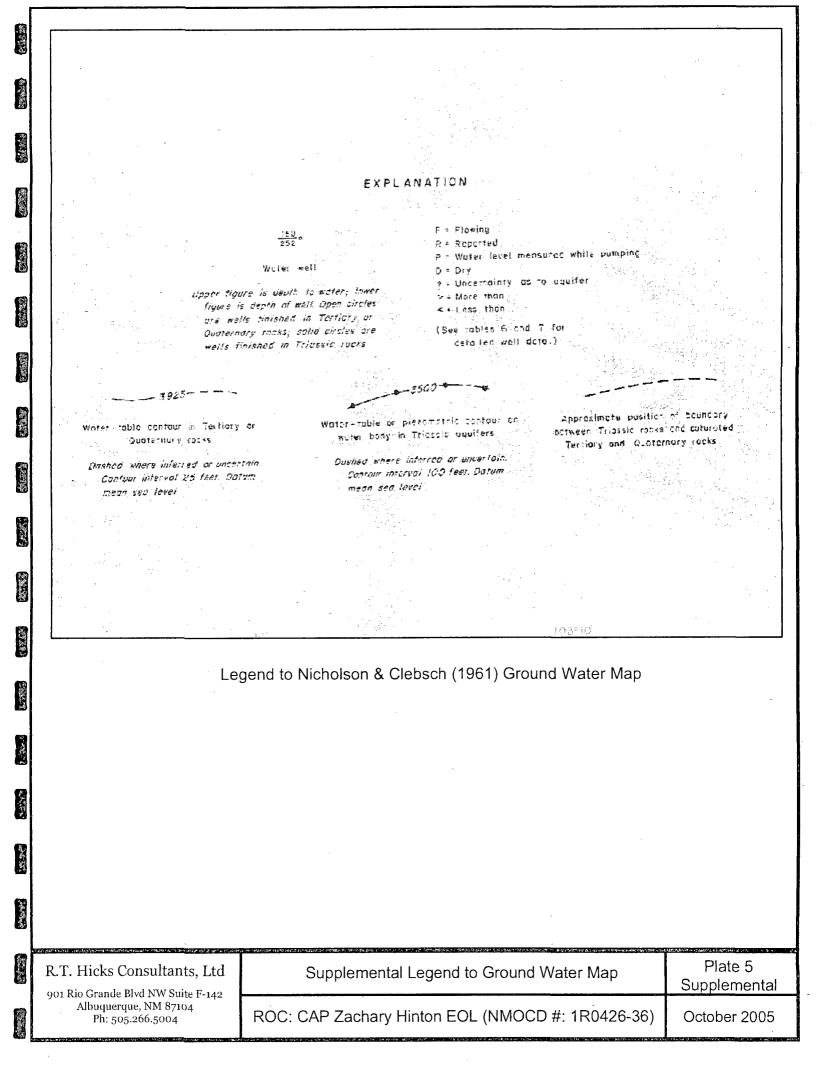


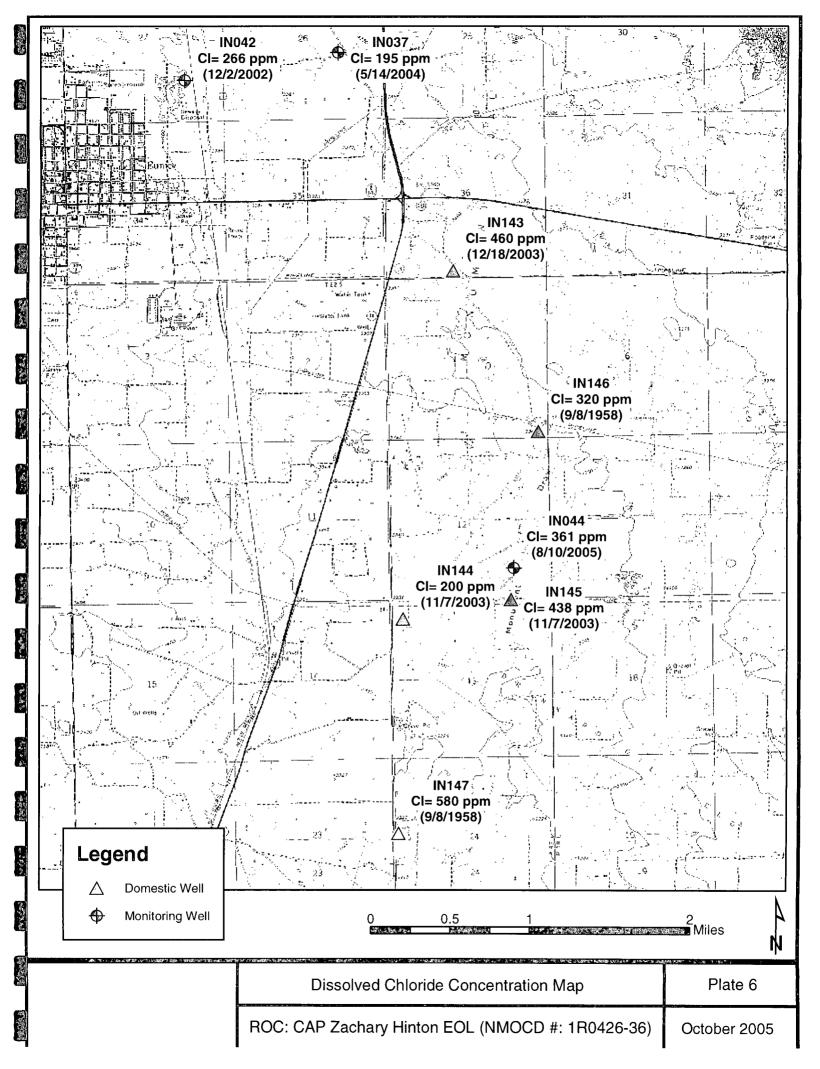












Depth	Lithologic Description	Measured Soil Chloride Concentration mg/kg	Bulk Density of Sample kg/cubic meter	Thickness of Column (ft)	Calculated Chloride Mass in Column (kg/m2)
ground surface					
	0-3 feet Sandy Top Soil				
	3 13 foot	1500	1858	5	4.616726087
10	Cali	2000	1858	5	6.155634783
	13-19 feet Sandy Clay	2450	1858	5	7.540652609
20		3000	1856	5	9.223513043
		1750	1858	5	5.386180435
30		3270	1858	5	10.06446287
	19-56 feet	8160	1858	5	25.11498991
40	Various Colored Sands	5300	1858	5	16.31243217
		5000	1858	5	15.38908696
50		6410	1858	5	19.72880948
Aquifer 56		500	1858	5	1.538908696
60	Aquifer = Gray Sand 56-60 ft				
Total Depth of MW	Aquifer = Sandy Clay 60-63 ft	Ü	Calculated Chloride Load	ad	121.071397
R.T. Hicks Consultants, Ltd.	RICE OF	perating Company			Plate 7
901 Rio Grande NW Albuquerque, NM	Borehole Lithology Calculation	of Chloride Load, Zachary Hinton EOL, Lea County	ary Hinton EOL, Lea	Oct	October 2005

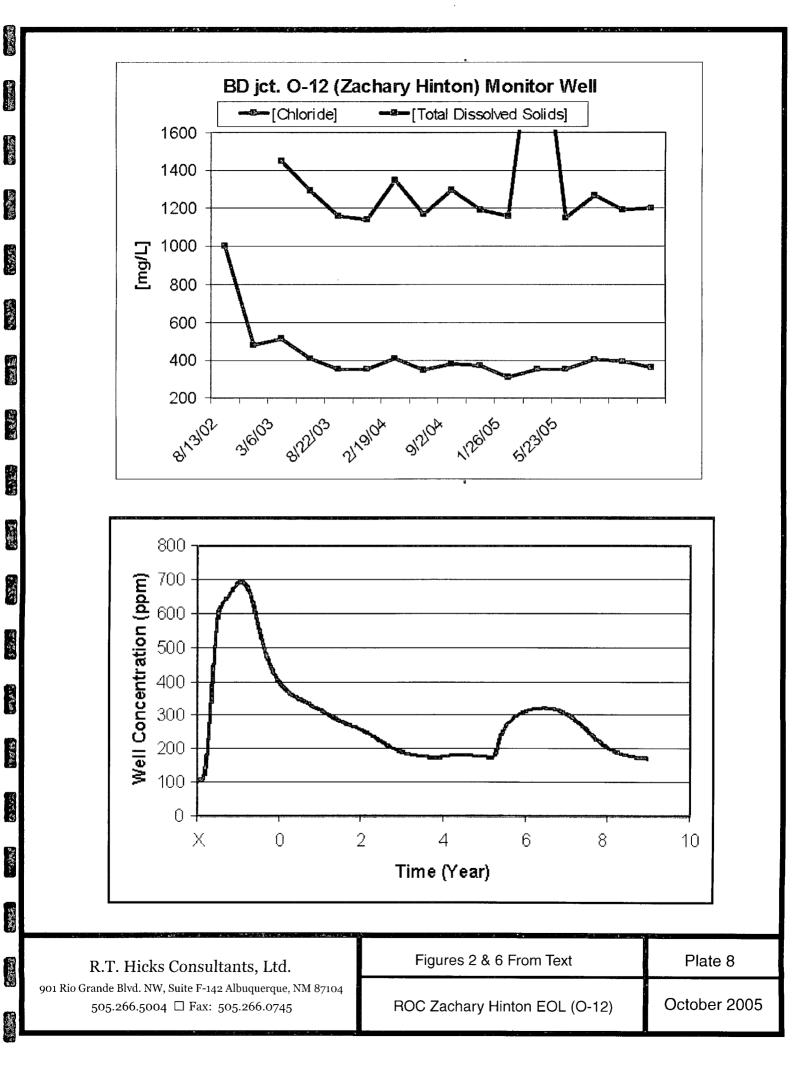
with the life life and the life for

A. 17. 18.

1. 18 A.

1. C. S.

200 B 200



TABLES

and a state

A. 7. A.

Sato draw

1. N. 286.

10 July 10

1.0

14 June 1

AL . .

100 000

1. 2 m

 $\left(\frac{16}{2} + V_{\rm sp} \right) = \left(\frac{16}{2} + V_{\rm sp} \right)$

1 × 3

9. a artai 2° 1

2. 2 Car

H with the state

•	3		E.meiner	Marthan							
Internal Number	Site 1D	Соттон Name	UTM NAD 83) (UTM	(UTM NAD 83)	values (NAD 83) Location	System	Data From	Well Type	Well Type Well Operator	Well Owner	Land Owner
IN037	21S.373.26.J.JCT.1	Jct. J-26-1	675771.36	3591704.7	Sec 26, T21S, R37E	Habbs BD	ROC	Monitoring Well			
IN042	21S.37E.27.I.JCT.1	Jct. I-27-1	674232.27	3591428.4	Sec 27, T21S, R37E	Hobbs BD	ROC	Monitoring Well			
IN044	22S.37E.12.0.EOL.1	Zachary Hinton EOL (O-12 EOL)	677561.08	3586541.5	Sec 12, T22S, R37E	Hobbs BD	ROC	Monitoring Well	ROC		
IN143	22S.37E.36.N.344	Windmill NE of Zach Hinton	676940.77	3589522.0	Sec 36, T22S, R37E	Domestic Well	RT Hicks	Domestic Well			
IN144	22S.37E.13.D.111	Peters Well West	676440.95	3/58/6034	Sec 13, T22S, R37E	Domestic Well	ROC	Domestic Well			:
IN145	22S.37E.13.A.221	Peters Well East	677533.62	3586224.7	Sec 13, T22S, R37E	Domestic Well	ROC	Domestic Well			
IN146	22S.37E.01.P.444	22.37.1.44	677802.92	3587913.7	Sec 01, T22S, R37E	Domestic Well	Nicholson & Clebsch	Domestic Well		-	
IN147	22S.37E.24.E.133B	22.37.24,133B	676401.38	3583865.7	Sec 24. T22S, R37E	Domestic Well	Nicholson & Clebsch	Domestic Well			

ちんもないたい

1. S. M. .

े _{"स} के के है

1 mg 1 mg 1

" "

Propert e

1. Sec. 6.

See.

Store and

و يجمع بالمحلية

1. and . . .

An State of

the gardy at

ふちょうよい

and the

a product a

W. W. W.

Rice Operating Company: CAP Zachary Hinton E0L (0-12) NMOCD File Number: 1R0426-36 October 2005

a said

1 Carlo Carlo

. Abs⁵. 4 w

+ + H 14 . 10 -

Ser inst

1.12 Law.

1. . . . W.

المعاقفة والمحد

\$-5-18-4

a may an

Same and

" " " " " and

a 23 m.

\$\$ \$\$ \$\$

Table 2d: Inorganic Chemistry - Cations

TCOM	1 20 1	11410004	S A	014				
10001	JCt, J-26-1	- +007/+1/ C	<u>.</u>		SZ	NS	NS	
1037	Jct. J-26-1	5 /7 /2004	NS	SN	NS	NS	NS	
1N037	Jct. J-26-1	2 /18/2004	SN	NS	NS	SN	NS	
1N037	Jct. J-26-1	10/30/2003	NS	NS	NS	NS	NS	
IN037	Jct. J-26-1	8 /22/2003	NS	NS	SN	SN	SN SN	
IN037	Jct. J-26-1	6 /5 /2003	NS	NS	NS	SN	NS	
1N037	Jct. J-26-1	2 /28/2003	SN	NS	NS	NS	NS	
1037	Jct. J-26-1	10/29/2002	NS	NS	NS	NS	NS	
IN042	Jct. 1-27-1	12/2 /2002	SN .	NS.	SN SN	S	SN	
IN044	Zachary Hinton EOL (O-12 EOL)	8 /10/2005	88	10.7	45.6	242	SN	
IN044	Zachary Hinton EOL (0-12 EOL)	5 /23/2005	NS	NS	NS	SS	NS	
IN044	Zachary Hinton EOL (0-12 EOL)	3 /22/2005	120	18.9	61.9	344	NS	
IN044	Zachary Hinton EOL (O-12 EOL)	1 /26/2005	SN	NS	NS	SN	NS	
IN044	Zachary Hinton EOL (0-12 EOL)	12/21/2004	NS	NS	SN	SN	SN	
IN044	Zachary Hinton EOL (O-12 EOL)	9 /2 /2004	NS	NS	NS	SN	NS	
IN044	Zachary Hinton EOL (0-12 EOL)	4 /17/2004	NS	NS	NS	SN	NS	
IN044	Zachary Hinton EOL (0-12 EOL)	2 /19/2004	SN	NS	NS	S	NS	
IN044	Zachary Hinton EOL (0-12 EOL)	11/20/2003	SZ	NS	NS	SN	SN	
IN044	Zachary Hinton EOL (0-12 EOL)	8 /22/2003	NS	NS	NS	SN	NS NS	
IN044	Zachary Hinton EOL (0-12 EOL)	6 /5 /2003	SN	NS	SN	SN	NS	
IN044	Zachary Hinton EOL (O-12 EOL)	3 /6 /2003	SN	NS	NS	SN	SN	
IN044	Zachary Hinton EOL (0-12 EOL)	10/25/2002	SN	NS	S	SS	NS	
IN044	Zachary Hinton EOL (0-12 EOL)	8 /13/2002	SN	NS	SN I	SN SN	NS 	
IN044	Zachary Hinton EOL (O-12 EOL)	5 /15/2002	NS	, NS ,	SN	SN NS	NS	
IN044	Zachary Hinton EOL (O-12 EOL)	3 /5 /2002	SN	NS	NS	NS	SN	

Rice Operating Compuny: CAP Zuchary Hinton EOL (0-12) NMOCD File Number: 1R0426-36 October 2005

Page 1 of 2

an a had

The party and

望 安ち 太子

1 4. 4. 1. - also

1 4 m - 2 8 m

Ser Salar

م ومالي مالي

ak Kar

م والانتراسي من الم

" Participa

Sourced S.

all as the

8 " Bar - "

1. 224 + 11.

6 + X + 40

1. 1. C. .

States .

2. B.

Table 2d: Inorganic Chemistry - Cations

Internal Number (IN)	Соттон Name	Date	Calcium (ppm)	Potussium (ppm)	Calcium (ppm) Potassium (ppm) Magnesium (ppm) Sodium (ppm) K + Na (ppm)	Sodium (ppm)	$K + Na \ (ppm)$	
IN044	Zachary Hinton EOL (O-12 EOL)	3 /5 /2002	SN	NS	SN	NS	NS	
IN064	B-20		NS	SN	SN	NS	NS	
IN065	B-30	12/22/2000	SN	SN	S	NS	SN	
020NI	C-13		SN	SN	SN	NS	NS	
IN078	H-4		NS	ŝ	SN	ŝ	SN	
IN101	0-17-1	8 /17/2001	SN	SN	SN	NS	NS	
IN143	Windmill NE of Zach Hinton	12/18/2003	101	8.56	66	176	NS	
(N144	Peters Well West	11/7 /2003	65	4.49	46	96	NS	
IN145	Peters Well East	11/7 /2003	102	8.51		154	SN 	
IN146	22.37.1.44	9 /8 /1958	SN	SN	SN	SN	SN 	
IN146	22.37,1,44	10/14/1953	222	SN	107	SN	375	
IN 147	22.37.24.133B	9 /8 /1958	SN	SN	NS	SN	NS	
IN147	22.37.24.133B	4 /22/1955	SN	SN	SN	SN	247	
IN147	22.37.24.133B	10/14/1953	218	NS	131	SN	254	

NS: Not Sampled, ND: Non-Detect

NMIVQCC Standards (ppm)

Rice Operating Company: CAP Zachary Hinton EOL (0-12) NMOCD File Number: 1R0426-36 October 2005

Page 2 of 2

Table 2b: Historic Organic Chemistry

IN037	Jct. J-26-1	5 /14/2004	SN	NS	NS	NS	
IN037	Jct. J-26-1	5 /7 /2004	Q	QN	QN	Q	
10037	Jct. J-26-1	2 /18/2004	QN	QN	Ŋ	QN	
1N037	Jct. J-26-1	10/30/2003	QN	Q	QN	QN	
1037	Jct. J-26-1	8 /22/2003	9	Q	ON .		
1N037	Jct. J-26-1	6 /5 /2003	ŊŊ	DN	QN	DN	
1N037	Jct. J-26-1	2 /28/2003	QN	QN	QN	QN	
10037	Jct. J-26-1	10/29/2002	QN	Q	QN	QN	
IN042	Jct. I-27-1	12/2 /2002	QN	ON I	ON ,	Q	
IN044	Zachary Hinton EOL (0-12 EOL)	8 /10/2005	DN N	ON .	ON .	Q	
IN044	Zachary Hinton EOL (0-12 EOL)	5 /23/2005	QN	QN I	UN	Q	
IN044	Zachary Hinton EOL (O-12 EOL)	3 /22/2005	QN	QN	Q	QN	
IN044	Zachary Hinton EOL (O-12 EOL)	1 /26/2005	QN	Ð	Q	QN	
IN044	Zachary Hinton EOL (0-12 EOL)	12/21/2004	Q	Q	Q	QN	
IN044	Zachary Hinton EOL (0-12 EOL)	9 /2 /2004	QN	NS	QN	QN	
IN044	Zachary Hinton EOL (0-12 EOL)	4 /17/2004	QN	Q	QN	QN	
IN044	Zachary Hinton EOL (0-12 EOL)	2 /19/2004	Q	Q	Ŋ	QN	
IN044	Zachary Hinton EOL (0-12 EOL)	11/20/2003	UN .	Q,	Q	Q	
IN044	Zachary Hinton EOL (0-12 EOL)	8 /22/2003	DN	Q	Q	Q	
IN044	Zachary Hinton EOL (0-12 EOL)	6 /5 /2003	QN	Q	ΩN	Q	
IN044	Zachary Hinton EOL (0-12 EOL)	3 /6 /2003	Q	Q	QN	QN	
IN044	Zachary Hinton EOL (0-12 EOL)	10/25/2002	Q	QN	Q	QN	
IN044	Zachary Hinton EOL (O-12 EOL)	8 /13/2002	QN	Q	QN	QN	
IN044	Zachary Hinton EOL (0-12 EOL)	5 /15/2002	Q	ON .	QN	GN N	
IN044	Zachary Hinton EOL (0-12 EOL)	3 /5 /2002	NS	N	NS	NS	
NMWOCC Standards (ppm)	(ude		0.01	0.75	0.75	0.62	

Rice Operating Compuny: CAP Zachury Hinton EOL (0-12) NMOCD File Number: 1R0426-36 October 2005

S. S. Same

Acres more an

1. 30 x 2. 25

A Star . And

Car Braker B

50

a Bitsain

12 March

2.72.9 . 400 ver

1. a a b

A 244 .

125 - 18 - 18dan (

"ender all all

34 a. 35

7 84.9.15

Patter.

APP F MAR

A state of the state

- Barris Coni

1. 3 3. 10 - 20 10 - 20

200

an interior 2

Lot to S

2.2.44

14) 141 141

A MARTIN

1000

 $A_{1}^{(n-1)} = \sum_{i=1}^{n-1} A_{i}^{(n-1)}$

 $e^{-2} e^{-\frac{2}{2}} e^{-2}$

- A. 6. 8 m. 1

I go by the

Table 2b: Historic Organic Chemistry

IN034 Zachary Hinton EOL (0-12 EOU) IN064 B-20 IN055 B-30 IN070 C-13 IN078 H-4 IN101 O-17-1 IN143 Windmill NE of Zech Hindon	3 /5 /2002 12/22/2000 6 /17/2001	Q S S S S	UN SN SN SN	ON	QN	
		S S S S	NS NS			
		S S S.	SN	NS	SZ	
		SN SN -		NS	RS	
		SN	NS	NS	RS	
	8 /17/2001		SN	SN .	NS N	•
		NS	SN	NS	SZ	
	12/18/2003	NS	ŝ	NS	NS	
	11/7 /2003	QN	Q	QN	QN	
IN145 Peters Well East	11/7 /2003	QN	ON .	DN .	QN N	
IN146 22.37.1.44	9 /8 /1958	SN	NS	SN	SZ 	
IN146 22.37.1.44	10/14/1953	SN	SN	NS	SZ	
IN147 22.37.24.133B	9 /8 /1958	SN	SN	NS	NS	
	4 /22/1955	SN .	SN	SN	SN SN SN SN SN SN SN SN SN SN SN SN SN S	
IN147 22.37.24.133B	10/14/1953	SN	NSN	NS	SN	

0.62 0.75 0.75 0.01 NMWQCC Standards (ppm)

Rice Operating Company: CAP Zachary Hinton EOL (0-12) NMOCD File Number: 1R0426-36 October 2005

Page 2 of 2

Internal Number (IN)	Соттон Name	Date	Chloride (ppm)	Sulfate (ppm)	(mdd) SQL	Total Alkalinity (ppn)	Bicarbonate (ppm)	Carbonate (ppm)	Conductivity (microhmos)
10037	Jct. J-26-1	5/14/2004	195	NSN	736	SN	SN	SN	NS
1N037	Jct. J-26-1	5/7/2004	390	NS	1440	NS	NS	NS	NS
1N037	Jct. J-26-1	2/18/2004	478	SN	1630	SN	NS	NS	NS
10037	Jct. J-26-1	10/30/2003	620	SN	2040	SN	SN	NS	NS
IN037	Jct. J-26-1	8/22/2003	957	SN,	2620	SN	SN	NS	NS
1037	Jct. J-26-1	6/5/2003	1460	NS	3280	NS	NS	NS	NS
1N037	Jct. J-26-1	2/28/2003	3470	NS	6870	NS	NS	NS	NS
1037	Jct. J-26-1	10/29/2002	4520	SN	9020	NS	NS	NS	NS
IN042	Jct. I-27-1	12/2/2002	266	SN	1200	N	SN.	SN	NS
IN044	Zachary Hinton EOL (0-12 EOL)	8/10/2005	361	227	1200	180	SN	NS	SN
	Zachary Hinton EOL (O-12 EOL)	5/23/2005	393	SN	1190	SN	SN	NS	NS
	Zachary Hinton EOL (O-12 EOL)	3/22/2005	403	202	1270	192	NS	NS	NS
IN044	Zachary Hinton EOL (0-12 EOL)	1/26/2005	351	SN	1150	SN	SN	NS	SN
IN044	Zachary Hinton EOL (O-12 EOL)	12/21/2004	354	SN	2370	SN .	NS	NS	NS
IN044	Zachary Hinton EOL (O-12 EOL)	9/2/2004	310	NS 	1160	NS	S N N	NS	NS
IN044	Zachary Hinton EOL (O-12 EOL)	4/17/2004	372	NS	1190	NS	SN	NS	NS
N044	Zachary Hinton EOL (O-12 EOL)	2/19/2004	380	SN	1297	NS	NS	NS	NS
IN044	Zachary Hinton EOL (0-12 EOL)	11/20/2003	346	SN	1170	SN	SN	SN	NS
IN044	Zachary Hinton EOL (O-12 EOL)	8/22/2003	408	NS	1350	SN SN	SN	SN	SN
IN044	Zachary Hinton EOL (O-12 EOL)	6/5/2003	354	NS	1140	NS	NS		
IN044	Zachary Hinton EOL (O-12 EOL)	3/6/2003	354	NS	1160	NS	NS	NS	NS
IN044	Zachary Hinton EOL (O-12 EOL)	10/25/2002	408	NS	1290	NS	NS	NS	NS
IN044	Zachary Hinton EOL (0-12 EOL)	8/13/2002	514	NS	1450	NS	SN N	NS	SN
IN044	Zachary Hinton EOL (0-12 EOL)	5/15/2002	478	SN	1470	SN	NS NS	SN -	SN SN
IN044	Zachary Hinton EOL (O-12 EOL)	3/5/2002	SN	SN	NS	SN	SN	NS	SN

Rice Operating Company; CAP Zachary Hinton EOL (0-12) NMOCD File Number: 1R0426-36 October 2005

and the second second

1. 45 m the

\$ St. 9. 2

an one set

14 M

1. No. 18

2. 115 484

an all it us

- Then the

The states of

Andre - A

and the second

 $\left[\frac{x_{i}}{x_{i}} + \frac{1}{2} \frac{x_{i}}{x_{i}} \right] \leq 1$

「中国の

Mr. Car

Internal Number (IN)	Common Name	Date	Chloride (ppm)	Chloride (ppm) Sulfate (ppm) TDS (ppm)	(mdd) SQL	Total Alkalinity (ppm)	Bicarbonate (ppm)	Carbonate (ppm)	Total Alkalinity (ppm) Bicarbonate (ppm) Carbonate (ppm) Conductivity (microhmos)
IN044	Zachary Hinton EOL (O-12 EOL)	3/5/2002	1000	NS	2403	SN	NS	SN.	NS
IN064	B-20		NS	NS	NS	NS	SN	NS	NS
IN065	B-30	12/22/2000	NS	SN	SN	NS	SN	NS	NS
020NI	C-13		NS	S	NS	NS	ŝ	NS	NS
IN078	4-H		NS	SN	NS	NS	SN	SN	SN .
IN101	0-17-1	8/17/2001	NS	NS	NS	NS	ŝ	NS	NS
IN143	Windmill NE of Zach Hinton	12/18/2003	460	118	1391	207	180	NS	180
IN144	Peters Well West	11/7/2003	200	62	892	221	269	NS	269
IN145	Peters Well East	11/7/2003	438	93 :-	NS	166	202	NS	202
IN146	22.37.1.44	9/8/1958	320	448	NS	580	211	NS	211
iN146	22.37.1.44	10/14/1953	525	841	2280	994	189	SN	189
IN147	22.37.24.133B	9/8/1958	580	622	NS	1080	216	NS	216
IN147	22.37.24.133B	4/22/1955	770	598	SN.	1360	216	SN	216
IN147	22.37.24.133B	10/14/1953	675	482	1960	1080	187	SN	187

NS: Not Sampled, ND: Non-Detect

1000 009 250 NMWQCC Standards (ppm)

Rice Operating Compuny; CAP Zachary Hinton EOL (0-12) NMOCD File Number: 1R0426-36 October 2005

R. T. Hicks Consultants, Ltd.

12 - ABB- 4

Sales a

Star Star B

al friends

and a gradient

6° N 64

2 . May .

PST TRANSPORT

3 . 5 . 5 . 5 . 6 .

· Walter

1.10 - 2 Adres 1

*** 142,000 C.

to a straight of the straight

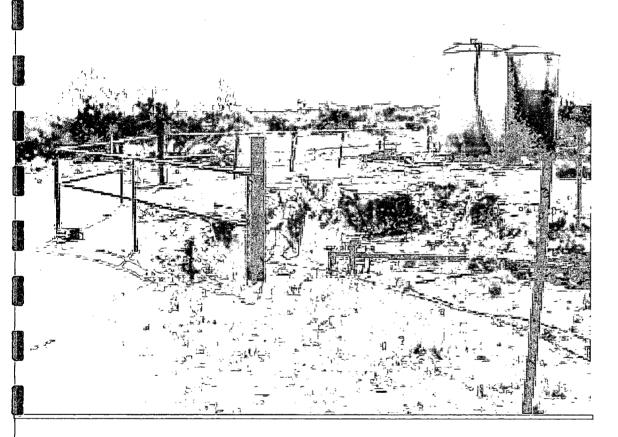
a Brach

Sugar by

Page 2 of 2

January 30, 2004

Corrective Action Plan



Zachary Hinton EOL Junction Box

R.T. HICKS CONSULTANTS, LTD.

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

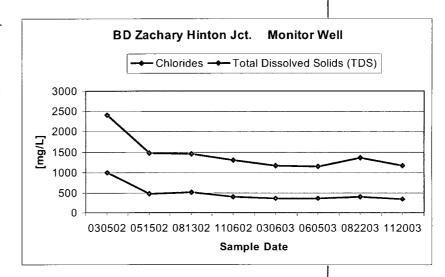
1.0 PURPOSE AND BACKGROUND

The Zachary Hinton EOL Junction Box is located about 2.5 miles southeast of the intersection of State Routes 18 and 8/176, near Eunice, New Mexico. Plate 1 of the NMOCD-approved work plan (Appendix A) shows the location of the site relative to Eunice. The work plan identified the following tasks:

- 1. Collection and Evaluation of Data for Simulation Modeling
- 2. Evaluate Migration of Chloride Flux from the Vadose Zone to Ground Water
- 3. Design Remedy and Submit Report

The goal of our work is to identify the surface and subsurface remedy for the site that creates the greatest environmental benefit while causing the least environmental damage.

The disclosure report prepared by Rice Operating Company (ROC) in January 21, 2003 (Appendix B) summarizes the initial activities at the site. The soil boring and backhoe excavation data show relatively consistent concentrations of chloride from 11 feet below ground surface (2000 ppm chloride) to 50 feet below ground surface (6410 ppm chloride). The consistency of these chloride



concentrations suggests that a release from the junction box may have created saturated conditions in the vadose zone. Hydrocarbons, often associated with releases from produced water pipelines, were not present in concentrations that warrant further inquiry (see ROC Disclosure Report.)

Figure 1 presents ground water quality data from the monitoring well that is located within 20 feet of the former Zachary Hinton EOL junction

CORRECTIVE ACTION PLAN - Zachary Minton EOL Junction Box January 29, 2004

Figure 1. Ground water quality data near Zachary Hinton EOL junction box.

box (Table 1). Chloride concentrations were about 1000 mg/L in early 2002, soon after replacement of the junction box. Throughout 2003, chloride concentrations remained stable (less than 500 mg/L).

Sea and

19. A. A. A.

Sec. S

よう 御い

Wals P

3. 18 A. 2

ما المركز ال

A state

frisk with

As stated in the work plan, R.T. Hicks Consultants, Ltd. used HYDRUS-1D to simulate chloride fate and transport to ground water and to develop a surface remedy for the site. This report presents the results of our study and proposes a final remedy for the site to permit closure of the regulatory file.

CORRECTIVE ACTION PLAN - Zachary Minton EQL Junction Box January 29, 2004

2.0 APPROACH

1.2.5

324

We used the numerical model HYDRUS-1D to simulate the transport of chloride from the surface through the vadose zone to ground water. We used the predicted flux of chloride to ground water from HYDRUS-1D as input into a simple ground water mixing-model to evaluate the impact on ground water quality. As Appendix C describes, this modeling effort requires 11 input parameters. Appendix C also describes the modeling approach used in this effort.

In our previous work with HYDRUS-1D, we found that some input parameters had little effect on the prediction of chloride concentration in ground water while other factors had a profound effect. The Sensitivity Analysis presented in Appendix C describes the relative importance of each of the eleven input parameters. Two of these eleven factors (release volume and height of the spill) are not relevant in our simulations, since we evaluated the movement of the chloride load already in the soil profile. Site specific data exist for the most important input factors (e.g. chloride load, depth of ground water, soil texture, etc.).

3.0 DATA EMPLOYED FOR THE ZACHARY HINTON SITE

For some input parameters we employed regional data or values based upon professional judgment (see Table 2). For most of the input data to our simulations, we relyed upon site data collected by Rice Operating Company. Our field inspection of the site and our evaluation of the data allow us to conclude that the site data used in our simulations reflect the conditions at the site.

Plate 2 shows the soil profile texture and thickness of the vadose zone at the site (input parameters # 1 and #2 of Table 2). We input the soil texture into HYDRUS-1D and allowed the model's library to generate the hydraulic properties. We then used these hydraulic properties in simulations of these scenarios.

Based upon our experience, we employed a dispersion length of 100 cm (input #3). The selected dispersion length is 7% of the total length of the HYDRUS-1D model (55 feet). Many researchers suggest that a dispersion length that is 7-10% of the total model length provides reasonable results for simulation experiments.

We used the soil moisture content (input # 4) presented in Table 2 from HYDRUS-1D simulations. Because we did not have site-specific soil moisture data, we assumed a "dry" soil profile then used the climate data to add moisture to the profile via precipitation over 100 years. We found that initial soil moisture in the profile changed over this 100-year period, responding to the climatic conditions. Therefore, we ran the simulations under both "wet" and "dry" conditions as determined by the 100-year simulation experiment. As Table 2 shows, we elected to employ the "wet" conditions in our simulations because leakage from the junction box over the past years has created "wet" conditions within the profile.

Plate 2 shows the measured soil chloride concentration per unit weight of soil. We converted these values to concentrations per liter of soil water (input #5) by using the equations in Appendix D. The length of the release (input #6) was measured in the field.

The daily climate data available from the Pearl weather station near the Hobbs Airport served as input for all climate indices required by HYDRUS-1D (input #7). We simulated 10 years after the release with

CORRECTIVE ACTION PLAN - Zachary Hinton EOL Junction Box January 29, 2004

average precipitation 36 cm/year.

Constant and a second

Anda

1020

the set

Subat

138° 13

N. 24 4

Sec. Solar

Sect. A

State Card

And Co

1 . A

Rath

Creek a

19000

Sec.

"武武海"

ALL REAL STA

For the input parameter #8, background ground water chloride concentration, we used 100 mg/L based upon data from the City of Eunice. We used data for the Ogallala Aquifer as described in Nicholsen and Clebsch, (1961) as input to the mixing model (input #9, ground water flux; input#10, aquifer thickness).

We also used data from the BD Zachary Hinton Jct monitor well to verify the predictions of the HYDRUS-1D model and the mixing model.

CORRECTIVE AGTION PLAN - Zachary Hinton FOL Junction Box January 29, 2064

4.0 SET-UP OF SIMULATIONS

SCENARIO 1: NO ACTION

The no action alternative evaluates the potential of the chloride mass in the vadose zone to materially impair ground water quality at the site in the absence of any action by Rice Operating Company and in the absence of any natural restoration (e.g. re-establishing vegetation). As described in Appendix C, the distribution of the mass of chloride in the vadose zone (input #5) is the most important input parameter for prediction of chloride concentrations in ground water. For this and all simulations, we assumed the chloride concentrations shown in Plate 1 existed in the profile at time zero. At time zero, we also assume that man-made leakage of produced water has ceased and the chloride concentration in the monitoring well is equal to background (100 mg/L). While the first and second assumptions are acceptable, the assumption that the chloride concentration in the monitoring well is equal to background is false. We make this last assumption as a matter of convenience to simplify our model and we explain the effect of this simplification in our discussion of the results of the simulations.

The chloride concentration of soil water $Cl^{soil water}$ (mg/liter) depends on the gravimetric chloride content of moist soil Clg^{moist soil} (mg/kg of moist soil), the bulk density of the soil Dsoil^{dry} (kg/m³), and the volumetric water content of the soil èv (m³/m³) input #4 . To convert the chloride concentration in the soil to chloride concentration in soil water (see Appendix D), we used a soil density of 1,858 kg/cubic meter and the soil moisture content in Table 2.

We entered the chloride concentration of soil water in the soil profile in HYDRUS and ran the simulation for 10 years with total precipitation and evaporation from the soil. Vegetation was assumed to not be present to enhance water transfer from soil to the atmosphere. We calibrated the results from the model with the chloride data from a monitoring well located 20 feet downgradient from the center of the spill.

SCENARIO 2: REDUCE INFILTRATION

To minimize the potential for any leaching of residual chloride from the vadose zone, we assumed a surface remedy that would reduce infiltration of precipitation. To simulate such a remedy, we simply reduced the precipitation by assuming that heavy rains (that cause the majority of

CORRECTIVE ACTION PLAN - Zachary Ninton LOL Junction Box January 29, 2004 the infiltration) run off after 1.5 cm fell. This simulation predicts the effect of (a) sloping the site to cause runoff of the larger precipitation events and/or (b) placement of a graded compacted layer at the surface to minimize infiltration, facilitate runoff and prevent ponding of precipitation. All other input parameters are the same as Scenario 1.

SCENARIO 3: VEGETATION

24.13

This scenario consists of placing 30 cm of silt loam and reseeding with pasture. The transpiration is zero during the winter months but soil evaporation takes place. During the growing season, evapotranspiration is greatest. All other input parameters are the same as Scenario 1.

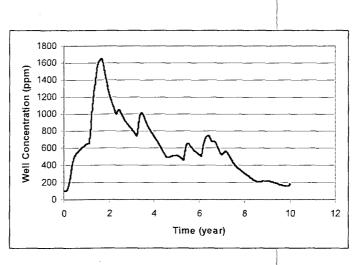
SCENARIO 4: A SILT CLAY BELOW THE TOP SOIL

In this scenario we placed 60 cm of a silt clay below the top soil under the same conditions of Scenario 3. Placing the clay below the top soil minimizes infiltration into the deeper profile and provides a place for the infiltration of winter precipitation to reside until the plants take it up in the following spring and summer. All other input parameters are the same as Scenario 1.

CORRECTIVE ACTION FLAM - Zackary Minton Kol Junction Box January 29, 2004

5.0 SIMULATION RESULTS AND DISCUSSION

Figure 2 shows the response of Scenario 1 in a monitoring well located 20 feet from the center of the spill at the release site. The simulation shows chloride concentration increasing to a maximum of 1,652 ppm in year 1.7. As stated in the previous section, in this and other simulations. when man-made leakage ceased, the chloride concentrations in the vadose zone are equal to that represented in Plate 1. To simplify our modeling experiment, we

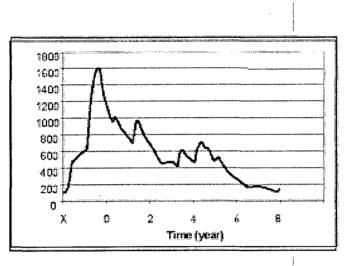


assumed that the chloride concentration in the monitoring well at time zero in Figure 2 is equal to background (100 mg/L). Therefore, the initial increase in chloride concentration from background (100 mg/L) to a maximum (1,652 in this simulation) is the model's response to the downward movement of the initial distribution of chloride in the profile. Because the well was installed after replacement of the junction box and cessation of periodic leakage, we cannot know the chloride concentration at the monitoring well during past man-made leakage events. We hypothesize, however, that chloride concentration in ground water would be 1,652 mg/L or more during the time that the juction box periodically released produced water. Chloride concentrations in the monitoring well might remain at or above the 1,652 mg/L during the years of periodic discharges from the former junction box, as chloride migrated from the ground surface to ground water via saturated flow. After replacement of the junction box, water additions to the soil profile cease and the soil profile would drain. During the drainage of the soil profile, chloride concentrations in the monitoring well would decrease as saturated flow ceased and slower, unsaturated flow conditions occurred in the profile.

Figure 3 modifies the HYDRUS-1D output to better represent the conditions described above. In this Figure, time X represents background conditions, before any leakage from the junction box. As periodic leakage occurs, chloride concentration in ground water rises and chloride is

CORRECTIVE ACTION PLAN - Zachary Histor EOL Junction Box January 29, 2004 Figure 2. Chloride concentration in the monitoring well for the no action scenario. (Scenario 1)

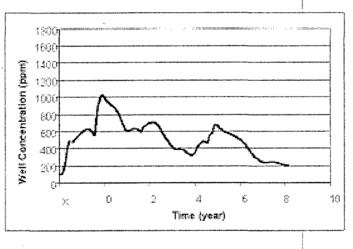
distributed throughout the unsaturated zone, as shown in Plate 1. We believe that the maximum chloride concentration in ground water in Figure 3 (1,652 mg/L) is approximately what we would have observed during the period of leakage from the junction box if the monitoring well had been installed. After repair of the junction box (here noted as approximately time zero), chloride



concentrations decline as discussed above and as shown in Figure 3. About five years after repair of the junction box under the No Action Scenario, ground water chloride approaches background concentrations. Figure 3. Modification of HYDRUS-1D simulation results to illustrate a more realistic time scale for Scenario 1.

Figure 4 shows the results of our simulations of Scenario 2 with the same modified time line as in Figure 3. Reducing infiltration of precipitation creates a maximum concentration 1,048 mg/ L marked approximately as year 0 to show when junction box repair occured. Reducing infiltration slows the drainage of vadose zone water relative to the no action scenario. Therefore, water and chloride

2012



enter the ground water more slowly in this scenario as compared to the no action scenario. In other words, the chloride flux (mass/time) into ground water is lower in Scenario 2 than in scenario 1. The ground water flux and aquifer thickness, however, remain the same in both scenarios. The lower chloride flux into ground water results in a lower maximum concentration observed in the monitoring well. This lower flux also results in a longer time of predicted non-compliance at the monitoring well.

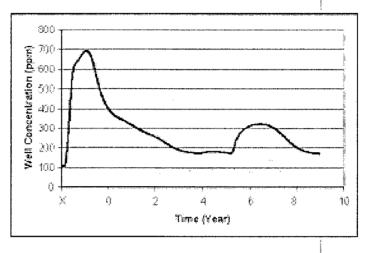
Figure 4. Modification of HYDRUS-1D simulation results to show a more realistic time scale for chloride concentration in the monitoring well for the scenario reducing the infiltration. (Scenario 2)

CORRECTIVE ACTION PLAK - Zachary Hinton EOL Junction Box January 29, 2004

About six years after repair of the junction box, the majority of the chloride has drained from the vadose zone and concentrations in the well declines to the standard of 250 mg/L. We did not simulate the length of time neces-

sary for ground water to reach background conditions under this scenario.

Figure 5 shows the results of the Scenario 3, which assumes further reduction of infiltration due to evapotranspiration as a result of plant cover. The maximum chloride concentration in the well is 693 mg/L at



approximately zero time on the modified scale. As discussed previously, the time of maximum chloride concentration is the time when the junction box is repaired. The chloride concentration declines to the standard of 250 mg/L in year 2.11. However, we predict an increase in ground water chloride concentrations to 323 ppm in year 6.5 followed by a decrease to the standard by year 7.5. This increase at year 6.5 is probably due to increased infiltration associated with the El Niño weather pattern. Because most the chloride has drained from the profile by year 6.5, we conclude that any additional increase in ground water chloride concentration (perhaps at year 14) would not exceed the ground water standard of 250 mg/L.

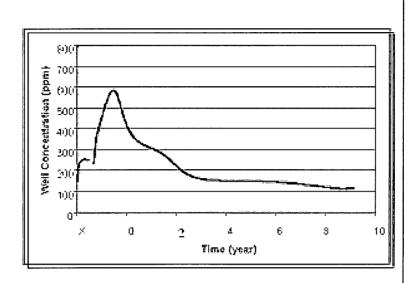
The concentrations in the root zone in Scenario 3 are quite high as result of capillary rise that accumulates the salts at the top of the profile. Concentrations of 4,000 ppm will prevent the grass of developing unless chloride moves deeper into the subsurface due to a soil flushing program or natural rainfall.

Figure 6 shows the result of Scenario 4 with the modified time scale. The maximum concentration in the well is 604 ppm in year 0. It declines to 250 ppm in year 1.75. The concentrations in the root zone are about 1300 ppm, suitable for vegetation. By year 8, background conditions exist in the monitoring well.

Figure 1 shows the chloride concentration in the monitoring well at the Zachary Hinton site. This well was installed after replacement of the

CORRECTIVE ACTION PLAN - Zachary Hinton EOL Junction Box January 29, 2064 Figure 5. Modification of HYDRUS-1D simulation results to illustrate a more realistic time scale, chloride concentration in the well for the vegetation scenario. (Scenario 3)

produced water pipeline junction that we believe caused the release of chloride to the subsurface. The data show chloride concentraton declining from 1,000 mg/L to 500



mg/L over a two-month period. The concentration then declines to about 400 mg/L after one year. Obviously, these data do not correlate with the model predictions of Scenario 1, no action. Instead, the field data are more similar to the predictions of Scenario 3, where infiltration into the vadose zone is relatively low due to evapotranspiration associated with vegetation.

The similarity between Figures 1 and 5 should not be surprising if one visits the site. Vegetation does exist around the area of the suspected release (Figure 7). We believe the current flux of chloride from the vadose zone to ground water is approximately the same as that simulated in Scenario 3. We can also conclude from Figure 7 that the chloride concentration in the root zone is low enough to support vegetation. The no action scenario, which does not provide for evapotranspiration or

any reduced infiltration, obviously overestimates the impact of the chloride load to ground water quality.



CORRECTIVE ACTION PLAN - Zachary Hinton EOL Junction Box January 29, 2004 Figure 6. Modification of HYDRUS-1D simulation results showing a more realistic time scale of chloride concentration in the well for the scenario with vegetation and a silt clay layer below the topsoil. (Scenario 4).

Figure 7. Vegetation near the release site.

6.0 GROUND WATER QUALITY AND FLOW

Although the quality of the City of Eunice water supply wells is about 100 mg/L chloride (see Nicholson and Clebsch, 1961), a more detailed investigation of the area near the Zachary Hinton EOL site shows higher background levels. Plate 2 shows the locations of wells with past and present water quality data and Table 3 presents the results for chloride.

The chloride concentration in the City of Eunice wells and the Peters West well are below Water Quality Control Comission standards for ground water. Wells within or near Monument Draw, however, generally exceed the standards. The difference between the water quality west of Monument Draw and the water quality within and near the Draw has been evident since the 1950s when Nicholson and Clebsch sampled the water of the area (Table 3).

Today, as in the 1950s, ground water flows from the west toward Monument Draw. Ground water then flows south within the draw as shown in Plate 3 from Nicholson and Clebsch (1961). Up gradient from the Zachary Hinton EOL site, chloride concentrations in the Active Windmill of Section 36 (see Plate 2) is 460 ppm. The chloride in this active windmill is consistent with the chloride concentrations observed in wells 22.37.1.440 and 22.37.24.133b (average of 422 and 675 ppm respectively) in the 1950s. The Peters East well, which lies within Monument Draw, exhibits a chloride concentration of 438 ppm while the chloride concentration in the Zachary Hinton EOL monitoring well is 354 ppm. This measuable difference in chemistry between the Zachary Hinton Site and the Peters East well could be due to the effect of higher quality ground water flowing into the Monument Draw area from the west (e.g. 200 ppm chloride in the Peters West well), or the difference may be due to normal variance associated with sampling and analysis.

Connective Action PLAN - Zechney Hillars Editmetion Box Innectory 20, 2004

7.0 CONCLUSION AND RECOMMENDED ACTION

The HYDRUS-1D simulations for the Zachary Hinton site provide reasonably good, albeit conservative, predictions of chloride concentrations in ground water for the various scenarios. Currently, about two years after the repair of the pipeline and cessation of water leakage, chloride concentrations in the ground water monitoring well are 354 ppm, background correlations. The field data correlate well with early time predictions of Scenario 3, reduced flux due to vegetation. We conclude Scenario 3 predicts higher chloride concentrations than observed.

We conclude that the background chloride concentration in ground water at the Zachary Hinton EOL site is about 350 ppm. We base this conclusion on historical and recent water quality analyses from the area. Natural restoration has mitigated the transient impact of past leakage from the site. Data from the Peters East well suggest that past leakage from the Zachary Hinton EOL Junction box have not caused measurable degradation of ground water quality.

We recommend restoring the ground surface in the excavation using soil that will permit re-vegetation. Because the water quality at the site has returned to background conditions, we recommend plugging and abandonment of the existing monitoring well and closure of the regulatory file for this site, pending documentation of appropriate surface reclamation.

CORRECTIVE ACTION PLEN - Zachury Histor Foldmerion Sox Izanaary 20, 2004

September 12, 2003

Simulation of Chloride Transport

RICE OPERATING COMPANY ZACHARY HINTON

Prepared for: Rice Operating Company 122 West Tavlor

Hobbs, NM 88240

R.T. HICKS CONSULTANTS, LTD.

A 640 100

2.74 J

and the

14

بدقيته فالمهدية

100 C 20

- it append

م تلویق همیا

Land

and the second

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

6.0 GROUND WATER QUALITY AND FLOW

Although the quality of the City of Eunice water supply wells is about 100 mg/L chloride (see Nicholson and Clebsch, 1961), a more detailed investigation of the area near the Zachary Hinton EOL site shows higher background levels. Plate 2 shows the locations of wells with past and present water quality data and Table 3 presents the results for chloride.

The chloride concentration in the City of Eunice wells and the Peters West well are below Water Quality Control Comission standards for ground water. Wells within or near Monument Draw, however, generally exceed the standards. The difference between the water quality west of Monument Draw and the water quality within and near the Draw has been evident since the 1950s when Nicholson and Clebsch sampled the water of the area (Table 3).

Today, as in the 1950s, ground water flows from the west toward Monument Draw. Ground water then flows south within the draw as shown in Plate 3 from Nicholson and Clebsch (1961). Up gradient from the Zachary Hinton EOL site, chloride concentrations in the Active Windmill of Section 36 (see Plate 2) is 460 ppm. The chloride in this active windmill is consistent with the chloride concentrations observed in wells 22.37.1.440 and 22.37.24.133b (average of 422 and 675 ppm respectively) in the 1950s. The Peters East well, which lies within Monument Draw, exhibits a chloride concentration of 438 ppm while the chloride concentration in the Zachary Hinton EOL monitoring well is 354 ppm. This measuable difference in chemistry between the Zachary Hinton Site and the Peters East well could be due to the effect of higher quality ground water flowing into the Monument Draw area from the west (e.g. 200 ppm chloride in the Peters West well), or the difference may be due to normal variance associated with sampling and analysis.

CORRECTIVE ACTION PLAN - Zachary Hinton EQL Junction Box January 23, 2004

7.0 CONCLUSION AND RECOMMENDED ACTION

The HYDRUS-1D simulations for the Zachary Hinton site provide reasonably good, albeit conservative, predictions of chloride concentrations in ground water for the various scenarios. Currently, about two years after the repair of the pipeline and cessation of water leakage, chloride concentrations in the ground water monitoring well are 354 ppm, background correlations. The field data correlate well with early time predictions of Scenario 3, reduced flux due to vegetation. We conclude Scenario 3 predicts higher chloride concentrations than observed.

We conclude that the background chloride concentration in ground water at the Zachary Hinton EOL site is about 350 ppm. We base this conclusion on historical and recent water quality analyses from the area. Natural restoration has mitigated the transient impact of past leakage from the site. Data from the Peters East well suggest that past leakage from the Zachary Hinton EOL Junction box have not caused measurable degradation of ground water quality.

We recommend restoring the ground surface in the excavation using soil that will permit re-vegetation. Because the water quality at the site has returned to background conditions, we recommend plugging and abandonment of the existing monitoring well and closure of the regulatory file for this site, pending documentation of appropriate surface reclamation.

SORRECTIVE ACTION PLAN - Zachary Hinton Foll Junction Box January 29, 2004

ALL BRAN

September 12, 2003

Simulation of Chloride Transport

RICE OPERATING COMPANY ZACHARY HINTON

Prepared for:

Rice Operating Company 122 West Taylor Hobbs, NM 88240

R.T. HICKS CONSULTANTS, LTD.

No. and No.

-diam'r

Sec. 1

25.85

1. S. S. M.

は使い国

Sec. N

and the state of

Sta and

C. Ball

A KAGA

1 4 M

.....

Sec. 1

Same and

the given

and the second

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

Table of Contents

NUMBER OF

and the second

a constanting

anation w

Sec.

No. 2

N. A.

States -

State.

مريحية. مريحية

termin t

 $\frac{f(t)}{d(t,t)} = \frac{f(t)}{d(t,t)} + \frac{f(t)}{d($

a designations

Sec. 20

1.0	Purpose	. 1
2.0	Approach	. 2
	Data Employed for the Zachary Hinton Site	
	3.1 Scenerio 1: No Action	
	3.2 Scenerio 2: Reduce Infiltration	
	3.3 Scenerio 3: Vegetation	. 4
	3.4 Scenerio 4: A Silt Clay Below the Top Soil	
4.0	Results and Discussion	. 5
5.0	Conclusion and Recommended Action	. 6

FIGURES

Figure 1: Chloride concentration in the monitoring well for the no action scenario. (Scenario 1).

Figure 2: Chloride concentration in the monitoring well for the scenario reducing the infiltration. (Scenario 2).

Figure 3: Chloride concentration in the well for the vegetation scenario. (Scenario 3).

Figure 4: Chloride concentration in the well for the scenario with vegetation and a silt clay laver below the topsoil. (Scenario 4).

Figure 5: Chloride concentration in the well for the monitoring well at the Zachary Hinton site.

Figure 6: To be inserted after the field program

TABLES

Table 1: Input Parameters for the Simulations

PLATES

and an and

1. S. M.

Plate 1: Soil Profile Texture and Thickness of the Vadose Zone at the Site

APPENDICES

Appendix A: HYDRUS-1D: Description of Modeling Approach Appendix B: Equations Used to Calculate Chloride Load

1.0 PURPOSE

The Zachary Hinton EOL Junction Box is loacated about 2.5 miles southeast of the intersection of State Routes 18 and 8/176, near Eunice, New Mexico. The disclosure report prepared by Rice Operating Company (ROC) in January 21, 2003 summarizes activities to date. The soil boring and backhoe excavation data show relatively consistent concentrations of chloride from 11 feet below ground surface (2000 ppm chloride) to 50 feet below ground surface (6410 ppm chloride). The consistency of these chloride concentrations suggests that a release from the junction box may have created saturated conditions in the vadose zone. Hydrocarbons, often associated with releases from produced water pipelines, were not present in concentrations that warrant further inquiry (see ROC Disclosure Report).

R.T. Hicks Consultants, Ltd. used HYDRUS1D to simulate chloride fate to address potential environmental concerns at the site. This report presents the results of our study and proposes a final remedy for the site to permit closure of the regulatory file.

SIMULATION OF CHLORIPE TRANSPORT - ZACHARY HINTON Rice Operating Company September 12, 2003

2.0 APPROACH

We used the numerical model HYDRUS1D to simulate the transport of chloride from the surface through the vadose zone to ground water. We used the predicted flux of chloride to ground water from HYDRUS1D as input into a simple ground water mixing-model to evaluate the impact on ground water quality. As Appendix A describes, this modeling effort requires 11 input parameters. Appendix A also describes our modeling approach used in this effort.

In our previous work with HYDRUS1D, we found that some input parameters had little effect on the prediction of chloride concentration in ground water while other factors had a profound effect. The Sensitivity Analysis presented in Appendix A describes the relative importance of each of the eleven input parameters. Two of these eleven factors (release volume and height of the spill) are not relevant in our simulations, since we will evaluate the movement of the chloride load already in the soil profile. Site specific data exist for the most important input factors (e.g. chloride load, depth ot ground water). For some input parameters we employed regional data or values based upon professional judgment (see Table 1).

Simulation of chlorine teansport -zachary hinton Rice Operating Company September 12, 2003

3.0 DATA EMPLOYED FOR THE ZACHARY HINTON SITE

We present four scenarios to describe possible chloride migration at the site. Plate 1 shows a typical soil profile texture and thickness of the vadose zone at the site (input parameters # 1 and #2). We input the soil texture into HYDRUS1D and allowed the model's library to generate the hydraulic properties . We then used these hydraulic properties in simulations of these scenarios.

Based upon our experience, we employed a dispersion length of 100 cm (input #3). The selected dispersion length is 7% of the total length of the HYDRUS1D model (55 feet). Many researchers suggest that a dispersion length that is 7-10% of the total model length provides reasonable results for simulation experiments. We used the soil moisture content (input # 4) presented in Table 1 from hydrus simulations.

Plate 1 shows the measured soil chloride concentration per unit weight of soil. We convert these values to concentrations per liter of soil water (input $#_5$) by using the equations in Appendix B. The length of the release (input $#_6$) was measured in the field.

The daily climate data available from the Pearl weather station near the Hobbs Airport served as input for all climate indices required by HYDRUS1D (input #7). We simulated 10 years with average precipitation 36 cm/year.

For the input parameter #8, background ground water chloride concentration, we used 100 m g/L based upon site data. We used data for the Ogallala Aquifer as described in Nicholsen and Clebsch, (1961) as input to the mixing model (input #9, ground water flux; input#10, aquifer thickness).

We also used data from the BD Zachary Hinton Jct monitor well to verify the predictions of the HYDRUS1D model and the mixing model.

3.1 SCENARIO 1: NO ACTION

The no action alternative evaluates the potential of the chloride mass in the vadose zone to materially impair ground water quality at the site. As described in Appendix A, the distribution of the mass of chloride in the vadose zone (input 5) is the most important input parameter for prediction of chloride concentrations in ground water. The chloride concentration of soil water Cl^{soil} water (mg/liter) depends on the gravimetric chloride content of moist soil Clg^{moist} soil (mg/kg of moist soil), the bulk density of the soil Dsoil^{dry} (kg/m³), and the volumetric water content of the soil èv (m³/m³) input #4 . To convert the chloride concentration in the soil to chloride concentration in soil water (Appendix B), we used a soil density of 1858 kg/cubic meter and the soil moisture content in table 1.

SINULATION OF CALCALDE TEANSPORT - ZACHARY HINTON Rice Operating Company September 12, 2003

We enter the chloride concentration of soil water in the soil profile in HYDRUS and run the simulation for 10 years with total precipitation and evaporation from the soil.

We calibrate the results from the model with the chloride data from a monitoring well located 20 feet downgradient from the center of the spill.

3.2 SCENARIO 2: REDUCE INFILTRATION

To minimize the potential for any leaching of residual chloride from the vadose zone, we assumed a surface remedy that would reduce infiltration of precipitation. To simulate such a remedy, we simply reduced the precipitation by assuming that heavy rains (that cause the majority of the infiltration) run off after 1.5 cm fell. This simulation predicts the effect of (a) sloping the site to cause runoff of the larger precipitation events (b) placement of a graded compacted layer at the surface to minimize infiltration, facilitate runoff and prevent ponding of precipitation. All other input parameters are the same as Scenario 1.

3.3 SCENARIO 3: VEGETATION

This scenario consists of placing 30 cm of silt loam and reseeding with pasture. The transpiration is zero during the winter months but soil evaporation takes place. All other input parameters are the same as Scenario 1.

3.4 SCENARIO 4: A SILT CLAY BELOW THE TOP SOIL

In this scenario we place a 60 cm of a silt clay below the top soil under the same conditions of Scenario 3. Placing the clay below the top soil minimizes infiltration into the deeper profile and provides a place for the infiltration of winter to reside until the plants take it up in the following spring and summer. All other input parameters are the same as Scenario 1.

SIMULATION OF COLORIDE TRANSPORT - ZACEASY SINTON Bice Operating Company Soptomber 12, 2003

4.0 RESULTS

Figure 1 shows the response of Scenario 1 in a monitoring well located 20 feet from the center of the spill at the release site. The simulation shows chloride concentration increasing to a maximum of 1652 ppm in year 1.7. In this and other simulations, this early-time increase in chloride concentration from background (100 mg/L) to a maximum is due to the initial conditions assumed in the model – it does not represent our prediction of ground water chloride concentration. Because we assume a background chloride concentration in ground water of 100 mg/L, the chloride concentration in ground water returned by our simulation at time zero is 100 mg/L. After time zero, chloriderich pore water in the vadose zone begins to drain into the aquifer. Examination of Plate 1 shows that the bottom of the vadose zone (50-56 feet below land surface) exhibits 500 ppm chloride in soil samples while the sampling interval from 45-50 feet shows 6410 ppm. Therefore, the calculated mass of chloride per unit time (the flux of chloride) that enters the aquifer during the early time of the simulation considers the drainage of relatively low chloride concentrations in pore water from the 50-56 foot depth interval. As the chloride-rich water from the 45-50 foot depth interval drains into the aquifer, the chloride concentration in the well begins to rise. At time 1.7 years, we believe the chloride mass associated with the depth interval 30-35 feet (8160 ppm in soil samples) is draining into the aquifer. After 1.7 years, the concentration in the well declines and increases repeatedly as the model responds to weather changes (e.g. monsoon cycles) and differences in the chloride load of the depth intervals. After year 8.3, most of the chloride is leached from the profile and the concentration in the observation well meets the ground water standard of 250 mg/L.

Figure 2 shows the results of our simulations of Scenario 2. Reduction of infiltration of precipitation creates a maximum concentration 1048 mg/L in year 1.7. Reducing infiltration slows the drainage of vadose zone water relative to the no action scenario. Therefore, water and chloride enter the ground water more slowly in this scenario as compared to the no action scenario. In other words, the chloride flux (mass/time) into ground water is lower in scenario 2 than in scenario 1. The ground water flux and aquifer thickness, however, remain the same in both scenarios. The lower chloride flux into ground water results in a lower maximum concentration observed in the monitoring well. This lower flux also results in a longer time of predicted non-compliance at the monitoring well. Nine and one half years pass before the majority of the chloride has drained from the vadose zone and concentrations in the well decline to the standard of 250 mg/L.

Figure 3 shows the results of the Scenario 3, which assumes further reduction of infiltration due to evapotranspiration of a plant cover. The maximum concentration in the well is 693 mg/L in year 1.08, which declines to the standard of 250 mg/L in year 4.11. However we predict an increase in ground water chloride concentrations to 323 ppm in year 8.5 followed by a decreas to the standard by year 9.5. This increase at year 8.5 is probably due to in-

SEMULATION OF CHLORIDE TEANSPORT - ZACHARY EINTON Rice Operating Company September 12, 2003

creased infiltration associated with the El Niño weather pattern. Because most the chloride has drained from the profile by year 8.5, we conclude that any additional increase in ground water chloride concentration (perhaps at year 16) would not exceed the ground water standard of 250 mg/L.

However, the concentrations in the root zone in scenario 3 are quite high as result of capillary rise that accumulates the salts at the top of the profile. Concentrations 4000 ppm will prevent the grass of developing unless chloride moves deeper into the subsurface due to a soil flushing program.

Figure 4 shows the result of Scenario 4. The maximum concentration in the well is 604 ppm in year 1.28. It declines to 250 ppm in year 3.75. The concentrations in the root zone are about 1300 ppm, suitable for vegetation. Figure 5 shows the chloride concentration in the monitoring well at the Zachary Hinton site. This well was installed after replacement of the produced water pipeline junction that we believe caused the release of chloride to the subsurface. The data show chloride concentration declining from 1000 mg/L to 500 mg/L over a two-month period. The concentration then declines to about 300 mg/L after one year. Obviously, these data do not correlate with the model predictions of Scenario 1, no action. Instead, the field data appear to agree with the predictions of Scenario 3, where infiltration into the vadose zone is relatively low due to evapotranspiration associated with vegetation. In fact, the correlation between the field data of Figure 5 and the predictions of Figure 3 are striking.

The similarity between Figures 3 and 5 should not be surprising if one visits the site. Vegetation does exist around the area of the suspected release (Figure 6 – to be inserted after the field program). We believe the current flux of chloride from the vadose zone to ground water is approximately the same as that simulated in Figure 3. We can also conclude from Figure 6 that the chloride concentration in the root zone is low enough to support vegetation. The no action scenario, which does not provide for evapotranspiration or any reduced infiltration, obviously overestimates the impact of the chloride load to ground water quality.

SEMULATION OF CELONIDE TRANSPORT - ZACHARY HINTON Rice Operating Gempany September 12, 2003

5.0 CONCLUSION AND RECOMMENDED ACTION

The HYDRUS1D simulations for the Zachary Hinton site provide reasonably good predictions of chloride concentrations in ground water for the various scenarios. Currently, about two years after the repair of the pipeline and cessation of water leakage, chloride concentrations in the ground water monitoring well are 345 ppm. The field data correlate very well with Scenario 3, reduced flux do to vegetation. We conclude that future chloride concentrations in the existing monitoring well will continue to follow the pattern predicted by Scenario 3.

What is most encouraging is that all scenarios, even the most conservative "no action" scenario, lead to chloride concentrations less than 250 ppm within ten years.

We recommend restoring the ground surface near the excavation using soil that will permit revegetation. Because the industry has little long-term ground water data on such sites with excellent characterization of the chloride load, we recommend semi-annual sampling of the existing monitoring well and analysis of TDS and chloride for two years. If the data continues to correlate with the predictions expressed in Figure 3, as we suspect, this ground water data will provide comfort to the State and landowners that the predictions of the HYDRUS and mixing model can be employed for other sites throughout the Permian Basin.

SIMULATION OF CHLORIBE TRANSPORT - ZACHEEY EINTON Rice Operating Company Soutember 12, 2003

FIGURES

Same Preserve

a way to a the

N. A. M. K.

のである

- 4. 100 - 10 0

1. Sec. 17

1. A. 184

No. mille

48 - 29 - 19° -

a datas

T. Service

A total

10 8-8 1- 5 10%

Figure 1. Chloride concentration in the monitoring well for the no action scenario. (Scenario 1).

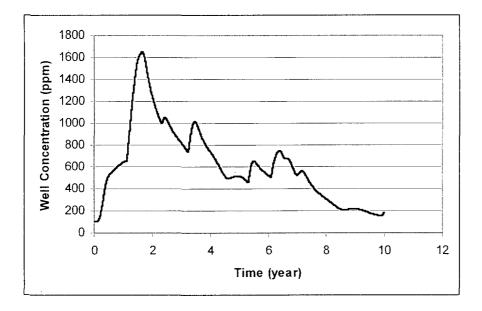
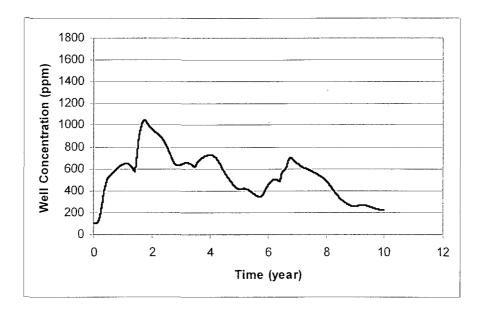


Figure 2. Chloride concentration in the monitoring well for the scenario reducing the infiltration. (Scenario 2).



and the second second

and the second sec

22. Anti, 5 x

Advanto -

10.7 M

din mige

And the

5.800 180

語い言語

and the second

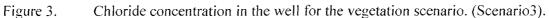
A and a line

Care of the

No.

an Star

* State



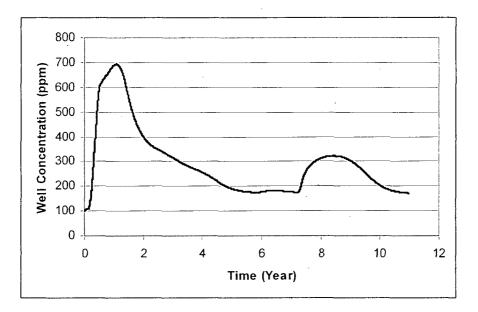
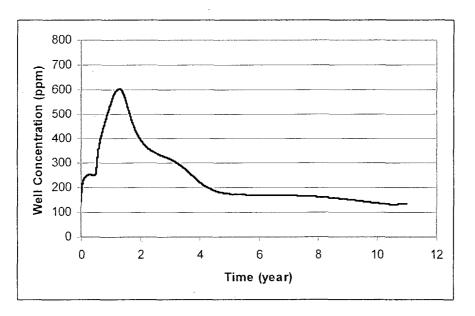


Figure 4. Chloride concentration in the well for the scenario with vegetation and a silt clay layer below the topsoil.(Scenario 4).



Figi

and a main

S. Kandad

Age Age

State of the

and Probability

And And

and the se

ALL LAN

Statistical Statistica Statistical Statisticae Statisticae Statisticae Statist

S. A. A.

S. Same

が、時代ない

in should be

and so and a second

The start

2.03 C

ALL ALLA

17. A.

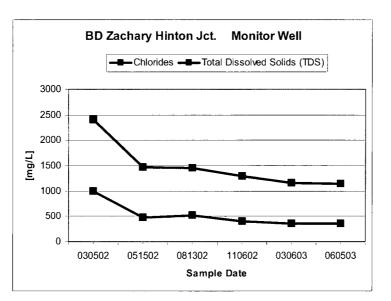


Figure 5. Chloride concentration in the monitoring well at Zachary Hinton

Service a r

بو برادینی

rea & Marine a

10 Bur Burgan

a suite

a pico

Sec. - 182

1 0 m

Sugar San

Service of

i de la constante da la consta

Sea No.

and a second

10 - Al - April

No. Sec.

Sec. A. two inc

De ligen es

West and

TABLES

a phillips

13. A 18

بالم زيدلية لأو

1. 5 1 5 m

Same and and a

The sea of the

S. Pouga :

The Barthan

AL SALES

ague out

Same St.

 $= \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{j=1}^{n-1} \sum_{j=1}^{n-1} \sum_{j=1}^{n-1} \sum_{i=1}^{n-1} \sum_{j=1}^{n-1} \sum_{j=1}^{n-1$

S. 9. 5 . 4

1. S. S. S. S.

2. 2. 6.2

& Linhard

- Sala Bara Sant

S. Contras

Table 1.Input parameters for the simulations

A Yester of

あいままます

Stan Star

Sec. Sec.

and a free

Strange and a

" of the second of

いたまた

No. Beat

1.22

Same .

and Links

D. . . Contractor

undratus t

1. 1. 2. S. C.

Breeze

Sec. 1

Strates.

Parameter	Values	Source of Data
1. Depth to Ground Water	56	Site Data
(feet)		
2. Vadose Zone Texture (see	Attached well log	Site Data
Plate 1)	_	
3. Dispersion Length (meters)	1	Professional Judgment
4. Water Content θ_{g} (%)	High θ_{g}	Estimated from hydrus
, , , , , , , , , , , , , , , , , , ,	Layer 1 : 10%	simulations
	Layer 2:30%	
	Layer 3 : 25%	
5. Vadose Zone Chloride	Attached well log	ROC data from Disclosure
Distribution (gr/kg)		Report
6. Length of release	20	Field measurements
perpendicular to ground water		
flow (feet)		
7. Cimate Index	Pearl, NM station	NOAA data
	(Hobbs)	
8. Background Ground Water	100	Samples from nearby wells
Chloride (mg/L)		
9. Ground Water Flux	1.4	Calculated from regional
(cm/day)		hydrological data
10. Aquifer Thickness (feet)	35	Nicholson and Clebsh (1960)
- , , ,		and SEO data

PLATES

Sa manufacture of

the star and

an saint

「おいない」

Segue a sal

4. 4. 8. 4. 4. 4. 8.

Louis And

Sanderster.

Sector Sec.

1.54 A.K.

AN - Ver day &

ACR.

1.00

14 5 m 3.1

الحرار الحالية

1. 2. 3. 1.

ารับ มีบูล์

Salan, o

Brings Brit. . SPID , we get the and the state 20 . S . at E berg Sales and 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 -. Satisfy S. M. Harden the second 1 A 10 . J. M. 14 A. J Minter

a states

State of

15 XX .

Depth	Lithologic Description	Measured Soil Chloride Concentration mg/kg	Bulk Density of Sample kg/cubic meter	Thickness of Column (ft)	Calculated Chloride Mass in Column (kg/m2)
ground surface					
~ 1	0-3 feet Sandy Top Soil				
		1500	1858	Ŋ	ъ
	3-13 feet				
10		2000	1858	5	G
	33-19 feet Sandy Clay	2450	1858	5	ω
20		3000	1856	S	o
		1750	1858	5	£
30		3270	1858	5	10
	19-56 feet	8160	1858	5	25
40	Various Colored Sands	5300	1858	5	16
		5000	1858	5	15
50	<u></u>	6410	1858	5	20
Aquifer 56		500	1858	5	7
60	Aquifer = Gray Sand 56-60 ft				
Total Depth of MW	Aquifer = Sandy Clay 60-63 ft		Calculated Chloride Load	g	121
R.T. Hicks Consultants, Ltd. 901 Rio Grande Blvd. NW. Suite	RICE OP	Operating Company			Plate 1
F-142 Albuquerque, NM 87104	Calculation of Chloride Loa	Chloride Load, Zachary Hinton EOL, Lea County	, Lea County	12	12-Sep-2003

Appendix B Relevant Correspondence

(States

a state

Sec. 1

R.T. Hicks Consultants, Ltd.

901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

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

October 13, 2005

Mr. Daniel Sanchez *Enforcement & Compliance Manager* **New Mexico Oil Conservation Division** 1220 South St. Francis Drive Santa Fe, New Mexico 87505

RE: Zachary Hinton EOL Junction Box (O-12) Sec 12, T22S, R37E NMOCD Case #1R0426-36

Dear Mr. Sanchez:

14.5

20.0

Lunde.

dig (and

R.T. Hicks Consultants, Ltd. is pleased to submit the attached Stage I & II Abatement Plan for the above referenced site. If you have any questions or concerns, please don't hesitate to contact us.

Sincerely, R.T. Hicks Consultants, Ltd.

Katie Lee

Katie Lee Staff Scientist

Copy:

Wayne Price, NMOCD; OCD Hobbs Office; & Kristin Pope, Rice Operating Company

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

June 29, 2005

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

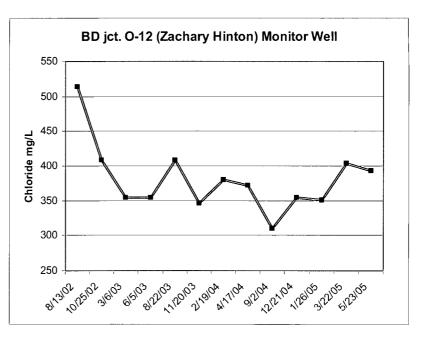
RE: Zachary Hinton EOL UL O Sec 12, T22S, R37E 1R0426-36

Dear Mr. Sanchez:

In your letter of May 5, 2005, NMOCD required Rice Operating Company (ROC) to submit an abatement plan for the above-referenced site on or before July 15, 2005. We respectfully request that NMOCD re-consider this request based upon the information presented in our January 2004 Corrective Action Plan (2004 CAP), our response to NMOCD comments (December 2004), and the ground water data presented below. All of these submissions are included in the attached disc.

As the recent data (figure) show, ground water chloride concentrations decreased from over 500 ppm in 2002 to the regional background concentration of 300-400 ppm by 2003. Data presented on page 12 of the 2004 CAP discuss the regional water quality.

Eleven quarters of ground water monitoring allow us to conclude that natural attenuation has effectively restored ground water quality at the site. Alternatively, one could also conclude from these data



that the first sample taken in 2002 was unusually high, perhaps due to disequilibrium in the ground water caused by the drilling process.

We believe that the HYDRUS-1D modeling within the CAP demonstrates that:

1. Water contaminants in the vadose zone will not with reasonable probability contaminate ground water or surface water, in excess of the standards in Paragraphs (2) and (3) below, through leaching, percolation, or other transport mechanisms, or as the water table elevation fluctuates.

July 1, 2005 Page 2

We believe the 11 quarters of ground water monitoring and the research on regional ground water quality presented within the CAP show:

- 2. Ground-water pollution at any place of withdrawal for present or reasonably foreseeable future use (e.g. the Zachary Hinton monitoring well or future down gradient wells), where the TDS concentration is 10,000 mg/L or less, conforms to the following standards:
 - a. Toxic pollutant(s) as defined in 20.6.2.7 NMAC are not present; and
 - b. The standards of 20.6.2.3103 NMAC are met.

Due to the location of the site, we believe it is obvious that:

3. Surface-water is not affected by the site and surface water conforms to the Water Quality Standards for Interstate and Intrastate Surface Waters in New Mexico 20.6.4 NMAC.

Therefore, we respectfully request NMOCD:

- withdraw their request for an Abatement Plan for this site,
- carefully review our previous submissions, and
- evaluate the site for closure of the regulatory file.

Thank you for consideration of this request.

Sincerely, R.T. Hicks Consultants, Ltd.____

and all T.H.

Randall Hicks Principal

Copy:

10.00

2.82.3

Kristin Pope, Rice Operating Company

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

January 30, 2004

5, 10 C

And Marine

Sec. 20

1.4.4.5

and a

a Turke

Du sa su

and the second

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

RE: Zachary Hinton EOL Final Report

Dear Mr. Price

On behalf of Rice Operating Company, we are pleased to submit the final Corrective Action Plan for the above-referenced site. We are pleased to report that the chloride concentration in samples from the on-site monitoring well has returned to background levels. We conclude that the residual chloride in the vadose zone poses no threat to human health or the environment. We recommend filling the excavation with soil capable of sustaining vegetation and plugging the monitoring well.

Please contact us with any comments or questions regarding our recommended closure protocol for this site.

Sincerely, R.T. Hicks Consultants, Ltd.

and all T.H.J

Randall Hicks Principal

R.T. HICKS CONSULTANTS, LTD.

Suite 266

219 Central Avenue NW

. Billio

Albuquerque, NM 87112

505.266.5004

Fax: 505.246-1818

July 2, 2003

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

RE: Zachary Hinton EOL Junction Box, Section 12, 22S, 37E Unit O

Dear Mr. Price

Rice Operating Company retained R.T. Hicks Consultants, Ltd. 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 Zachary Hinton EOL Junction Box is located about 2.5 miles southeast of the intersection of State Routes 18 and 8/176, near Eunice, New Mexico. Plate 1 shows the location of the site.

Rice Operating Company (ROC) prepared a disclosure report dated January 21, 2003 that summarizes activities to date. This report is part of the annual submission to NMOCD, due in April of each year. For your convenience, we have attached a copy of this ROC report and a copy of recent ground water data from the adjacent monitoring well. The soil boring and backhoe excavation data show relatively consistent concentrations of chloride from 11 feet below ground surface (5200 ppm chloride) to 50 feet below ground surface (6410 ppm chloride). The consistency of these concentrations suggests that a release from the junction box may have created saturated conditions in the vadose zone.

ROC installed a monitoring well adjacent to the junction box. Four quarters of ground water data show chloride concentrations in ground water are currently between 400 and 500 mg/L. The most recent analysis of total dissolved solids (11/6/02) from this well shows a result of 1290 mg/L. Because these values exceed the New Mexico Water Quality Commission Standards, we propose the work outlined below.

Page 2 7/2/2003

1. Evaluate Migration of 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 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 ROC.

We might provide simulations of two "no action" scenarios. For both simulations, we will employ the input parameters to HYDRUS and the mixing model outlined in Table 1. In the first simulation, we will assume that vegetation is not present over the release site (no evapotranspiration) and a minimum aquifer thickness of 10 feet. This will simulate restriction of any released chloride to a portion of the underlying aquifer. If this first simulation does not return results that are consistent with the existing ground water monitoring data, we will increase the aquifer thickness in the mixing model to the maximum value allowed by data (a bout 35 feet). At other sites, we have found that chloride can be distributed throughout the thickness of the aquifer. Employing the entire thickness of the aquifer in the mixing model calculations may be appropriate for the Zachary Hinton site.

Input Parameter	Source
Vadose Zone Thickness	Attached well log
Vadose Zone Texture	Attached well log
Dispersion Length	Professional judgment
Soil Moisture	Nearby Field Measurements
Vadose Zone Chloride Load	ROC Data from Disclosure Report
Length of release perpendicular to ground	Field Measurements
water flow	
Climate	Pearl, NM station (Hobbs)
Background Chloride in Ground Water	Samples from nearby wells
Ground Water Flux	Calculated from regional hydraulic
	data
Aquifer Thickness	Nicholson and Clebsch (1960) and
	SEO data

Table 1: Input Parameters for Simulation Modeling

S. . Sala

Page 3 7/2/2003

1.18

2. Collection and Evaluation of Data for Simulation Modeling

The HYDRUS1D and mixing model simulation requires input of 10 parameters. As Table 1 shows, we must collect site specific data for several of these parameters, some data are available from previous ROC work at the site, and other data are available from public sources. Our previous work with the American Petroleum Institute showed that soil moisture values did not strongly influence the ability of the model to predict chloride migration from the vadose zone to ground water. We plan to use soil moisture data from nearby sites for model input.

We propose a field program to collect important site-specific data for model input. First we will measure the depth to ground water at five nearby windmills and the adjacent monitoring well to determine the hydraulic gradient (Plate 1). We have examined these abandoned and active windmills; we can measure these water levels. To establish background chloride concentrations in ground water, we propose to sample the active windmill located in Section 13 (Plate 1) and, if possible, two additional up gradient wells in Sections 2 and 11 (identified as "Field Check Required" on Plate 1).

3. Design Remedy and Submit Report

ROC has completed the repair of the pipeline junction at the Zachary Hinton EOL. We do not anticipate additional releases of produced water at this site. Our modeling of the "no action alternative" (Task 1) may show that the residual chloride mass in the vadose zone poses a threat to ground water quality. If such 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. excavation, disposal and replacement of clean soil to remove the chloride mass,
- 2. installation of a low permeability barrier to minimize natural infiltration,
- 3. surface grading and seeding to eliminate any ponding of precipitation and promote evapotranspiration, thereby minimizing natural infiltration, and
- 4. 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.

Page 4 7/2/2003

We will use the ground water mixing model or a suitable alternative to assist in the design of a ground water remedy. It is possible, however, that the background chloride concentrations in ground water measured in the nearby windmills are equal to or higher than the chloride concentration in the adjacent monitoring well. Such data would strongly suggest that the Zachary Hinton EOL Junction Box has not caused any material impairment of ground water quality. If we find no evidence of impairment of water quality due to past activities at Zachary Hinton EOL Junction Box, we will not prepare a ground water remedy. If data suggest that the Zachary Hinton EOL Junction Box has contributed chloride to ground water and caused ground water impairment, we will examine the following alternatives:

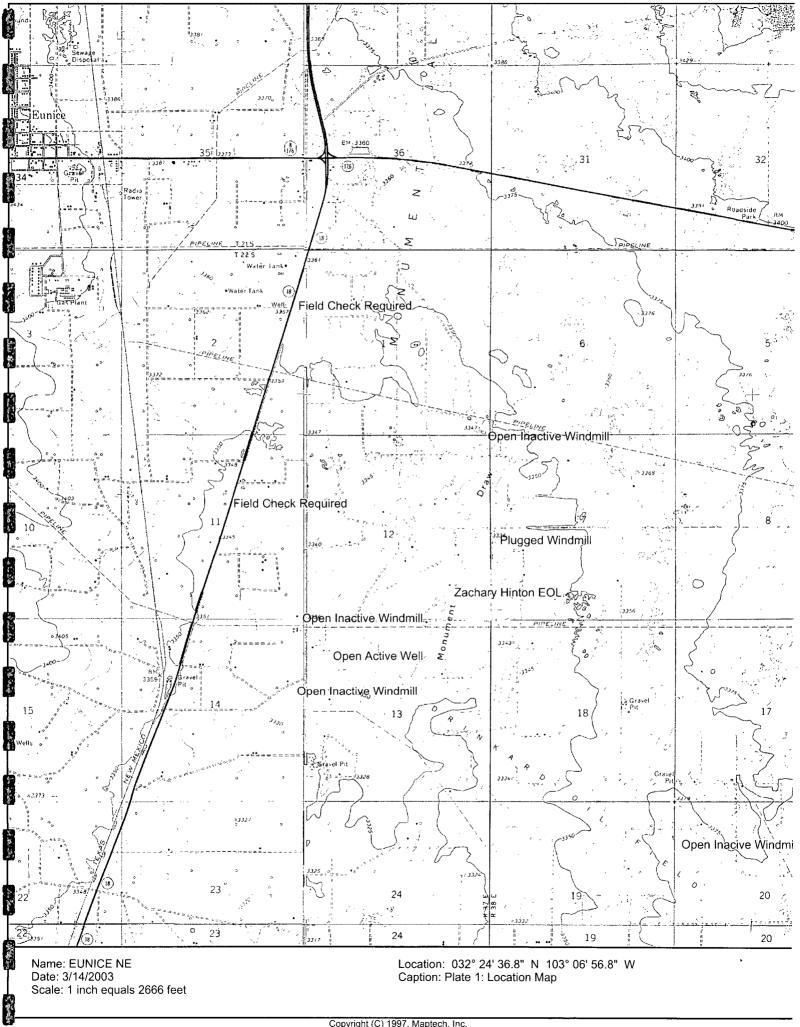
- 1. Natural restoration due to dilution and dispersion,
- 2. Pump and dispose to remove the chloride mass in the saturated zone,
- 3. Pump and treat to remove the chloride mass in the saturated zone,
- 4. Because of the location of the site, institutional controls negotiated with the landowner may provide an effective remedy. Such controls may be restriction of water use to livestock until natural restoration returns the water quality to state standards, a provision for alternative supply well design, or a provision for well head treatment to mitigate any damage to the water resource.

We plan to commence data collection for the HYDRUS1D simulations described above in mid July. Your approval to move forward with this workplan will facilitate our access to nearby windmills and speed the implementation of a surface remedy.

Sincerely, R.T. Hicks Consultants, Ltd.

Kanddet T. Hef

Randall T. Hicks Principal



Copyright (C) 1997, Maptech, Inc.

Appendix C Model Explanation

ALC: No. of

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

Final Site Investigation and Abatement Completion Reports: Zachary Hinton

MODFLOW SIMULATION

Model Input

and and

1.22

Sec. 2

22.25

4 1.43

Plate C-1 presents the model grid and shows the location of the former EOL junction box as two recharge cells lying side-by-side, each 4m by 6m in size, up-gradient from MW-1. Although the EOL junction box is about 4 meters by 4 meters (12 feet by 12 feet), the model assumes that recharge of brine leakage from the site disperses as it infiltrates the sub-surface, impacting an area wider than the size of the junction box. Because saturated and unsaturated flow in the vadose zone is generally vertical with small lateral spreading in sandy vadose zone profiles, the size of the recharge cells is a conservative assumption in this model.

The model assumes that the chloride concentration in the released brine is 100,000 mg/L and employs this concentration for the quality of recharge to the aquifer. The recharge rate employed by the model is 150 mm/year. Published reports suggest that recharge to ground water in the arid southwest ranges from 0.01 to more than 150 mm/year (Table 1, from Scanlon, 1991, and Table 2, from Keese et. al., 2005; both are included at the end of this appendix). In their model, Mush-arrarieh and Chudnoff (1999) employ a value of 9.6 mm/year for the area near Eunice. Using 150 mm/year as a recharge rate appears appropriate for this site where periodic releases of brine would cause a higher moisture content than the sites described in the referenced publications.

These two input parameters yield the chloride flux to the aquifer at the recharge cells and we adjusted these two factors to create the observed 1000 mg/L in ground water at MW-1 (about 650 mg/L above background). For example, if the produced water chemistry from the Zachary Hinton battery exhibited an average chloride concentration of only 50,000 mg/L, model calibration would demand increasing the recharge rate to about 300 mm/year. We tested a recharge rate of 600 mm/year in the model and found no perturbation of the water table elevation; therefore, higher recharge rates for the simulation experiment would be acceptable for model calibration. The full text of the publications that describe recharge is included at the end of this appendix.

Table C-1 (below) shows the other input data and the source of the data. The model assumes that the background chloride concentration of the aquifer is 0.0 mg/L. The down-gradient and up-gradient boundary conditions are constant head, forcing a uniform hydraulic gradient across the model that is consistent with site observations.

Modi	low and M	T3D Inpu	It Parameters
Description	Value	Unit	Source of Data
Model X Extent	2000	meters	
Model Y Extent	3000	meters	
Number of Layers	. 1		
Hydraulic Conductivity (Kx, Ky, K	1.6E-04	m/sec	Musharrafieh and Chudnoff, 1999
Layer Thickness	19	meters	Site Data
Depth to Water	16	meters	Site Data
Transmissivity	4.8E-04	m^2/sec	Musharrafieh and Chudnoff, 1999
Saturated Thickness	3	meters	Nicholson and Clebsch, 1960 and Site Data
Total Porosity	0.3		Professional Judgement
Effecitive Porosity	0.15		Professional Judgement
Specific Yeild (Sy)	0.2		Musharrafieh and Chudnoff, 1999
Recharge (0 to 20 years)	150	mm/year	Professional Judgement
Recharge Concentration (0 to 20	100,000	mg/L	Professional Judgement
Specific Storage (Ss)	1.00E-05	1/m	Musharrafieh and Chudnoff, 1999
Long. Dispersitvity	10	m	Professional Judgement
Horiz/Long Dispersivity	0.1		Professional Judgement
Vert/Long Dispersivity	0.01		Professional Judgement
Diffusion Coeff	0	m^2/day	Professional Judgement

Table C-1: MODFLOW and MT3D Input Data

2012

Results of Simulations

Plate C-2 shows the chloride concentration in the aquifer five years after recharge begins. This simulation suggests that five years of periodic brine releases at the Zachary Hinton EOL Junction Box would cause a chloride concentration of 780 mg/L above background in an observation well 10 meters down-gradient from the release site and a chloride concentration 900 mg/L above background at the release site itself. After 10 years of periodic brine releases that result in an average flux of brine to the aquifer of 150 mm/year, ground water at the simulated observation well is about 780 mg/L above background chloride concentration. The resultant ground water plume (defined by the 100 mg/L contour line) is 1,018 meters long and 55 meters wide, as Plate C-3 shows.

Twenty years of periodic releases do not materially change the extent or magnitude of the simulated ground water plume. As illustrated in Plate C-4, after 20 years, the chloride concentration in the monitoring well is 760 mg/L above back ground chloride concentration, the plume is 1,060 meters long and 55 meters wide. This simulation suggests a dynamic equilibrium between the input of chloride at the recharge (release) site and the dispersion/dilution effects of ground water transport.

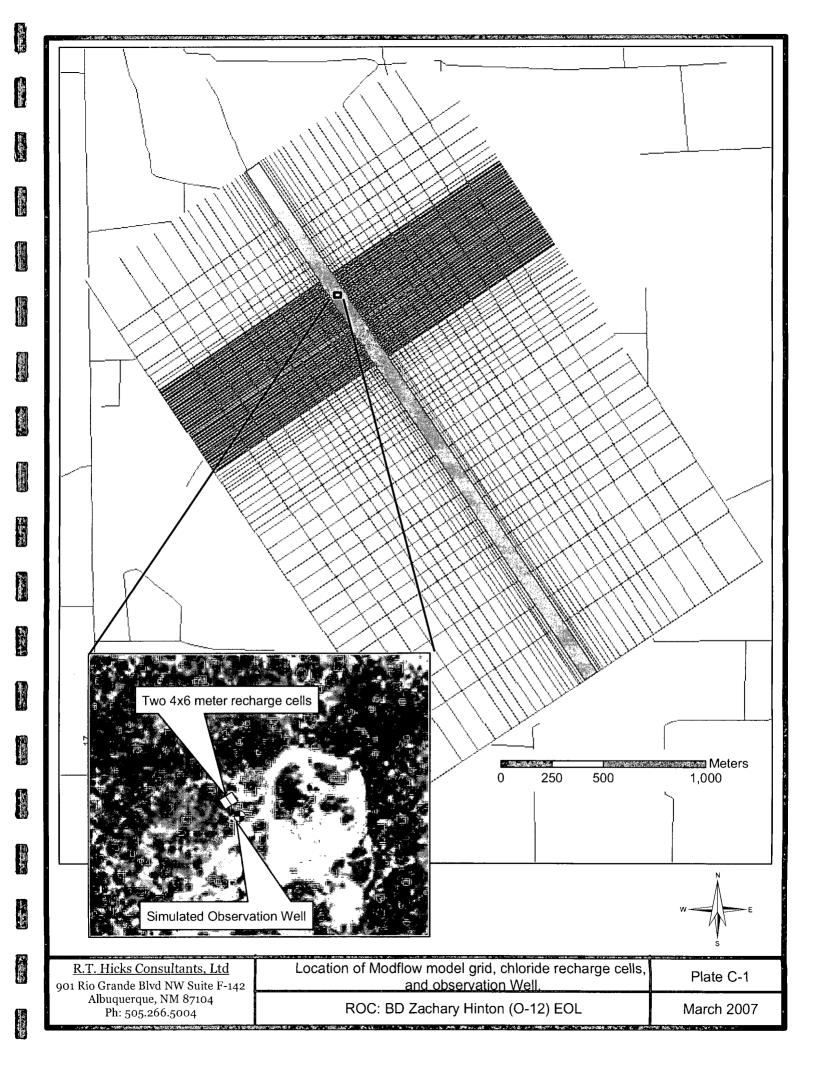
Final Site Investigation and Abatement Completion Reports: Zachary Hinton

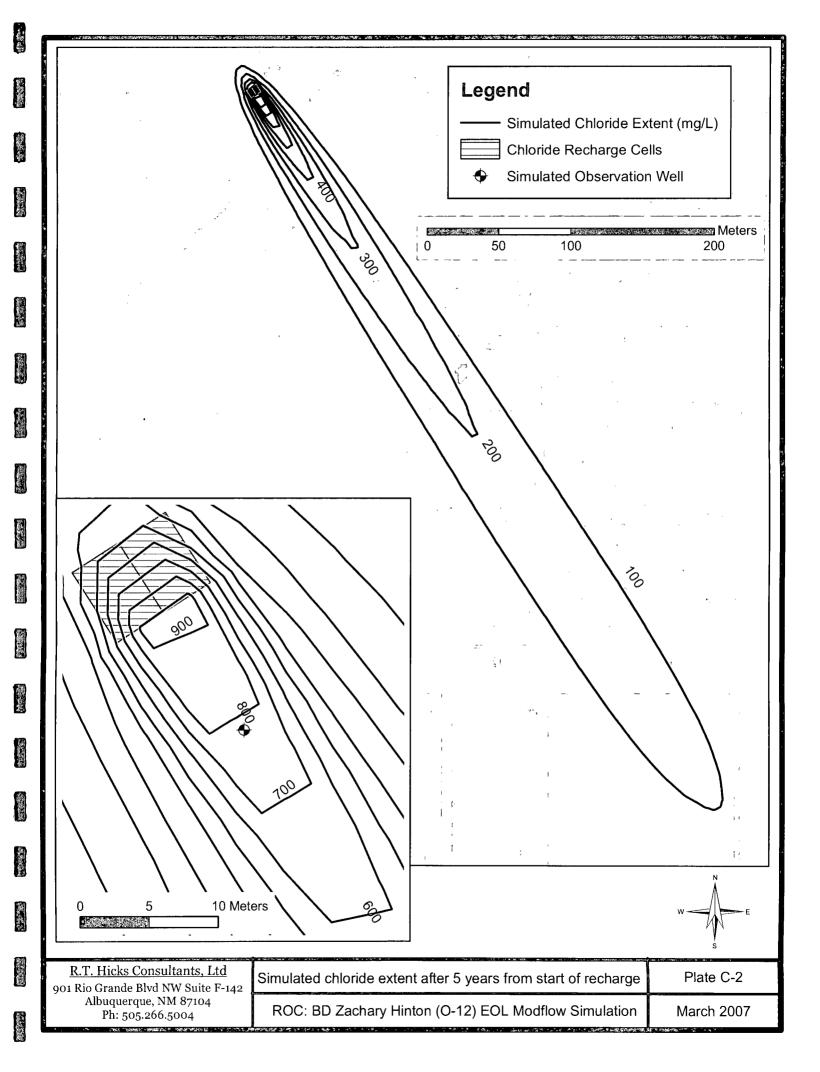
At year 20, the recharge rate in the model is 0.0 mm/year, which simulates cessation of periodic brine releases after upgrade of the line. One year after cessation of recharge, the chloride concentration in the monitoring well returns to background level as the chloride migrates down-gradient, dilutes, and disperses. The magnitude and extent of the plume decreases, as shown in Plate C-4. Plate C-5 of the main report shows the simulation two years after cessation of intermittent brine releases. Three years after cessation of recharge, the area of interest returns to background ground water quality.

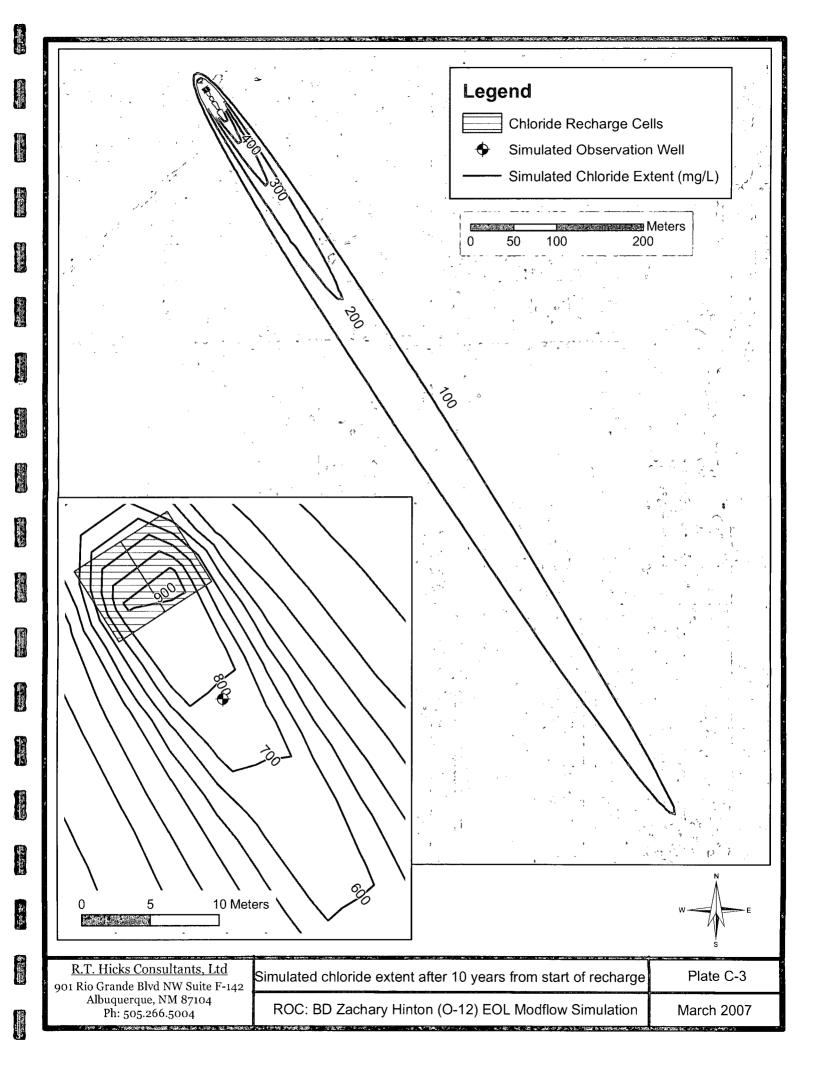
Simulation Conclusions

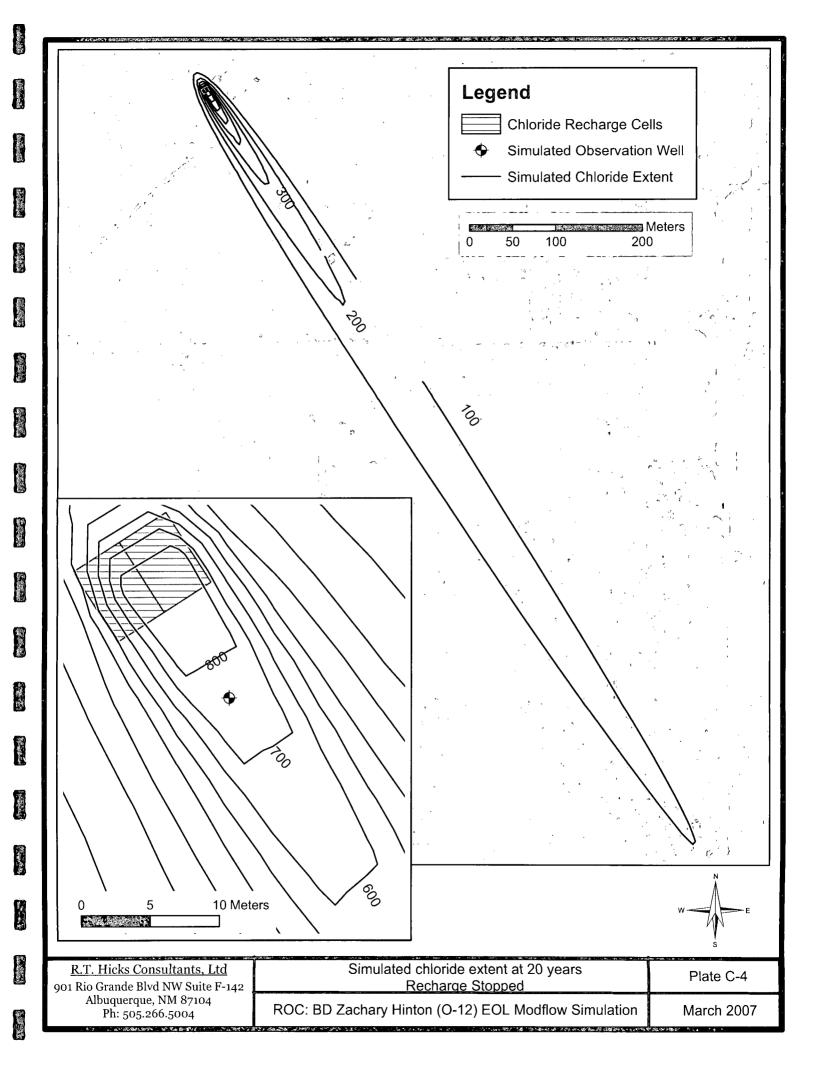
This simple simulation experiment predicts that periodic releases of brine from the Zachary Hinton site will cause ground water chloride to rise above background quality by about 900 mg/L near the source area (the recharge cells). Because background chloride in the aquifer is about 300–400 mg/L, the model predicts a chloride concentration of about 1,100–1,200 mg/L at the source. This prediction is consistent with the initial chloride concentration at MW-1 because we manipulated the chloride flux to ground water (within reasonable limits) to create this result. This adjustment is part of model calibration.

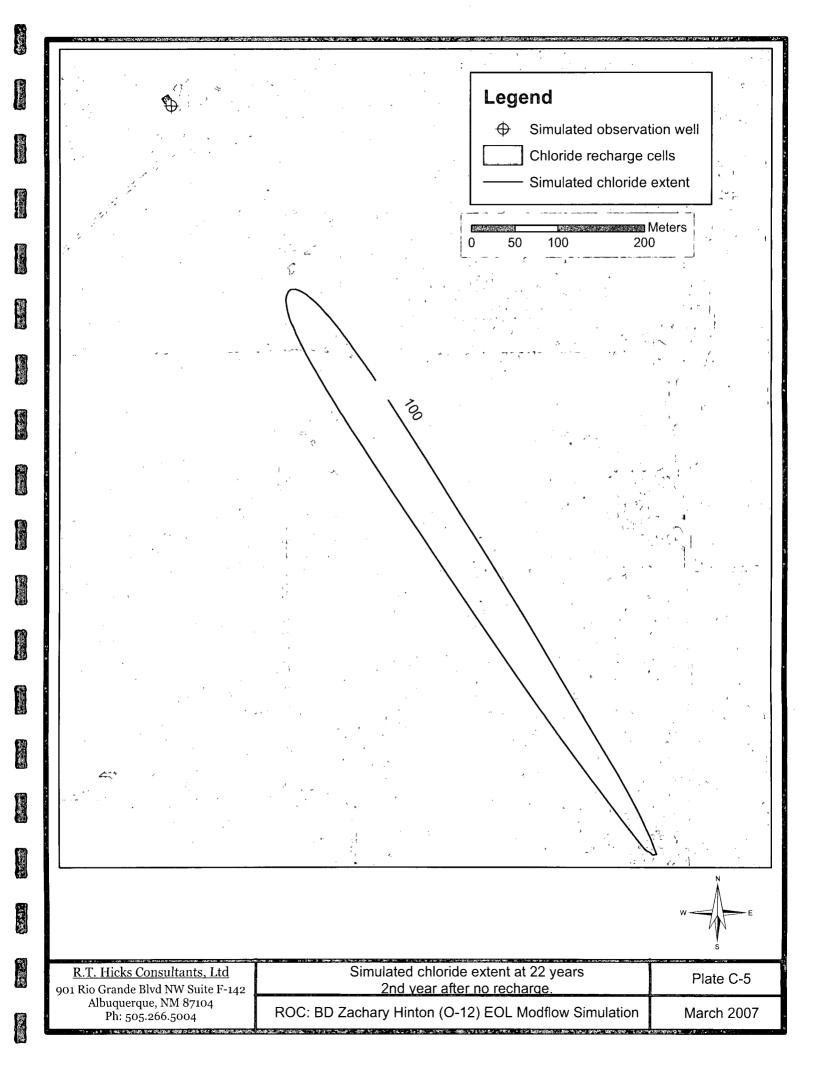
The model predicts that natural dilution and dispersion rapidly reduce chloride concentrations in ground water after the cessation of recharge (i.e. intermittent brine releases from the EOL Junction Box). Although the model is simple and assumes that the recharge stops immediately, the predictions conform with the data from this site and to observed ground water impairment at other junction box sites; therefore, additional adjustment of input data (e.g.: hydraulic conductivity) is not required to calibrate the model to observed conditions.











EVALUATION OF MOISTURE FLUX FROM CHLORIDE DATA IN DESERT SOILS*

Bridget R. Scanlon

Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas78713, U.S.A. (Recieved 19 November 1990; revised and accepted 23 January 1991)

ABSTRACT

Scanlon, B.R., 1991. Evaluation of moisture flux from chloride data in desert soils. J. Hydrol., 128: 137-156.

Chloride-concentration data from 10 soil profiles in a 40 km² area of the Chihuahuan Desert of Texas were used to assess chloride mass balance methods of evaluating moisture flux. The relative importance of advective and diffusive transport mechanisms was determined. Moisture fluxes were calculated from measured chloride concentrations on the basis of a steady-state flow model. To evaluate controls on unsaturated flow, moisture fluxes from this study were compared with those from other regions.

The chloride profiles displayed large variations in concentrations and had (a) low chloride concentrations ($\leq 100 \text{ g m}^{-3}$) near land surface, (b) maximum chloride concentrations (1,900 to 9,300 g m⁻³) at depths of 1.3 to 4.6 m, and (c) gradually decreasing chloride concentrations with depth below the peak. Steep concentration gradients (up to 12,000 g m⁻³ m⁻¹), characteristic of chloride profiles in these desert soils, indicate a potential for molecular diffusion; however, low moisture contents (≤ 0.1) in the zone of steep concentration gradients resulted in diffusive fluxes that were 2 to 3 orders of magnitude lower than the advective fluxes; therefore, diffusive fluxes were neglected in flux calculations. Because the chloride accession rate was assumed to be constant throughout the study area, calculated moisture fluxes are inversely proportional to chloride concentrations in the soil water. Highest moisture fluxes (up to 6 mm yr⁻¹) were calculated near land surface and are related to chloride leaching as a result of precipitation. Within the upper meter of the unsaturated zone, soil moisture fluxes decreased sharply to 0.1 mm yr⁻¹ as most of the water evapotranspired in this zone. Soil moisture fluxes decreased to a minimum at the chloride peak and then increased gradually as chloride concentrations decreased with depth below the peak. Reductions in chloride concentrations below the peak are attributed to differences in moisture fluxes as a result of paleoclimatic variations. Comparisons of chloride profiles from different regions indicate that geomorphic setting plays a major role in controlling moisture flux in the unsaturated zone.

INTRODUCTION

Chloride profiles have been used in a variety of settings to evaluate moisture fluxes in the unsaturated zone (Allison et al., 1985; Phillips et al., 1988). In arid

0022-1694/91/\$03.50 © 1991 — Elsevier Science Publishers B. V. All rights reserved.

^{*}Publication authorized by the Director, Bureau of Economic Geology, The University of Texas at Austin.

10.480.2

systems, downward water flux is very difficult to quantify because it represents a small percentage of the total water balance. The chloride mass balance approach, which provides estimates of moisture flux during long time periods, has many advantages over conventional physical approaches in partly vegetated, arid systems because meteorologic data from these systems indicate large interannual variations in precipitation that would necessitate monitoring physical parameters over a long time to obtain reliable estimates of moisture flux. The water balance approach, in which downward water flux is computed from the difference between precipitation, evapotranspiration, and runoff, is generally inaccurate in arid systems because evapotranspiration constitutes most of the total water budget and estimates of evapotranspiration from micrometeorologic techniques are not sufficiently accurate in partly vegetated desert regions. The use of Darcy's Law to estimate moisture fluxes is also problematic because of the complexity of flow in desert soils where liquid and vapor transport may occur in response to water potential and temperature gradients. Highly nonlinear relationships between moisture content, water potential, and hydraulic conductivity result in large uncertainties in these flux calculations.

In contrast to physical methods that provide moisture flux data for the duration of the monitoring period, profiles of chloride concentrations yield information on moisture fluxes over long periods (up to 50,000 yr; Allison et al., 1985). In addition, unlike many of the physical methods in which the accuracy of moisture flux calculations decreases as the flux decreases, the accuracy of flux estimates from the chloride mass balance approach does not necessarily decrease because chloride concentrations increase as the moisture flux decreases. This increase in chloride concentrations results from evapotranspiration because chloride is nonvolatile and because plant uptake is minimal. Chloride data also provide information on spatial variability in downward water movement because each profile represents a point estimate of moisture flux. Good agreement has been found between estimates of moisture flux based on the chloride approach and those based on tritium data in a humid region (Allison et al., 1985). Results from chloride profiles have also been corroborated with data from stable isotope profiles (Sharma and Hughes, 1985; Fontes et al., 1986).

Thick unsaturated zones in arid regions are being considered as potential sites for radioactive waste disposal facilities because low precipitation and high evapotranspiration rates result in low recharge potentials and because the low permeability of a thick unsaturated zone may provide a natural barrier to radionuclide migration to the water table. The unsaturated zone in a 40 km² area of the Chihuahuan Desert in Texas (Fig. 1) is being considered as a potential repository of low-level radioactive waste. The objective of this study was to

139

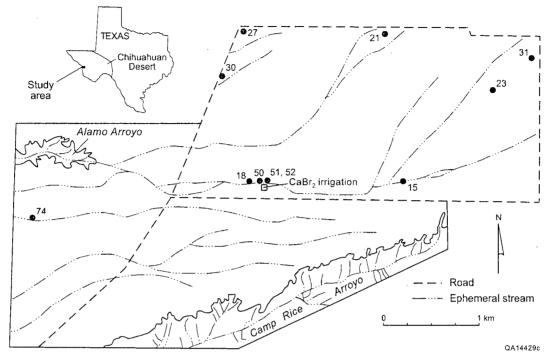


Figure 1. Location of sampled boreholes. Inset shows location of study area within the Chihuahuan Desert of Texas.

evaluate the moisture flux and its spatial variability in the upper 15 m of the unsaturated zone of this system. This paper focuses on chemical methods of analyzing water movement based on the distribution of environmental chloride. Key components of the research include evaluation of (1) the chloride mass balance method for determination of moisture fluxes, (2) the relative importance of advective and diffusive fluxes, (3) the spatial variability in moisture fluxes, and (4) controls on chloride profiles and moisture fluxes based on comparisons with other regions.

Chloride Mass Balance

Chloride concentrations in soil water have been used to evaluate moisture fluxes in semiarid systems (Bresler, 1973; Peck et al., 1981; Sharma and Hughes, 1985; Johnston, 1987). Chloride is an ideal tracer because it is chemically conservative. According to the theory of chloride transport (Bresler, 1973; Peck et al., 1981), the solute flux (J_S), under steady-state conditions, can be described by:

$$J_{\rm s} = -D_{\rm h}(\theta, v) \frac{\partial c}{\partial z} + cq_{\rm W} \tag{1}$$

140

ALL

A States

53 Sec.

1. 1. 8. 20

1. S. S. S.

100

where D_h is the hydrodynamic dispersion coefficient, a function of θ (the volumetric moisture content) and v (the average soil moisture velocity); z is the vertical space coordinate; c is the concentration; and q_W is the volumetric soil-moisture flux. J_s was approximated by the mean annual precipitation rate (P: 280 mm yr⁻¹ [J. Griffiths, pers. comm., 1990]), times the chloride concentration in precipitation and in dry fallout (Cl_p) for this study area (Sharma and Hughes, 1985; Mattick et al., 1987). The mean chloride concentration (Cl_p: 0.29 g m⁻³) was calculated from the prebomb ³⁶Cl/Cl ratio (0.46 × 10⁻¹²) measured in soil water from borehole 51, and the natural ³⁶Cl fallout at the site estimated as 20 atoms ³⁶Cl m⁻² s⁻¹ (Bentley et al., 1986; Scanlon et al., 1990). The resultant J_s value was 0.08 g m⁻² yr⁻¹.

Rearranging equation (1) yields the soil-moisture flux:

$$q_{\rm w} = \frac{1}{c} \left(J_{\rm s} + D_{\rm h}(\theta, v) \frac{\partial c}{\partial z} \right)$$
⁽²⁾

The first term in the outer parentheses represents the flux that results from advection and the second term represents the flux from dispersion. The mechanical dispersion coefficient (D_m) and the effective molecular diffusion coefficient (D_e) comprise the hydrodynamic dispersion coefficient. D_m is assumed to be negligible because flow velocities are less than 7 m yr⁻¹, which Olsen and Kemper (1968) specify as the water velocity below which mechanical dispersion can be ignored. D_e includes the effects of tortuosity and water content. Recent studies of D_e values of silts, sands, and gravels indicate that De is primarily a function of moisture content and only secondarily dependent on soil type (Conca, in press; Conca and Wright, 1990). At low-moisture fluxes, the diffusive flux may be dominant. The diffusive flux was estimated from the first derivative of c(z) times D_e . Cubic splines were fitted to the observed chloride profiles to smooth the data and to calculate the first derivative in equation (2). Moisture content data from the profiles were used to calculate De based on the relationship between moisture content and D_e from Conca (pers. comm., 1990). The moisture flux is divided by the volumetric moisture content to obtain the moisture velocity (q_W/θ) , which represents the actual rate of solute transport.

In many arid systems the hydrodynamic dispersion coefficient was assumed to be negligible (Allison et al., 1985; Stone, 1990) and equation (2) was simplified to:

 $q_{\rm W} = J_{\rm S} / c \tag{3}$

The travel time (t) represented by chloride at depth z can be evaluated by dividing the total mass of chloride from the surface to that depth by the

chloride flux:

$$t = \frac{\Sigma Cl_{sw} \times z}{J_s}$$

where c is approximated by Cl_{SW} (chloride concentration in soil water).

Chloride profiles provide a qualitative estimate of moisture flux because there are many assumptions associated with the chloride mass balance approach. These assumptions are:

(1) one-dimensional, vertical, downward, piston-type flow; (2) precipitation as the only source of chloride; (3) mean annual precipitation and chloride concentration of precipitation constant through time; and (4) steady-state chloride flux equal to the chloride accession rate in rainfall. The accuracy of the flux estimates from chloride data depends on the reliability of the physical flow model used to interpret the data. Although this model of chloride movement predicts that chloride concentrations should increase through the root zone and remain constant below the root zone, many previously published chloride profiles show that chloride concentration decreases below the peak; therefore, some of the assumptions associated with the model may not be valid for different systems. The reduction in chloride concentration below the peak was attributed to groundwater dilution (Phillips et al., 1988), nonpiston-type flow (Sharma and Hughes, 1985), or failure of the steady-state flow assumption as a result of paleoclimatic variations (Allison et al., 1985; Phillips and Stone, 1985). An alternative method was used to analyze some chloride profiles in Western Australia that did not assume a downward moisture flux (Peck et al., 1981). This analysis showed that steep concentration gradients below the chloride peak resulted in the flux being dominated by diffusion rather than advection and that the calculated moisture flux was upward, in contrast to the downward flux assumed by the chloride mass balance theory. These studies underline the importance of evaluating the conceptual flow model that is used to analyze the chloride data and the applicability of the assumptions to each study area.

Anion exclusion may also affect the accuracy of flux estimates based on chloride data. Most studies of anion exclusion are restricted to laboratory column experiments in which ionic Cl or 36 Cl migrated faster than 3 H (Biggar and Nielsen, 1962; Krupp et al., 1972; Wierenga and van Genuchten, 1989). Faster migration of Cl relative to that of 3 H was also recorded in field tracer experiments (Gvirtzman et al., 1986; van de Pol et al., 1977). Calculated anion velocities were as much as twice the estimated water velocities in clay-rich soils (Gvirtzman et al., 1986; James and Rubin, 1986). In desert soils, such as in New Mexico and the present study area, deeper penetration of 3 H relative to that of 36 Cl was attributed to

142

25.24

ふんの

Sec. A.

10.3

Sec. 2

L'ANDA

(4)

downward movement of 3 H in the vapor phase (Phillips et al., 1988; Scanlon, in press). These data suggest that although Cl may be excluded from the liquid phase, flux estimates based on Cl data should not overestimate the water (liquid + vapor) flux in desert soils.

Study Area Description

. A. M.

100

A Sec.

57 E.V.

The second

16. M

for the second

1. 3 Ca

1. 10 M

1.18

This study area (31° 25' N, 105° 40' E) is located in the Hueco Bolson, which is a 200-m- thick sediment-filled basin within the Chihuahuan Desert of Texas (Fig. 1). The Hueco Bolson is part of the Rio Grande Rift and formed as a result of Basin and Range deformation during the Tertiary (Henry and Price, 1986). The unsaturated zone consists of 0 to 15 m of silty to gravelly loam of the Tertiary and Quaternary Camp Rice Formation, underlain by approximately 140 m of clay with interbedded silt and sand of the upper Tertiary Fort Hancock Formation. Shallow coarse-grained material was deposited in alluvial and eolian environments, whereas the deeper clay sediments were deposited in a predominantly lacustrine environment. A discontinuous layer of caliche occurs at a depth of 1 to 2 m.

Regional climate is subtropical arid (Larkin and Bomar, 1983); mean annual precipitation is 280 mm and has large interannual variations that range from 110 to 440 mm in El Paso, located 65 km northwest of the study area. Approximately 60% of the precipitation falls between June 1 and September 30 as convective storms. Mean annual potential evapotranspiration (Class A pan) is approximately seven times mean annual precipitation.

The present surface of the Hueco Bolson is an alluvial plain that slopes 1 to 1.5% toward the Rio Grande. Modern ephemeral streams that drain the alluvial plain lack well-defined channels (maximum relief 0.6 m). The upper reaches of the ephemeral streams drain into incised channels (arroyos) southwest of the study area (Fig. 1). Streams are generally dry except after precipitation events. Shrubs, such as creosote (*Larrea tridentata*) and mesquite (*Prosopis glandulosa*), are common and root to depths of 1 to 5 m. The topography is relatively flat with slopes of less than 1%. Because of the low topography, precipitation events predominantly result in sheet flow across the area (S. Akhter, pers. comm., 1989).

METHODS

To determine ambient moisture and chloride contents, approximately 230 soil samples were collected from 10 boreholes drilled during 1988 and 1989 (Fig. 1). These boreholes were rotary drilled with hollow-stem augers without drilling fluids. Samples were collected in Shelby tubes, and the sampling interval varied from approximately 0.3 to 1 m. Many of the boreholes were drilled to the top of the

clay-rich Fort Hancock Formation at a depth of 10 to 15 m, which the auger could not penetrate.

Gravimetric-moisture content was determined by drying at least 80 g of soil at 105°C for 48 hr. Although volumetric-moisture content could not be directly determined in 90% of the samples because the material was not sufficiently cohesive, volumetric-moisture content of these samples was calculated from gravimetric-moisture content using a bulk density of 1.4 (average bulk density measured in 27 samples). To determine chloride content, double-deionized water was added to the oven-dried soil sample in a 1:1 or 2:1 ratio. Samples were agitated on a reciprocal shaker table for 8 hr, then centrifuged for 10 min at 5,000 rpm. The supernatant was filtered through 0.45 μ m filters. Chloride was then analyzed by ion chromatography or by potentiometric titration. To test if oven drying had any effect on chloride concentration, four samples at field moisture were split and one half of each was oven dried. Soil texture of these samples was not determined. Comparison of the chloride concentrations of the splits showed that oven drying had no effect on chloride concentrations.

Textures of approximately 100 soil samples were measured. The samples were ground to disaggregate calichified materials. The greater-than-2-mm fraction was determined by dry sieving, and the percent of sand, silt, and clay was evaluated by hydrometer analysis following Bouyoucos (1962). Sediment samples that contained gravel were classified according to Folk (1974) and those that did not contain gravel were classified according to the U.S. Department of Agriculture (1975).

RESULTS AND DISCUSSION

In the following sections, 6 of the 10 measured chloride profiles are described in detail; descriptions of the other profiles can be found in Scanlon (in press). The chloride profiles are plotted at different scales in figure 2. All measured chloride profiles are bulge shaped and consist of low chloride concentrations near the surface, at depths of generally less than 0.3 m, and maximum chloride concentrations at depths of 1.3 to 4.6 m that decrease to low concentrations with depth (Fig. 2). Chloride profiles display a wide variability in their maximum chloride concentrations, which range from 1,900 g m⁻³ (Figs. 2c and 2h) to 9,300 g m⁻³ (Fig. 2aa).

The chloride profile from borehole 15 is characterized by low concentrations (< 100 g m³) in the upper meter of the unsaturated zone (Fig. 2c). This zone of low concentration corresponds to high moisture content (0.11 to 0.19 m³ m⁻³) that reflects infiltration of a recent precipitation event. Below this surficial leached zone, chloride concentrations increase sharply to 1,900 g m⁻³ as a result of

144

a spell lange

12.000

1000

1.80

15 MA

Call March

0

1.64

調整

12 Buch

1 4 M

14 . A. B.

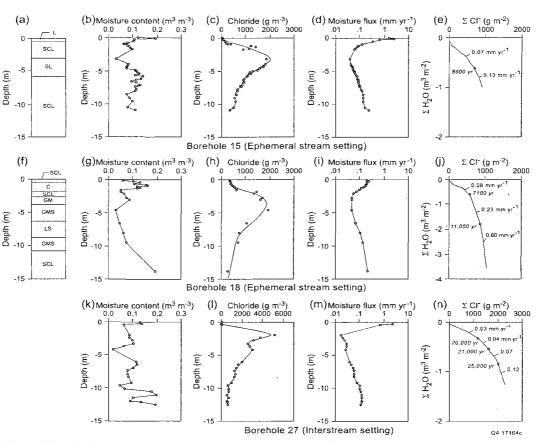


Figure 2(a-ac). Data from six boreholes on soil texture, moisture content, chloride concentration, and fitted cubic spline, and calculated moisture flux based on equation (3) plotted against depth, and cumulative chloride plotted against cumulative water content. Note the different scales used for various profiles. Soil textures: g, gravel; s, sand; l, loam; c, clay; msg, muddy sandy gravel; gms, gravelly muddy sand; ls, loamy sand; sl, sandy loam; scl, sandy clay loam; cl, clay loam; gm, gravelly mud; and sc, sandy clay.

evapotranspirative enrichment. Chloride concentration gradients increased with depth at rates of up to $-900 \text{ g m}^{-3} \text{ m}^{-1}$. The peak chloride concentration was recorded at a depth of 3.2 m. Chloride concentrations decrease gradually to 340 g m^{-3} below the peak, and chloride concentration gradients range from $500 \text{ g m}^{-3} \text{ m}^{-1}$ to $10 \text{ g m}^{-3} \text{ m}^{-1}$ in this zone. Chloride concentrations in samples from the shallow zone of borehole 18 are much higher (350 to 400 g m⁻³) (Fig. 2h) and the moisture contents much lower (0.06 to 0.13 m³ m⁻³) (Fig. 2g) than those from borehole 15 because borehole 18 was sampled after a long dry period. The chloride concentration gradients, peak concentrations, and depth of the chloride peak are similar in the profiles from boreholes 15 and 18. Both profiles sample the ephemeral stream setting.

145

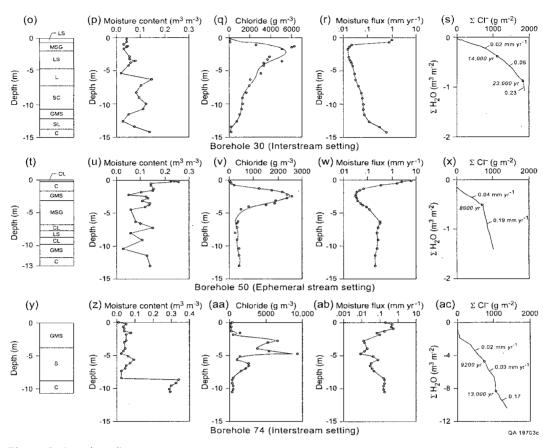


Figure 2. (continued)

Boreholes 27 and 30 were located in interstream settings (Fig. 1) and their chloride profiles are similar (Figs. 2l and 2q). Both profiles have a leached section of approximately 0.5 m. Chloride concentration gradients are very steep above the peak ($\geq -6,000$ g m⁻³ m⁻¹), whereas these gradients are much lower (2,000 to 10 g m⁻³ m⁻¹) below the peak.

Borehole 50 was sampled in an ephemeral stream after a rainfall event. The shallow zone is characterized by low chloride concentrations (2 to 7 g m⁻³) and high moisture contents (0.14 to 0.26 m³ m⁻³) (Figs. 2u and 2v). Below the surficial leached zone, moisture content shows no systematic relationship with depth. Chloride concentration gradients above the chloride peak are $\geq -2,000$ g m⁻³ m⁻¹, whereas those below the peak range from 1,200 to 5 g m⁻³ m⁻¹. Comparisons of chloride concentrations in samples from nearby (10 m away) borehole 51 (Fig. 1) give an indication of local variability. Peak chloride concentrations (2,000 g m⁻³) are similar in the two profiles; however, the depth of the peak is approximately 1 m deeper in the profile from borehole 50.

146

Chloride concentrations in samples from borehole 74 (Fig. 2aa), also located in an ephemeral stream setting (Fig. 1), are higher than those recorded in all other profiles. The chloride profile is multipeaked and not as smooth as other measured profiles. Chloride concentration gradients are steepest in this profile (up to 12,000 g m⁻³ m⁻¹) and vary markedly with depth. The soil texture above 8 m depth (gravelly muddy sand to sand; Fig. 2y) is much coarser grained than that in the other profiles (predominantly sandy clay loam). The transition from shallow coarse material to deeper clay corresponds to a marked increase in moisture content of 0.3 m³ m⁻³ (Fig. 2z). The clay-rich Fort Hancock Formation is found at a shallower depth (8 m) in this borehole than in the other boreholes to the northeast (13 to 15 m in boreholes 23, 30, and 50).

Chloride concentrations in the surficial sediments vary depending on the relationship between the sampling time and precipitation events. At depths greater than approximately 0.5 m, chloride concentrations represent longer time periods and are not affected by individual precipitation events. No systematic relationship was found between the chloride profiles and the present geomorphic setting. The lack of a relationship may result from these two geomorphic systems being hydrologically similar because most of the runoff occurs as sheet flow (S. Akhter, pers. comm., 1989), and the topographic difference between the two settings is small (0.6 m). Alternative hypotheses are that the geomorphic systems are not stable over the long time periods reflected in these chloride profiles, or that soil textural variations are more important in controlling moisture flux, as shown by the profile from borehole 74.

Transport Mechanisms

The general advection-dispersion equation (equation 2) was fitted to the chloride concentration data to evaluate the relative importance of advection and diffusion. Smooth chloride profiles are generally thought to reflect redistribution of chloride as a result of diffusion. Chloride concentration gradients were up to 12,000 g m⁻³ (borehole 74). These large concentration gradients should yield high diffusive fluxes. Effective diffusion coefficients (D_e) estimated from the moisture content data in the profiles and the relationship between moisture content and D_e developed by Conca (pers. comm., 1990) was approximately 10^{-11} m² s⁻¹ in most profiles. The range in D_e (10^{-10} to 10^{-12}) was higher in samples from borehole 74 because the range of moisture content was greater with lower moisture contents in the coarser grained material and higher moisture contents in the clay section (Fig. 2z).

Above the chloride peak, increasing chloride concentrations with depth gave rise to upward diffusive fluxes that ranged from 10^{-3} to 10^{-4} mm yr⁻¹. Below the chloride peak, downward diffusive fluxes ranged from 10^{-3} to 10^{-5} mm yr⁻¹. Although the multipeaked chloride profile from borehole 74 could be expected to reflect lower diffusive fluxes in this profile relative to those in other profiles, the diffusive fluxes are actually similar because the effect of steeper concentration gradients cancels the lower De values in samples from borehole 74. The low calculated diffusive fluxes for all profiles (10^{-3} to) $10^{-5} \text{ mm yr}^{-1}$) are attributed in part to low moisture contents ($\leq 0.1 \text{ m}^3 \text{ m}^{-3}$) in the zone of high concentration gradients. De gradually decreases with moisture content, from a value of 10^{-9} m² s⁻¹ at a moisture content of 0.5 m³ m⁻³ to a value of 10^{-10} m² s⁻¹ at a moisture content of 0.1 m³ m⁻³ (Conca, in press). Below a moisture content of 0.1 m³ m⁻³, D_e decreases sharply to 10^{-13} m² s⁻¹ at a moisture content of 0.01 to 0.005 m³ m⁻³. Another factor that contributes to the low diffusive fluxes is that the effects of absolute concentrations and steep concentration gradients on the diffusive flux cancel each other (equation 2) as the zones of high chloride concentrations and steep concentration gradients coincide.

In contrast to the diffusive flux, which varies in direction according to the chloride concentration gradients, the calculated advective flux must always be downward because the chloride approach assumes a constant downward chloride flux. The calculated advective flux ranges from 10^{-2} to 10^{-1} mm yr⁻¹ in most profiles and is approximately 2 to 3 orders of magnitude higher than the diffusive flux. These data suggest that the diffusive flux can be neglected and soil moisture flux can be approximated by the advective flux, as seen in equation (3).

Because the chloride flux is assumed to be constant throughout the study area, variations in the soil moisture chloride concentrations reflect differences in moisture flux. Therefore, the chloride concentration in soil water increases to the peak value as the moisture flux decreases, and chloride concentrations decrease below the peak as moisture flux increases (Fig. 2). The highest moisture fluxes were recorded in samples from the shallow zone of borehole 50 (Fig. 2w) where chloride had been leached ($\leq 10 \text{ g m}^{-3}$) by a recent precipitation event. The advective fluxes in all profiles decrease sharply to 0.1 mm yr⁻¹ within the top meter of the unsaturated zone because almost 100% of the soil water is evapotranspired in this zone. Calculated moisture fluxes are at a minimum where soil moisture chloride concentrations peak, and they increase gradually with depth below the peak as chloride concentrations decrease. Soil moisture velocities (q_w/ θ) generally parallel soil moisture flux profiles and are approximately 2 orders of magnitude greater than soil moisture fluxes.

148

· mout.

and and

S. Barres

CV Vat

In addition to diffusion, chloride concentration gradients also give rise to osmotic potential gradients that cause advective flux in the direction of higher chloride concentrations. Osmotic potentials (ψ_{π} ; units mega Pascals, MPa) were calculated from soil water chloride concentrations according to the Vant Hoff equation (Campbell, 1985):

 $\psi_{\pi} = (v C \chi R T) / 1000$

調査の

1. 20

Sec. 2

where v is the number of osmotically active particles (2 for NaCl), C is the concentration (moles kg⁻¹), χ is the osmotic coefficient (Robinson and Stokes, 1959), R is the gas constant

(8.3142 J mole⁻¹ °K⁻¹), and T is temperature (°K). Osmotic coefficients decrease with increasing chloride concentration. Maximum osmotic potential gradients of 2 MPa m⁻¹ were calculated for the chloride profile from borehole 74 (Scanlon et al., in press). The remaining profiles were characterized by osmotic potential gradients generally less than 0.4 MPa m⁻¹. These osmotic potential gradients are negligible compared with the measured water potential gradients (≤ 15 MPa m⁻¹ in borehole 74 [Scanlon et al., in press]), and fluxes resulting from the osmotic potential gradients should have a minimal effect on flow.

Validity of Assumptions of Chloride Approach

As outlined in the introduction, many assumptions are used to estimate moisture fluxes from chloride data, and the validity of these assumptions in this study area needs to be examined. The one-dimensional vertical flow assumption is considered valid because, except at borehole 74 where topographic slopes are up to 2%, all chloride profiles are from topographically flat areas having slopes of less than 1%. In sloping topography, the chloride method underestimates moisture fluxes because lateral flow is neglected (Mattick et al., 1987). The direction of moisture flux is assumed to be downward. If the moisture flux were in fact upward, the highest chloride concen-trations would occur at the land surface, as seen in chloride profiles from the Sahara (Fontes et al., 1986). Maximum chloride concentrations observed at depths of 1.3 to 4.6 m in the Hueco Bolson indicate that the net moisture flux is downward in this depth interval of the unsaturated zone. Precipitation is assumed to be the only source of chloride; there are no chloride sources or sinks below the root zone. The sediments in this study area are terrestrial and do not contain any chloride of marine origin. The low observed chloride concentrations in soil water indicate that chloride is not in equilibrium with chloride minerals. The bases of some of the profiles are characterized by chloride

B.R. SCANLON

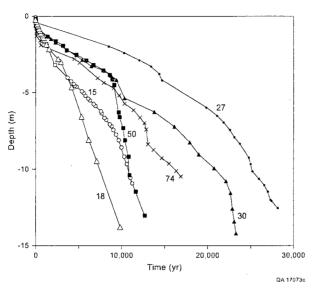


Figure 3. Chloride mass balance age calculated according to equation (4). Borehole numbers shown adjacent to each line.

concentrations as low as 100 g m^{-3} , which further indicates that any in situ chloride source is negligible.

The piston-flow assumption is more difficult to assess. The applicability of piston flow depends on the temporal and spatial scales being considered. Near the soil surface where desiccation cracks develop, nonpiston flow may be dominant. Higher moisture fluxes based on groundwater chloride relative to those based on chloride concentration in the unsaturated zone in many areas have been attributed to nonpiston flow or bypass of the matrix with low-chloride water (Peck et al., 1981; Sharma and Hughes, 1985; Johnston, 1987). Chloride profiles in these areas are generally smooth, which indicates that the smoothness of the profiles does not help discriminate between piston and nonpiston flow. Flow along preferential pathways that bypasses the matrix is used to explain the reduction in chloride concentrations below the peak in some profiles (Sharma and Hughes, 1985). Many profiles characterized by a large amount of preferential flow are from wetter regions (precipitation 800 to 1,200 mm yr^{-1} [Sharma and Hughes, 1985; Johnston, 1987]) than the Hueco Bolson (precipitation 280 mm yr⁻¹). The water potentials (matric and osmotic potentials) in the Hueco Bolson are very low (-2 to -16 MPa [Scanlon et al., in press]); therefore, most of the water is adsorbed onto grain surfaces and is unlikely to move along larger openings or root channels.

The long time period represented by chloride profiles in this study (10,000 to 30,000 yr; Fig. 3) spans paleoclimatic variations and may invalidate the steadystate subsurface flow assumption. The decrease in soil water chloride

150

たがた

Sal and

100 P. 2.

1. a. a. a. a.

3

Sec.

14 H A 4

an an

concentrations below the peak may represent temporally varying precipitation, chloride input, moisture flux, or other environmental conditions (Allison et al., To examine the possibility of changing environmental conditions, 1985). cumulative chloride concentration was plotted against cumulative water content for each borehole. Cumulative water content was used instead of depth to factor out variations in water content (Allison et al., 1985). Moisture fluxes were calculated from the straight-line portions of these plots, which signify uniform environmental conditions. In these flux calculations, Cl_{SW} is the weighted mean soil water chloride concentration in a depth interval that has a constant ratio of cumulative chloride to water content; the constant ratio indicates uniform environmental conditions during a period of recharge. Profiles have either multiple line segments or curved lines, both of which suggest varying environmental conditions (Figs. 2e, 2j, 2n, 2s, 2x, and 2ac). An increase in slope of the cumulativechloride-versus-water-content profiles with depth reflects past conditions with greater water and/or chloride flux than present rates of flux. If a constant chloride flux is assumed, calculated moisture fluxes range from 0.03 to 0.7 mm yr⁻¹. Many of the profiles indicate a change in the moisture flux from 9,000 to 6,000 yr, higher moisture fluxes having occurred before this period and lower moisture fluxes from this period to the present. This is consistent with paleoclimatic data that suggest that the climate during the late Wisconsinan and early Holocene (22,000 to 8,000 yr) was much wetter than middle to late Holocene (8,000 yr to present) (Van Devender and Spaulding, 1979). In addition to higher precipitation rates in the past, the seasonality of the precipitation is also thought to differ, winter frontal storms being dominant before 8,000 yr, summer convective storms being more typical of the climate since then (Van Devender and Spaulding, 1979), which would further reduce the moisture flux from 8,000 yr to the present.

Controls on Chloride Profiles and Moisture Fluxes

Chloride profiles and moisture fluxes from the Hueco Bolson were compared with those from other regions to evaluate controls on unsaturated flow and solute transport processes. Possible controls on these processes include climate and paleoclimate, geomorphic and hydrologic settings, and soil texture.

Moisture fluxes from chloride profiles in sand dunes in a humid region in Western Australia ranged from 50 to 115 mm yr⁻¹, which is much higher than those estimated for sand dunes in an arid region (flux 0.06 mm yr⁻¹) in South Australia (Table 1). The wetter region was characterized by up to 50% flow along preferential pathways that bypassed the matrix (Sharma and Hughes, 1985). Moisture flux differences between these two regions are much greater than flux

151

TABLE 1

Comparison of physical and chemical data from Texas, New Mexico, and Australia

	Precipitation (mm/yr ⁻¹)	Water table depth (m)	Geomorphic setting	Soil texture	Maximum chloride (g/m ⁻³)	Moisture flux (mm/yr ⁻¹)
Texasª (Hueco Bolson)	280 (arid)	150	Ephemeral stream interstream	Clay to muddy- sandy-gravel Clay to muddy- sandy-gravel	9300 6300	0.01 to 0.7 0.03 to 0.27
New Mexico ^{h,c} (Eastern) (Central)	444 or 385 (semiarid) 220 (arid)	30 ح	Playa Sand hills Pleistocene	Sandy loam to	≤ 100 ≤ 300 60 to 2720	2.8-12.4° 1.3-4.3ª 1-3
24 km N of Socorro ^{d.e} (3*) (3**)		100	alluvium Holocene terrace	loamy sand sand		I-3
40 km NE of Las Cruces ^d	, 220 (arid)	100		Sandy loam to Śandy clay loam	680	0.1
South Australia	300 (arid)	28-40	Undisturbed		7500	0.1-0.17
Adelaide		,	1° sinkhole 2° sinkhole Vegetated dunes		22500 30 20000	0.07-0.09 ≥ 60 0.06
Western Australia 40 km N of Perth [∉]	800 (humid)	06	Cleared dunes Dunes	sand	250 -500	50-115

B.R. SCANLON

152

2. 29 Mar

「「「日」」

P. S. M. C.

Long The ...

5 22 220

A Sector

14-20

Sale and a

1.12 m

Bay watte

the shares

1. No. 5

A State of the

Same .

Service of

S. C. Startes

Ser and

20.00

differences attributed to paleoclimatic variations in the Hueco Bolson (0.01 to 0.26 mm yr⁻¹) and in South Australia (0.01 to 0.17 mm yr⁻¹) (Allison et al., 1985). Calculated moisture fluxes are directly affected by uncertainty in the estimated chloride accession rate. Estimated moisture fluxes for chloride profiles in eastern New Mexico ranged from 1 to 12 mm yr⁻¹ (Stone, 1990) based on measured chloride concentrations in precipitation of 2.4 g m⁻³; however, moisture fluxes for the same chloride profiles were four times less when a value of chloride concentration of precipitation from a nearby area of 0.6 g m⁻³ was used (Phillips and Stone, 1985).

Chloride profiles were measured in a variety of geomorphic settings in New Mexico and South Australia. Geomorphic settings that varied from sand hills to playas (depressions that are frequently ponded) were sampled in eastern New Mexico, and moisture fluxes ranged from 1 to 4 mm yr⁻¹ in the sandy areas to 12 mm yr⁻¹ in the playas (Stone, 1990). The moisture-flux estimate for the playas represents the lower limit of the actual moisture flux because runoff into the playa was not included in the calculations. Undisturbed calcrete, primary and secondary sinkholes, and vegetated and unvegetated sand dunes were sampled for chloride in South Australia (Allison et al., 1985). Calculated moisture fluxes in the undisturbed calcrete and primary sinkhole ranged from 0.07 to 0.17 mm yr⁻¹, and an increase in moisture flux in the past was attributed to paleoclimatic variations. Because runoff was not included in the chloride calculations for secondary sinkholes, the recharge estimate of 60 mm yr^{-1} represents the lower limit of moisture flux in this geomorphic setting. Higher moisture fluxes in the unvegetated dunes relative to the vegetated dunes signify the importance of transpiration in reducing the moisture flux in these systems (Table 1). These variations in moisture flux with geomorphic setting are much greater than those recorded between ephemeral stream and interstream settings in the Hueco Bolson, probably because differences in topography between these two geomorphic systems in the Hueco Bolson are small (0.6 m).

The subsurface hydrologic system may also affect the shape of the chloride profile and calculated moisture fluxes. The unsaturated zone in the northern Sahara is characterized by maximum chloride concentrations at the soil surface and an exponential decrease in concentration to the water table that is at a depth of 20 m (Fontes et al., 1986). The profiles are attributed to groundwater discharge, which is corroborated by stable isotope data. The lack of sensitivity of the chloride profiles to subsurface hydrology is demonstrated by two closely spaced (2 km apart) chloride profiles in New Mexico. The water table in the Pleistocene alluvium site near Socorro is 5 m deep, and measured water potentials are high (≥ -0.8 MPa) (Stephens and Knowlton, 1986). The water table is much deeper in the Holocene terrace (Table 1), and under steady-state flow equilibrium water potentials should be approximately 1 order of magnitude lower than those in the Pleistocene alluvium. Soil texture in both systems ranges from sandy loam to sand. Moisture fluxes based on chloride profiles are similar (1 to 3 mm yr⁻¹) and suggest that long-term moisture fluxes are insensitive to variations in water potential in the unsaturated zone or in water-table depth.

The effect of soil texture on calculated moisture fluxes was examined by comparing chloride profiles and moisture fluxes in Holocene terrace environments near Socorro and in another site near Las Cruces (Phillips et al., 1988). Water-table depth and geomorphic setting are similar in both areas (Table 1). Lower moisture fluxes calculated from chloride profiles near Las Cruces relative to those recorded in the Holocene terrace area were attributed to finer grained sediments near Las Cruces compared with those measured in the Holocene terrace (Table 1). Large porosities associated with finer grained sediments retain water for longer periods of time in the shallow zone where it is more readily evapotranspired.

The combined effects of grain size and climatic factors also affect transport mechanisms in the unsaturated zone. Soil texture in profiles from an area in Western Australia ranges from gravel in the shallow zone (1 to 5 m) to clay at a depth of 5 to 30 m (Peck et al., 1981; Johnston, 1987). Precipitation rates are high in this area (600 to 1,300 mm yr⁻¹) and result in high moisture contents of $0.4 \text{ m}^3 \text{ m}^{-3}$ in the clay section. The chloride profiles are bulge shaped and are characterized by steep concentration gradients. The combination of high moisture contents in the clay and steep chloride concentration gradients results in downward diffusive fluxes being dominant below the chloride peak and net upward advective fluxes of 0.05 to 0.5 mm yr⁻¹ below the chloride peak in some profiles.

Implications for Waste Disposal

Data from chloride profiles have direct implications for evaluation of wastedisposal sites. One of the primary uncertainties associated with waste disposal is the prediction of long-term climatic variations and their effect on moisture flux. Chloride profiles in the Hueco Bolson represent up to 30,000 yr of moisture flux and probably span paleoclimatic variations. The range in moisture fluxes, represented by the chloride profiles, can be used to evaluate sensitivity of contaminant migration from proposed sites to variations in flux. Moisture fluxes in wetter regions may approximate the flux beneath leaking waste-disposal facilities in more arid systems. Flow along preferential pathways appears to be more prevalent in wetter climates (Sharma and Hughes, 1985; Johnston, 1987). If unsaturated flow bypasses the matrix, contaminant transport rates would be much greater than those estimated on the basis of piston flow.

Comparison of chloride profiles in several regions showed that calculated recharge rates are much more sensitive to geomorphic settings than to paleoclimatic variations. Because of the strong dependence of moisture flux on geomorphic setting it is important to characterize geomorphic variations within an area and to measure chloride profiles in each setting to adequately quantify recharge at a site. The variability in moisture fluxes gives some indication of the number of chloride profiles required to obtain an estimate of the areal moisture flux.

CONCLUSIONS

ay (10. 3. 4

Chloride profiles were quite variable in the study area, and maximum concentrations ranged from 1,900 to 9,300 g m⁻³ m⁻¹. Although chloride-concentration gradients were steep (up to 12,000 g m⁻³ m⁻¹), diffusive moisture fluxes were negligible (10⁻³ to 10⁻⁵ mm yr⁻¹) because of the low observed moisture contents ($\leq 0.1 \text{ m}^3 \text{ m}^{-3}$) in the zone of steep concentration gradients. Advective moisture fluxes ranged from 10⁻¹ to 10⁻² mm yr⁻¹ in most profiles and approximated the total moisture flux. Because the chloride flux (0.08 g m⁻² yr⁻¹) was assumed to be constant throughout the area, the moisture flux was inversely related to the chloride concentration in the soil water. Reductions in chloride concentration with depth below the peak were attributed to higher moisture fluxes in the past, an inference that was generally consistent with paleoclimatic reconstructions of the area.

Comparisons among chloride profiles in different regions indicated that variations in geomorphic setting, climate, and soil texture are among the primary controls of moisture fluxes in the unsaturated zone. Information on the relative importance of different controls on unsaturated moisture flux can be used to evaluate various parameters in site characterization studies related to waste disposal. In addition, data on soil moisture flux variations provided by chloride profiles can be used in sensitivity analyses related to performance assessment of different sites.

ACKNOWLEDGMENTS

This project was funded by the Texas Low-Level Radioactive Waste Disposal Authority under interagency contract no. IAC (88-89)0932. The conclusions of the author are not necessarily approved or endorsed by the Authority. The assistance of B. C. Richter in sample collection is gratefully appreciated. Grainsize analyses were conducted by the Soils Laboratory at the University of Wisconsin. A. R. Dutton provided helpful review of the report. The manuscript was edited by T. F. Hentz and A. R. Masterson. Word processing was by Melissa Snell. Figures were drafted by J. Jobst under the direction of R. L. Dillon.

155

REFERENCES

- Allison, G. B., Stone, W. J., and Hughes, M. W., 1985. Recharge in karst and dune elements of a semi-arid landscape as indicated by natural isotopes and chloride. J. Hydrol., 76: 1-26.
- Bentley, H. W., Phillips, F. M., and Davis, S. N., 1986. ³⁶Cl in the terrestrial environment. In: Fritz, P., and Fontes, J.-C., eds., Handbook of environmental isotope geochemistry: New York, Elsevier Science, pp. 422-475.
- Biggar, J. W., and Nielsen, D. R., 1962. Miscible displacement: II. Behavior of tracers. Soil Sci. Soc. Am. Proc., 26: 125-128.
- Bouyoucos, G. J., 1962. Hydrometer method improved for making particle size analyses of soils. Agron. J., 54: 464-465.
- Bresler, E., 1973. Simultaneous transport of solutes and water under transient unsaturated flow conditions. Water Resour. Res., 9: 975-986.
- Campbell, G. S., 1985. Soil physics with basic: transport models for soil-plant systems: New York, Elsevier, 150 p.
- Conca, J. L., in press. Experimental determination of transport parameters in unsaturated geologic media: Environmental Sciences, Washington State University, 27 p.
- Conca, J. L., and Wright, J., 1990. Diffusion coefficients in gravel under unsaturated conditions. Water Resour. Res., 26: 1055-1066.
- Folk, R. L., 1974. Petrology of sedimentary rocks: Austin, Texas, Hemphill, 182 p.
- Fontes, J. C., Yousfi, M., and Allison, G. B., 1986. Estimation of long-term, diffuse groundwater discharge in the Northern Sahara using stable isotope profiles in soil water. J. Hydrol., 86: 315-327.
- Gvirtzman, H., Ronen, D., and Magaritz, M., 1986. Anion exclusion during transport through the unsaturated zone. J. Hydrol., 87: 267-283.
- Henry, C. D., and Price, J. G., 1986. Early Basin and Range development in Trans-Pecos Texas and adjacent Chihuahua: magmatism and orientation, timing, and style of extension. J. Geophys. Res., 91: 6213-6224.
- James, R. V., and Rubin, J., 1986. Transport of chloride ion in water-unsaturated soil exhibiting anion exclusion. Soil. Sci. Soc. Am., J., 50: 1142-1149.
- Johnston, C. D., 1987. Distribution of environmental chloride in relation to subsurface hydrology. J. Hydrol., 94: 67-88.
- Krupp, H. K., Biggar, J. W., and Nielsen, D. R., 1972. Relative flow rates of salt and water in soil. Soil Sci. Soc. Am. Proc., 36: 412-417.

1 6. W

ALC: NO

322

Sales -

22.3.10

10 PP 10

194 490

و حقيقة للم

1 2 m

1.1.2.2.3

No.

- Larkin, T. J., and Bomar, G. W., 1983, Climatic atlas of Texas: Texas Department of Water Resources, Report No. LP-192, 151 p.
- Mattick, J. L., Duval, T. A., and Phillips, F. M., 1987, Quantification of groundwater recharge rates in New Mexico using bomb ³⁶Cl, bomb ³H and chloride as soil-water tracers: Las Cruces, New Mexico, Water Resources Research Institute, Report No. 220, 184 p.
- Olsen, S. R., and Kemper, W. D., 1968. Movement of nutrients to plant roots. Adv. Agron., 20: 91-151.
- Peck, A. J., Johnston, C. D., and Williamson, D. R., 1981. Analyses of solute distributions in deeply weathered soils. Agric. Water Management, 4: 83-102.
- Phillips, F. M., Mattick, J. L., and Duval, T. A., 1988. Chlorine 36 and tritium from nuclear weapons fallout as tracers for long-term liquid movement in desert soils. Water Resour. Res., 24: 1877-1891.
- Phillips, F. M., and Stone, W. J., 1985. Chemical considerations in groundwater recharge. Socorro, New Mexico, Symposium on Water and Science, New Mexico Water Resources Research Institute, pp. 109-125.
- Phillips, F. M., Trotman, K. N., Bentley, H. W., and Davis, S. N., 1984. The bomb 36-Cl pulse as a tracer for soil-water movement near Socorro, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Water Quality Pollution in New Mexico, Hydrologic Report 7, pp. 270-280.
- Robinson, R. A., and Stokes, R. H., 1959. Electrolyte solutions: London, Butterworths Publishing, 571 p.
- Scanlon, B. R., Kubik, P. W., Sharma, P., Richter, B. C., and Gove, H. E., 1990. Bomb Chlorine-36 analysis in the characterization of unsaturated flow at a proposed radioactive waste disposal facility, Chihuahuan Desert, Texas. Nucl. Instr. Meth. Phys. Res., 52: 489-492.
- Scanlon, B. R., Wang, F. P., and Richter, B. C., in press. Field studies and numerical modeling to evaluate controls on unsaturated flow in an arid system. Univ. Texas Austin, Bur. Econ. Geol., Rept. Inv.
- Scanlon, B. R., in press. Environmental and applied tracers as indicators of liquid and vapor transport in the Chihuahuan Desert of Texas. Univ. Texas Austin, Bur. Econ. Geol., Rept. Inv.
- Sharma, M. L., and Hughes, M. W., 1985. Groundwater recharge estimation using chloride, deuterium and oxygen-18 profiles in the deep coastal sands of western Australia. J. Hydrol., 81: 93-109.
- Stephens, D. B., and Knowlton, R. J., 1986. Soil water movement and recharge through sand at a semiarid site in New Mexico. Water Resour. Res., 22: 881-889.

- Stone, W. J., 1990. Natural recharge of the Ogallala aquifer through playas and other non-stream-channel settings, eastern New Mexico. In: Gustavson, T.C., eds., Geologic framework and regional hydrology: upper Cenozoic Blackwater Draw and Ogallala Formations, Great Plains. Univ. Texas Austin, Bur. Econ. Geol., pp. 180-192.
- U.S. Department of Agriculture, 1975, Soil taxonomy. Washington, D.C., Soil Conservation Service, 754 p.
- van de Pol, R. M., Wierenga, P. J., and Nielsen, D. R., 1977. Solute movement in a field soil. Soil Sci. Soc. Am. J., 41: 10-13.
- Van Devender, T. R., and Spaulding, W. G., 1979. Development of vegetation and climate in the Southwestern United States. Science, 204: 701 -710.
- Wierenga, P. J., and van Genuchten, M. Th., 1989, Solute transport through small and large unsaturated soil columns. Ground Water, 27: 35-42.

o Paste

S. Legal.

S. Total

ANA

1. 40 M

1.26.28

The second

10 a - 10

Sec. Bri

Same and

Assessing controls on diffuse groundwater recharge using unsaturated flow modeling

K. E. Keese, B. R. Scanlon, and R. C. Reedy

Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin, Austin, Texas, USA

Received 23 November 2004; revised 16 February 2005; accepted 28 February 2005; published 16 June 2005.

[1] Understanding climate, vegetation, and soil controls on recharge is essential for estimating potential impacts of climate variability and land use/land cover change on recharge. Recharge controls were evaluated by simulating drainage in 5-m-thick profiles using a one-dimensional (1-D) unsaturated flow code (UNSAT-H), climate data, and vegetation and soil coverages from online sources. Soil hydraulic properties were estimated from STATSGO/SSURGO soils data using pedotransfer functions. Vegetation parameters were obtained from the literature. Long-term (1961-1990) simulations were conducted for 13 county-scale regions representing arid to humid climates and different vegetation and soil types, using data for Texas. Areally averaged recharge rates are most appropriate for water resources; therefore Geographic Information Systems were used to determine spatial weighting of recharge results from 1-D models for the combination of vegetation and soils in each region. Simulated 30-year mean annual recharge in bare sand is high (51-709 mm/yr) and represents 23-60% (arid-humid) of mean annual precipitation (MAP). Adding vegetation reduced recharge by factors of 2-30 (humid-arid), and soil textural variability reduced recharge by factors of 2-11 relative to recharge in bare sand. Vegetation and soil textural variability both resulted in a large range of recharge rates within each region; however, spatially weighted, long-term recharge rates were much less variable and were positively correlated with MAP ($r^2 = 0.85$ for vegetated sand; $r^2 = 0.62$ for variably textured soils). The most realistic simulations included vegetation and variably textured soils, which resulted in recharge rates from 0.2 to 118 mm/yr (0.1-10% of MAP). Mean annual precipitation explains 80% of the variation in recharge and can be used to map recharge.

Citation: Keese, K. E., B. R. Scanlon, and R. C. Reedy (2005), Assessing controls on diffuse groundwater recharge using unsaturated flow modeling, *Water Resour. Res.*, *41*, W06010, doi:10.1029/2004WR003841.

1. Introduction

[2] Understanding controls on the water cycle, such as climate, vegetation, and soils, is important in evaluating the potential impact of climate variability and land use/land cover (LU/LC) change on the water cycle. Land surface models are currently being used on regional scales to assess the relative importance of these influences on the water cycle [Bonan, 1997; Pielke et al., 1998]. These models focus on evapotranspiration (ET) and feedback between the land surface and climate and have not been applied to estimating subsurface components of the water cycle. Recharge (addition of water to an aquifer) is a critical component of the water cycle for water resources and as a vector for nutrients and contaminants from the land surface to underlying aquifers. The need to control recharge at regional scales for environmental purposes, such as management of water resources and reduction in salinization, underscores the importance of understanding fundamental controls on recharge. Examples include removal of brush and riparian vegetation in semiarid regions of the southwestern United States to increase recharge and reforestation in areas of Australia to reduce recharge and associated

Copyright 2005 by the American Geophysical Union. 0043-1397/05/2004WR003841\$09.00

salinity problems [Allison et al., 1990; Dugas et al., 1998; Dawes et al., 2002; Wilcox, 2002].

[3] The basic controls on diffuse groundwater recharge include climate, vegetation, soils, and topography. Diffuse recharge refers to areally distributed recharge derived from precipitation or irrigation and should be distinguished from focused or concentrated recharge in topographic depressions, such as streams, lakes, and playas. Comparison of previous recharge estimates from various studies indicates that recharge is higher in humid versus arid regions; however, most studies focus on recharge in arid regions [Lerner et al., 1990; Robins, 1998]. The presence of vegetation markedly reduces recharge in semiarid to arid basins [Gee et al., 1994]. Vegetation type also significantly impacts recharge rates: recharge is higher in areas of annual crops and grasses than in areas of trees and shrubs [Prvch, 1998]. Replacement of deep-rooted native eucalyptus trees with shallow-rooted crops in Australia increased recharge by about two orders of magnitude ($\leq 0.1 \text{ mm/yr}$ for native mallee vegetation to 5-30 mm/yr for crop/pasture rotations) [Allison et al., 1990]. Field and modeling studies have shown that recharge is greater in coarser versus finer textured soils [Cook and Kilty, 1992; Rockhold et al., 1995; Kearns and Hendrickx, 1998]. The influence of topography on recharge is variable. Catchment-scale modeling studies indiALL ART

3432

cate that subsurface lateral flow was negligible in some catchments and flow could be treated as 1-D [*Dawes et al.*, 1997; *Hatton*, 1998; *Zhang et al.*, 1999].

[4] Previous studies have evaluated controls on groundwater recharge using field studies or numerical modeling. Kennett-Smith et al. [1994] related variations in recharge to precipitation and clay content using a simple water balance model and field recharge estimates. Sophocleous [1992] used multiple regression analysis to link variations in fieldbased recharge estimates primarily to variations in precipitation and also to variations in soil water storage, water table depth, and spring precipitation rate for a 3,400-km² area in Kansas. Petheram et al. [2002] evaluated impacts of land use on recharge by reviewing previous recharge studies in Australia and correlated recharge to precipitation in areas of annual vegetation and sandy soils ($r^2 = 0.6$). However, comparison of recharge rates among the different studies was difficult because of the wide variety of techniques used that represented a range of space and timescales.

[5] Physical, chemical, and modeling approaches can be used to estimate recharge on the basis of surface water, unsaturated zone, and groundwater data [Scanlon et al., 2002b]. Numerical modeling is the only tool that can predict recharge, and it is also extremely useful in isolating the relative importance of different controls on recharge, provided that the model properly accounts for physical and biological processes. Various types of codes can be used to simulate recharge, such as land-atmosphere, watershed, unsaturated zone, and groundwater codes. Although landatmosphere codes simulate all the processes required to estimate recharge, including Richards' equation for simulating unsaturated flow and a variety of approaches for simulating evapotranspiration (ET) [Cotton et al., 2003; Dai et al., 2003], these codes have generally not been used to simulate recharge. Watershed codes have been used to estimate groundwater recharge [Hatton, 1998; Zhang et al., 1999]; however, the large number of parameters required makes it difficult to obtain a unique solution. Unsaturated zone codes range from simple bucket codes [Hatton, 1998; Hevesi et al., 2002; Lewis and Walker, 2002] to those based on Richards' equation [Braud et al., 1995; Faver et al., 1996], as well as some that include plant growth modules [Dawes and Hatton, 1993; Zhang et al., 1996]. Simulation studies of recharge using unsaturated zone codes range from bare ground [Scanlon and Milly, 1994; Scott et al., 2000] to vegetated systems [Rockhold et al., 1995; Kearns and Hendrickx, 1998]. One-dimensional unsaturated zone modeling has been used with GIS coverages of vegetation and soils to determine areally distributed recharge [Fayer et al., 1996]. Sensitivity analyses to assess controls on recharge using unsaturated zone codes were fairly simplistic, ranging from monolithic to simple twolayered soil profiles, with or without vegetation and different vegetation types (shrubs/grasses) [Rockhold et al., 1995: Kearns and Hendrickx, 1998]. Groundwater model calibration or inversion can also be used to estimate recharge rates: however, model inversion using hydraulic head data is limited only to estimating the ratio of recharge to hydraulic conductivity [Sanford, 2002]. Such recharge estimates are generally not considered highly reliable because hydraulic conductivity can vary over several orders of magnitude. More reliable recharge estimation requires information on

water fluxes or ages in addition to hydraulic head to calibrate the model [Sanford, 2002].

[6] Primary difficulties with modeling recharge are data requirements and model parameterization. The following online data sources have made recharge simulations much more feasible. Weather generators, such as GEM (Generation of weather Elements for Multiple applications), include databases of meteorological stations and can generate data for other regions [Hanson et al., 1994; Richardson, 2000]. Geographic Information Systems (GIS) distributions of soils are provided by the State Soil Geographic (STATSGO) database (1:250,000 scale) and Soil Survey Geographic (SSURGO) database (1:24,000 scale). Pedotransfer functions are available to transfer soil texture information into water retention and hydraulic properties required for modeling [Schaap et al., 2001]. Vegetation distribution and land use (National Land Cover Data) can be obtained from online sources [McMahon et al., 1984; Vogelmann et al., 2001]. Remote sensing also provides information on vegetation parameters at different resolutions (30 m; LandSat TM to 1.1 km; MODIS). Percent bare area can be estimated from fractional vegetation coverage using satellite data such as AVHRR or MODIS. Information on leaf area index is available from normalized difference vegetation index (NDVI) [Myneni et al., 1997]. It is more difficult to obtain information on rooting depths; however, estimates can be obtained from the literature [e.g., Canadell et al., 1996].

[7] The purpose of this study was to determine the relative importance of different controls on diffuse groundwater recharge using unsaturated, one-dimensional flow models of recharge for regions representing a range of climate (arid-humid), vegetation (shrubs, grasses, forests, crops), and soil (fine-coarse grained, monolithic and layered) conditions on the basis of data from Texas. This study focuses on long-term (30 year), areally averaged recharge rates that are appropriate for assessing water resources and evaluating aquifer vulnerability to nutrient loading. Unique aspects of the study are the (1) range of climate, vegetation, and soil conditions examined, (2) use of online and published data for input and parameterization of models. (3) combination of 1-D modeling and GIS coverages to develop areally averaged recharge estimates, (4) length of simulations (1961-1990), and (5) comparison with field-based estimates.

2. Materials and Methods

2.1. Study Area Description: Climate, Soils, and Vegetation

[8] The broad study area is the state of Texas (~700,000 km²) (Figure 1). Thirteen study regions, representing a variety of climate, vegetation, and soil types were used in this study to simulate the water balance for a 30 year period (1961–1990). Simulated regions were also located to represent recharge areas of major porous media aquifers in the state (Figure 1 and Table 1). Each study region represents a one- or two-county area above an aquifer (1152–3042 km²), with the exception of region 2 (entire outcrop of Cenozoic Pecos Alluvium Aquifer: 14,980 km²). The topography of the regions is generally flat, with average slopes $\leq 0.5\%$ in the High Plains and Gulf Coast regions and slightly higher slopes in the remaining regions ($\leq 1.3\%$) (Table 1). Long-term (1961–1990) mean annual precipita-

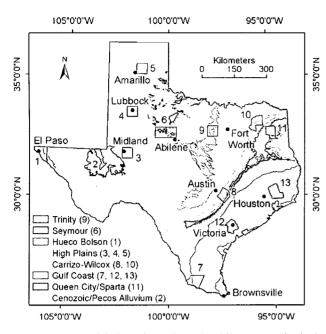


Figure 1. Modeled study regions (1-13), meteorological station locations (city name), and major porous media aquifer outcrop areas. Regions are numbered in order of increasing precipitation; refer to Table 1 for region names.

tion (MAP) ranges from 224 mm/yr in the west to 1,184 mm/yr in the east. Annual precipitation at individual meteorological stations ranged from 110 mm (region 1, El Paso, 1969) to 1783 mm (region 13, Houston, 1973). Summer precipitation (June-August) is dominant throughout much of the state, particularly in western (43%) and northern (33-48%) regions (Figure 2). Spring precipitation is dominant in central regions (29-33%). whereas fall precipitation is dominant in southeastern regions (28-39%). Precipitation is fairly uniformly distributed in the more humid regions in the east. Winter precipitation (December-February) is generally low throughout most of the state (8-16%), with the exception of the humid east (21%). The coefficient of variation (CV) in annual precipitation is greatest in semiarid regions in the west (0.35) and less throughout the rest of the area (CV: 0.21-0.24) (Figure 3 and Table 2). Vegetation ranges from

Table 1. General Characteristics of Modeled Regions^a

predominantly shrubs and grasses in the west, shrub/forest to forest/shrub in the central area, and forest and forest/ shrub in the east (Figure 4). Cropland areas dominate much of the northern and southeastern regions. Variations in clay content in the upper 1.5 to 2 m soil profile depths based on STATSGO data generally follow the distribution of underlying geologic units, e.g., high clay content in the central region of the Southern High Plains (region 5), corresponding to the underlying Blackwater Draw Formation, and high clay content in the northern and central parts of the Gulf Coast (regions 12 and 13), corresponding to the underlying Beaumont Formation (Figure 5).

2.2. Model Description

[9] Unsaturated flow modeling was used to simulate drainage below the root zone, which is equated to ground-water recharge and assumes that climate and land use/land cover remain constant over timescales required for water to move from the root zone to the water table. The UNSAT-H code (version 3.0 [*Fayer*, 2000]) was chosen because previous code comparison studies showed that water balance simulations based on UNSAT-H compare favorably with field data [*Scanlon et al.*, 2002a]. UNSAT-H is a 1-D, finite difference code that simulates nonisothermal liquid flow and vapor diffusion in response to meteorological forcing. The simulations focus on the water balance:

$$D = P - ET - R_0 - \Delta S \tag{1}$$

where *D* is deep drainage below the root zone, *P* is precipitation, *ET* is evapotranspiration, R_0 is surface runoff, and ΔS is change in water storage. UNSAT-H simulates subsurface water flow using Richards' equation:

$$\frac{\partial \theta}{\partial t} = -\frac{\partial q}{\partial z} = \frac{\partial}{\partial z} \left(K(\theta) \frac{\partial H}{\partial z} \right) - S(z, t)$$
$$= \frac{\partial}{\partial z} \left(K(\theta) \frac{\partial h}{\partial z} - K(\theta) \right) - S(z, t)$$
(2)

where θ is volumetric water content, q is water flux, K is hydraulic conductivity, H is hydraulic head, h is matric potential head, and S is a sink term used to describe the removal of water by plants. UNSAT-H includes multiple analytical functions for water retention and unsaturated hydraulic conductivity.

Region Number	Region	MAP, mm/yr	PET, mm/yr	P/PET	HZ	Region Arca, km ²	Topographic Slope Mean, %	Slope SD, %	Mcan Sand, %	Mcan Silt, %	Mcan Clay, %
1	El Paso	224	2087	0,11	Α	2079	0.73	1.36	69	20	11
2	CPA	380	2169	0.18	А	14980	0.38	0.42	60	21	19
3	Midland	380	2169	0.18	А	1388	0.25	0.27	56	20	24
4	Lubbock	474	2034	0.23	SA	2313	0.46	0.72	43	26	31
5	Carson	497	2096	0.24	SA	2363	0.54	0.88	29	35	35
6	Fisher/Jones	620	2132	0.29	SA	1577	0.45	0.42	52	21	26
7	Starr	671	1788	0.38	SA	2474	0.55	0.61	64	13	24
8	Bastrop	810	1732	0.47	SA	1197	1.01	1.04	49	21	30
9	Parker	855	1819	0.47	SA	1464	1.31	1.17	48	23	28
10	Hopkins/Rains	855	1819	0.47	SA	1152	0.52	0.49	41	28	31
11	Upshur/Gregg	855	1819	0.47	SA	1972	1.05	1.20	51	23	26
12	Victoria	933	1651	0.57	SH	2303	0.22	0.31	41	23	36
13	Liberty	1184	1362	0.87	Н	3042	0.17	0.31	27	33	40

^aCPA, Cenozoic Pecos Alluvium aquifer; MAP, 30 year mean annual precipitation; PET, 30 year mean annual potential evapotranspiration; HZ, humidity zone [United Nations Environment Programme, 1992], A, arid; SA, semiarid; SH, subhumid; H, humid.

22.422

S. Sale

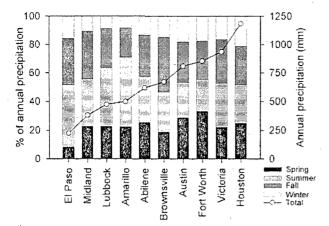


Figure 2. Mean (30 year) annual precipitation and seasonal distribution of mean annual precipitation for the 10 meteorological stations used in the simulations: spring (March-May), summer (June-August), fall (September-November), and winter (December-February).

[10] The upper atmospheric boundary condition is simulated as a system-dependent boundary condition that changes from a prescribed head to a prescribed flux, depending on climate and subsurface conditions. If the applied flux (precipitation or evapotranspiration) is \leq the potential flux and the matric potential head at the surface is between 0 and a prespecified dry value (h_{dry}) , then the potential flux, which is controlled by external conditions, applies. Runoff is simulated implicitly by UNSAT-H. If the precipitation rate exceeds the infiltration capacity of the soil, excess water runs off (infiltration excess or Hortonian runoff). If the matric potential head at the surface reaches 0, the soil becomes saturated, a constant head boundary condition applies (h = 0), and excess water runs off (saturation excess or Dunne runoff). If the soil surface becomes too dry (h \leq h_{drv}), a constant head boundary condition applies ($h = h_{drv}$) and evaporation or evapotranspiration is controlled by the rate at which water can be transmitted to the surface. Ponding is not simulated with this code. Plant water uptake is simulated according to the approach proposed by Feddes et al. [1978] that partitions PET into potential evaporation (PE) and potential transpiration (PT) using an empirical equation developed by Ritchie and Burnett [1971], which distributes PT over the root zone on the basis of depth variations in root density and reduces this PT to actual transpiration on the basis of matric potential head [Fayer, 2000].

2.3. Model Application

[11] The water balance for a 30 year period (1961–1990) was simulated for 13 study regions. Input data requirements for the model include meteorologic forcing, vegetation parameters, hydraulic parameters for different soil types, and initial conditions. To assess the relative importance of different controls on groundwater recharge, four different scenarios were used: (1) nonvegetated, monolithic sand, (2) nonvegetated, texturally variable soil, (3) vegetated, monolithic sand, and (4) vegetated, texturally variable soil. The simplest simulations of nonvegetated, monolithic sand were used to provide an upper bound on recharge rates. Complex, texturally variable soil profiles were simulated

without vegetation to evaluate the impact of soil texturalvariability on recharge. Vegetation was added to the monolithic and texturally variable soil profiles to determine its impact on simulated recharge. The most realistic scenario is represented by vegetated, texturally variable soils.

[12] A soil-profile depth of 5 m was chosen for the simulations because it is deeper than root zone depths of the vegetation used. In addition, soil textural information is available only for the upper 2 m from STATSGO and SSURGO, and texture in the 2 to 5 m zone was assumed equal to that of the lowest data available. Sensitivity of simulated recharge to profile depth was evaluated. In monolithic profiles, nodal spacing ranged from 2 mm at the top and base of the profile and increased by a factor of \sim 1.2 with depth to a maximum value of 230 mm within the profile. In layered soil profiles, nodal spacing was also reduced near textural interfaces to a value of ~ 20 mm. Initial conditions were set arbitrarily at a matric potential head of -3 m for higher precipitation regions (6–13) and -10 m for all other regions. The impact of initial conditions on simulation results was evaluated by reinitializing simulations multiple times with the final conditions of each run; however, rerunning simulations once was found to be sufficient for minimizing the impact of initial conditions.

[13] Meteorological data for 10 stations were obtained from the database in the GEM code [Hanson et al., 1994]. Some station data were used to simulate recharge in more than one region (Midland station, regions 2 and 3; Fort Worth station, regions 9-11). The 1961-1990 period was chosen because of availability of solar radiation for potential evapotranspiration calculations from the National Solar Radiation Data Base (National Renewable Energy Laboratory, Golden, Colorado; 1992). Meteorologic input to the model included daily precipitation, daily average dew point temperature, wind speed and cloud cover, total daily solar radiation, and minimum and maximum daily temperatures. Daily precipitation was applied at a prespecified default intensity of 10 mm/hr, and ET is not simulated during this time. Previous code comparisons showed that the approach used in codes to simulate precipitation and evapotranspiration when daily precipitation is used as input can have a large impact on simulated recharge and that the UNSAT-H approach adequately simulates measured data [Scanlon et

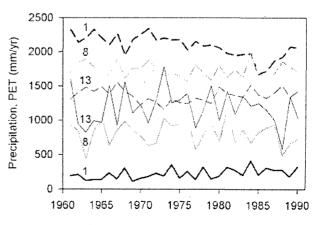


Figure 3. Total annual precipitation (solid lines) and PET (dashed lines) for stations that represent a range of precipitation and PET (1, El Paso; 8, Austin; 13, Houston).

Table 2. Simulation Results for the Four Basic Scenarios^a

	Mz	ĄР		Nonv	/egetat	ed Sar	ıd	No	0	tated T iable S		lly	Veg	etated S	Sand		Vegetated Te Variable S			,
			R	echarge	e			Rech	arge				Rech	arge		Rech	arge			
Region	Total	CV	Total	CV	R/P	AE	PET/AE	Total	R/P	AE	$R_{\rm O}$	ΔS	Total	R/P	AET	Total	R/P	AET	Ro	ΔS
1	224	0.35	51	0.22	23	173	12.1	19	9	205	0	0.0	2	1	222	0.2	0.1	224	0	-0.7
2	380	0.35	137	0.20	36	243	8.9	80	21	286	14	0.0	34	9	346	11.1	2.9	356	14	-0.7
3	380	0.35	137	0.20	36	243	8.9	56	15	316	7	-0.1	11	3	369	1.5	0.4	375	4	-0.6
4	474	0.23	180	0.24	38	294	6.9	19	4	366	90	-0.4	33	7	441	0.8	0.2	390	85	-0.9
5	497	0.21	174	0.16	35	323	6.5	16	3	286	195	-1.0	29	6	468	0.4	0.1	312	186	-1.4
6	620	0.23	269	0.19	43	351	6.1	88	14	364	168	-0.4	80	13	540	5.6	0.9	435	180	-0.8
7	671	0.24	338	0.19	50	334	5.4	191	29	454	25	0.0	115	17	556	33.8	5.0	610	27	-0.1
8	810	0.21	406	0.20	50	403	4.3	98	12	586	125	0.0	95	12	715	10.1	1.3	619	181	-0.8
9	855	0.22	432	0.18	51	423	4.3	193	23	587	74	0.0	106	12	749	29.0	3.4	727	99	-0.4
10	855	0.22	432	0.18	51	423	4.3	146	17	663	46	0.0	83	10	772	4.7	0.6	792	59	-0.4
11	855	0.22	432	0.18	51	423	4.3	193	23	639	24	0.0	111	13	744	35.1	4.1	795	25	-0.2
12	933	0.23	507	0.22	54	427	3.9	91	10	423	419	-0.2	285	31	648	25.7	2.8	520	388	-0.3
13	1184	0.22	709	0.18	60	475	2.9	230	19	619	335	-0.2	369	31	815	117.7	9.9	748	319	-0.2

^aRunoff and change in storage is 0 for nonvegetated and vegetated monolithic sand profiles. All ratios are expressed as percent. Units are mm/yr. MAP, measured 30 year mean annual precipitation; CV, coefficient of variation; R, simulated 30 year mean annual recharge; R/P, recharge to precipitation ratio; AE, actual evaporation; AET, actual evaportanspiration; ΔS, change in water storage; R_O, runoff.

al., 2002a]. A modified Penman-Monteith equation was used to calculate PET [*Doorenbos and Pruitt*, 1977]. Parameter h_{dry} was set to -100 m. A unit gradient lower boundary condition was used that corresponds to free drainage or gravitational flow and is most appropriate for simulating unimpeded recharge.

[14] Distribution of vegetation types for each of the modeled regions was obtained from a GIS coverage of vegetation in Texas [McMahon et al., 1984] (Figures 4 and 6). Crop vegetation types were derived from the percentage of area harvested over the simulation period (USDA National Agricultural Statistics Service). Vegetation parameters required for UNSAT-H include percent bare area, planting and harvesting dates for crops, time series of leaf area index (LAI) and rooting depth (RD), and root length density (RLD). These parameters were obtained mostly from the literature (see auxiliary material).¹ Additional information was obtained from discussions with ecologists and crop specialists. Time series for LAI and root growth were specified on particular days of the year and linearly interpolated. Root growth was simulated for crops only; other plant types were perennial. The RLD function is based on the assumption that normalized total root biomass is related directly to RLD (ρ_{rL}) and can be related to depth below the surface (z) by

$$\rho_{rL} = a \exp(-bz) + c \tag{3}$$

where a, b, and c are coefficients that optimize fit to normalized biomass data. Some vegetation classes contain more than one vegetation type. For example, forests are classified as 75% trees and 25% grasses. Recharge estimates for these regions were obtained by simulating different vegetation types separately and areally weighting results. The 1-D modeling approach used in this study does not account for effects of neighboring plant root systems and may overestimate recharge in areas where deeper rooted vegetation extends into areas with shallower rooted vegetation. Recharge would be overestimated most in areas where the difference in rooting depths is greatest. However, this error is considered relatively minor considering that information on the distribution of different vegetation types is only approximate. Dominant vegetation types that represented $\sim 70-80\%$ of the area of each region were simulated.

[15] Soil profiles for the simulations ranged from monolithic sand to texturally variable profiles. Hydraulic properties for the sand were obtained from the UNSODA database (UNSODA 4650: K_s: 5.87 m/day; θ_s : 0.38; θ_r : 0; α : 5.03 1/m; n: 1.7736 [*Leij et al.*, 1996]). SSURGO version 2 data [*U.S. Department of Agriculture (USDA)*, 1994] were used to provide information for texturally variable soil profiles for all regions but were unavailable for region 2, where STATSGO data [*USDA*, 1995] were used for the entire (multicounty) outcrop area of the aquifer. Pedotransfer functions were used to determine soil hydraulic properties. Rosetta software uses neural network programming and a database of measured texture, water retention, and saturated hydraulic conductivity to provide estimates of van

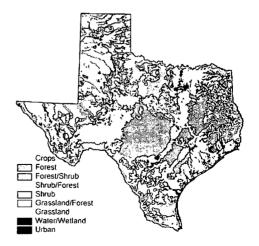


Figure 4. Dominant vegetation associations in Texas [*McMahon et al.*, 1984].

¹Auxiliary material is available at ftp://ftp.agu.org/apend/wr/2004WR003841.

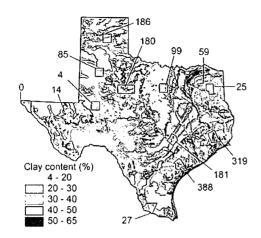


Figure 5. Average soil profile clay content derived from STATSGO database. Water-covered areas are shown in blue. Simulated runoff using vegetated, texturally variable soils are shown for each region.

Genuchten water retention parameters and saturated hydraulic conductivity for input to unsaturated flow models [Schaap et al., 2001]. Only texture and bulk density information was available from the STATSGO database for input to Rosetta. Soil layer texture, bulk density, and volumetric water content at -3 and -150 m head were available from the SSURGO version 2 database for input to Rosetta. Simulations were run for soil profiles that represented ~80% of the area of each simulated region, which corresponded to 6-29 profiles for all profiles for a region showed that recharge rates could be categorized into distinct groups, resulting in a more manageable 3-7 representative profiles for each region.

[16] Simulated recharge results are represented by a single temporal (30 year) and spatial average recharge value for each region, using GIS coverages to determine the area represented by each vegetation type, soil type, or combination of vegetation and soil types to spatially weight 1-D results. A total of 460 simulations were conducted for the final analysis. For monolithic profile simulations, models were developed for each of the 10 meteorological stations, resulting in 10 representative recharge values. For vegetated and texturally variable soil profile simulations, 13 recharge values representative of each of the study regions

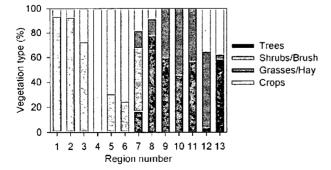


Figure 6. Percentages of vegetation types found in each region.

were determined. Recharge rates for each region (30 year, spatially weighted average) were plotted versus long-term (30 year) MAP, and equations were fit to the results for each of the four modeling scenarios (i.e., nonvegetated monolithic and texturally variable soil profiles and vegetated monolithic and texturally variable soil profiles). Power law equations were used because they resulted in higher correlation coefficients and lower residual standard deviations than linear or log linear equations. Finally, the power law equation representing the vegetated, texturally variable soils scenario was used to generate a continuous statewide recharge rate map based on the distribution of MAP. Although shown for the entire state, results should be applied only to outcrop areas of the porous media aquifers shown.

[17] Sensitivity of recharge to climate, vegetation, and soils was evaluated in the four different scenarios considered, isolating the impact of each of these parameters. Additional sensitivity analyses were conducted to evaluate variations in vegetation parameters, initial conditions, PET, and depth of soil profile. Vegetation parameters evaluated included percent bare area, leaf area index, root depth, and root length density. Each parameter was increased and decreased by 50 percent, with the exception of percent bare area, which is 0 for the base case and was increased to 25 and 50%, and profile depth, which was increased from 5 to 10 m in the sensitivity analysis. Sensitivity analyses were conducted using data from region 6.

3. Results and Discussion

[18] Simulation results are represented for the four basic scenarios to assess relative importance of climate, vegetation, and soils in controlling recharge. Final mass balance errors were <5% of final recharge rates and <0.5 mm/yr.

3.1. Nonvegetated, Monolithic Sand Simulations

[19] Simulated mean (30 year) annual recharge for bare sand is high and ranges from 51 mm/yr in the arid west to 709 mm/yr in the more humid east, representing 23 (arid) to

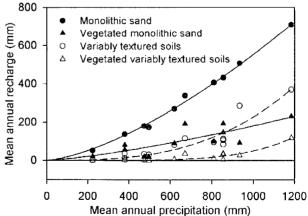


Figure 7. Relationships between long-term (30 year) MAP and simulated mean annual areally weighted recharge. Power law equations were fit to the results for monolithic sand profiles (solid lines) and variably textured soil profiles (dashed lines).

 Table 3. Power Law Equation Coefficients and Residual Statistics for Estimating Long-Term (30 Year) Mean Annual Recharge From Precipitation^a

x	Coefficien	ts		Res	idual
Modeling Scenario	а	b	r^2	σ	$ v_r $
Nonvegetated, monolithic sand	1.956×10^{-02}	1.484	0.996	8.5	8.5
Vegetated. monolithic sand	6.131×10^{-07}	2.855	0.854	28.6	28.4
Nonvegetated, lavered soil profiles	1.661×10^{-02}	1.345	0.624	28.2	34.3
Vegetated, layered soil profiles	3.242×10^{-09}	3.407	0.805	9.2	10.2

^aRecharge rates estimated from the power law equation for vegetated, texturally variable soils are shown in Figure 10. The power law model is $y = a_x^{a_y}$, where y is mean annual recharge (mm/yr) and x is precipitation (mm/yr). Here r^2 , coefficient of determination; σ , standard deviation; $|y_r|$, average absolute deviation.

60% (humid) of MAP (Table 2). Variations in mean annual recharge can be explained entirely by variations in MAP, using the power law relationship. Recharge increases with precipitation ($r^2 = 1.0$; Figure 7 and Tables 2 and 3). These recharge estimates provide an upper bound on actual recharge rates because vegetation and soil textural variability were not included. In addition, simulated runoff from the I-D model is zero, whereas runoff estimates based on a statewide water balance range from 0 mm/yr in the west to 415 mm/yr in the east [*Reed et al.*, 1997]. Lack of simulated runoff was attributed to the high saturated hydraulic conductivity of the sand (0.24 m/hr) relative to the prespecified precipitation intensity (0.01 m/hr).

[20] Temporal variability in mean annual recharge is similar throughout the state (CV: 0.16–0.24) and is less than that of precipitation (Table 2). Lower correlations between mean annual recharge and summer precipitation ($r^2 = 0.66$) relative to precipitation during the other seasons ($r^2 = 0.83-0.96$ for spring, fall, and winter) were attributed to higher evaporation during summer (Figures 2 and 8). Potential ET is much greater than simulated actual E; the PET/AE ratio decreased from 12.1 in the west (region 1) to 2.9 in the east (region 13) (Table 2). In arid regions most infiltrated water is returned to the atmosphere through evaporation, as shown by the tracking of precipitation and evaporation in region 1 (Figure 9). The high correlation $(r^2 = 0.83)$ between evaporation and precipitation in this region may be attributed to evaporation rarely being energy limited (high PET). Annual recharge is not directly correlated with annual precipitation $(r^2 = 0.03)$ because there is a lag between elevated precipitation and precipitation are not as highly correlated $(r^2 = 0.66, region 13)$, which may be related to energy limitations on ET (lower PET). There is little lag between high precipitation and recharge, as shown by the strong correlation between annual precipitation and recharge $(r^2 = 0.90, region 13)$.

3.2. Nonvegetated, Texturally Variable Soil Simulations

[21] Simulated mean (30 year) annual, areally averaged recharge ranges from 16 mm/yr in the north to 230 mm/yr in the southeast for texturally variable soil profiles, representing 3 to 29% of MAP (Figure 7 and Table 2). These recharge rates are 2 to 11 times lower than those based on monolithic sand profiles, indicating the importance of soil textural variability in controlling recharge. The lower recharge rates may reflect finer textured soils, or they may be related to reductions in recharge caused by profile layering, both fine over coarse (capillary barrier effect) and coarse over fine layering. Reductions in recharge in the texturally variable soil simulations correspond to increased runoff, evaporation, or both. Approximately 60% of the variation in recharge can be explained by variations in precipitation using the power law relationship $(r^2 = 0.62, Table 3)$. Multiple linear regression using log-log data shows that including clay content (profile average) with precipitation explains 80% of the variation in recharge. Recharge varies over 1 to 2 orders of magnitude locally. within each region, because of textural variability among soil profiles.

[22] Variations in simulated mean (30 year) annual runoff generally reflect differences in climate and texture among

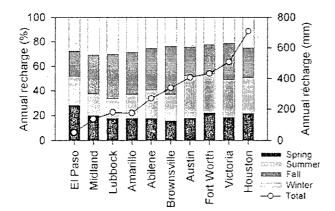


Figure 8. Seasonal distribution of simulated recharge for monolithic sand at each of the meteorological station locations.

C. Barris

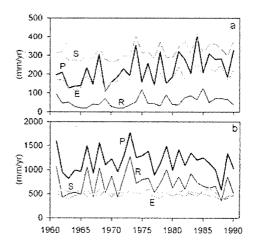


Figure 9. Mean annual water budget parameters for nonvegetated, monolithic sand simulations at (a) region 1 and (b) region 13. P, precipitation; E, evaporation; R, recharge; S, storage.

7 of 12

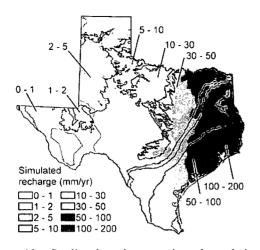


Figure 10. Predicted recharge using the relationship between precipitation and simulated recharge for vegetated, texturally variable soils.

regions. Simulated runoff is positively correlated with mean clay content ($r^2 = 0.57$) and negatively correlated with mean sand content ($r^2 = -0.49$). Sandy areas, particularly regions 1, 2, 3, and 7, have low runoff and generally correspond to areas of low or moderate precipitation. Most regions with clay-rich soils have higher runoff and generally overlie finegrained geologic units. Simulated recharge rates in clay-rich soils may not accurately reflect actual recharge rates if preferential flow occurs in these settings because this process is not included in the simulations.

3.3. Vegetated, Monolithic Sand Simulations

[23] To assess the impact of vegetation without the influence of soil textural variability, simulations of recharge were conducted in vegetated, monolithic sands (Table 2). Vegetation markedly reduces simulated mean annual recharge (2-369 mm/yr; 1-31% of MAP) by factors of 2 to 30 relative to recharge for nonvegetated simulations. MAP explains 85% of the variance in simulated recharge using the power law relationship (Table 3 and Figure 7). Simulated runoff was 0 for nonvegetated and vegetated simulations. Vegetation type also affects simulated recharge, as seen in the 1 to 2 orders of magnitude range in simulated recharge for different vegetation types within a study region. In general, lower recharge rates in areas with trees relative to grasses can be attributed to greater rooting depth of trees (\leq 4.3 m) relative to grasses (1 m). Shrubs are generally more effective than crops in reducing recharge because of greater rooting depth and longer growing season. Crops also differ in their recharge rates: e.g., factor of 4 lower recharge beneath cotton (maximum rooting depth 2.1 m) relative to sorghum (maximum rooting depth 1.5 m), in region 4.

3.4. Vegetated, Texturally Variable Soil Simulations

[24] Texturally variable soils with vegetation are the most realistic representation of actual conditions and should provide the most reliable recharge estimates for the different regions. Simulated mean (30 year) annual, areally averaged recharge is lowest in the arid west (0.2 mm/yr) and highest in the humid east (118 mm/yr), representing 0.1 to 10% of MAP (Figure 7 and Table 2). Variability of MAP explains 80% of the variability in recharge among regions using the power law relationship ($r^2 = 0.81$, Table 3). The correlation between recharge and precipitation was used to map recharge throughout the entire study area (Figure 10).

[25] Vegetation markedly reduced recharge relative to that for nonvegetated, texturally variable soils. Reduction factors were greater in more arid regions in the west (7-78) relative to more humid regions in the east (2-31) and reflect the enhanced ability of vegetation to reduce recharge in more water-limited regions (Table 2). Local variability in simulated recharge within regions was generally within an order of magnitude and reflects variability due to differences in vegetation and soil texture.

[26] Simulated mean (30 year) annual runoff and runoff estimates based on measured stream gauge data (1961-1990) used to develop a statewide water balance [Reed et al., 1997] are generally consistent in many regions considering that the 1-D modeling approach does not account for subsurface lateral flow and routing (Table 4). Discrepancies between the two estimates in other regions cannot readily be explained, with the exception of regions 4 and 5 in the Southern High Plains, where overestimation of runoff may be attributed to predominantly internal drainage to ephemeral lakes or playas and little runoff to gauged stream networks. Runoff is one of the most difficult parameters to simulate because it depends on accurate representation of rainfall intensity and hydraulic conductivity of surficial sediments that may be crusted, as shown by detailed comparisons of simulated and measured runoff at a controlled field experiment [Scanlon et al., 2002a].

[27] Relative controls of different vegetation types in vegetated, texturally variable soil simulations are similar to those for vegetated monolithic sands: lower recharge in deep-rooted trees relative to shallow-rooted grasses, shrubs relative to crops, and cotton relative to sorghum. For example, in region 9, simulated recharge beneath trees is 0, whereas simulated recharge beneath grasses ranges from 1 to 156 mm/yr for different soils. Relative amounts of evaporation and transpiration vary with vegetation type and soil texture. Transpiration is much greater than evaporation for trees, irrespective of texture. Evaporation is higher than transpiration in finer textured soils than in coarser textured soils, irrespective of vegetation type, which is attributed to

Table 4. Comparison of Simulated Runoff (RO_{sim}) With Spatially Averaged Runoff Estimates (RO_{est}) Determined From *Reed et al.* 1997 for Each Region^a

	5		
Region	RO _{sim}	RO _{est}	RO _{est} SD
1	0	4	5
2	14	0	4
3	4	0	1
4	85	6	1
5	186	3	8
6	179	15	4
7	27	3	7
8	180	118	37
9	99	55	41
10	59	268	53
11	25	232	22
12	387	148	26
13	314	328	22

^aUnits are in mm/yr. SD, standard deviation.

Table 5. Sensitivity of Recharge to Variations in Leaf Area IndexLAI that(LAI), Root Depth (RD), Bare Area (% BA), Initial Conditionsdoubles

(LAI), Root Depth (RD), Bare Area (% BA), Initial Conditions (IC), Potential Evapotranspiration (PET), and Profile Depth (PD) for Four Soil Profiles in Region 6^{a}

		Eff	iect
	BC R	R	F
LAI variable			
50% LAI	0.7	1.3	1.8
50% LAI	3.2	7.2	2.2
50% LAI	15.6	27.6	1.8
50% LAI	23.5	38.0	1.6
150% LAI	0.7	0.6	. 0.8
150% LAI	3.2	2.4	0.7
150% LAI	15.6	12.1	0.8
150% LAI	23.5	18.8	0.8
RD constant			
50% RD	0.7	3.7	5.1
50% RD	3.2	14.8	4.6
50% RD	15.6	27.7	1.8
50% RD	23.5	43.2	1.8
150% RD	0.7	0.1	0.2
150% RD	3.2	0.7	0.2
150% RD	15.6	6.2	. 0.4
150% RD	23.5	11.5	0.5
Percent BA constant			
25% BA	0.7	1.2	1.6
25% BA	3.2	6.1	1.9
25% BA	15.6	25.0	1.6
25% BA	23.5	35.1	1.5
50% BA	0.7	5.9	8.1
50% BA	3.2	21.7	6.7
50% BA	15.6	47.3	3.0
50% BA	23.5	59.3	2.5
PET variable			
50% PET	0.7	27.9	38.2
50% PET	3.2	47.4	14.6
50% PET	15.6	77.6	5.0
50% PET	23.5	88.4	3.8
150% PET	0.7	0.3	0.4
150% PET	3.2	0.3	0.1
150% PET	15.6	4.5	0.3
150% PET	23.5	7.9	0.3
PD constant			
10 m PD	0.7	0.9	1.2
10 m PD	3.2	3.3	1.0
10 m PD	15.6	13.5	0.9
10 m PD	23.5	22.0	0.9

^aIn order of fine-coarse grained soil profiles. Factor (F) refers to the ratio of 30 year mean annual recharge (R), including the effect (e.g., $LAI \times 50\%$) to the base case (BCR) recharge rate. Variable/constant indicates that a parameter changes or is held constant with time during the simulated period. Units are in mm/yr.

finer textured soils retaining more water near the soil surface longer, allowing greater evaporation.

3.5. Sensitivity Analyses

[28] Sensitivity analyses were conducted for region 6 because it represents average climate and soil conditions in the study area. Sensitivity of simulated recharge to different vegetation parameters is variable (Table 5). Increasing percent bare area from 0 to 50% increases recharge up to a factor of 8. Simulated recharge is inversely related to root depth because decreasing root depth allows water to drain more readily below the root zone. Decreasing root depth increases recharge by factors of 2 to 5, whereas increasing root depth decreases recharge by factors of 0.2 to 0.5. Simulated recharge is more sensitive to decreasing

LAI than increasing LAI. Decreasing LAI by 50% almost doubles recharge, while increasing LAI by 50% decreases recharge by 20%. Models were insensitive to variations in root-length density. Decreasing PET increases recharge by factors ranging from 4 in coarse-grained soils to 38 in finegrained soils and was balanced by a reduction in ET, whereas increasing PET had the opposite effect.

[29] It is important to assess sensitivity of model output to variations in initial conditions, profile depth, and equilibration times to assess reliability of simulated recharge. The model is insensitive to variations in initial conditions. Increasing profile depth from 5 to 10 m decreases recharge in coarse-grained soils by a factor of 0.9 and increases recharge by a factor of 1.2 in fine-grained soil, which may be an artifact of drainage of initial water in the profile. Model equilibration times are greater for more arid settings and more clay-rich soils. Therefore final recharge estimates in these settings may represent an upper bound on actual recharge rates.

3.6. Comparison of Simulated Recharge Estimates With Those Based on Other Techniques

[30] Simulated recharge rates from this study were compared with those based on earlier studies (Table 6). Previous field and modeling investigations in the Chihuahuan Desert in west Texas indicate that there is no recharge in interdrainage settings [*Scanlon et al.*, 1999], which is generally consistent with the low (0.2 mm/yr) simulated recharge in this study (Table 2). Bulge-shaped chloride profiles and upward matric potential gradients indicate that this system has been drying out for the last 10,000 to 15,000 years since the Pleistocene [*Scanlon et al.*, 2003a].

[31] In the Southern High Plains, it is difficult to compare simulated recharge rates from this study, which represent diffuse recharge in interdrainage settings, with previous recharge estimates from groundwater data because most recharge in this region is focused beneath playas. Therefore simulated recharge at regions in the Southern High Plains (4 and 5) (0.4–0.8 mm/yr) is less than recharge estimates based on the chloride mass balance (CMB) approach applied to groundwater (11 mm/yr [*Wood and Sanford*, 1995]), as expected. Field studies indicate that there is no recharge in natural ecosystems in interplaya settings, as shown by chloride bulges and upward matric potential gradients [*Wood and Sanford*, 1995; *Scanlon and*]

Table 6. Comparison of Simulated Recharge Estimates (R_{sim}) With Recharge Estimated Using Other Techniques $(R_{est})^{a}$

Region	<i>R_{sim}</i> , mm/yr	R_{est} . mm/yr	Method	Source ^b	
1	0.2	0	WP; UZ CMB	1	
4,5	0.4 - 0.8	11 .	GW CMB	2	
3, 4	0.8 - 1.5	4-28	UZ CMB	3	
6	5.6	5-30	UZ CMB	3	
8	10.1	5 - 20	UZ/GW CMB	4	
11	35.1	43-71	GW CMB	5	

^aEstimation methods include: WP, water potential; UZ CMB, unsaturated zone chloride mass balance approach; GW CMB, groundwater chloride mass balance approach.

^bSources are as follows: 1, *Scanlon et al.* [1999]; 2, *Wood and Sanford* [1995]; 3, *Scanlon et al.* [2003]; 5, R. C. Reedy (Burcau of Economic Geology, University of Texas at Austin, unpublished data, 2002).

W06010

cultivated regions and may underestimate actual recharge because the effect of cultivation on hydraulic properties of surficial sediments was not included in the simulations. [32] Simulated recharge in region 6 (5.6 mm/yr) is within

[32] Simulated recharge in region 6 (5.6 mil/yr) is within the lower range of field-based estimates, using the CMB approach applied to the unsaturated zone (UZ) in natural and nonirrigated cultivated regions (5-30 mm/yr) [*Scanlon et al.*, 2003b]. Higher values from the field studies may be attributed to restriction of field regions to a large sand dune setting, whereas the spatially averaged value from this modeling study also includes finer grained soils found in other regions.

[33] Simulated recharge at region 8 (10.1 mm/yr) is within the range of field-based recharge estimates based on the chloride mass balance (CMB) approach applied to the unsaturated zone and groundwater (5–20 mm/yr [*Dutton et al.*, 2003]). Recharge estimates based on the CMB approach applied to groundwater for region 11 range from 43 to 71 mm/yr and are slightly higher than that simulated (35.1 mm/yr). The discrepancy may be attributed to bias toward high-permeability units in field-based estimates.

[34] Although the number of comparisons between simulated and field-based recharge estimates is limited, simulated recharge rates in this study are generally consistent with those based on previous field studies, and discrepancies can generally be explained by inclusion or exclusion of different types of recharge (e.g., focused versus diffuse recharge in the Southern High Plains) and concentrating on different zones (e.g., high-permeability versus lowpermeability units).

3.7. Recommendations for Future Studies

[35] This study represents a relatively simple approach to estimating recharge using a 1-D unsaturated flow model and data found online and in the literature. Future simulations should consider using actual precipitation intensity where data are available and develop input to simulate recharge in irrigated regions. The most fundamental conceptual aspect of unsaturated flow modeling that should be addressed is simulation of vegetation dynamics. Current simulations prescribe vegetation input that precludes vegetation response to variability in soil moisture and precipitation. Two-way coupling between vegetation growth and soil moisture variability related to climate should provide more realistic simulations of recharge, particularly in semiarid-arid regions. In addition, representation of the continuum of roots and various rooting depths associated with vegetation communities is essential for reliable recharge estimation.

3.8. Implications for Water Resources

[36] Reliable recharge estimates are critical for evaluation of and optimal management of water resources. Long-term average recharge rates are beneficial to groundwater managers because management plans are developed generally for decadal timescales. The relationship between precipitation and recharge developed in this study for vegetated, texturally variable soils was used to map spatial variability of recharge for the groundwater model of the Carrizo-Wilcox aquifer in Texas [*Kelley et al.*, 2004]. Scaling factors were developed for the groundwater model that varied these recharge rates with topography and subsurface geology with high recharge in upland areas and above more permeable geologic units, similar to the B value discussed by *Hatton* [1998].

[37] Understanding of climatic and vegetation controls on groundwater recharge shown by simulations in this study can be used to assess potential impacts of climate variability and land use/land cover change on groundwater availability by using space as a proxy for time. The effect of vegetation types on simulated recharge can be used to provide preliminary estimates of potential impacts of removing invasive woody species in many areas of Texas. The state is currently investing millions of dollars in this program to increase water availability [*Wilcox*, 2002].

4. Conclusions

[38] 1. Unsaturated zone modeling using online data is a useful approach for simulating diffuse recharge in porous media systems from point to regional scales where input data are available.

[39] 2. Climate, vegetation, and soils each exert controls on groundwater recharge. (1) High simulated long-term (30 year) mean annual recharge (51-709 mm/yr) in nonvegetated sandy profiles represents 23 to 60% (aridhumid) of MAP and provides an upper bound on actual recharge. (2) Soil textural variability controls recharge, as shown by the large reduction by factors of 2 to 11 in simulated recharge for nonvegetated, texturally variable soils relative to those in monolithic sands. (3) Presence and type of vegetation control recharge, as shown by the reduction in recharge in vegetated relative to that in nonvegetated monolithic sand (factors of 2-30, humid-arid) and vegetated relative to that in nonvegetated, texturally variable soil (factors of 2-80, humid-arid). Relative reductions in recharge due to vegetation were greater in semiarid-arid relative to more humid regions and reflect the enhanced ability of vegetation to reduce recharge in more water-limited regions.

[40] 3. The most realistic long-term (30 year) recharge estimates based on vegetated, texturally variable soils range from 0.2 to 118 mm/yr, representing 0.1 to 10% (arid-humid) of long-term MAP.

[41] 4. Approximately 80% of the variability in simulated recharge can be explained by variability in MAP in vegetated, layered soil profiles using the power law relationship. MAP can be used as a predictor of mean annual recharge.

[42] 5. Simulated long-term, spatially averaged recharge rates generally compare favorably with recharge estimates based on previous field studies.

[43] 6. Simulated long-term (30 year), spatially averaged runoff is generally within the range of estimates based on gauge data in statewide water balance modeling for most regions. Discrepancies in the Southern High Plains can be explained by internal drainage to playas.

[44] 7. Unsaturated zone modeling provides a valuable tool for isolating controls on groundwater recharge. Understanding these controls can be used to assess potential impacts of climate variability and land use/land cover change on groundwater recharge.

[45] Acknowledgments. The authors would like to acknowledge the funding for this study provided by the Environmental Protection Agency through the Texas Commission for Environmental Quality. Additional funding was also provided to Kelley Keese through the Jackson School of Geosciences and the Geology Foundation. Mike Fayer provided valuable insights on UNSAT-H simulations and water balance modeling. The authors greatly appreciate extremely helpful and thorough reviews provided by Seann Reed, Marcel Schaap, Lu Zhang, and two anonymous reviewers.

References

- Allison, G. B., P. G. Cook, S. R. Barnett, G. R. Walker, I. D. Jolly, and M. W. Hughes (1990), Land clearance and river salinisation in the western Murray Basin, Australia. J. Hydrol., 119, 1-20.
- Bonan, G. B. (1997), Effects of land use on the climate of the United States, *Clim. Change*, 37, 449-486.
- Braud, I., A. C. Dantas-Antonino, M. Vauclin, J. L. Thony, and P. Ruelle (1995), A simple soil-plant-atmosphere transfer model (SiSPAT) development and field verification, J. Hydrol., 166, 213–250.
- Canadell, J., R. B. Jackson, J. R. Ehleringer, H. A. Mooney, O. E. Sala, and E.-D. Schulze (1996), Maximum rooting depth of vegetation types at the global scale, *Oecologia*, 108, 583–595.
- Cook, P. G., and S. Kilty (1992), A helicopter-borne electromagnetic survey to delineate groundwater recharge rates, *Water Resour. Res.*, 28, 2953– 2961.
- Cotton, W. R., et al. (2003), RAMS 2001: Current status and future directions, *Meteorol. Atmos. Phys.*, 82, 5-29.
- Dai, Y. X., et al. (2003), The Common Land Model (CLM), Bull. Am. Meteorol. Soc., 84, 1013–1023.
- Dawes, W. R., and T. J. Hatton (1993), TOPOG_IRM, 1, model description, *Tech. Memo. 93/5*, Div. of Water Resour., Commonw. Sci. and Ind. Res. Organ., Canberra.
- Dawes, W. R., L. Zhang, T. J. Hatton, P. H. Reece, G. T. H. Beale, and I. Packer (1997), Application of a distributed parameter ecohydrological model (TOPOG_IRM) to a small cropping rotation catchment, *J. Hydrol.*, 191, 67–89.
- Dawes, W. R., M. Gilfedder, M. Stauffacher, J. Coram, S. Hajkowicz, G. R. Walker, and M. H. Young (2002), Assessing the viability of recharge reduction for dryland salinity control: Wanilla, Eyre Peninsula, Aust. J. Soil Res., 40, 1407–1424.
- Dennehy, K. F., B. W. Bruce, and C. A. McMahon (2005), Evaluation of recharge beneath irrigated and natural settings in the Southern High Plains, U.S. Geol. Sum: Water Resour. Invest. Rep., in press.
- Doorenbos, J., and W. O. Pruitt (1977), Guidelines for Predicting Crop Water Requirements, Irrig. Drain. Pap. 24, 2nd ed., 144 pp., Food and Agric. Organ., Rome.
- Dugas, W. A., R. A. Hicks, and P. Wright (1998), Effect of removal of *Juniperus ashei* on evapotranspiration and runoff in the Seco Creek watershed, *Water Resour. Res.*, 34, 1499–1506.
- Dutton, A. R., B. Harden, J. P. Nicot, and D. O'Rourke (2003), Groundwater availability model for the central part of the Carrizo-Wilcox aquifer in Texas, contract report, Tex. Water Dev. Board, Austin.
- Fayer, M. J. (2000), UNSAT-H version 3.0: Unsaturated soil water and heat flow model, theory, user manual, and examples, *Rep. PNNL-13249*, Pac. Northwest Natl. Lab., Richland, Wash.
- Fayer, M. J., G. W. Gee, M. L. Rockhold, M. D. Freshley, and T. B. Walters (1996), Estimating recharge rates for a groundwater model using a GIS, *J. Environ. Qual.*, 25, 510–518.
- Feddes, R. A., P. J. Kowalik, and H. Zaradny (1978), Simulation of Field Water Use and Crop Yield, 189 pp., PUDOC, Wageningen, Netherlands.
- Gee, G. W., P. J. Wierenga, B. J. Andraski, M. H. Young, M. J. Fayer, and M. L. Rockhold (1994), Variations in water balance and recharge potential at three western desert sites. *Soil Sci. Soc. Am. J.*, 58, 63-71.
- Hanson, C. L., K. A. Cumming, D. A. Woolhiser, and C. W. Richardson (1994). Microcomputer program for daily weather simulation, *Publ. ARS-114*, 38 pp., Agric. Res. Serv., U.S. Dep. of Agric., Washington, D. C.
- Hatton, T. J. (1998), The Basics of Recharge and Discharge, part 4, Catchment Scale Recharge Modeling, Commonw. Sci. and Ind. Res. Organ., Collingwood, Victoria, Australia.
- Hevesi, J. A., A. L. Flint, and L. E. Flint (2002), Preliminary estimates of spatially distributed net infiltration and recharge for the Death Valley

Region, Nevada-California, U.S. Geol. Surv. Water Resour. Invest. Rep., 02-4010, 36 pp.

- Kearns, A. K., and J. M. H. Hendrickx (1998), Temporal variability of diffuse groundwater recharge in New Mexico, *Tech. Rep. No.* 309, 43 pp., N.M. Water Resour. Res. Inst., Soccoro.
- Kelley, V., N. Deeds, and J. P. Nicot (2004), Groundwater availability model of the Queen City Sparta Aquifer, contract report, Tex. Water Dev. Board, Austin.
- Kennett-Smith, A., P. G. Cook, and G. R. Walker (1994), Factors affecting groundwater recharge following clearing in the south western Murray Basin, J. Hydrol., 154, 85–105.
- Leij, F. J., W. J. Alves, M. T. van Genuchten, and J. R. Williams (1996), The UNSODA unsaturated soil hydraulic database, user's manual, version 1.0, *Rep. EPA/600/R-96/095*, Natl. Risk Manage. Lab., U.S. Environ. Prot. Agency, Cincinnati, Ohio.
- Lerner, D. N., A. S. Issar, and I. Simmers (1990), Groundwater Recharge, Intl. Assoc. of Hydrogeol., Kenilworth, U. K.
- Lewis, M. F., and G. R. Walker (2002). Assessing the potential for episodic recharge in south-western Australia using rainfall data, *Hydrogeol. J.*, 10, 229–237.
- McMahon, C. A., R. G. Frye, and K. L. Brown (1984), The vegetation types of Texas including cropland, *Bull. 7000-120*, 40 pp., Texas Parks and Wildlife Dep., Austin.
- Myneni, R. B., R. R. Nemani, and S. W. Running (1997), Estimation of global leaf area index and absorbed PAR using radiative transfer models, *IEEE Trans. Geosci. Remote Sens.*, 35, 1380-1393.
- Petheram, C., L. Zhang, G. R. Walker, and R. Grayson (2002), Towards a framework for predicting impacts of land-use on recharge: 1. A review of recharge studies in Australia, *Aust. J. Soil Res.*, 40, 397–417.
- Pielke, R. A. S., R. Avissar, M. Raupach, A. J. Dolman, X. Zeng, and A. S. Denning (1998). Interactions between the atmosphere and terrestrial ecosystems: Influence on weather and climate, *Global Change Biol.*, 4, 461–475.
- Prych, E. A. (1998), Using chloride and chlorine-36 as soil-water tracers to estimate deep percolation at selected locations on the U.S. Department of Energy Hanford Site, Washington, U.S. Geol. Surv. Water Supply Pap., 2481, 67 pp.
- Reed, S. M., D. R. Maidment, and J. Patoux (1997), Spatial water balance of Texas, *Tech. Rep. 97-1*, Cent. for Res. in Water Resour., Univ. of Tex. at Austin, Austin.
- Richardson, C. W. (2000), Data requirements for estimation of weather generation parameters, *Trans. ASAE*, 43, 877–882.
- Ritchie, J. T., and E. Burnett (1971), Dryland evaporative flux in a subhumid climate 2. Plant influences, Agron. J., 63, 56-62.
- Robins, N. S. (1998), Groundwater Pollution, Aquifer Recharge and Vulnerability, Geol. Soc. Spec., 130.
- Rockhold, M. L., M. J. Fayer, C. T. Kincaid, and G. W. Gee (1995), Estimation of natural ground water recharge for the performance assessment of a low-level waste disposal facility at the Hanford site, *Rep. PNL-10508*. Pac. Northwest Natl. Lab., Richland, Wash.
- Sanford, W. (2002), Recharge and groundwater models: An overview, *Hydrogeol. J.*, 10, 110-120.
- Scanlon, B. R., and R. S. Goldsmith (1997), Field study of spatial variability in unsaturated flow beneath and adjacent to playas, *Water Resour*. *Res.*, 33, 2239–2252.
- Scanlon, B. R., and P. C. D. Milly (1994), Water and heat fluxes in desert soils: 2. Numerical simulations, *Water Resour. Res.*, 30, 721-733.
- Scanlon, B. R., R. P. Langford, and R. S. Goldsmith (1999), Relationship between geomorphic settings and unsaturated flow in an arid setting, *Water Resour. Res.*, 35, 983–999.
- Scanlon, B. R., M. Christman, R. C. Reedy, I. Porro, J. Simunek, and G. Flerchinger (2002a), Intercode comparisons for simulating water balance of surficial sediments in semiarid regions, *Water Resour. Res.*, 38(12), 1323, doi:10.1029/2001WR001233.
- Scanlon, B. R., R. W. Healy, and P. G. Cook (2002b), Choosing appropriate techniques for quantifying groundwater recharge, *Hydrogcol. J.*, 10, 18– 39.
- Scanlon, B. R., K. Keese, R. C. Reedy, J. Simunck, and B. J. Andraski (2003a), Variations in flow and transport in thick desert vadose zones in response to paleoclimatic forcing (0–90 kyr): Field measurements, modeling, and uncertainties, *Water Resour. Res.*, 39(7), 1179, doi:10.1029/2002WR001604.
- Scanlon, B. R., R. C. Reedy, and K. E. Keese (2003b). Estimation of groundwater recharge in Texas related to aquifer vulnerability to contamination, report, Tex. Comm. on Environ. Qual., Austin.

- Schaap, M. G., F. J. Leij, and M. T. van Genuchten (2001), ROSETTA: A computer program for estimating soil hydraulic parameters with hierarchical pedotransfer functions, J. Hydrol., 251, 163-176.
- Scott, R. L., W. J. Shuttleworth, T. O. Keefer, and A. W. Warrick (2000), Modeling multiyear observations of soil moisture recharge in the semiarid American Southwest, *Water Resour. Res.*, 36, 2233–2247.
- Sophocleous, M. (1992). Groundwater recharge estimation and regionalization: The Great Bend Prairie of central Kansas and its recharge statistics, *J. Hydrol.*, 137, 113–140.
- United Nations Environment Programme (1992), World Atlas of Desertification, Edward Arnold, London.
- U.S. Department of Agriculture (USDA) (1994), State soil geographic (STATSGO) Data Base, *Misc. Publ. 1492*, Nat. Resour. Conserv. Serv., Washington, D. C.
- U.S. Department of Agriculture (USDA) (1995), Soil Survey Geographic Data Base, SSURGO, *Misc. Publ. 1527*, Nat. Resour. Conserv. Serv., Washington, D. C.
- Vogelmann, J. E., S. M. Howard, L. Yang, C. R. Larson, B. K. Wylie, and N. van Driel (2001), Completion of the 1990s National Land Cover Data set for the conterminous United States from Landsat Thematic Mapper

data and ancillary data sources, *Photogramm. Eng. Remote Sens.*, 67, 650-662.

- Wilcox, B. P. (2002), Shrub control and streamflow on rangelands: A process based viewpoint. J. Range Manage., 55, 318–326.
- Wood, W. W., and W. E. Sanford (1995), Chemical and isotopic methods for quantifying ground-water recharge in a regional, semiarid environment, *Ground Water*, 33, 458–468.
- Zhang, L., W. R. Dawes, and T. J. Hatton (1996), Modeling hydrologic processes using a biophysically based model—Application of WAVES to FIFE and HAPEX-MOBILHY, *J. Hydrol.*, *185*, 147–169.
- Zhang, L., W. R. Dawes, T. J. Hatton, P. H. Reece, G. T. H. Beale, and I. Packer (1999), Estimation of soil moisture and groundwater recharge using the TOPOG_IRM model, *Water Resour: Res.*, 35, 149-161.

K. E. Keese, R. C. Reedy, and B. R. Scanlon, Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin, Austin, TX 78713-8924, USA. (keese@mail.utexas.edu)

Appendix D Laboratory Analyses

ļ

ĺ

Ŵ

Ì

COLUMN





Analytical Report

Prepared for:

Kristin Farris-Pope Rice Operating Co. 122 W. Taylor Hobbs, NM 88240

Project: BD Zachary Hinton Project Number: None Given Location: Lea County

Lab Order Number: 6A25021

Report Date: 02/01/06

Rice Operating Co.Project:BD Zachary HintonFax: (505) 397-1473122 W. TaylorProject Number:None GivenReported:Hobbs NM, 88240Project Manager:Kristin Farris-Pope02/01/06 11:42

ANALYTICAL REPORT FOR SAMPLES

Sample 1D	Laboratory ID	Matrix	Date Sampled	Date Received
Monitor Well #1	6A25021-01	Water	01/23/06 09:45	01/25/06 13:25

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

and and

気影像

2. 370.45

States -

1 . W.W.

1. Same

3 . S. B. B. S.

1. " "et y

10.20

PAR W

Jack 19

1 y 20. 00 -

1. S. N.

Acres in

10 St. 450

Same and

and and

D i Al I None Civen	
Project Number: None Given	Reported:
Project Manager: Kristin Farris-Pope	02/01/06 11:42
ŀ	Project Manager: Kristin Farris-Pope

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (6A25021-01) Water									
Benzene	ND	0.00100	mg/L	ł	EA62618	01/26/06	01/27/06	EPA 8021B	
Toluene	ND	· 0.00100		"		"	"	n	
Ethylbenzene	ND	0.00100	**	"		"	0	"	
Xylene (p/m)	ND	0.00100							
Xylene (o)	ND	0.00100		"					
Surrogate: a,a,a-Trifluorotoluene		95.2 %	80-12	0	"	"	"	"	
Surrogate: 4-Bromofluorobenzene		89.2 %	80-12	0	"	"	"	"	

Environmental Lab of Texas

a hard rate my

a series

Rectarded a

All and the second

·13. 君孟

A. 40 %

1. 2. 2. 2. 2.

Sec. 6.

12 13 21

\$. . 9 a. 2.

1. 8. W

a constant

State State

A. A.

Ric	ce Operating Co.	Project: BD Zachary Hinton	Fax: (505) 397-1471
12	2 W. Taylor	Project Number: None Given	Reported:
Ho	bbs NM, 88240	Project Manager: Kristin Farris-Pope	02/01/06 11:42

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 (6A25021-01) Water									
Total Alkalinity	172	2.00	mg/L	I	EA62406	01/26/06	01/26/06	EPA 310.1M	
Chloride	306	10.0		20	EA63004	01/30/06	01/30/06	EPA 300.0	
Total Dissolved Solids	1170	5.00		I	EA63003	01/26/06	01/27/06	EPA 160.1	
Sulfate	184	10.0		20	EA63004	01/30/06	01/30/06	EPA 300.0	

Environmental Lab of Texas

Aprile - African

19.14

approx.

ない 後

Star Party

L'EN

1. 84 A.

1 and a start

State of

2. 4 . V. 2

1 . S. 4

AN TA

Star of the

and the

Rice Operating Co.	Project: BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	Reported:
Hobbs NM, 88240	Project Manager: Kristin Farris-Pope	02/01/06 11:42

Total Metals by EPA / Standard Methods

Environmental Lab of Texas

Analyte Monitor Well #1 (6A25021-01) Water	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Calcium '	93.8	0.100	mg/L	10	EA62615	01/26/06	01/26/06	EPA 6010B	
Magnesium	44.4	0.0100	•		н	*	н		
Potassium	8.85	0.500				**	н	"	
Sodium	208	0,500	•	50	ъ	17	н	"	

0.132.61

の影響を思

100

S. Strategie

Contration and

1. 18 M. 1

1. a. a.

S. S. Same of

and the second

3.65 2 W. 24

Ser bus

0.0

" hands

「「「「「「」」」

語を見た

Alasta and

	Project Nu Project Mai rganics by	mber: No nager: Ki	istin Farris-Po	эре				Repo 02/01/06							
	Project Mai	nager: Ki	istin Farris-Po												
		GC - ()nality C-		Project Manager: Kristin Farris-Pope										
		JC - (Organics by GC - Quality Control												
	Environmental Lab of Texas														
	Reporting		Spike	Source		%REC	0.00	RPD							
Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes						
ND	0.00100	mg/L													
ND	0.00100														
ND	0.00100	и													
ND	0.00100	"													
	0.00100	"													
38.5		ug/l	40.0		96.2	80-120									
42.4		"	40.0		106	80-120									
			Prepared: 0	1/26/06 A	nalyzed: 01	/27/06									
0.0566	0.00100	mg/L	0.0500		113	80-120		`							
0.0557	0.00100		0.0500		111	80-120									
0.0547						80-120									
					102	80-120									
0.0538	0.00100	"	0.0500		108	80-120			_						
41.2		ug4	40,0		103	80-120									
32.8		n	40.0		82.0	80-120									
			Prepared: 0	1/26/06 A	nalyzed: 01	/28/06									
51.3		ug/i	50.0		103	80-120									
52.5		"	50.0		105	80-120									
54.5		•	50.0		109	80-120									
104		11	100		101	80-120									
55.6		и	50.0		111	80-120									
34.3		"	40.0		85.8	80-120									
39.5		"	40.0		98.8	80-120									
Source: 6A24010-01 Prepared: 01/26/06 Analyzed: 01/27/06															
0.0559	0.00100	mg/L	0.0500	ND	112	80-120									
0.0548	0.00100	••	0 0500	ND	110	80-120									
0.0515	0.00100	"	0.0500	ND	103	80-120									
0.0835	0.00100		0.100	ND	83.5	80-120									
0.0512	0.00100	n	0.0500	ND	102	80-120									
37.5		ug I	40.0		93.8	80-120									
	ND ND ND ND 38.5 42.4 0.0566 0.0557 0.0547 0.102 0.0538 41.2 32.8 51.3 52.5 54.5 101 55.6 34.3 39.5 Sou 0.0559 0.0548 0.0515 0.0835 0.0512	ND 0.00100 ND 0.00100 ND 0.00100 ND 0.00100 ND 0.00100 38.5 42.4 0.0556 0.00100 0.0557 0.00100 0.0557 0.00100 0.0557 0.00100 0.0538 0.00100 41.2 32.8 51.3 52.5 54.5 101 55.6 34.3 39.5 Source: 6A24010- 0.0515 0.00100 0.0515 0.00100 0.0515 0.00100 0.0515 0.00100 0.0512 0.00100	ND 0.00100 " 38.5 ug/l 42.4 " 0.0556 0.00100 mg/L 0.0557 0.00100 " 0.0547 0.00100 " 0.102 0.00100 " 0.102 0.00100 " 0.102 0.00100 " 51.3 ug/l 32.8 51.3 ug/l * 55.6 " * 39.5 " * Source: 6A24010-01 " 0.0515 0.00100 " 0.0548 0.00100 " 0.0515 0.00100 " 0.0515 0.00100 " 0.0512 0.00100 "	ND 0.00100 mg/L ND 0.00100 " 38.5 ug/l 40.0 42.4 " 40.0 12.4 " 40.0 Prepared: 0 0.0556 0.00100 mg/L 0.0557 0.00100 " 0.0500 0.0547 0.00100 " 0.0500 0.0538 0.00100 0.0500 0.0500 41.2 ug/l 40.0 32.8 " 40.0 100 55.6 50.0 51.3 ug/l 50.0 54.5 50.0 34.3 " 40.0 39.5 " 40.0 39.5 " 40.0 39.5 " 40.0 39.5 " 40.0 0.0500 0.0500 0.05559 0.00100 <td>ND 0.00100 mg/L ND 0.00100 " 38.5 ug/l 40.0 42.4 " 40.0 0.0556 0.00100 mg/L 0.0557 0.00100 " 0.0538 0.00100 " 0.0538 0.00100 " 0.0538 0.00100 " 41.2 ug/l 40.0 32.8 " 40.0 51.3 ug/l 50.0 41.2 ug/l 50.0 51.3 ug/l 50.0 51.3 ug/l 50.0 54.5 " 50.0 55.6 " 50.0 34.3 " 40.0 32.5 " 40.0 32.5 " 40.0</td> <td>ND 0.00100 mg/L ND 0.00100 " ND 0.00100 " ND 0.00100 " ND 0.00100 " 38.5 ug/l 40.0 96.2 42.4 " 40.0 106 Prepared: 01/26/06 Analyzed: 01 0.0566 0.00100 0.0500 113 0.0557 0.00100 0.0500 109 0.102 0.00100 0.0500 108 41.2 ug/l 40.0 102 0.0538 0.00100 0.0500 108 41.2 ug/l 40.0 82.0 Prepared: 01/26/06 Analyzed: 01 51.3 ug/l 50.0 103 52.5 " 50.0 103 54.5 " 50.0 101 55.6 " 50.0 111 34.3 " 40.0 85.8 39.5 " 40.0</td> <td>ND 0.00100 " ND 0.00100 " ND 0.00100 " 38.5 ug/l 40.0 96.2 80-120 42.4 " 40.0 10.6 80-120 Prepared: 01/26/06 Analyzed: 01/27/06 0.0566 0.00100 mg/L 0.0500 113 80-120 0.0557 0.00100 " 0.0500 111 80-120 0.0557 0.00100 " 0.0500 109 80-120 0.0538 0.00100 " 0.0500 108 80-120 0.0538 0.00100 " 0.0500 108 80-120 41.2 ug/l 40.0 103 80-120 32.8 " 40.0 103 80-120 51.3 ug/l 50.0 103 80-120 54.5 " 50.0 103 80-120 55.6 " 50.0 111 80-120<td>ND 0.00100 mg/L ND 0.00100 " 38.5 ng/l 40.0 96.2 \$\$M-120\$ 42.4 " 40.0 106 \$\$80-120\$ Prepared: 01/26/06 Analyzed: 01/27/06 0.0566 0.00100 mg/L 0.0500 113 \$\$0-120\$ 0.0557 0.00100 " 0.0500 109 \$\$0-120\$ 0.0547 0.00100 " 0.0500 108 \$\$0-120\$ 0.0538 0.00100 " 0.0500 108 \$\$0-120\$ 101 " 0.0 8\$0 120 32.8 " 40.0 A\$2.0 \$\$0-120\$ 52.5 " \$0.0 103 \$\$0-120\$ 101 " 100 101 \$\$0-120\$ 55.6</td><td>ND 0.00100 mg/L ND 0.00100 " ND 0.00100 " ND 0.00100 " ND 0.00100 " 38.5 ug/l 40.0 96.2 80-120 42.4 " 40.0 106 80-120 Prepared: 01/26/06 Analyzet: 01/27/06 0.0556 0.00100 mg/L 0.0500 113 80-120 0.0557 0.00100 " 0.0500 109 80-120 0.0547 0.00100 " 0.0500 108 80-120 0.0538 0.00100 " 0.0500 108 80-120 41.2 ug/t 40.0 103 80-120 32.8 " 40.0 103 80-120 52.5 " 50.0 103 80-120 52.5 " 50.0 103 80-120 55.6 " 50.0 111 80-120</td></td>	ND 0.00100 mg/L ND 0.00100 " 38.5 ug/l 40.0 42.4 " 40.0 0.0556 0.00100 mg/L 0.0557 0.00100 " 0.0538 0.00100 " 0.0538 0.00100 " 0.0538 0.00100 " 41.2 ug/l 40.0 32.8 " 40.0 51.3 ug/l 50.0 41.2 ug/l 50.0 51.3 ug/l 50.0 51.3 ug/l 50.0 54.5 " 50.0 55.6 " 50.0 34.3 " 40.0 32.5 " 40.0 32.5 " 40.0	ND 0.00100 mg/L ND 0.00100 " ND 0.00100 " ND 0.00100 " ND 0.00100 " 38.5 ug/l 40.0 96.2 42.4 " 40.0 106 Prepared: 01/26/06 Analyzed: 01 0.0566 0.00100 0.0500 113 0.0557 0.00100 0.0500 109 0.102 0.00100 0.0500 108 41.2 ug/l 40.0 102 0.0538 0.00100 0.0500 108 41.2 ug/l 40.0 82.0 Prepared: 01/26/06 Analyzed: 01 51.3 ug/l 50.0 103 52.5 " 50.0 103 54.5 " 50.0 101 55.6 " 50.0 111 34.3 " 40.0 85.8 39.5 " 40.0	ND 0.00100 " ND 0.00100 " ND 0.00100 " 38.5 ug/l 40.0 96.2 80-120 42.4 " 40.0 10.6 80-120 Prepared: 01/26/06 Analyzed: 01/27/06 0.0566 0.00100 mg/L 0.0500 113 80-120 0.0557 0.00100 " 0.0500 111 80-120 0.0557 0.00100 " 0.0500 109 80-120 0.0538 0.00100 " 0.0500 108 80-120 0.0538 0.00100 " 0.0500 108 80-120 41.2 ug/l 40.0 103 80-120 32.8 " 40.0 103 80-120 51.3 ug/l 50.0 103 80-120 54.5 " 50.0 103 80-120 55.6 " 50.0 111 80-120 <td>ND 0.00100 mg/L ND 0.00100 " 38.5 ng/l 40.0 96.2 \$\$M-120\$ 42.4 " 40.0 106 \$\$80-120\$ Prepared: 01/26/06 Analyzed: 01/27/06 0.0566 0.00100 mg/L 0.0500 113 \$\$0-120\$ 0.0557 0.00100 " 0.0500 109 \$\$0-120\$ 0.0547 0.00100 " 0.0500 108 \$\$0-120\$ 0.0538 0.00100 " 0.0500 108 \$\$0-120\$ 101 " 0.0 8\$0 120 32.8 " 40.0 A\$2.0 \$\$0-120\$ 52.5 " \$0.0 103 \$\$0-120\$ 101 " 100 101 \$\$0-120\$ 55.6</td> <td>ND 0.00100 mg/L ND 0.00100 " ND 0.00100 " ND 0.00100 " ND 0.00100 " 38.5 ug/l 40.0 96.2 80-120 42.4 " 40.0 106 80-120 Prepared: 01/26/06 Analyzet: 01/27/06 0.0556 0.00100 mg/L 0.0500 113 80-120 0.0557 0.00100 " 0.0500 109 80-120 0.0547 0.00100 " 0.0500 108 80-120 0.0538 0.00100 " 0.0500 108 80-120 41.2 ug/t 40.0 103 80-120 32.8 " 40.0 103 80-120 52.5 " 50.0 103 80-120 52.5 " 50.0 103 80-120 55.6 " 50.0 111 80-120</td>	ND 0.00100 mg/L ND 0.00100 " 38.5 ng/l 40.0 96.2 \$\$M-120\$ 42.4 " 40.0 106 \$\$80-120\$ Prepared: 01/26/06 Analyzed: 01/27/06 0.0566 0.00100 mg/L 0.0500 113 \$\$0-120\$ 0.0557 0.00100 " 0.0500 109 \$\$0-120\$ 0.0547 0.00100 " 0.0500 108 \$\$0-120\$ 0.0538 0.00100 " 0.0500 108 \$\$0-120\$ 101 " 0.0 8\$0 120 32.8 " 40.0 A\$2.0 \$\$0-120\$ 52.5 " \$0.0 103 \$\$0-120\$ 101 " 100 101 \$\$0-120\$ 55.6	ND 0.00100 mg/L ND 0.00100 " ND 0.00100 " ND 0.00100 " ND 0.00100 " 38.5 ug/l 40.0 96.2 80-120 42.4 " 40.0 106 80-120 Prepared: 01/26/06 Analyzet: 01/27/06 0.0556 0.00100 mg/L 0.0500 113 80-120 0.0557 0.00100 " 0.0500 109 80-120 0.0547 0.00100 " 0.0500 108 80-120 0.0538 0.00100 " 0.0500 108 80-120 41.2 ug/t 40.0 103 80-120 32.8 " 40.0 103 80-120 52.5 " 50.0 103 80-120 52.5 " 50.0 103 80-120 55.6 " 50.0 111 80-120						

San and

State State

Contraction of the

Salarian.

State State

14 Ball

Total and

STAR.

None of the second

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

.

Rice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number:	None Given	Reported:
Hobbs NM, 88240	Project Manager:	Kristin Farris-Pope	02/01/06 11:42

Organics by GC - Quality Control

Environmental Lab of Texas

		Reporting		Spike	Source		%REC		RPÐ	
Analyte	Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes

Batch EA62618 - EPA 5030C (GC)

Contraction of the

Sec. Sec.

いたのであ

調査

4. 4. A. F. F. F.

Section of

1.40%

12 Ber 1

A Carton

1. A. S. S.

ar annan

80. D

A MARINA

Sec. 1

art w

Matrix Spike Dup (EA62618-MSD1)	Sou	ree: 6A24010-	01	Prepared: 0	1/26/06 A	1/28/06			
Benzene	0.0482	0.00100	mg/L	0.0500	ND	96.4	80-120	15.0	20
Tolnene	0.0484	0.00100		0.0500	ND	96.8	80-120	12.8	20
Ethylbenzene	0.0456	0.00100	4	0.0500	ND	91.2	80-120	12.2	20
Xylene (p/m)	0.0841	0.00100	"	0.100	ND	84.1	80-120	0,716	20
Xylene (0)	0.0448	0.00100	н	0.0500	NÐ	89.6	80-120	12.9	20
Surrogate: a,a,a-Trifluorotoluene	33.0		ug/l	40.0		82.5	80-120		
Surrogate: 4-Bromofluorobenzene	32.4		"	40.0		81.0	80-120		

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240		Fax: (505) 397-1471 Reported: 02/01/06 11:42								
General	Chemistry Para			ristin Farris-P Standard		ls - Qua	lity Con	trol		
		Environn	iental I	Lab of Te	kas					,
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch EA62406 - General Preparatio	n (WetChem)									
Blank (EA62406-BLK1)				Prepared &	: Analyzed:	01/26/06				
Fotal Alkalinity	ND	2.00	mg/L							
LCS (EA62406-BS1)				Prepared &	: Analyzed:	01/26/06				
Bicarbonate Alkalinity	220		mg/L	200		110	85-115			
Duplicate (EA62406-DUP1)	Sou	rce: 6A19005-	-01	Prepared &	Analyzed:	01/26/06				
Fotal Alkalinity	258	2.00	mg/L		256			0,778	20	
Reference (EA62406-SRM1)				Prepared &	Analyzed:	01/26/06				
Total Alkalimity	97.0		mg/L	100	······	97.0	90-110			
Batch EA63003 - General Preparatio	n (WetChem)									
Blank (EA63003-BLK1)	<u> </u>			Prepared: (01/26/06 A	nalyzed: 01	/27/06			
Total Dissolved Solids .	ND	5.00	mg/L							
Duplicate (EA63003-DUP1)	Sou	rce: 6A25018-	-01	Prepared: (01/26/06 A	nalvzed: 01	/27/06			
Total Dissolved Solids	2020	5.00	mg/L	·	2080	[*]		2.93	5	
Batch EA63004 - General Preparatio	n (WetChem)									
Blank (EA63004-BLK1)				Prepared &	Analyzed:	01/30/06				
Sulfate	ND	0.500	mg/L							
Chloride	ND	0.500	'n							
- CIG (D + 23004 DCIA)				Prepared &	Analyzed	01/30/06				
LCS (EA63004-BS1)				rieparea a	. man <u>y</u> zeu.	01150100				

States and

が開設

States a

N.S.F.C.S.S.

1 Start &

ALC: NO.

Sec. Sec.

S. S. S. S. S.

にある

記れ

1252.3

語を語ざ

B. Ward Beer

A Palie

NE CAN

S. A. Stra

10 Pr 20-1

No.

n	· · · · · · · · · · · · · · · · · · ·	
Rice Operating Co.	Project:	BD Zachary Hinton
122 W. Taylor	Project Number:	None Given
Hobbs NM, 88240	Project Manager:	Kristin Farris-Pope

Reported: 02/01/06 11:42

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 EA63004 - General Preparation (V	VetChem)									
Calibration Check (EA63004-CCV1)				Prepared &	Analyzed:	01/30/06				
Sulfate	9.82		mg/L	10.0		98.2	80-120			
Chloride	8.64		•	10.0		86.4	80-120			
Duplicate (EA63004-DUP1)	Sourc	e: 6A25018-	01	Prepared &	Analyzed:	01/30/06				
Sulfate	84.4	25.0	mg/L		88.2			4.40	20	
Chloride	879	25.0	*		886			0.793	20	

Environmental Lab of Texas

Sec. Sec.

Service and

3284.52

No.

334

100.00

a cine

Page and a

3. 30 3. 3

a for a lot

Sur Sur

- midulariy

b surfaces

S STAPPE

14 C 20

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 8 of 10

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

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

a lot light

STREET, S

A CONTRACT

20.00

1. A. . . .

Max 2

A. Same

Sec. Sec.

1.28.20

24.26

re re se

28.6.3

1. 3. B. C.

Project:BD Zachary HintonProject Number:None GivenProject Manager:Kristin Farris-Pope

Total Metals by EPA / Standard Methods - Quality Control

Environmental Lab of Texas

		Reporting		Spike	Source		%REC		RPD	
Analyte	Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes
Batch EA62615 - 6010B/No Digestion		·····							-	
Blank (EA62615-BLK1)				Prepared &	Analyzed:	01/26/06				
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500								
Sodium	ND	0.0100	н							
Calibration Check (EA62615-CCV1)				Prepared &	Analyzed:	01/26/06				
Calcium	2.12		mg/L	2.00		106	85-115			
Magnesium	1.99		••	2.00		99.5	85-115			
Potassium	1.88		"	2.00		94.0	85-115			
Sodium	1.94		"	2.00		97.0	85-115			
Duplicate (EA62615-DUP1)	Sou	rce: 6A19005-	01	Prepared &	Analyzed:	01/26/06				
Calcium	224	0.500	mg/L		222			0.897	20	
Maguesium	115	0.0500			120			4.26	20	
Potassium	14.6	0,500			15.2			4.03	20	
Sodium	306	0.500	*		313			2.26	20	

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

う気

Serence -

- Salar

122 W. 1	erating Co. Faylor iM, 88240	Project Number	BD Zachary Hinton None Given Kristin Farris-Pope	Fax: (505) 397-147 Reported: 02/01/06 11:42
~		Notes and De	finitions	
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:

Suma Site

きの湯

Start B

S my site

1997 July 1

10.2

Raland K Julies

2/1/2006

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.

Date:

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

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

Page 10 of 10

an a		1								TAT bisbriel2	×												
-									a osqu	(alubarto2-ard) TAT H2U9				 				0495+73.43			(S)		
									,				 						z	ب ر	ŝ		
_														 					Dala 1	Ŋ	ा भू		
										N.O.R.M. No.O.R.M. Dissolved Solids	×		 	 					Cooler	N N	tou		
75	L	ton		2			or:		 	RCI				 					act? ners(ceipt:		:SI		
	CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST	Zachary Hinton		Lea County			Analyze For	- <u> ×</u>	-	Seiniviolatiles STEX 80218/5030	\times		 	 			\dashv		Sample Containers Intact? Labels on container? Custody Seals. (Containers Temperáture Upon Recelipt.		Laboratory Comments:		
1(223)	: REG	tchar		aC			Ä		Ĺ	səlitsloV			 						Sampla Containers ir Labels on container? Custody Seals: Cont Temperäture Upon R		/ Con		
6 70	NSIS.	D Ze		۲¢				<u>نہ اہ</u>		Metals: As Ag Ba Cd Cr Pb Hg Se				 			_		la Co s on c dy Se eratur		rator		
S. A. A.	ANAL	ш ё		ا ق	₽ E E			TOTAL:	┢	Anions (Cl, SO4, CO3, HCO3) SAR / ESP / CEC	×						\dashv	\neg	Samp Labeli Custo Temp		Labo		
	AND.	t Nan	Project#:	Project Loc:	g					Cations (Ca, Mg, Va, K)	×			 									
19-19-19-19-19-19-19-19-19-19-19-19-19-1	ORD .	Project Name: BD	đ	Proj					-	Other (specify): 1005 1006							-	-			Time	Time	1325
100	REC(ά,							Matrix	h			 						mo				
25.	λαο	1		,	1	I.	1		eNa										vd.c		Date	Date	12-00
2. C. S.	cus r				1				-	Other (Specify) Water			 	 					Sec				01-25-06
	OF C				Ì					None (1) † Liter HDPE	-								E E				
N.W.W.	HAIN					2			Native	'OS [™] H HO®N			 	 			_	_	nksı				
	ŭ					397-147			Preservative	HCI (2) 40 ml glass viais	2	-	 		_			—	ıfra				
24 24					l	397				^c onh				 					ట లెల్				5
24.93.22.7]				(505)					×		 9300 M 44	 					Шo				3
						ë]		No. of Containers	с С	,	 						let.c				الح
		com				Fax No:				bəlqme2 əmiT	9:45								ceswd@valornet.com & mfranks@riceswd.com				ういて
		kpriceswd@valornet.com				A	K	\downarrow)	beiqmeS eteO	1/23/2006								priceswo		ived by:	ived by ELOT:	Venne
	0 9 5 0 9 5	oriceswd(2		01	631-9310					+		 ~ ~ ~						TS TO: H		Time Received	Time Received	
and the second	D Of TOXAS Phone: 432-563-1713 Fax: 432-563-1713	ł	Company	treet	xico 8824	on (505)		iet.com		ш									PLEASE Email RESULTS TO: kpri			ç –	
ESSE.	Phone: 4 Fiax: 4	Farris Po	Derating	. Taylor S	New Me	193-9174		e@valorr		FIELD CODE									SE Emai			Date	_
		Project Manager: Kristin Farris Pope	Company Name RICE Operating Company	company Address: 122 W. Taylor Street	city/state/Zip: Hobbs, New Mexico 88240	Tetephone No: (505) 393-9174 Sampler Signature: Rozanne Johnson (505) 631-9310		Email: <u>rozanne@valornet.com</u>			Monitor Well #1								PLEA	4			
and the second	MMO 20 East s 79765	yject Managı	ompany Nar	any Addres	City/State/Z	Felephone N		ĒŢ		(fino	Second Mon			200		2. N.V.			ctions:	V	IT I	A A	
	Environmental 12800 West I-20 East Odessa, Texas 79765	Prc	ŭ	Comp		Samp				AB # (lab use only)	Service and the		and a Way						Special Instructions:		Relinquished by:	Rozanne Johnson Relinquished by	
	FF 63						•,							<u>.</u>					<u>ດ</u>			R	·]

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

Slient:	Rice Op.
Date/Time:	1/25/06 13:25
o rder #:	6A15021
Initials	ARE

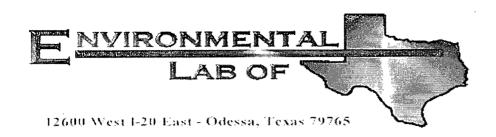
Sample Receipt Checklist Yes No -2.5 Temperature of container/cooler? ÇΙ Shipping container/cooler in good condition? No Es, Custody Seals intact on shipping container/cooler? Not present ES. Na Custody Seals intact on sample bottles? No Not present , Xæsj Chain of custody present? No ¥25 Sample Instructions complete on Chain of Custody? No ¥ē5, Chain of Custody signed when relinquished and received? Kas 1 No Chain of custody agrees with sample labe!(s) No ¥=5 Container labels legible and intact? No XEB. Sample Matrix and properties same as on chain of custody? No ¥≈s Samples in proper container/bottle? No œ I No Samples properly preserved? 250 1 Sample bottles intact? YES No Preservations documented on Chain of Custody? X55 1 No Containers documented on Chain of Custody? 651 No Sufficient sample amount for indicated test? No YES All samples received within sufficient hold time? No ¥59 | VOC samples have zero headspace? (32 | No Not Applicable

~	,		
()there	COCOR	Vation	<u> </u>
Other	UUSC:	VENUL	с.

· · · · · · · · · · · · · · · · · · ·			
Contact Person: Regarding:	Variance Documentation: Date/Time:	_ Contacted by:	
Corrective Action Taken:			

-

P.30



5 (C. 62

No. of the other states of

3. 3. M. S. S. S.

an stree

S.S. Sar

のない

11263

3. 14 the

CALES?

「「な」の

S. S. B. Ma

C. W. W.

1.2462.32

Analytical Report

Prepared for: Kristin Farris-Pope Rice Operating Co. 122 W. Taylor Hobbs, NM 88240

Project: BD Zachary Hinton Project Number: None Given Location: Lea County

Lab Order Number: 6D27011

Report Date: 05/04/06

Rice Operating Co.Project:BD Zachary HintonFax: (505) 397-1471122 W. TaylorProject Number:None GivenReported:Hobbs NM, 88240Project Manager:Kristin Farris-Pope05/04/06 14:09

考える

a state

Contraction of the

and the second

C. S. B. B.

14.121

1. 100 Mar 100 40

a surger

Charles and

1.25%

1. 2 m

1. S. S. S.

142 an 1

See 12

ALL CAL

Service of

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Monitor Well #1	6D27011-01	Water	04/24/06 09:30	04/27/06 10:30

122 W. Taylor Project Number: None Given	
	Reported:
Hobbs NM, 88240 Project Manager: Kristin Farris-Pope	05/04/06 14:09

Organics by GC

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (6D27011-01) Water									··· .
Benzene	ND	0.00100	mg/L	l	ED62807	04/28/06	04/30/06	EPA 8021B	
Toluene	ND	0.00100		"		"	"	"	
Ethylbenzene	ND	0.00100							
Xylene (p/m)	ND	0.00100		"				n	
Xylene (o)	ND	0.00100	**	"			"		
Surrogate: a.a.a-Trifluorotoluene		102 %	80-12)	"	"	'n	"	
Surrogate: 4-Bromofluorobenzene		103 %	80-12	0	u	"	"	"	

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

SAN STR

Adventige

1. 67 2 - 3

32.59

1. 2. A. C.

1202

Sec. Sec.

1420

R. Car

R. C. L.

Same Street St.

S. N. San

155-102-1

S. S. S.

S. Andrew

Rice Operating Co.		Project: BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Projec	ct Number: None Given	Reported:
Hobbs NM, 88240	Projec	et Manager: Kristin Farris-Pope	05/04/06 14:09

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 (6D27011-01) Water									
Fotal Alkalinity	184	~2.00	mg/L	I	EE60301	05/03/06	05/03/06	EPA 310.1M	
Chloride	326	5.00		10	EE60116	05/01/06	05/01/06	EPA 300.0	
Total Dissolved Solids	1190	5.00	"	I	EE60115	04/27/06	04/28/06	EPA 160.1	
Sulfate	167	5.00		10	EE60116	05/01/06	05/01/06	EPA 300.0	

19 m 10

1-15.29

A LANS

Sec. 60

1. 2 A 2 1

-THE S

14 A A

S. Frank

1000

8.77. B.S.

5 . Cak

Sec. Sec.

- 年間

Sec. Sec.

S. A. A. M.

Second The

Rice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number:	None Given	Reported:
Hobbs NM, 88240	Project Manager:	Kristin Farris-Pope	05/04/06 14:09

Total Metals by EPA / Standard Methods

Environmental Lab of Texas

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Monitor Well #1 (6D27011-01) Water									
Calcium	85.0	0.100	mg/L	10	ED62719	04/27/06	04/27/06	EPA 6010B	
Magnesium	43.4	0.0100		п	и	"	н		
Potassium	9.70	0.500				**	н.,		
Sodium	238	0.500	**	50			0	17	

く書い

語の

たい。

2 June

ない

1.2 A Sa

N.R.W

Soften "Is

all a fra

A State

100 m

Store of the

1 Me Zak

State of the

Constanting of the

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240		Project Nu	mber: No	D Zachary Hint one Given istin Farris-Poj		,			Fax: (505) Repor 05/04/06	ted:
	O	rganics by		uality Col Lab of Texa		÷				
		CHVHORI			45					
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch ED62807 - EPA 5030C (GC)							`			
Blank (ED62807-BLK1)				Prepared: 04	/28/06 Ai	nalyzed: 04	/30/06			
Benzene	ND	0.00100	mg/L							
Fohiene	ND	0.00100								
Ethylbenzene	ND	0,00100	*							
Xylene (p/m)	ND	0.00100								
Xylene (o)	ND	0.00100							·	
Surrogate: a,a,a-Trifluorotoluene	42.7		ug/l	40.0		107	80-120			
Surrogate: 4-Bromofluorohenzene	42.2		"	- 40,0		106	80-120			
LCS (ED62807-BS1)				Prepared: 04	/28/06 Ai	nalyzed: 04	/30/06			
Benzene	0.0599	0.00100	mg/L	0.0500		120	80-120			
Toluene	0.0580	0.00100		0.0500		116	80-120			
Ethylbenzene	0.0551	0.00100		0.0500		110	80-120			
Xylene (p/m)	0.120	0.00100		0.100		120	80-120			
Xylene (0)	0.0596	0.00100	"	0.0500		119	80-120			
Surrogate: a,a,a-Trifluorotoluene	43.0		ug4	40.0		108	80-120			
Surrogate: 4-Bromofluorobenzene	42.2		"	40.0		106	80-120			
Calibration Check (ED62807-CCV1)				Prepared: 04	/28/06 Ai	nalyzed: 05	/01/06			
Benzene	55.0		ug/l	50.0		110	80-120			
Foluene	53.0			50.0		106	80-120			
Ethylbenzene	55.9			50.0		112	80-120			
Xylene (p/m)	110		•	100		110	80-120			
Xylene (o)	55.9			50.0		112	80-120			

Matrix Spike (ED62807-MS1)	Sou	-ce: 6D27008-	01	Prepared: 0	4/28/06 A	nalyzed: 0.	5/01/06
Benzene	0.0576	0.00100	mg/L	0.0500	ND	115	80-120
Toluene	0.0568	0.00100	"	0.0500	ND	114	80-120
Ethylbenzene	0.0587	0.00100	"	0.0500	ND	117	80-120
Xylene (p/m)	0.120	0.00100	"	0.100	, ND	120	80-120
Xylene (0)	0.0600	0.00100	••	0.0500	ND	120	80-120
Surrogate: a,a,a-Trifluorotoluene	41.7		ug/l	40.0		104	80-120
Surrogate: 4-Bromofluorobenzene	47.5		"	40.0		119	80-120

..

40.0

39.1

Surrogate: 4-Bromofluorobenzene

N. 82934

and the second second

1960 AV.2

1.000

Wat Ball

C. A.D.

3.00 E

(CARA)

THE REAL

No.

A. 64.1 20

1. S. S. S.

The State

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

97.8

80-120

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

Page 5 of 10

Rice Operating Co.	Project:	BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number:	None Given	Reported:
Hobbs NM, 88240	Project Manager:	Kristin Farris-Pope	05/04/06 14:09

Organics by GC - Quality Control

Environmental Lab of Texas

		Reporting		Spike	Source		%REC		RPD	
Analyte	Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes

Batch ED62807 - EPA 5030C (GC)

and the second

107 - 100 S

を見たい

12121

Same and

N. 82.2.0

Stor and

2 - 3-2-2

調整を

· early

A Far .. in

Sec. Sec.

1. E. S.

14 2 mg

Matrix Spike Dup (ED62807-MSD1)	Sou	rce: 6D27008-	01	Prepared: 0	4/28/06 Ai	nalyzed: 0	5/01/06		
Benzene	0.0597	0.00100	mg/L	0.0500	ND	119	80-120	3.42	20
Tolnene	0.0579	00100,0	"	0.0500	ND	116	80-120	1.74	20
Ethylbenzene	0.0585	0.00100	**	0.0500	ND	117	80-120	0.00	20
Xylene (p/m)	0.120	0.00100		0.100	ND	120	80-120	0.00	20
Xylene (0)	0.0598	0.00100	••	0.0500	ND	120	80-120	0.00	20
Surrogate: a,a,a-Trifluorotoluene	43.5		ug4	40,0		109	80-120		
Surrogate: 4-Bromofluorobenzene	46.4		"	40.0		116	80-120		

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240		Project Nu	mber: No	D Zachary Hir one Given ristin Farris-P				·	Fax: (505) Repo 05/04/0	rted:
General Cl	nemistry Para	meters by Environm				ls - Qua	lity Con	trol		
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Note
Batch EE60115 - General Preparation (V										
Blank (EE60115-BLK1)				Prepared (04/27/06 Ai	nalyzed: 04	/28/06			
Total Dissolved Solids	ND	5.00	mg/L			ina ji sou o i				
Duplicate (EE60115-DUP1)	Som	rce: 6D27015-	.01	Prenared ()4/27/06 At	nalvzed: 04	/28/06			
Total Dissolved Solids	3020	5.00	mg/L	r repured: e	3040	inity zear of		0.660	5	
Batch EE60116 - General Preparation (VetChem)	<u></u>								
Blank (EE60116-BLK1) Chloride	ND	0.500	mg/L	Prepared &	Analyzed:	05/01/06				
Sulfate	ND	0.500	ng/L							
LCS (EE60116-BS1)				Prepared &	Analyzed	05/01/06				
Sulfate	9.47	0.500	mg/L	10.0	. A shary zed.	94.7	80-120		· · ·	
Chloride	9.71	0.500	"	10.0		97.1	80-120			
Calibration Check (EE60116-CCV1)				Prepared &	Analyzed:	05/01/06				
Chloride	9.86		mg/L	10.0		98.6	80-120			
Sulfate	8.11			10.0		81.1	80-120			
Duplicate (EE60116-DUP1)	Sour	-ce: 6D27008-	01	Prepared &	Analyzed:	05/01/06				
Sulfate	80.0	2.50	mg/L		79.2			1.01	20	
Chloride	49.3	2.50			49.0			0.610	20	
Batch EE60301 - General Preparation (V	VetChem)									
Blank (EE60301-BLK1)				Prepared &	. Analyzed:	05/03/06				
Total Alkalinity	ND	2.00	mg/L							

Environmental Lab of Texas

183 B

2.2.2

Caller.

States -

A State

S. W.S. S.

TALK T

24.20

Mar and

1997

A CANER

30.6

Ser of

の理想を

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

,

2.00

and the second

Six sig

1. A. C.

22000

のないです。

Reported: 05/04/06 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 EE60301 - General Preparatio	on (WetChem)									
LCS (EE60301-BS1)				Prepared &	: Analyzed:	05/03/06				
Bicarbonate Alkalinity	214		mg/L	200		107	85-115			
Duplicate (EE60301-DUP1)	Sou		01	Prepared &	Analyzed:	05/03/06				
Total Alkalinity	29.0	2.00	mg/L		28.0			3.51	20	
Reference (EE60301-SRM1)				Prepared &	Analyzed:	05/03/06				
Total Alkalinity	96.0		mg/L	100		96.0	90-110			

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Euvironmental Lab of Texas.

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

[Rice Operating Co.	Project: BD Zach	ary Hinton	Fax: (505) 397-1471
	122 W. Taylor	Project Number: None Giv	ven	Reported:
	Hobbs NM, 88240	Project Manager: Kristin F	arris-Pope	05/04/06 14:09

Total Metals by EPA / Standard Methods - Quality Control

Environmental Lab of Texas

		Reporting		Spike	Source		%REC		RPD	1
Analyte	Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	Notes

Batch ED62719 - 6010B/No Digestion

あるの

S. Stanger

語言で

N F MAN

10.20

21. 2. 2

2.235.5

328.8

State of the second

1. 28 E. C.

State State

1 geo. 2.

States and

對過度

Blank (ED62719-BLK1)				Prepared & Analyzed: 04/27/06				
Całcium	ND	0.0100	mg/L					
Magnesium	ND	0.00100						
Potassium	ND.	0.0500	"					
Sodium	ND	0.0100	"					
Calibration Check (ED62719-CCV1)		-		Prepared & Analyzed: 04/27/06				
Calcium	2.08		mg/L		85-115			
Magnesium	2.16				85-115			
Potassium	1.94		п		85-115			
Sodium	1.96		11		85-115			
Duplicate (ED62719-DUP1)	Sou	rce: 6D26006-	01	Prepared & Analyzed: 04/27/06				
Calcium	0.0366	0.0100	mg/L	0.0367		0.273	20	
Magnesium	ND	0.00100	"	ND			20	
Potassium	0.275	0.0500		0.275		0.00	20	
Sodium	13.0	0.100		12.1		7.17	20	

Rice Operating Co. 122 W. Taylor Hobbs NM, 88240		Project: BD Zachary Hinton Project Number: None Given	Fax: (505) 397-1471 Reported:
		Project Manager: Kristin Farris-Pope	05/04/06 14:09
		Notes and Definitions	
DET	Analyte DETECTED		
ND	Analyte NOT DETECTED at or above the reporting	linnit	
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

11 . AL

and the second

Sector S

Sec. 20

2.52.6

1. 54

Wanter .

AT 2 W

0.0

21.34

1. 2 X 4 Y

2 243

100

The set

10.24

Report Approved By:

Raland K Julie

5/4/2006

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.

Date:

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

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

Page 10 of 10

								-							• • • •			_				<u> </u>
1 Carton										TAT brebnet8		\downarrow			_							
							r	ana faanaa	(alubano2-919) TAT HSUS				_					-			
									,			-+	-		+	+			+-	z z		
																				_t ₽		
										sbilo2 bevlosei() [sto]	×											
										10.R.M.										¥		
1.2.5		ton		≥				<u>ة</u>		sci						_	_	_			ŝ	
	EST	Ξ		County				Analyze For	<u><</u>	BLEX 80518\2030 Bewinolegies					+	-+					men	
917 P.	EQU	han		ŭ				₽ 	+-	salitelov										ntaine britair britair britair	Con	
	CHAIN OF CUSTODY RECORD AND ANAL YSIS REQUEST	Project Name: BD Zachary Hinton		Геа					ąś	2 pH d9 10 b0 b8 pA ar islately	•									I I	Laboratory Comments.	
45	SX TI	ВÜ						TCLP:	TOTAL	SAR / ESP / CEC			_					_		bels stod	bora	
le l	ANA	Ime:	ct #:	Loc:	∺ Od				°	Anions (Cl, SO4, CO3, HCO3)					_					S B S P	<u> </u>	
<i>(</i> 79	AND	ct Na	Project #:	Project Loc:	α.					CPH: 418.1 8015M 1005 100 Cations (Ca, Mg, Va, K)	×	-+		-+	-+					-	Time 	Time 30
	, מאמ	noje	Ľ.	Pro	1					Olher (specify): Olher (specify):											Time 4 :0/	Time [0:30
A state	ECC.	p							ž	lios				-+	+			\neg	+			100
	ΑYα								Matríx	ວຼີຊາດຊີອ										5	Date 4/27/54	Date
No.	, STØ,								-	Water	\times					_		_		vd.	10 1	le .
	ПО									Ofher (Specify)					-+			+		Sesi		
	IO N						i		Ş	H ₂ SO ₄ Nore (1) 1 Liter HOPE						+				- ig		
	сна	ľ				71			Preservative	HOVN				-+						ks Ks		
	. –					-14			orese.	HCI (S) 40 mi 6jase viais	2									lan L		
						397-1471				¹ ONH			_							ul u	2	
						22)			L	IC6										- 2	1	075
						<u>(5</u>				No. of Containers	0								<u> </u>	cou	W	R I
19. AN				Ì		Fax No: (505)										Ì				kpope@riceswd.com & mfranks@riceswd.com	270	
						E E				belqms2 amiT	9:30									sec		
			ļ				$\left(\right)$													D I I	1 3	8
		COM						7			6					ł				be(E IOI
				1				1	2	Delqms2 ets0	4/24/2006									0dý	A PAR	
		Ses					0	\sim	\mathbf{X}	polone0 etca	4/24										Received by	Received by
		0 Ü					931	$ $ \vee	2										~	1 Y	Rec	Re Re
.	· · · ·	kpope@riceswd					3-10		$\overline{\ }$											113	e 2	20 e
	• T C X 2 S 432-563-1800 432-563-1713	헛	<u>y</u> ng		240) و													ns.	Time 6.00	Time (0.30
(19)			npe	ير	88		(50	Com												E E E E E E E E E E E E E E E E E E E		
18	432-432	be	Ö	tree	Xic.		ñ	let.o		u					1					nail	Date 27/06	Date 27/0
	D Of TEXAS Phone: 432-563-1800 Fax: 432-563-1713	Р0	ting	S S	city/state/zip: Hobbs, New Mexico 88240	74	JDS(L	Email: rozanne@valornet.com												PLEASE Email RESULTS TO:	Date 4/27/00	1/27/06
	ល្អ អ្ន	urris	era	aylc	ev	-91	þ	<u> </u>												ASE		
al year	87 	цЦ	Õ	۲. ۲	Z S	390	nne	ue(Ū										Ē		
	unased Sites	istir	Ы	2	qqc	05)	IEZC	Zan			/ell #									<u>a</u>	N	Man
1	<i>w</i>	고 고	<u>a</u>	1	푀	: <u>5</u>	ŭ	0			Monitor Well #1											W
14 - A.V.	0	ager.	Vame	ress	diZ/e	e No	iture	mail			lonit										11	0
1.45	ast 765	Man	any î	Add	Stafe	Telephone No: (505) 393-9174	Signe	ш		<u></u>	3 - 22 F.		<u>S</u> S		33	133					1th	H.
	20 E	Project Manager: Kristin Farris Pope	company Name RICE Operating Company	Company Address: 122 W. Taylor Street	city	Teleţ	sampler signature: Rozanne Johnson (505) 631-9310													Ction /	1.4	1. 3
	st -	Pr	Q	Com			Sam			150		懰								str /		ed by
	Environmental Lab of Texas 12600 West 1-20 East Odessa, Texas 79765 Fax: 432-563-1713			ų						10,100				100						Special Instructions	Reingdished by: Refaune Johnson	Relinquished by
arva.	260(260(Spec	Kellar Server	Relin
										n a server a a server espectra a server en espect	<u>نين د. د.</u>	1.222.23	- ye sî j		الشندن	<u></u>		I				2

-

Stand and

Environmental Lab of Texas	
Variance / Corrective Action Report – Sample Log-In	
<u>Pice Op.</u>	

Bar#: _ 602701/

ic

1 8 C

a Alexan

ht

als:

1.000

Sample Receipt Checklist

perature of container/cooler?	Yes	No	2.0 CI
ping container/cooler in good condition?	XES	Nio	(
cing container/cooler in good condition? ody Seals intact on shipping container/cooler?	Es !	No	Not present i
ody Seals intact on sample bottles?	1 625 1	No	Not present
in of custody present?	(as	No	1
ple Instructions complete on Chain of Custody?	Yes I	No 1	······
in of Custody signed when relinquished and received?		No	
in cricustody agrees with sample label(s)	Kes 1	Na	
tainer labels legible and intact?	1001	No	
tainer lacets legicle and intact? Tole Matrix and properties same as on chain of custody? Toles in procer container/bottle?	Yeg 1	No I	
aples in procer container/cottle?	1 Yes	No	·
ncies properly preserved?	Yes	No I	
noie bottles intact?		No I	
servations documented on Chain of Custody?	1 Ves 1	No 1	
itainers documented on Chain of Custody?	735	No	
ficient sample amount for indicated test?	1 Vez 1	No	
samples received within sufficient hold time?	(De)	No	
C samples have zero headspace?	(E)	No	Not Accilcable

her observations:

Lever Ca

21.128

AND STOLEN

Variance Documentation: Date/Time: _____Contacted by: _____ Sparding: ______ Drrective Action Taken:

UMULANIA TRACEANALYSIS, INC. MARINA MULANIA

6701 Aberdeen Avenue, Suite 9 155 McCutcheon, Suite H Lubbock, Texas 79424 800•378•1296 El Paso, Texas 79932 888•588•3443 E-Mail jab@traceanalysis.com 806•794•1296 FAX 806•794•1298 915•585•3443 FAX 915•585•4944

Analytical and Quality Control Report

Kristen Farris-Pope Rice Operating Company 122 W Taylor Street Hobbs, NM, 88240

and the second

2.20.2

100

12821

大学学校

た国会

読む

11.46

1.00

Project Location:Lea County,NMProject Name:BD Zachary HintonProject Number:BD Zachary Hinton

Report Date: August 9, 2006

Work Order: 6072143

Enclosed are the Analytical Report and Quality Control Report for the following sample(s) submitted to TraceAnalysis, Inc.

			Date	Time	Date
Sample	Description	Matrix	Taken	Taken	Received
96140	Monitor Well #1	water	2006-07-19	12:55	2006-07-21

These results represent only the samples received in the laboratory. The Quality Control Report is generated on a batch basis. All information contained in this report is for the analytical batch(es) in which your sample(s) were analyzed.

This report consists of a total of 10 pages and shall not be reproduced except in its entirety, without written approval of TraceAnalysis, Inc.

Michael april

Dr. Blair Leftwich, Director

Service.

- 20 B

A BAR

語語の

13.20 M

の、「見てい

and the state

- Single Single

A.

調査部

a manager

er Saladi

調整が

Analytical Report

Sample: 96140 - Monitor Well #1

Analysis: Alkalinity QC Batch: 28340 Prep Batch: 24777		Analytical Method: Date Analyzed: Sample Preparation:	SM 2320B 2006-07-26 2006-07-25	Prep Method: Analyzed By: Prepared By:	
Parameter	Flag	RL Result	Units	Dilution	RL
Hydroxide Alkalinity	T tug	<1.00	mg/L as CaCo3		1.00
Carbonate Alkalinity		<1.00	mg/L as CaCo3	1	1.00
Bicarbonate Alkalinity		188	mg/L as CaCo3	1	4.00
Total Alkalinity		188	mg/L as CaCo3	1	4.00

Sample: 96140 - Monitor Well #1

Analysis: BTEX QC Batch: 28277 Prep Batch: 24759		Analytical M Date Analyz Sample Prep	ed:	S 8021B 2006-07-24 2006-07-24		Prep Meth Analyzed Prepared I	By: MT
		R	L				
Parameter Fla	ng	Resu	lt	Units		Dilution	RL
Benzene		< 0.0010	00	mg/L		1	0.00100
Toluene		< 0.0010	00	mg/L		1	0.00100
Ethylbenzene		< 0.0010	00	mg/L		1	0.00100
Xylene	•	< 0.0010	00	mg/L		1	0.00100
					Spike	Percent	Recovery
Surrogate	Flag	Result	Units	Dilution	Amount	Recovery	Limits
Trifluorotoluene (TFT)		0.0961	mg/L	1	0.100	96	66.2 - 127.7
4-Bromofluorobenzene (4-BFB)	1	0.0585	mg/L	1	0.100	58	70.6 - 129.2

Sample: 96140 - Monitor Well #1

Analysis: Cations QC Batch: 28356 Prep Batch: 24749		Analytical Method: Date Analyzed: Sample Preparation:	S 6010B 2006-07-26 2006-07-24	Prep Method: Analyzed By: Prepared By:	
		RL			
Parameter	Flag	Result	Units	Dilution	RL
Dissolved Calcium		98.2	mg/L	<u>l</u>	0.500
Dissolved Potassium		12.8	mg/L	1	1.00
Dissolved Magnesium		49.3	mg/L	1	1.00
Dissolved Sodium		230	mg/L	10	1.00

Sample: 96140 - Monitor Well #1

Analysis:	Ion Chromatography	Analytical Method:	E 300.0	Prep Method:	N/A
QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	Sample Preparation:	2006-08-02	Prepared By:	WB

¹BFB surrogate recovery outside normal limits. ICV/CCV and TFT surrogate recovery show the method to be in control.

Report Date: August 9, 2006 BD Zachary Hinton				r: 6072143 nry Hinton		-	umber: 3 of ea County,N
		RL				1.2	
Parameter Flag	g	Result	· · · · · · · · · ·	Units	D1	lution	R
Chloride Sulfate		375 234		mg/L mg/L	0.14 W 77	50 50	0.50 0.50
Sample: 96140 - Monitor Well	#1						
Analysis: TDS		Analytical	Method:	SM 2540C		Prep N	Aethod: N/
QC Batch: 28406		Date Analy		2006-07-27	,		zed By: SN
Prep Batch: 24850		Sample Pre		2009-07-26			ed By: SN
			RL				
Parameter	Flag		lesult	Units		Dilution	R
Total Dissolved Solids			1318	mg/L	····	2	10.0
Prep Batch: 24759 Parameter	Flag	QC Prepa	l	2006-07-24 MDL Result	Unit		red By: M
Benzene	0		< 0.00		mg/	Ĺ	0.00
Toluene			< 0.00		mg/		0.00
Ethylbenzene			< 0.00		mg/		0.00
Xylene			< 0.00	00603	mg/	L	0.00
Sumaata	Flag	Dogult	Lluita	Dilution	Spike	Percent	Recover Limits
Surrogate Trifluorotoluene (TFT)	Flag	Result 0.0949	Units mg/L	Ditution	Amount 0.100	Recovery 95	
4-Bromofluorobenzene (4-BFB)		0.0633	mg/L	l	0.100	63	58.5 - 11
	h: 28340		alyzed:	2006-07-26			yzed By: L 1red By: L
Method Blank (1) QC Batel QC Batch: 28340 Prep Batch: 24777		Date An QC Prep		2006-07-25		1	
QC Batch: 28340	Flag		aration: M	2006-07-25 DL sult	Uni	-	R
QC Batch: 28340 Prep Batch: 24777 Parameter Hydroxide Alkalinity	Flag		M Re <1	DL sult .00	mg/L as	ts CaCo3	R
QC Batch: 28340 Prep Batch: 24777 Parameter Hydroxide Alkalinity Carbonate Alkalinity	Flag		M Re <1 <1	DL sult .00 .00	mg/L as mg/L as	ts CaCo3 CaCo3	R
QC Batch: 28340 Prep Batch: 24777 Parameter Hydroxide Alkalinity	Flag		M Re <1 <1 <4	DL sult .00	mg/L as	ts CaCo3 CaCo3 CaCo3 CaCo3	

QC Batch:28356Date Analyzed:2006-07-26Analyzed By:TPPrep Batch:24749QC Preparation:2006-07-24Prepared By:TS

dates dates

Control of

" (mailer

States of

1. 27.90

and she

State State

(B) (A)

45.00

17. B 1

Garage.

181 B.

5-28 P.

State State

Son Street Land

A. T. Salar

Report Date: August 9, 2 BD Zachary Hinton	2006		der: 6072143 hary Hinton		Page Number: Lea Cour	
			MDL			
Parameter	Flag		Result	Units		RL
Dissolved Calcium			0.132	mg/L.		0.5
Dissolved Potassium Dissolved Magnesium			1.08 <0.704	mg/L mg/L		1
Dissolved Sodium			0.836	mg/L		1
Method Blank (1) Q	C Batch: 28406					
QC Batch: 28406		Date Analyzed:	2006-07-27		Analyzed By:	SM
Prep Batch: 24850		QC Preparation:	2006-07-26		Prepared By:	SM
			MDL			
Parameter	Flag		Result	Units		RL
Total Dissolved Solids			< 5.000	mg/L		10
Method Blank (1) Q QC Batch: 28782 Prep Batch: 25167	C Batch: 28782	Date Analyzed: QC Preparation:	2006-08-02 2006-08-02		Analyzed By: Prepared By:	WB WB
QC Batch: 28782 Prep Batch: 25167		QC Preparation:	2006-08-02 MDL			WB
QC Batch: 28782 Prep Batch: 25167 Parameter	Flag	QC Preparation:	2006-08-02 MDL Sesult	Units		WB RL
QC Batch: 28782 Prep Batch: 25167		QC Preparation:	2006-08-02 MDL	Units mg/L mg/L		WB RL 0.5
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride		QC Preparation:	2006-08-02 MDL Result 0181	mg/L		WB RL 0.5
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1)		QC Preparation: R <0. <0.	2006-08-02 MDL eesult 0181 0485	mg/L	Prepared By:	WB RL 0.5 0.5
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340		QC Preparation:	2006-08-02 MDL Result 0181	mg/L		WB RL 0.5 0.5
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340 Prep Batch: 24777	Flag	QC Preparation: R <0. <0. Date Analyzed: QC Preparation: Sample	2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25	mg/L mg/L	Prepared By: Analyzed By Prepared By:	WB RL 0.5 0.5 : LJ LJ RPD
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340 Prep Batch: 24777 Param	Flag Duplicate Result	QC Preparation: R <0. <0. Date Analyzed: QC Preparation: Sample Result	2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units	mg/L	Prepared By: Analyzed By Prepared By: RPD	WB RL 0.5 0.5 : LJ LJ LJ LJ
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340 Prep Batch: 24777 Param Hydroxide Alkalinity	Flag Duplicate Result <1.00	QC Preparation: R <0. <0. <0. <0. <0. <0. <0. <0.	2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3	mg/L mg/L	Prepared By: Analyzed By Prepared By: RPD 0	WB RL 0.5 0.5 : LJ LJ RPD Limit 20
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340 Prep Batch: 24777 Param Hydroxide Alkalinity Carbonate Alkalinity	Flag Duplicate Result <1.00 <1.00	QC Preparation: R C C<td>2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3 mg/L as CaCo3</td><td>mg/L mg/L</td><td>Prepared By: Analyzed By Prepared By: RPD 0 0</td><td>WB RL 0.5 0.5 0.5 C LJ LJ RPD Limit 20 20</td>	2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3 mg/L as CaCo3	mg/L mg/L	Prepared By: Analyzed By Prepared By: RPD 0 0	WB RL 0.5 0.5 0.5 C LJ LJ RPD Limit 20 20
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340 Prep Batch: 24777 Param Hydroxide Alkalinity	Flag Duplicate Result <1.00	QC Preparation: R <0. <0. <0. <0. <0. <0. <0. <0.	2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3	mg/L mg/L	Prepared By: Analyzed By Prepared By: RPD 0	WB RL 0.5 0.5 C S LJ LJ LJ LJ Limi 20
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340 Prep Batch: 24777 Param Hydroxide Alkalinity Carbonate Alkalinity	Flag Duplicate Result <1.00 <1.00 110	QC Preparation: R <0. <0.<td>2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3 mg/L as CaCo3 mg/L as CaCo3</td><td>mg/L mg/L</td><td>Prepared By: Analyzed By Prepared By: RPD 0 0 2</td><td>WB RL 0.5 0.5 0.5 C. LJ LJ RPD Limi 20 20 12.6</td>	2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3 mg/L as CaCo3 mg/L as CaCo3	mg/L mg/L	Prepared By: Analyzed By Prepared By: RPD 0 0 2	WB RL 0.5 0.5 0.5 C. LJ LJ RPD Limi 20 20 12.6
QC Batch: 28782 Prep Batch: 25167 Parameter Chloride Sulfate Duplicates (1) QC Batch: 28340 Prep Batch: 24777 Param Hydroxide Alkalinity Carbonate Alkalinity Bicarbonate Alkalinity Total Alkalinity	Flag Duplicate Result <1.00 <1.00 110	QC Preparation: R <0. <0.<td>2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3 mg/L as CaCo3 mg/L as CaCo3</td><td>mg/L mg/L</td><td>Prepared By: Analyzed By Prepared By: RPD 0 0 2</td><td>WB RL 0.5 0.5 0.5 C. LJ LJ RPD Limi 20 20 12.6</td>	2006-08-02 MDL tesult 0181 0485 2006-07-26 2006-07-25 Units mg/L as CaCo3 mg/L as CaCo3 mg/L as CaCo3	mg/L mg/L	Prepared By: Analyzed By Prepared By: RPD 0 0 2	WB RL 0.5 0.5 0.5 C. LJ LJ RPD Limi 20 20 12.6

is future

Same and

が、観光

A 22.96

1000

Carle Pay

in Walter

2.20

The second of

122.2232

No. of the second s

in and

Ser of the

1.20

Siether

なたの

	Duplicate	Sample				RPD
Рагат	Result	Result	Units	Dilution	RPD	Limit
Total Dissolved Solids	768.0	928.0	mg/L	2	19	17.2

Report Date: August 9, 2006 BD Zachary Hinton				rder: 6072143 chary Hinton	·		Page	Numbe Lea C	er: 5 of ounty,N
Laboratory Control Spike (LCS-1)								
QC Batch: 28277			Analyzed:	2006-07-24				alyzed H	
Prep Batch: 24759		QC P1	reparation:	2006-07-24	ŀ		Prej	pared B	sy: M
	LCS		**	0.1	Spike	Matrix	D		Re
Param	Resul		Units		Amount	Result	Re		Lin
Benzene Toluene	0.109 0.108		mg/L	1	0.1 0.1	0 0	10		
Ethylbenzene	0.108		mg/L mg/L	I	0.1	0	10		
Xylene	0.109		mg/L mg/L	1	0.3	0	107.		
Percent recovery is based on the spil				oike and spike					
	LCSD			Spike	Matrix		Rec.		RP
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Lin
Benzene		mg/L	1	0.1	0	109		4.7	20
Toluene		mg/L	- 1	0.1	0	108		4.7	20
Ethylbenzene		mg/L	1	0.1 0.3	0	109 107.333		7.6 5.1	20 20
Xylene Percent recovery is based on the spil		mg/L is base	l d on the si						
	LCS		-		-		LCSI	ר	Rec.
					SDIKE				R PC
Surrogate			CSD esult	Units Dil	Spike . Amoun	t Rec.			
Surrogate Trifluorotoluene (TFT)	Result 0.101	R	esult	Units Dil mg/L I	•		Rec.		Limit
	Result	R 0	esult .101		. Amoun	t Rec.	Rec		Limit 81.8 - 1
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB)	Result 0.101 0.112	R 0	esult .101	mg/L I	. Amoun 0.100	t Rec. 101	Rec.		Limit 81.8 - 1
Trifluorotoluene (TFT)	Result 0.101 0.112	R 0	esult .101	mg/L I	. Amoun 0.100	t Rec. 101	Rec.		Limit 81.8 - 1
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356	Result 0.101 0.112	R 0 0 Date	esult 101 .111 Analyzed:	mg/L I mg/L I 2006-07-20	Amoun 0.100 0.100	t Rec. 101	Rec. 101 111	alyzed	Limit 81.8 - 1 72.7 - 1 By: T
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1	Result 0.101 0.112	R 0 0 Date	esult .101 .111	mg/L I mg/L I 2006-07-20	Amoun 0.100 0.100	t Rec. 101	Rec. 101 111		Limit 81.8 - 1 72.7 - 1 By: T
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356	Result 0.101 0.112	R 0 0 0 0	esult 101 .111 Analyzed:	mg/L I mg/L I 2006-07-20	Amoun 0.100 0.100	t Rec. 101	Rec. 101 111 An Pre	alyzed	Limit 81.8 - 1 72.7 - 1 By: T By: T
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356	Result 0.101 0.112	R 0 0 0 0	esult 101 .111 Analyzed:	mg/L I mg/L I 2006-07-20	Amoun 0.100 0.100	t Rec. 101 112	Rec. 101 111 An Pre	alyzed	Limit 81.8 - 11 72.7 - 11 By: T By: T Ree
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749	Result 0.101 0.112	R 0 0 0 0 0 0 0 0 0 0 0 0 0	esult .101 .111 Analyzed: reparation	mg/L I mg/L I 2006-07-20 2006-07-24	. Amoun 0.100 0.100	t Rec. 101 112 Matrix	Rec. 101 111 An Pre	alyzed Epared F	Limit 81.8 - 11 72.7 - 11 By: T By: T Ree
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param	Result 0.101 0.112) LCS Resu	R 0 0 Date QC P	esult .101 .111 Analyzed: reparation Units	mg/L I mg/L I 2006-07-20 2006-07-24	Amount	t Rec. 101 112 Matrix Result	Rec. 101 111 An Pre R 10	ec. alyzed pared F epared F 03.4 01.6	Limit 81.8 - 11 72.7 - 11 By: T
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium	Result 0.101 0.112) LCS Resul 51.7 50.8 51.5	R 0 0 Date QC P	esult .101 .111 Analyzed: reparation <u>Units</u> mg/L	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I	. Amoun 0.100 0.100 5 4 5 4 5 5 5 5 5 5 5 0 50 50	t Rec. 101 112 Matrix Result 0 0 0	Rec. 101 111 An Pre R 10 10	ec. ec. 03.4 03.4	Limit 81.8 - 11 72.7 - 11 By: T By: T Ree
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium	Result 0.101 0.112) LCS Result 51.7 50.8 51.5 50.5	R 0 0 Date QC P	esult .101 .111 Analyzed: reparation Units mg/L mg/L mg/L	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I I I I I I I	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	t Rec. 101 112 Matrix Result 0 0 0 0	Rec. 101 111 An Pre R 10 10	ec. alyzed pared F epared F 03.4 01.6	Limit 81.8 - 11 72.7 - 11 By: T By: T Ree
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium	Result 0.101 0.112) LCS Resul 51.7 50.8 51.5 50.5 ke result. RPD	R 0 0 Date QC P	esult .101 .111 Analyzed: reparation Units mg/L mg/L mg/L	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I I I J Dike and spike	2. Amoun 0.100 0.100 5 5 4 5 50 50 50 50 50 50 50 50 50	t Rec. 101 112 Matrix Result 0 0 0 0	Rec. 101 111 An Pre R 10 10 11	ec. ec. 03.4 03.4	Limit 81.8 - 11 72.7 - 11 By: T By: T Rea Lin
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spil	Result 0.101 0.112) LCS Resul 51.7 50.8 51.5 50.5 ke result. RPD LCSD	R 0 0 Date QC P	esult .101 .111 Analyzed: reparation Units mg/L mg/L mg/L mg/L cd on the sp	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I I I J bike and spike Spike	Amount 0.100 0.100 5 5 4 5 5 4 5 5 5 0 50 50 50 50 50 50 50 50 50 50 5	t Rec. 101 112 Matrix Result 0 0 0 0 0 0 0 0 0 0 0 0 0	Rec. 101 111 An Pre R 10 10 11 1 Rec.	ec. 03.4 01.6 01	Limit 81.8 - 11 72.7 - 11 By: T By: T Rea Lin
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spil Param	Result 0.101 0.112) LCS Resul 51.7 50.8 51.5 50.5 ke result. RPD LCSD Result	R 0 0 Date QC P It is base	esult .101 .111 Analyzed: reparation Units mg/L mg/L mg/L mg/L cd on the sp Dil.	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I I J pike and spike Spike Amount	Amoun 0.100 0.100 5 5 4 5 5 4 5 5 5 5 0 50 50 50 50 50 50 50 50 50 50	t Rec. 101 112 Matrix Result 0 0 0 0 ult. Rec.	Rec. 101 111 An Pre R 10 10 11	ec. 03.4 01 RPD	Limit 81.8 - 11 72.7 - 11 By: T By: T Rea Lim
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spil Param Dissolved Calcium	Result 0.101 0.112) LCS Resul 51.7 50.8 51.5 50.5 ke result. RPD LCSD Result 51.7	R 0 0 Date QC P It is base Units mg/L	esult .101 .111 Analyzed: reparation Units mg/L mg/L mg/L mg/L mg/L d on the sp Dil. 1	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I I J pike and spike Amount 50	Amount 0.100 0.100 5 5 4 5 5 4 5 5 5 0 50 50 50 50 50 50 50 50 50 50 5	t Rec. 101 112 Matrix Result 0 0 0 0 0 0 0 0 0 0 0 0 0	Rec. 101 111 An Pre R 10 10 11 1 Rec.	ec. 03.4 01.6 01	Limit 81.8 - 11 72.7 - 11 By: T By: T Ret Lim RP Lim 20
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spil Param Dissolved Calcium Dissolved Calcium Dissolved Potassium	Result 0.101 0.112) LCS Resul 51.7 50.8 51.5 50.5 ke result. RPD LCSD Result	R 0 0 Date QC P It is base Units mg/L mg/L	esult .101 .111 Analyzed: reparation Units mg/L mg/L mg/L mg/L mg/L d on the sp Dil. 1	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I I J pike and spike Spike Amount	Amount 0.100 0.100 0.100 5 5 4 5 5 4 5 5 5 5 0 50 50 50 50 50 50 50 50 50 50	t Rec. 101 112 Matrix Result 0 0 0 0 ult. Rec.	Rec. 101 111 An Pre R 10 10 11 1 Rec.	ec. 03.4 01 RPD 0 3	Limit 81.8 - 11 72.7 - 1 By: T By: T Ret Lin RP Lin 20 20
Trifluorotoluene (TFT) 4-Bromofluorobenzene (4-BFB) Laboratory Control Spike (LCS-1 QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spil Param Dissolved Calcium	Result 0.101 0.112) LCS Resul 51.7 50.8 51.5 50.5 ke result. RPD LCSD Result 51.7 49.3	R 0 0 Date QC P It is base Units mg/L	esult .101 .111 Analyzed: reparation Units mg/L mg/L mg/L mg/L mg/L cd on the sp Dil. 1 1	mg/L I mg/L I 2006-07-20 2006-07-24 Dil. I I J Dike and spike Spike Amount 50 50	Amount 0.100 0.100 0.100 5 5 4 5 5 4 5 5 5 5 0 50 50 50 50 50 50 50 50 50 50	t Rec. 101 112 Matrix Result 0 0 0 0 0 0 0 0 0 0 0 0 0	Rec. 101 111 An Pre R 10 10 11 1 Rec.	ec. 03.4 01.6 03 01 RPD 0	Limit 81.8 - 11 72.7 - 1 By: T By: T Re Lin RP Lin 20

に発展

を

And the sea

調整

222

and the

202

S. S. S. Sand

Total Land

2.14.50

Section 2

000.01	00000	D	200(00 02		
QC Batch:	28/82	Date Analyzed:	2006-08-02	Analyzed By:	WВ
Prep Batch:	25167	QC Preparation:	2006-08-02	Prepared By:	WB

BD Zachary Hinton		Work Order: 6072143 BD Zachary Hinton						Page Number: 6 of 10 Lea County,NM			
	LCS	8			Spike	Mati	-ix		Rec.		
Param	Resu	ılt	Units	Dil.	Amoun	t Resi	ılt	Rec.	Limi		
Chloride	12.2	2	mg/L	1	12.5	0		97.6			
Sulfate	12.:	5	mg/L	1	12.5	0		100			
Percent recovery is based on the sp	pike result. RPD	is based	on the s	pike and s	pike duplicate	result.					
	LCSD			Spik	e Matrix		Rec.		RPD		
Param	Result	Units	Dil.	Amou	int Result	Rec.	Limit	RPD	Limi		
Chloride	12.3	mg/L	1	12.5	5 0	97.6		0.8	20		
Sulfate	12.5	mg/L	1	12.5	5 0	100		0	20		
Matrix Spike (MS-1) Spiked S	ample: 96149										
QC Batch: 28277	ample: 96149		nalyzed:	2006-0' 2006-0'				nalyzed By repared By:			
QC Batch: 28277	ample: 96149 ⁻ MS		-			Matrix		repared By:			
QC Batch: 28277		QC Pre	-		7-24	Matrix Result		repared By:	MŢ		
QC Batch: 28277 Prep Batch: 24759	MS	QC Pre	paration:	2006-0'	7-24 Spike Amount 0.100		Pr	repared By: c. 17 70	MT Rec. Limit .9 - 120		
QC Batch: 28277 Prep Batch: 24759 Param Benzene	MS Result	QC Pre	paration: hits g/L	2006-0'	7-24 Spike Amount 0.100 0.100	Result <0.000255 <0.000210	Pr 	repared By: cc. 07 70 05 70	MT Rec. Limit .9 - 126 .8 - 125		
QC Batch: 28277 Prep Batch: 24759 Param Benzene Toluene Ethylbenzene	MS Result 0.107 0.105 0.106	QC Pre	paration: hits g/L g/L g/L	2006-0'	7-24 Spike Amount 0.100 0.100 0.100	Result <0.000255 <0.000210 <0.000317	Pr Re 10 10 10	repared By: 	MT Rec. Limit .9 - 120 .8 - 125 .8 - 125		
QC Batch: 28277 Prep Batch: 24759 Param Benzene Toluene	MS Result 0.107 0.105	QC Pre	paration: hits g/L g/L g/L	2006-0'	7-24 Spike Amount 0.100 0.100	Result <0.000255 <0.000210	Pr 	repared By: 	MT Rec. Limit .9 - 120 .8 - 123		
QC Batch: 28277 Prep Batch: 24759 Param Benzene Toluene Ethylbenzene	MS Result 0.107 0.105 0.106 0.311	QC Pre	paration: hits g/L g/L g/L g/L	2006-0' Dil. 1 1 1	7-24 Spike <u>Amount</u> 0.100 0.100 0.100 0.300	Result <0.000255 <0.000210 <0.000317 <0.000603	Pr Re 10 10 10	repared By: 	MT Rec. Limit .9 - 120 .8 - 123 .8 - 123		

		MSD			Spike	Matrix		Rec.		RPD
Param		Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Benzene	2	NA	mg/L	1	0.100	< 0.000255	0	70.9 - 126	200	20
Toluene	3	NA	mg/L	1	0.100	< 0.000210	0	70.8 - 125	200	20
Ethylbenzene	4	NA	mg/L	1	0.100	< 0.000317	0	74.8 - 125	200	20
Xylene	5	NA	mg/L	1	0.300	< 0.000603	0	75.7 - 126	200	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

0		MS	MSD	.	D'1	Spike	MS	MSD	Rec.
Surrogate		Result	Result	Units	Dil.	Amount	Rec.	Rec.	Limit
Trifluorotoluene (TFT)	6	0.101	NA	mg/L	1	0.1	101	0	73.6 - 121
4-Bromofluorobenzene (4-BFB)	7	0.110	NA	mg/L	1	0.1	110	0	81.8 - 114

Matrix Spike (MS-1) Spiked Sample: 96124

,

(There is

が歌き

S. S. S. S.

聖堂湯本

Ser sie

2 aligned

S. S. S. S.

Const and

A31.32

認定に呈

16 N. W.

記るの違い

S. North Co

S. 44.62

AN 124.

No.

QC Batch:	28356	Date Analyzed:	2006-07-26	Analyzed By:	TP
Prep Batch:	24749	QC Preparation:	2006-07-24	Prepared By:	TS

⁴RPD is out of range because a matrix spike duplicate was not prepared.
 ⁵RPD is out of range because a matrix spike duplicate was not prepared.

⁶RPD is out of range because a matrix spike duplicate was not prepared.

⁷RPD is out of range because a matrix spike duplicate was not prepared.

²RPD is out of range because a matrix spike duplicate was not prepared.

³RPD is out of range because a matrix spike duplicate was not prepared.

Report Date: August 9, 2006		Work Order: 6072143	Page Number: 7 of 10	
BD Zachary Hinton		BD Zachary Hinton	Lea County.NM	
······································	MS	Sp	ike Matrix	Rec.

Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Dissolved Calcium	416	mg/L	1	50.0	361	110	68.4 - 138
Dissolved Potassium	73.8	mg/L	1	50.0	22	104	82 - 129
Dissolved Magnesium	208	mg/L	1	50.0	147	122	61.2 - 135
Dissolved Sodium	633	mg/L	1	50.0	578	110	81.8 - 125

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	MSD			Spike	Matrix		Rec.		RPD
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Dissolved Calcium	406	mg/L	- 1	50.0	361	90	68.4 - 138	2	20
Dissolved Potassium	81.3	mg/L	1	50.0	22	119	82 - 129	10	20
Dissolved Magnesium	194	mg/L	1	50.0	147	94	61.2 - 135	7	20
Dissolved Sodium	637	mg/L	1	50.0	578	118	81.8 - 125	1	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Matrix Spike (MS-1) Spiked Sample: 96141

QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	QC Preparation:	2006-08-02	Prepared By:	WB

	MS			Spike .	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Chloride	2210	mg/L	100	12.5	988	98	25.4 - 171
Sulfate	1580	mg/L	100	12.5	298	102	0 - 677

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	MSD			Spike	Matrix		Rec.		RPD
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Chloride	2200	mg/L	100	12.5	988	97	25.4 - 171	0	20
Sulfate	1550	mg/L	100	12.5	298	100	0 - 677	2	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Standard (ICV-1)

QC Batch: 28277			Date Analy	zed: 2006-07-	Analyzed By: MT		
			ICVs	ICVs	ICVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Benzene		mg/L	0.100	0.104	104	85 - 115	2006-07-24
Toluene		mg/L	0.100	0.104	104	85 - 115	2006-07-24
Ethylbenzene		mg/L	0.100	0.104	104	85 - 115	2006-07-24
Xylene		mg/L	0.300	0.314	. 105	85 - 115	2006-07-24

Standard (CCV-1)

QC Batch: 28277

Date Analyzed: 2006-07-24

Analyzed By: MT

N. MARINE

100

Report Date: August 9, 2006 BD Zachary Hinton		9, 2006 Work Order: 6072143 BD Zachary Hinton				Page Number: 8 of 10 Lea County,NM		
Param	Flag	Units	CCVs True Conc.	CCVs Found Conc.	CCVs Percent Recovery	Percent Recovery Limits	Date Analyzed	
Benzene	1 145	mg/L	0.100	0.107	107	85 - 115	2006-07-24	
Toluene		mg/L	0.100	0.105	105	85 - 115	2006-07-24	
Ethylbenzene		mg/L	0.100	0.106	106	85 - 115	2006-07-24	
Xylene		mg/L	0.300	0.311	104	85 - 115	2006-07-24	

Standard (ICV-1)

QC Batch: 28340		D	ate Analyzed:	2006-07-26	Analyzed By: LJ		
			lCVs	ICVs	ICVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Total Alkalinity		mg/L as CaCo3	250	240	96	90 - 110	2006-07-26
Standard (CCV-1) QC Batch: 28340		D	ate Analyzed:	2006-07-26		Ana	alyzed By: LJ
			CCVs	CCVs	CCVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Total Alkalinity	-	mg/L as CaCo3	250	240	96	90 - 110	2006-07-26

Standard (ICV-1).

QC Batch: 28356			Date Analyzed:	2006-07-26		Ana	alyzed By: TP
			ICVs	ICVs	ICVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Dissolved Calcium		mg/L	50.0	50.7	101	90 - 110	2006-07-26
Dissolved Potassium		mg/L	50.0	52.0	104	90 - 110	2006-07-26
Dissolved Magnesium		mg/L	50.0	49.6	99	90 - 110	2006-07-26
Dissolved Sodium		mg/L	50.0	50.9	102	90 - 110	2006-07-26

Standard (CCV-1)

QC Batch: 28356			Date Analyzed:	2006-07-26		Ana	alyzed By: TP
			CCVs True	CCVs Found	CCVs Percent	Percent Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Dissolved Calcium		mg/L	50.0	51.2	102	90 - 110	2006-07-26
Dissolved Potassium		mg/L	50.0	54.6	109	90 - 110	2006-07-26
Dissolved Magnesium		mg/L	50.0	50.0	100	90 - 110	2006-07-26
Dissolved Sodium		mg/L	50.0	53.2	106	90 - 110	2006-07-26

States and

a bass

14 P. 19

- Barlander

の時代

Standard (ICV-1)							
QC Batch: 28406		Da	te Analyzed:	2006-07-27	7	Ana	lyzed By: SN
			ICVs	ICVs	ICVs	Percent	
			True	Found	Percent	Recovery	Date
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed
Total Dissolved Solids		mg/L	1000	1056	106	90 - 110	2006-07-2
Standard (CCV-1)							
QC Batch: 28406		Da	te Analyzed:	2006-07-27	7	Ana	lyzed By: SN
			CCVs	CCVs	CCVs	Percent	
							D .
			True	Found	Percent	Recovery	Date
Param	Flag	Units	True Conc.	Found Conc.	Percent Recovery	Recovery Limits	
Total Dissolved Solids Standard (ICV-1)	Flag	mg/L		Conc. 1075	Recovery 108	Limits 90 - 110	Analyzec 2006-07-2
Total Dissolved Solids Standard (ICV-1)	Flag	mg/L	Conc. 1000	Conc. 1075	Recovery 108	Limits 90 - 110	Analyzec 2006-07-2
Param Total Dissolved Solids Standard (ICV-1) QC Batch: 28782	Flag	mg/L Da	Conc. 1000	Conc. 1075 2006-08-02	Recovery 108	Limits 90 - 110 Anal	Analyzec 2006-07-2
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782	Flag	mg/L Da ICV	Conc. 1000 e Analyzed: s I(Fo	Conc. 1075 2006-08-02 CVs	Recovery 108 ICVs	Limits 90 - 110 Anal Percent	Analýzed 2006-07-2 yzed By: Wł Date
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag		mg/L Da ICV True	Conc. 1000 te Analyzed: s IG Fo C	Conc. 1075 2006-08-02 CVs pund	Recovery 108 ICVs Percent	Limits 90 - 110 Anal Percent Recovery	Analýzed 2006-07-2 yzed By: Wi Date Analyzed
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782	Units	mg/L Da ICV True Conc	Conc. 1000 e Analyzed: s 10 - Fo - C 1	Conc. 1075 2006-08-02 CVs bund onc.	Recovery 108 ICVs Percent Recovery	Limits 90 - 110 Anal Percent Recovery Limits	Analyzed 2006-07-2 yzed By: Wi Date Analyzed 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate	Units mg/L	mg/L Da ICV True Cone 12.5	Conc. 1000 e Analyzed: s 10 - Fo - C 1	Conc. 1075 2006-08-02 CVs pund onc. 2.4	Recovery 108 ICVs Percent Recovery 99	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110	Analyzed 2006-07-2 yzed By: WI Date Analyzed 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1)	Units mg/L	mg/L Da ICV True Cond 12.5 12.5	Conc. 1000 e Analyzed: s 10 - Fo - C 1	Conc. 1075 2006-08-02 CVs pund onc. 2.4 2.7	Recovery 108 ICVs Percent Recovery 99 102	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110	Analyzed 2006-07-2 yzed By: Wl Date Analyzed 2006-08-0 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1)	Units mg/L	mg/L Da ICV True Conc 12.5 12.5 Da	Conc. 1000 e Analyzed: s 10 Fo C C 1 1 1 e Analyzed:	Conc. 1075 2006-08-02 CVs pund onc. 2.4 2.7	Recovery 108 ICVs Percent Recovery 99 102	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110	Analyzed 2006-07-2 yzed By: Wl Date Analyzed 2006-08-0 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1)	Units mg/L	mg/L Da ICV True Cond 12.5 12.5	Conc. 1000 e Analyzed: s 10 Fo C 1 1 e Analyzed: s C	Conc. 1075 2006-08-02 CVs pund onc. 2.4 2.7 2006-08-02	Recovery 108 ICVs Percent Recovery 99 102	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 90 - 110 Anal Percent	Analyzed 2006-07-2 yzed By: Wł
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782	Units mg/L	mg/L Da ICV True Cond 12.5 12.5 Da CCV	Conc. 1000 e Analyzed: s IG Fo C I 1 1 e Analyzed: s C Fo Fo Fo Fo Fo Fo Fo Fo Fo Fo	Conc. 1075 2006-08-02 CVs ound onc. 2.4 2.7 2006-08-02 CVs	Recovery 108 ICVs Percent Recovery 99 102 CCVs	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 90 - 110	Analyzed 2006-07-2 yzed By: WI Date Analyzed 2006-08-0 2006-08-0 yzed By: WI
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782	Units mg/L mg/L	mg/L Da ICV True Conc 12.5 12.5 Da CCV True	Conc. 1000 e Analyzed: s IG FC C I 1 1 ve Analyzed: s C FC c C C C	Conc. 1075 2006-08-02 CVs ound onc. 2.4 2.7 2006-08-02 CVs ound	Recovery 108 ICVs Percent Recovery 99 102 CCVs Percent	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 90 - 110 Anal Percent Recovery	Analyzed 2006-07-2 yzed By: WI Date Analyzed 2006-08-0 2006-08-0 yzed By: WI Date

And Alang

Ang X

- 西美市市

Sala and

Party Law

1.4

建化截

SANK.

S. 2. 2.

S. Mark

Mar Charles

からう

1994 × 390.

Star Bar

14 ST.2

STATE:

Seal and

Report Date: August 9, 2006 **BD** Zachary Hinton

Brank town

Nymaprised er it

てもない

12. C. L.

の理論

ALC: NOT

AC XO

100

ないため

S. Second

and set the set

2005

Work Order: 6072143 BD Zachary Hinton

Page Number: 10 of 10 Lea County,NM

,

In MARKEN TRACEANALYSIS, INC.

6701 Aberdeen Avenue, Suite 9 155 McCutcheon, Suite H Lubbock, Texas 79424 800 • 378 • 1296 El Paso, Texas 79932 888 • 588 • 3443 E-Mail lab@traceanalysis.com

 806 • 794 • 1296
 FAX 806 • 794 • 1298

 915 • 585 • 3443
 FAX 915 • 585 • 4944

Analytical and Quality Control Report

Kristen Farris-Pope Rice Operating Company 122 W Taylor Street Hobbs, NM, 88240

語く聞

SCIENCE

No. 2.

2000

P.S. A.S.

1220.00

2362

花

Project Location:Lea County,NMProject Name:BD Zachary HintonProject Number:BD Zachary Hinton

Report Date: August 9, 2006

Work Order: 6072143

Enclosed are the Analytical Report and Quality Control Report for the following sample(s) submitted to TraceAnalysis, Inc.

			Date	Time	Date
Sample	Description	Matrix	Taken	Taken	Received
96140	Monitor Well #1	water	2006-07-19	12:55	2006-07-21

These results represent only the samples received in the laboratory. The Quality Control Report is generated on a batch basis. All information contained in this report is for the analytical batch(es) in which your sample(s) were analyzed.

This report consists of a total of 10 pages and shall not be reproduced except in its entirety, without written approval of TraceAnalysis, Inc.

Michael april

Dr. Blair Leftwich, Director

Report Date: August 9, 2006 BD Zachary Hinton

A the fure

Star Star

Salaged S

いないない

の言語を言い

X. 243

Prostant Co

Frezzie

1. W. W.

Bert and

K. 400

Sectors.

の構成する

Analytical Report

Sample: 96140 - Monitor Well #1

Analysis:	Alkalinity		Analytical Method:	SM 2320B	Prep Method:	N/A
QC Batch:	28340		Date Analyzed:	2006-07-26	Analyzed By:	LJ
Prep Batch:	24777		Sample Preparation:	2006-07-25	Prepared By:	LJ
			RL			
Parameter		Flag	Result	Units	Dilution	RL
Hydroxide A	Alkalinity		<1.00	mg/L as CaCo3	1	1.00
Carbonate A	lkalinity		<1.00	 mg/L as CaCo3 	I	1.00
Bicarbonate	Alkalinity		188	mg/L as CaCo3	1	4.00
Total Alkalir	nity		188	mg/L as CaCo3	1	4.00

Sample: 96140 - Monitor Well #1

Analysis: BTEX		Analytical M	1ethod:	S 8021B		Prep Meth	od: S 5030B
QC Batch: 28277		Date Analyz	ed:	2006-07-24		Analyzed	By: MT
Prep Batch: 24759		Sample Prep	aration:	2006-07-24		Prepared E	By: MT
		R	L				
Parameter Flag		Resu	ıłt	Units	I	Dilution	RL
Benzene		< 0.0010	00	mg/L		1	0.00100
Toluene		< 0.0010	0	mg/L		1	0.00100
Ethylbenzene		< 0.0010	00	mg/L		1	0.00100
Xylene		< 0.0010)0	mg/L		1	0.00100
					Spike	Percent	Recovery
Surrogate	Flag	Result	Units	Dilution	Amount	Recovery	Limits
Tri uorotoluene (TFT)		0.0961	mg/L	1	0.100	96	66.2 - 127.7
4-Bromo uorobenzene (4-BFB)	1	0.0585	mg/L	1	0.100	58	70.6 - 129.2

Sample: 96140 - Monitor Well #1

Analysis:CationsQC Batch:28356Prep Batch:24749		Analytical Method: Date Analyzed: Sample Preparation:	S 6010B 2006-07-26 2006-07-24	Prep Method: Analyzed By: Prepared By:	
		RL			
Parameter	Flag	Result	Units	Dilution	RL
Dissolved Calcium		98.2	mg/L	<u>l</u>	0.500
Dissolved Potassium		12.8	mg/L	· 1	1.00
Dissolved Magnesium		49.3	mg/L	1	1.00
Dissolved Sodium		230	mg/L	10	1.00

Sample: 96140 - Monitor Well #1

Analysis:	Ion Chromatography	Analytical Method:	E 300.0	Prep Method:	N/A
QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	Sample Preparation:	2006-08-02	Prepared By:	WB

¹BFB surrogate recovery outside normal limits. ICV/CCV and TFT surrogate recovery show the method to be in control.

Report Date: August 9, 2006 BD Zachary Hinton				er: 6072143 ary Hinton			umber: 3 of ea County,N
		RL		TT	~ .	·• . •	
Parameter Flag Chloride		Result 375		Units	D	ilution	R 0.50
Sulfate		375 234		mg/L mg/L		50 50	0.50
				ing/L			
Sample: 96140 - Monitor Well #	1						
Analysis: TDS		Analytical	Method:	SM 2540C		Prep N	1ethod: N/.
QC Batch: 28406		Date Analy		2006-07-27			zed By: SN
Prep Batch: 24850		Sample Pre		2009-07-26		Prepar	ed By: SN
D		D	RL	Linite		Dilution	D
Parameter Total Dissolved Solids	Flag		lesult 1318	Units		Dilution 2	R 10.0
Total Dissolved Solids		<u></u>	1318	mg/L		2	10.0
Method Blank (1) QC Batch:	28277				•		
QC Batch: 28277		Date And	luzed	2006-07-24		Δ nah/	zed By: M
Prep Batch: 24759		Date Analyzed: 2006-07-24 QC Preparation: 2006-07-24				Prepar	-
Parameter Benzene Toluene	Flag		< 0.0	MDL Result 00255 00210	Uni mg/ mg/	L	RL 0.00 0.00
Ethylbenzene			< 0.0	00317	mg/		0.00
Xylene			< 0.0	00603	mg/		0.00
Surrogate	Flag	Result	Units	Dilution	Spike Amount	Percent Recovery	Recover Limits
Tri uorotoluene (TFT)	8	0.0949	mg/L		0.100	95	76.1 - 11
4-Bromo uorobenzene (4-BFB).		0.0633	mg/L	1	0.100	63	58.5 - 1
Method Blank (1) QC Batch: QC Batch: 28340	28340	Date An	aluzad:	2006-07-26		Anali	yzed By: L
Prep Batch: 24777		QC Prep		2006-07-25			red By: L
Parameter	Flag			4DL esult	Uni	ts	R
Hydroxide Alkalinity	1 ,415			1.00	mg/L as		
Carbonate Alkalinity				1.00	mg/L as]
Bicarbonate Alkalinity				4.00	mg/L as		2
Total Alkalinity			/	4.00	mg/L as	CaCo3	4

Method Blank (1) QC Batch: 28356

QC Batch:	28356	Date Analyzed:	2006-07-26	Analyzed By:	ТΡ
Prep Batch:	24749	QC Preparation:	2006-07-24	Prepared By:	TS

学校に

Section 2

Sec. 20

startes.

A STATE

S-SECTION S-

3.3. m. m.

473-3- Ag

22.22

CALLS.

No Ken

1. 囊囊音乐

Section 1

17. 18. A

N. AND

Report Date: August 9, 2006	Work Order: 6072143	Page Number: 4 of 10
BD Zachary Hinton	BD Zachary Hinton	Lea County.NM
		· · · · · · · · · · · · · · · · · · ·

		MDL		
Parameter	Flag	Result	Units	RL
Dissolved Calcium		0.132	mg/L	0.5
Dissolved Potassium		1.08	mg/L	· I
Dissolved Magnesium		< 0.704	mg/L	1
Dissolved Sodium		0.836	mg/L	1

Method Blank (1) QC Batch: 28406

States and

No. No. of Concession, No.

Carles &

1. 282 . The

The second

3.962

No. and

いまた

Partie a

なが、愛

潮運興

12.22

QC Batch: 28406		Date Analyzed: 2006-07-27	7	Analyzed By:	SM
Prep Batch: 24850		QC Preparation: 2006-07-26	5	Prepared By:	SM
		MDL			
Parameter	Flag	Result	Units		RL
Total Dissolved Solid	ls	< 5.000	mg/L		10

Method Blank (1) QC Batch: 28782

QC Batch: Prep Batch:	28782 25167		Date Analyzed: QC Preparation:			Analyzed By: Prepared By:	
Parameter		Flag		MDL Result	Units		RL
Chloride			<0	.0181	mg/L		0.5
Sulfate			<0	.0485	mg/L		0.5

Duplicates (1)

QC Batch:	28340	Date Analyzed:	2006-07-26	Analyzed By:	LJ
Prep Batch:	24777	QC Preparation:	2006-07-25	Prepared By:	LJ

	Duplicate	Sample				RPD	
Param	Result	Result	Units	Dilution	RPD	Limit	
Hydroxide Alkalinity	<1.00	<1.00	mg/L as CaCo3	1	0	20	
Carbonate Alkalinity	<1.00	<1.00	mg/L as CaCo3	1	0	20	
Bicarbonate Alkalinity	110	108	mg/L as CaCo3	1	2	12.6	
Total Alkalinity	110	108	mg/L as CaCo3	1	2	11.5	

Duplicates (1)

QC Batch: 28406 Prep Batch: 24850		Analyzed: 200 reparation: 200	06-07-27 06-07-26	Analyzed E Prepared B	-	
	Duplicate	Sample				RPD
Param	Result	Result	Units	Dilution	RPD	Limit
Total Dissolved Solids	768.0	928.0	mg/L	2	19	17.2

BD Zachary Hinton			BD Zac	hary Hinton				Lea C	ounty,N
Laboratory Control Spike (LCS-	1)								
2C Batch: 28277 Prep Batch: 24759			Analyzed: reparation:	2006-07-24 2006-07-24				alyzed E pared B	
	LC	S			Spike	Matrix			Red
Param	Res		Units	_Dil.	Amount	Result		ec.	Lin
Benzene	0.10)9	mg/L	1	0.1	0	1	09	
Foluene	0.10)8	mg/L	1	0.1	0		08	
Ethylbenzene	0.10)9	mg/L	1 -	0.1	0	l	09	
Xylene	0.32	22	mg/L	1	0.3	0	107	.333	
Percent recovery is based on the spi	ike result. RP	D is base	ed on the sp	ike and spike	duplicate res	ult.			
.	LCSD		.	Spike	Matrix	D	Rec.		RP
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Lin
	0.104	mg/L	1	0.1	0	109		4.7	20
Benzene	0	mg/L	1	0.1	0.	108		4.7	20
Toluene	0.103	-							
Foluene Ethylbenzene	0.101	mg/L	1	0.1	0	109		7.6	
Foluene Ethylbenzene Xylene Percent recovery is based on the spi	0.101 0.306 ike result. RP LCS	mg/L mg/L D is base	1 ed on the sp CSD	0.3 ike and spike	0 duplicate res Spike	107.333 ult. LCS	LCS Rec	5.1 D	20 Rec.
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT)	0.101 0.306 ike result. RP LCS Resu 0.10	mg/L mg/L D is base L It R I 0	1 ed on the sp CSD esult U .101 n	0.3 ike and spike Units Dil. ng/L I	0 duplicate res Spike Amour 0.100	107.333 ult. LCS nt Rec. 101	Rec 101	5.1 D	20 Rec. Limit 31.8 - 1
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate	0.101 0.306 ike result. RP LCS Resu	mg/L mg/L D is base L It R I 0	1 ed on the sp CSD esult U .101 n	0.3 ike and spike Jnits Dil.	0 duplicate res Spike Amour	107.333 ult. LCS nt Rec. 101	Rec	5.1 D	20 Rec. Limit 31.8 - 1
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT)	0.101 0.306 ike result. RP LCS Resu 0.10 0.11	mg/L mg/L D is base L It R I 0	1 ed on the sp CSD esult U .101 n	0.3 ike and spike Units Dil. ng/L I	0 duplicate res Spike Amour 0.100	107.333 ult. LCS nt Rec. 101	Rec 101	5.1 D	20 Rec. Limit 31.8 - 11
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS-	0.101 0.306 ike result. RP LCS Resu 0.10 0.11	mg/L mg/L D is base L L L L R 1 0 2 0	1 ed on the sp CSD esult U .101 n .111 n	0.3 ike and spike Jnits Dil. ng/L 1 ng/L 1	0 duplicate res Spike Amour 0.100 0.100	107.333 ult. LCS nt Rec. 101	Rec 101 111	5.1 D	20 Rec. Limit 31.8 - 11 72.7 - 11
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356	0.101 0.306 ike result. RP LCS Resu 0.10 0.11	mg/L mg/L D is base L L L T 0 2 0 Date	1 ed on the sp CSD esult U .101 n .111 n Analyzed:	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26	0 duplicate res Spike Amour 0.100 0.100	107.333 ult. LCS nt Rec. 101	Rec 101 111	5.1 D 5.	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS-	0.101 0.306 ike result. RP LCS Resu 0.10 0.11	mg/L mg/L D is base L L L T 0 2 0 Date	1 ed on the sp CSD esult U .101 n .111 n	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26	0 duplicate res Spike Amour 0.100 0.100	107.333 ult. LCS nt Rec. 101	Rec 101 111	5.1 D	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749	0.101 0.306 ike result. RP LCS <u>Resu</u> 0.10 0.111 1)	mg/L mg/L D is base L L L H T O 2 O D ate QC P	1 ed on the sp CSD esult U .101 n .111 n Analyzed: reparation:	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26 2006-07-24	0 duplicate res <u>Amour</u> 0.100 0.100	107.333 ult. LCS nt Rec. 101 112 Matrix	Rec 101 111 A1 Pr	5.1 D 2. halyzed epared I	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T By: T Rec
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param	0.101 0.306 ike result. RP LCS Resu 0.10 0.11 1)	mg/L mg/L D is base L It R 1 0 2 0 Date QC P	1 ed on the sp CSD esult U .101 m .111 m Analyzed: reparation: Units	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26	0 duplicate res Spike 0.100 0.100 0.100	107.333 ult. LCS nt Rec. 101 112 Matrix Result	Rec 101 111 A1 Pr	5.1 D 	Limit 31.8 - 11 72.7 - 11 By: T
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium	0.101 0.306 ike result. RP: LCS Resu 0.10 0.11 1)	mg/L mg/L D is base L It R I 0 2 0 Date QC P CS Sult .7	1 ed on the sp CSD esult U .101 n .111 n Analyzed: reparation: Units mg/L	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26 2006-07-24	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100	107.333 ult. LCS nt Rec. 101 112 Matrix Result 0	Rec 101 111 A1 Pr F	5.1 D 	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T Rec
Foluene Ethylbenzene Kylene Percent recovery is based on the spi Surrogate Tri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium	0.101 0.306 ike result. RP: LCS Resu 0.10 0.11 1) 1) LC Res 51 50	mg/L mg/L D is base L It R I 0 2 0 Date QC P CS cult .7 .8	1 ed on the sp CSD esult U .101 m .111 r Analyzed: 'reparation: Units mg/L mg/L	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26 2006-07-24	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 50 50 50	107.333 ult. LCS nt Rec. 101 112 Matrix Result 0 0	Rec 101 111 A1 Pr F	5.1 D 	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T Rec
Foluene Ethylbenzene Kylene Percent recovery is based on the spi Surrogate Tri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium	0.101 0.306 ike result. RP: LCS Resu 0.10 0.111 1) 1) LC Res 51 50 51	mg/L mg/L D is base L It R I 0 2 0 Date QC P CS sult .7 .8 .5	1 ed on the sp CSD esult U .101 m .111 m Analyzed: reparation: Units mg/L mg/L	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26 2006-07-24	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 0.100 5.0 50 50 50 50	107.333 ult. LCS nt Rec. 101 112 Matrix Result 0 0 0	Rec 101 111 A1 Pr F	5.1 D 	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T Rec
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium	0.101 0.306 ike result. RP: LCS Resu 0.10 0.111 1) LC Res 51 50 51 50 51 50	mg/L mg/L D is base L It R 1 0 2 0 Date QC P CS sult .7 .8 .5 .5	1 ed on the sp CSD esult U .101 m .111 m Analyzed: reparation: units mg/L mg/L mg/L	0.3 ike and spike <u>Jnits</u> Dil. ng/L 1 2006-07-26 2006-07-24 Dil. 1 1 1 1 1	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 0.100 5.0 50 50 50 50 50	107.333 ult. LCS nt Rec. 101 112 Matrix Result 0 0 0 0	Rec 101 111 A1 Pr F	5.1 D 	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T By: T Rec
Foluene Ethylbenzene Kylene Percent recovery is based on the spi Surrogate Tri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium	0.101 0.306 ike result. RP: LCS Resu 0.10 0.111 1) LC Res 51 50 51 50 ike result. RP:	mg/L mg/L D is base L It R 1 0 2 0 Date QC P CS sult .7 .8 .5 .5	1 ed on the sp CSD esult U .101 m .111 m Analyzed: reparation: units mg/L mg/L mg/L	0.3 ike and spike <u>Jnits</u> Dil. ng/L 1 2006-07-26 2006-07-24 Dil. 1 1 1 1 1 1 1 1 1 1 1 1 1	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 0.100 5.0 50 50 50 50 50 50 50 50 50 duplicate res	107.333 ult. LCS nt Rec. 101 112 Matrix Result 0 0 0 0	Rec 101 111 A1 Pr	5.1 D 	20 Rec. Limit 31.8 - 11 72.7 - 11 72.7 - 11 72.7 - 11 72.7 - 11 72.7 - 11 72.7 - 11
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium	0.101 0.306 ike result. RP: LCS Resu 0.10 0.111 1) LC Res 51 50 51 50 51 50	mg/L mg/L D is base L It R 1 0 2 0 Date QC P CS sult .7 .8 .5 .5	1 ed on the sp CSD esult U .101 m .101 m .111 m Analyzed: reparation: Treparation: mg/L mg/L mg/L mg/L mg/L mg/L on the sp	0.3 ike and spike <u>Jnits</u> Dil. ng/L 1 2006-07-26 2006-07-24 Dil. 1 1 1 1 1	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 0.100 5.0 50 50 50 50 50	107.333 ult. LCS nt Rec. 101 112 Matrix Result 0 0 0 0	Rec 101 111 A1 Pr F	5.1 D 	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T Rec
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) Laboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spi	0.101 0.306 ike result. RP: LCS Resu 0.10 0.111 1) LCS 51 50 51 50 ike result. RP: LCSD	mg/L mg/L D is base L It R I 0 2 0 Date QC P CS cult .7 .8 .5 .5 D is base	1 ed on the sp CSD esult U .101 m .101 m	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26 2006-07-24 Dil. 1 1 1 1 1 ike and spike Spike	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 0.100 5.0 50 50 50 50 50 50 50 duplicate res Matrix	107.333 ult. LCS at Rec. 101 112 Matrix Result 0 0 0 0 0 0 0 0	Rec 101 111 A1 Pr	5.1 D 2. halyzed epared H Rec. 03.4 01.6 103 101	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T By: T Rea Lim
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) 4-Bromo uorobenzene (4-BFB) 2-aboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spi Param	0.101 0.306 ike result. RP: LCS Resu 0.10 0.111 1) LCS Res 51 50 51 50 ike result. RP: LCSD Result	mg/L mg/L D is base L It R I 0 2 0 Date QC P CS cult .7 .8 .5 .5 D is base Units	1 ed on the sp CSD esult U .101 m .101 m .111 m Analyzed: reparation: Units mg/L mg/L mg/L mg/L mg/L on the sp Dil. 1 1	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26 2006-07-24 Dil. 1 1 1 1 ike and spike Amount	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 5.0 50 50 50 50 50 50 50 50 duplicate res Matrix Result	107.333 ult. LCS at Rec. 101 112 Matrix Result 0 0 0 0 0 0 0 0 0 0 0	Rec 101 111 A1 Pr	5.1 D 2. halyzed epared H Rec. 03.4 01.6 103 101 RPD	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T Rea Lim
Foluene Ethylbenzene Xylene Percent recovery is based on the spi Surrogate Fri uorotoluene (TFT) 4-Bromo uorobenzene (4-BFB) 4-Bromo uorobenzene (4-BFB) 4-Bromo uorobenzene (4-BFB) 2-aboratory Control Spike (LCS- QC Batch: 28356 Prep Batch: 24749 Param Dissolved Calcium Dissolved Potassium Dissolved Magnesium Dissolved Sodium Percent recovery is based on the spi Param Dissolved Calcium	0.101 0.306 ike result. RP: LCS Resu 0.10 0.112 1) LCS Res 51 50 51 50 51 50 ike result. RP: LCSD Result 51.7	mg/L mg/L D is base L It R I 0 2 0 Date QC P CS sult .7 .8 .5 .5 D is base Units mg/L	1 ed on the sp CSD esult U .101 m .101 m .111 m Analyzed: reparation: 'reparation: mg/L mg/L mg/L mg/L mg/L ed on the sp Dil. 1 1	0.3 ike and spike Jnits Dil. ng/L 1 2006-07-26 2006-07-24 Dil. 1 1 1 1 1 1 1 1 1 1 1 1 1	0 duplicate res Spike Amour 0.100 0.100 0.100 0.100 0.100 0.50 50 50 50 50 50 50 50 50 50 50 50 50 5	107.333 ult. LCS ht Rec. 101 112 Matrix Result 0 0 0 0 0 0 ult. <u>Rec.</u> 103.4	Rec 101 111 A1 Pr	5.1 D 	20 Rec. Limit 31.8 - 11 72.7 - 11 By: T By: T By: T Rea Lim RP Lim 20

.

QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	QC Preparation:	2006-08-02	Prepared By:	WB

.

なたかで

12.2.1

Contra and

Sec. 1

State P

「「「「

1. A. C.

ALL A

1. J. C. M.

3.8 K

125727

1380

Sec. 82.3

電影

3.33° m

and the part

Sec.

Report Date: August 9, 2006 BD Zachary Hinton	Work Order: 6072143 BD Zachary Hinton						Page Number: 6 of 10 Lea County,NM	
Param	LCS Result	Units	Dil.	Spike Amount	Matrix Result	Rec.	Rec. Limit	
Chloride	12.2	mg/L	1	12.5	0	97.6		
Sulfate	12.5	mg/L	1	12.5	0	100		

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Param	LCSD Result	Units	Dil.	Spike Amount	Matrix Result	Rec.	Rec. Limit	RPD	RPD Limit
Chloride	12.3	mg/L	1	12.5	0	97.6		0.8	20
Sulfate	12.5	mg/L	. 1	12.5	0	100		0	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Matrix Spike (MS-1) Spiked Sample: 96149

and the second

1. B.F.

Billio

Sec. 24

1.10

1.4

P. S. P. S. S.

27 B 32

2. 20 20

100.00

1999 A

あるの

and the second

Stranger .

S. S. S.

QC Batch:	28277	Date Analyzed:	2006-07-24	Analyzed By:	MT
Prep Batch:	24759	QC Preparation:	2006-07-24	Prepared By:	MT

	MS			Spike	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Benzene	0.107	mg/L	1	0.100	< 0.000255	107	70.9 - 126
Toluene	0.105	mg/L	1	0.100	< 0.000210	105	70.8 - 125
Ethylbenzene	0.106	mg/L	1	0.100	< 0.000317	106	74.8 - 125
Xylene	0.311	mg/L	1	0.300	< 0.000603	104	75.7 - 126

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

,		MSD			Spike	Matrix		Rec.		RPD
Param		Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Benzene	2	NA	mg/L	1	0.100	< 0.000255	0	70.9 - 126	200	20
Toluene	3	NA	mg/L	I	0.100	< 0.000210	0	70.8 - 125	200	20
Ethylbenzene	4	NA	mg/L	I	0.100	< 0.000317	0	74.8 - 125	200	20
Xylene	5	NA	mg/L	1	0.300	< 0.000603	0	75.7 - 126	200	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

		MS	MSD			Spike	MS	MSD	Rec.
Surrogate		Result	Result	Units	Dil.	Amount	Rec.	Rec.	Limit
Tri uorotoluene (TFT)	6	0.101	NA	mg/L	1	0.1	101	0	73.6 - 121
4-Bromo uorobenzene (4-BFB)	7	0.110	NA	mg/L	1	0.1	110	0	81.8 - 114

Matrix Spike (MS-1) Spiked Sample: 96124

QC Batch:	28356	Date Analyzed:	2006-07-26	Analyzed By:	ТР
Prep Batch:	24749	QC Preparation:	2006-07-24	Prepared By:	ΤS

⁵RPD is out of range because a matrix spike duplicate was not prepared. ⁶RPD is out of range because a matrix spike duplicate was not prepared.

⁷RPD is out of range because a matrix spike duplicate was not prepared.

²RPD is out of range because a matrix spike duplicate was not prepared.

³RPD is out of range because a matrix spike duplicate was not prepared.

⁴RPD is out of range because a matrix spike duplicate was not prepared.

Report Date: August 9, 2006	Work Order: 6072143	Page Number: 7 of 10
BD Zachary Hinton	BD Zachary Hinton	Lea County,NM

	MS			Spike	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Dissolved Calcium	416	mg/L	1	50.0	361	110	68.4 - 138
Dissolved Potassium	73.8	mg/L	1	50.0	22	104	82 - 129
Dissolved Magnesium	208	mg/L	1	50.0	147	122	61.2 - 135
Dissolved Sodium	633	mg/L	1	50.0	578	110	81.8 - 125

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	MSD			Spike	Matrix		Rec.		RPD
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Dissolved Calcium	406	mg/L	l	50.0	361	90	68.4 - 138	2	20
Dissolved Potassium	81.3	mg/L	1	50.0	22	119	82 - 129	10	20
Dissolved Magnesium	194	mg/L	1	50.0	147	94	61.2 - 135	7	20
Dissolved Sodium	637	mg/L	J	50.0	578	118	81.8 - 125	1	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Matrix Spike (MS-1) Spiked Sample: 96141

QC Batch:	28782	Date Analyzed:	2006-08-02	Analyzed By:	WB
Prep Batch:	25167	QC Preparation:	2006-08-02	Prepared By:	WB

	MS			Spike	Matrix		Rec.
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit
Chloride	2210	mg/L	100	12.5	988	98	25.4 - 171
Sulfate	1580	mg/L	100	12.5	298	102	0 - 677

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

	MSD			Spike	Matrix		Rec.		RPD
Param	Result	Units	Dil.	Amount	Result	Rec.	Limit	RPD	Limit
Chloride	2200	mg/L	100	12.5	988	97	25.4 - 171	0	20
Sulfate	1550	mg/L	100	12.5	298	100	0 - 677	2	20

Percent recovery is based on the spike result. RPD is based on the spike and spike duplicate result.

Standard (ICV-1)

ALC: NO.

調に開

A. C. S. C.

1. U.S. 1

C. Martin

No.

10 Mar

1992.5

Part in

S. R. L. L.

A Share

QC Batch: 28277			Date Analy	zed: 2006-07-	Ana	Analyzed By: MT		
			ICVs	ICVs	ICVs	Percent		
			True	Found	Percent	Recovery	Date	
Param	Flag	Units	Conc.	Conc.	Recovery	Limits	Analyzed	
Benzene		mg/L	0.100	0.104	104	85 - 115	2006-07-24	
Toluene		mg/L	0.100	0.104	104	85 - 115	2006-07-24	
Ethylbenzene		mg/L	0.100	0.104	104	85 - 115	2006-07-24	
Xylene		mg/L	0.300	0.314	105	85 - 115	2006-07-24	

Standard (CCV-1)

QC Batch: 28277

Date Analyzed: 2006-07-24

Analyzed By: MT

Report Date: August 9 BD Zachary Hinton	9, 2006				Work C BD Za		Page Number: 8 of 10 Lea County,NM					
De se un				CCV Tru	e	CCVs Found	CCVs Percent	Percent Recovery	Date			
Param	Flag	Uni		Con		Conc.	Recovery	Limits	Analyzed			
Benzene			L	0.10		0.107	107	85 - 115	2006-07-2			
Ethylbenzene	luene		L	0.10		0.105 0.106	105 106	85 - 115 85 - 115	2006-07-2 2006-07-2			
Xylene		mg/ mg/		0.10		0.311	100	85 - 115	2006-07-2			
Standard (ICV-1)												
QC Batch: 28340				Date	Analyzed	: 2006-07-26		An	alyzed By: L			
					ICVs	ICVs	ICVs	Percent				
					True	Found	Percent	Recovery	Date			
Param	Flag		Units		Conc.	Conc.	Recovery	Limits	Analyzed			
Total Alkalinity		mg/L	as CaCo	3	250	240	96	90 - 110	2006-07-2			
Standard (CCV-1)												
QC Batch: 28340				Date	Analyzed	: 2006-07-26		An	alyzed By: L			
					CCVs	CCVs	CCVs	Percent	_			
D	-				True	Found	Percent	Recovery	Date			
Param Total Alkalinity	Flag		Units as CaCo		<u>Conc.</u> 250	Conc. 240	Recovery 96	Limits 90 - 110	Analyzee 2006-07-2			
		mg/L				240		90 - 110	2006-07-2			
Standard (ICV-1)												
QC Batch: 28356				Date	Analyzed	: 2006-07-26		Ana	lyzed By: T			
				•	lCVs	. ICVs	ICVs	Percent				
					True	Found	Percent	Recovery	Date			
Param		Flag	Units		Conc.	Conc.	Recovery	Limits	Analyze			
Dissolved Calcium Dissolved Potassium			mg/L		50.0	50.7	101	90 - 110 90 - 110	2006-07-2			
Dissolved Potassium Dissolved Magnesium			mg/L mg/L		50.0 50.0	52.0 49.6	104 99	90 - 110 90 - 110	2006-07-2			
Dissolved Sodium			mg/L mg/L		50.0	49.0 50.9	102	90 - 110	2006-07-2			
Standard (CCV-1)												
QC Batch: 28356				Date	Analyzed	: 2006-07-26		Ana	llyzed By: T			
~					CCVs	CCVs	CCVs	Percent	_			
Param		Flag	Units		True Conc.	Found Conc.	Percent	Recovery Limits	Date			
Dissolved Calcium		riag	mg/L		50.0	51.2	Recovery 102	<u></u> 90 - 110	Analyzee 2006-07-2			
Dissolved Potassium			mg/L		50.0	54.6	102	90 - 110 90 - 110	2006-07-2			
Dissolved Magnesium			mg/L		50.0	50.0	100	90 - 110	2006-07-2			
Dissolved Sodium			mg/L		50.0	53.2	106	90 - 110	2006-07-2			

Antonia

A STATE

Sec. 1

間の見

120.43

R. M. S.

ALC: N

2.2.3%

The Faille

State of

AN AN

である

BD Zachary Hinton		·····	BD Za	achary Hinton	l		Lea County,NI
Standard (ICV-1)							
QC Batch: 28406		Date	e Analyzed:	2006-07-2	7	Ana	lyzed By: SN
			ICVs	ICVs	ICVs	Percent	Data
Param	Flog	Units	True Conc.	Found Conc.	Percent Recovery	Recovery Limits	Date Analyzed
Total Dissolved Solids	Flag	mg/L	1000	1056	106	90 - 110	2006-07-2
Total Dissolved Solids		mg/L	1000	1030	100	90~110	2000-07-2
Standard (CCV-1)							
QC Batch: 28406		Date	e Analyzed:	2006-07-2	7	Ana	lyzed By: SN
			CCVs	CCVs	CCVs	Percent	
					Percent		Data
			True	Found	ECIUCIU	Recoverv	Date
Param	Flag	Units	True Conc.	Found Conc.		Recovery Limits	Date Analyzed
Param Total Dissolved Solids Standard (ICV-1) QC Batch: 28782	Flag	Units mg/L Date	Conc. 1000	Found Conc. 1075 2006-08-02	Recovery 108	Limits 90 - 110	Analyzed 2006-07-2
Total Dissolved Solids Standard (ICV-1)	Flag	mg/L Date ICVs	Conc. 1000 e Analyzed:	Conc. 1075	Recovery 108	Limits 90 - 110	Analyzec 2006-07-2
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782		mg/L Date ICVs True	Conc. 1000 e Analyzed:	Conc. 1075 2006-08-02 CVs 'ound	Recovery 108 2 ICVs Percent	Limits 90 - 110 Anal Percent Recovery	Analyzed 2006-07-2 lyzed By: WE Date
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag	Units	mg/L Date ICVs True Conc.	Conc. 1000 e Analyzed:	Conc. 1075 2006-08-02 CVs Sound Conc.	Recovery 108 2 ICVs Percent Recovery	Limits 90 - 110 Anal Percent Recovery Limits	Analyzed 2006-07-2 lyzed By: WE Date Analyzed
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride	Units mg/L	mg/L Date ICVs True Conc. 12.5	Conc. 1000 e Analyzed:	Conc. 1075 2006-08-02 CVs ound Conc. 12.4	Recovery 108 2 ICVs Percent Recovery 99	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110	Analyzed 2006-07-2 yzed By: WE Date Analyzed 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag	Units	mg/L Date ICVs True Conc.	Conc. 1000 e Analyzed:	Conc. 1075 2006-08-02 CVs Sound Conc.	Recovery 108 2 ICVs Percent Recovery	Limits 90 - 110 Anal Percent Recovery Limits	Analyzed 2006-07-2 yzed By: WE Date Analyzed 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride	Units mg/L	mg/L Date ICVs True Conc. 12.5	Conc. 1000 e Analyzed:	Conc. 1075 2006-08-02 CVs ound Conc. 12.4	Recovery 108 2 ICVs Percent Recovery 99	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110	Analyzed 2006-07-2 yzed By: WE Date Analyzed 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate	Units mg/L	mg/L Date ICVs True Conc. 12.5 12.5	Conc. 1000 e Analyzed:	Conc. 1075 2006-08-02 CVs ound Conc. 12.4	Recovery 108 2 2 1CVs Percent Recovery 99 102	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110	Analyzed 2006-07-2 yzed By: WE Date Analyzed 2006-08-0 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1)	Units mg/L	mg/L Date ICVs True Conc. 12.5 12.5	Conc. 1000 e Analyzed: F C v e Analyzed: c	Conc. 1075 2006-08-02 CVs ound Conc. 12.4 12.7 2006-08-02 CCVs	Recovery 108 2 2 1CVs Percent Recovery 99 102	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110	Analyzed 2006-07-2 yzed By: WE Date Analyzed 2006-08-0 2006-08-0
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782	Units mg/L mg/L	mg/L Date ICVs True Conc. 12.5 12.5 12.5 Date CCVs True	Conc. 1000 e Analyzed: F C , e Analyzed: F C F	Conc. 1075 2006-08-02 CVs ound Conc. 12.4 12.7 2006-08-02 CCVs ound	Recovery 108 2 1CVs Percent Recovery 99 102 2 CCVs Percent	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 90 - 110 Anal Percent Recovery	Analyzed 2006-07-2 lyzed By: WE Date Analyzed 2006-08-0 2006-08-0 2006-08-0 Uyzed By: WE
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782 Param Flag Standard (CCV-1) QC Batch: 28782 Param Flag	Units mg/L mg/L Units	mg/L Date ICVs True Conc. 12.5 12.5 12.5 Date CCVs True Conc.	Conc. 1000 e Analyzed: F C , e Analyzed: F C C F C C C C C C C C C C C C C	Conc. 1075 2006-08-02 CVs ound Conc. 12.4 12.7 2006-08-02 CCVs ound Conc.	Recovery 108 2 1CVs Percent Recovery 99 102 2 CCVs Percent Recovery	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 90 - 110 Anal Percent Recovery Limits	Analyzed 2006-07-2 lyzed By: WE Date Analyzed 2006-08-0 2006-08-0 2006-08-0 Uyzed By: WE Date Analyzed
Total Dissolved Solids Standard (ICV-1) QC Batch: 28782 Param Flag Chloride Sulfate Standard (CCV-1) QC Batch: 28782	Units mg/L mg/L	mg/L Date ICVs True Conc. 12.5 12.5 12.5 Date CCVs True	Conc. 1000 e Analyzed: F C , e Analyzed: F C C F C C	Conc. 1075 2006-08-02 CVs ound Conc. 12.4 12.7 2006-08-02 CCVs ound	Recovery 108 2 1CVs Percent Recovery 99 102 2 CCVs Percent	Limits 90 - 110 Anal Percent Recovery Limits 90 - 110 90 - 110 90 - 110 Anal Percent Recovery	Analyzed 2006-07-2 lyzed By: WE Date Analyzed 2006-08-0 2006-08-0 2006-08-0 Uyzed By: WE

Speed and

1224.23

15.00

Same -

Market and

ないで

in the second

1

な影

States -

とうない

Jan 1

ない

NAME -

STARKS!

4. A.S.

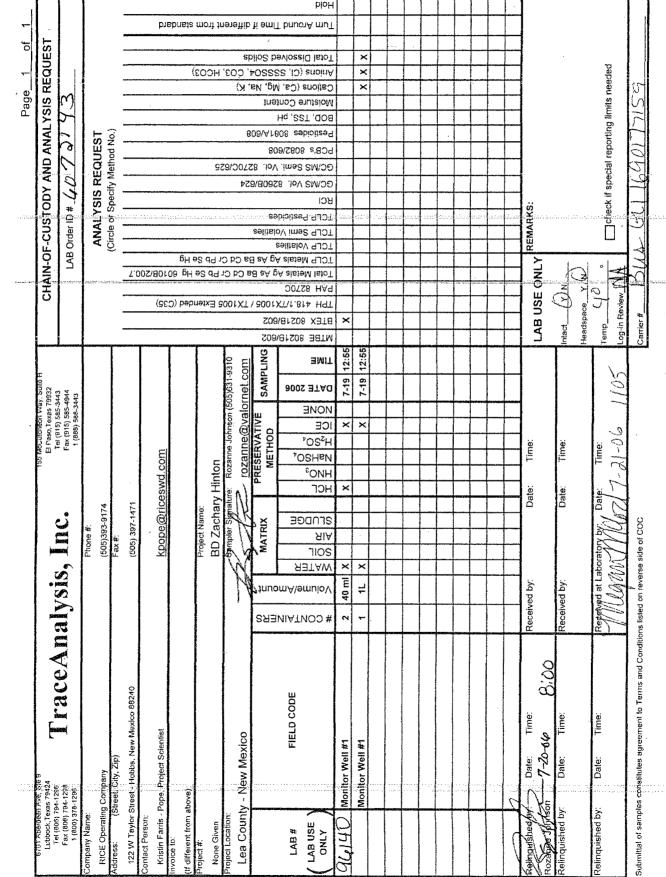
Sec. Sec.

Work Order: 6072143 BD Zachary Hinton рюн Turn Around Time it different from standard zbilo2 bevlozzi0 listoT × Anions (CI, SSSSO4, CO3, HCO3) × Cations (Ca, Mg, Va, K) ×

1. X. S.

1

Status Status



Appendix E Quality Assurance Protocols

Sec. 1

R.T. Hicks Consultants, Ltd.

901 Rio Grande Blvd. NW, Suite F-142 Albuquerque, NM 87104

Rice Operating Co.Project:BD Zachary Hinton122 W. TaylorProject Number:None GivenHobbs NM, 88240Project Manager:Kristin Farris-Pope										
Genera	l Chemistry Para	meters by Environm				ls - Qua	lity Con	trol		
Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Not
Batch EA62406 - General Preparati	on (WetChem)									
Blank (EA62406-BLK1)				Prepared &	Analyzed:	01/26/06				
Fotal Alkalinity	ND	2.00	mg/L			```				
LCS (EA62406-BS1)				Prepared &	Analyzed	01/26/06				
Bicarbonate Alkalinity	220		mg/L	200		110	85-115			
Duplicate (EA62406-DUP1)	Sou	rce: 6A19005-	.01	Prepared &	Analyzed	01/26/06				
Fotal Alkalinity	258	2.00	mg/L		256			0.778	20	
Reference (EA62406-SRM1)				Prepared &	Anaivzed	01/26/06				
Fotal Alkalinity	97.0	· · ·	mg/L	100	. mary 2004.	97.0	90-110			
Ratch FA63003 - Coneral Proparati	on (WetChem)									
Batch EA63003 - General Preparati	on (WetChem)			Prenared: 0	1/26/06 4	nalvzed: 01	/27/06		,	
Batch EA63003 - General Preparati Blank (EA63003-BLK1) Fotal Dissolved Solids	on (WetChem)	5.00	mg/L	Prepared: 0	1/26/06 A	nalyzed: 01	/27/06			· · · · · ·
Blank (EA63003-BLK1) Total Dissolved Solids	ND		-							··
Blank (EA63003-BLK1)	ND	5.00 rce: 6A25018- 5.00	-	Prepared: 0 Prepared: 0				2.93	5	
Blank (EA63003-BLK1) Fotal Dissolved Solids Duplicate (EA63003-DUP1) Fotal Dissolved Solids	ND Sou 2020	rce: 6A25018-	-01		1/26/06 A			2.93	5	· · · · · · · · · · · · · · · · · · ·
Blank (EA63003-BLK1) Fotal Dissolved Solids Duplicate (EA63003-DUP1)	ND Sou 2020	rce: 6A25018-	-01	Prepared: 0	1/26/06 A 2080	nalyzed: 01		2.93	5	
Blank (EA63003-BLK1) Fotal Dissolved Solids Duplicate (EA63003-DUP1) Fotal Dissolved Solids Batch EA63004 - General Preparati Blank (EA63004-BLK1)	ND Sou 2020 on (WetChem)	rce: 6A25018- 5.00	01 mg/L		1/26/06 A 2080	nalyzed: 01		2.93	5	
Blank (EA63003-BLK1) Fotal Dissolved Solids Duplicate (EA63003-DUP1) Fotal Dissolved Solids Batch EA63004 - General Preparati Blank (EA63004-BLK1) Sulfate	ND Sou 2020 on (WetChem) ND	rce: 6A25018- 5.00	-01	Prepared: 0	1/26/06 A 2080	nalyzed: 01		2.93	5	
Blank (EA63003-BLK1) Fotal Dissolved Solids Duplicate (EA63003-DUP1) Fotal Dissolved Solids Batch EA63004 - General Preparati Blank (EA63004-BLK1)	ND Sou 2020 on (WetChem)	rce: 6A25018- 5.00	01 mg/L	Prepared: 0	1/26/06 A 2080	nalyzed: 01		2.93	5	
Blank (EA63003-BLK1) Fotal Dissolved Solids Duplicate (EA63003-DUP1) Fotal Dissolved Solids Batch EA63004 - General Preparati Blank (EA63004-BLK1) Sulfate	ND Sou 2020 on (WetChem) ND	rce: 6A25018- 5.00	01 mg/L	Prepared: 0	11/26/06 A 2080 Analyzed:	nalyzed: 01 01/30/06		2.93	5	
Blank (EA63003-BLK1) Fotal Dissolved Solids Duplicate (EA63003-DUP1) Fotal Dissolved Solids Batch EA63004 - General Preparati Blank (EA63004-BLK1) Sulfate Chloride	ND Sou 2020 on (WetChem) ND	rce: 6A25018- 5.00	01 mg/L	Prepared: 0 Prepared &	11/26/06 A 2080 Analyzed:	nalyzed: 01 01/30/06		2.93	5	

Environmental Lab of Texas

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 7 of 10

Cost and an

L'ant the

STATES OF

N. S. Constant

D. S. L.

M. A.

Sec. Barre

a second

ficiality 3

Rice Operating Co.	Project: BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	Reported:
Hobbs NM, 88240	Project Manager: Kristin Farris-Pope	02/01/06 11:42

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 EA63004 General Preparation (WetChem)		_										
Calibration Check (EA63004-CCV1)			Prepared & Analyzed: 01/30/06										
Sulfate	9.82		mg/L	10.0		98.2	80-120						
Chloride	8.64			10.0		86.4	80-120						
Duplicate (EA63004-DUP1)	Sourc	Prepared &	Analyzed:	01/30/06									
Sulfate	84.4	25.0	mg/L	88.2				4.40	20				
Chloride	879	25.0	25.0 "		886			0.793	20				

Environmental Lab of Texas

S. South S.

True to

1000

Santa?

52.376

and the second

No.

R.C.W.

にあっ

100

AN AL

調整語

Sec. 2

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

12600 West 1-20 East - Odessa, Texas 79705 - (432) 563-1800 - Fax (432) 563-1713

Rice Operating Co.	Project: BD Zachary Hinton	Fax: (505) 397-1471
122 W. Taylor	Project Number: None Given	Reported:
Hobbs NM, 88240	Project Manager: Kristin Farris-Pope	02/01/06 11:42

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 EA62615 - 6010B/No Digestion										
Blank (EA62615-BLK1)										
Calcium	ND	0.0100	mg/L							
Magnesium	ND	0.00100	"							
Potassium	ND	0.0500	"							
Sodium	ND	0.0100	**							
Calibration Check (EA62615-CCV1)	,			Prepared &	Analyzed:	01/26/06				
Calcium	2.12		mg/L	2.00		106	85-115		•	
Magnesium	1.99	5		2.00		99.5	85-115			
Potassium	1.88			2.00		94.0	85-115			
Sodium	1.94		o	2.00		97.0	85-115			
Duplicate (EA62615-DUP1)	Sour	·ce: 6A19005-	01	Prepared &	Analyzed:	01/26/06				
Całcium	224	0.500	mg/L		222			0.897	20	
Magnesium	115	0.0500	1*		120	•		4.26	20	
Potassium	14.6	0.500			15.2			4.03	20	
Sodium	306	0.500	**		313			2.26	20	,

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

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

記名 Sec. Se ha

1

N.X.

Sec. 1

を見てい

いいの

-7 4 - 7 Q

a create

G C AN

Sec.

Rice Operating Co.	Project: BD Zachary Hinton
122 W. Taylor	Project Number: None Given
Hobbs NM, 88240	Project Manager: Kristin Farris-Pope

Fax: (505) 397-1471

Reported: 02/01/06 11:42

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:

語を読

P design

a land

Raland K Turk

2/1/2006

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.

Date:

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

The results in this report apply to the samples analyzed in accordance with the samples received in the laboratory. This analytical report must be reproduced in its entirety, with written approval of Environmental Lab of Texas.

Page 10 of 10

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

14.00																										
										TAT bisbrist																
-									-	RUSH TAT (Pre-Schedule)					-								S			
																				*	z z		N O			
10												,, ·								k	<u>}</u> /^		£.,			
1 32										sbilo2 beviossi0 listoT	×									-r	Cooler	сī	h C t			
										M.O.R.M.											1.1.	1	S			
100	· •	ton		2			i. O LL			RCI	<u> </u>					L						5	জ			
163	UES	Zachary Hinton		Lea County			Analyze	- ×	-	BTEX 80218/5030	[Labels on containers made Labels on container? Custody Seals: Container? Temmerturo Linco Panaint		Leboratory Comments:			
	REQ	haŋ		<u>ِ</u>			Ana			səlitticv səlitticv	<u> </u>							-			Labels on containers in Labels on container? Custody Seals: Cont	2	Mo			
A REAL	SIS F	Zac		Lea L					╈	Metals: As Ag Ba Cd Cr Pb Hg Se											R Col	5	ž	į,		
m	47.	Project Name: <u>BD</u>		'				TOLP		SAR / ESP / CEC											tody tody		orat			
ß	AN	ie.	*	ğ	₩04			TOTAL		Anions (Cl, SO4, CO3, HCO3)	×										Cus Cus Tem	5	Lab			
42.00	4ND	t Nai	Project#:	Project Loc:	ď					Cations (Ca, Mg, Va, K)	×					-							da .			
	RD,	ojec	ď	Proj					-	TPH: 416.1 8015M 1005 1006	_		100puive		_							, j	Time	Time		
	ECO	č		-					I_	Other (specify):											Ę				<u> </u>	
الغنية	Y RI								Matrix	10S				 							00.				اد.	
	TOD	I	I		I		1		ſ	Water	×	┝─┤									p _w ,		Date	Data	01-25-06	
	cus									Other (Specify)						-Traduc					Se Se Se				ō;	
ູພະ	CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST									Hone (1) 1 Liter HDPE	-		-					_			i a					
	AIN								ative	²os²h											ks(
	ວັ					47			Preservative	HOEN											87					
<u> </u>			1			397-147			à		2		_				_				a l					
						36				⁶ ONH											ంర				<u>k</u>	
						(505)					×										un ci				3	
						삨		Į		No. of Containers	3										et.c				Z	
						Fax No:				belqmte2 emiT	9:45										iceswd@valornet.com & mfranks@riceswd.com				5	
-		ξ				ц у				haloms2 amiT	6										€val				3	
a		et. C				\sim	+	\square	١	· · ·											vđ@			Ē		
a hite		Ш.				$\left(\right)$	4		/		/2006										Sa			bv ELOT	Ŷ	
		Valo						Υ		Date Sampled	3/20										, Li C		sd by:	nd by	Car.	
# 3		ĝ				/ 6					1/23/										kpri		Received	Received	Â	
	× .	SWC				\ Š	3 k									_			\dashv		ö				<u> </u>	
	()	kpriceswd@valornet.com			0	\sim \tilde{E}															ŝ	•	Time - J	3 ₽		
	Lab of Texas Phone: 432-563-1800 Fax: 432-563-1713	ğ	Company Name RICE Operating Company		city/state/Zip: Hobbs, New Mexico 88240	Telephone No: (505) 393-9174															PLEASE Email RÉSULTS TO:		Time	- 1 1 1 1		
	0 283 283		đ	Ţ	80	(50	ý	Email: <u>Fozanne@valornet.com</u>													ESI	}	i			
	44 44 600 600 600 600 600 600 600 600 60	Project Manager: Kristin Farris Pope	ပိ	Company Address: 122 W. Taylor Street	Xio	E		net		Ш											2		ate 7	Date Of		
	ş ş O	d	ting	5	Ň	174 hns	2	<u></u>		HELD CODE											nai		ő_ľ			
		ITIS	era	ayle	ew	-6- fe		275													ũ	-		-	{	
	65 	ц Ц	d	<u><</u> . T	گ ت	395 106		De(<u>.</u>				'						P SE		\cap			
		istir	Ы	2	á	<u>35)</u> 27ar		Zan	;		Monitor Well #1			ļ							Ē					
	407 407	Ϋ́	찔	12	비	R0 (5		ē			Ň										õ	5				
		ger:	ame	598	Zip:	No:	i	nail:			n ito		Ì	.								1	the	12		
	55 K	ana	۱۷ N	vqq te	tate/	ione inati	5	Ē			Ň										_		1 1	$\langle \uparrow \rangle$		
		set M	npar	ury A	ity/S	Telephone No: (505) 393-9174 bles stanature: Rozanne, Johns	i i									3							1-	M_{-}		
	Environmental 12800 West I-20 East Odessa, Texas 79765	Jroje	C C	edw	ö	Te Te				LAB # (ab use only)										Special Instructions			<u>∖</u> ≚√(.	
	, ⊤estann , ⊤estann	<u>ш</u>		ů		E.C.	;													- In a la		$\langle $	Relinquistbed by	Rozanne Johnsop Relinquished by		
	V 00 V										Ś									lei0	i i		創人	anne		
	0d£									3										Spe				Roze	[
																						$\overline{\bigcirc}$,	1	\backslash	
											· .		·. ·.		• .		. ·								.)	
							-																			

~

R. C. wynes

-

ŗ,