Investigation and Best Management Practice (BMP) Evaluation and Development Memorandum for

O'Ryan Seep, Pharaoh Seep, and Dugout Creek, Howard and Mitchell Counties, Texas

Prepared for:

Railroad Commission of Texas

Prepared by:

INTERA Incorporated
1812 Centre Creek Drive,
Suite 300
Austin, Texas 78754

August 2007

Investigation and BMP Evaluation and Development Memorandum for O'Ryan Seep, Pharaoh Seep, and Dugout Creek

Howard and Mitchell Counties, Texas

The information in this report was prepared under my supervision. The information is accurate and correct to the best of my knowledge. The information, data, and figures should not be used for purposes other than as elements of this overall report.

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Richard Scadden, P.E.

Senior Engineer

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Noreen Baker, P.G.

Senior Geologist

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1.0 INTRODUCTION

INTERA Incorporated (INTERA) was contracted by the Railroad Commission of Texas (RRC) to provide professional environmental engineering services at oil and gas industry exploration and production sites and associated facilities across the State of Texas. Under this contract, INTERA has been tasked with performance of an environmental assessment at Dugout Creek in Howard and Mitchell Counties, Texas. Dugout Creek is located east of Coahoma, Texas and south of Interstate 20 (Figure 1). The goal of the investigation is to better understand the saltwater impact in Dugout Creek for the purpose of determining the most effective method to reduce the salinity load to the Colorado River. Best Management Practices (BMPs) are being developed with the assistance of Crespo Consulting Services, Incorporated (Crespo) to manage the impacted runoff, and the installation of surface water containment structures is being considered. Data generated from the installation and sampling of the three monitoring wells will be used in support of any remedial design to help focus the BMP evaluation and development.

1.1 Background

INTERA has performed environmental assessments at the O'Ryan and Pharaoh Saltwater Seeps to delineate the extent of salt-impacted groundwater at these seeps and to determine the source of the saltwater contamination. The results of these assessments have been documented in several reports (DE&S 2001a, DE&S 2001b, INTERA 2002a, INTERA 2002b, INTERA 2003a, INTERA 2006a, and INTERA 2006b). In addition, initial assessment activities were conducted along Dugout Creek in 2006, the results of which are documented in the August 2006 report, Environmental Assessment of Dugout Creek, Howard and Mitchell Counties, Texas (INTERA 2006c). INTERA understands that the RRC would like to determine if the flow of saltwater from O'Ryan and Pharaoh seeps or any other surface or subsurface seepage and drainage has impacted Dugout Creek, and how best to mitigate and manage any potential negative impact from the seeps.

1.2 Objectives

The objectives of this investigation and evaluation report are twofold: 1) to further investigate potential sources of chloride contamination, aiding in the focus of any future mitigation strategies, and 2) to evaluate and develop best management practices to mitigate and manage saltwater impacts from O'Ryan Seep, Pharaoh Seep, or any other source along Dugout Creek. The overall objective is to reduce the salinity load to the Colorado River. In order to achieve this goal, the RRC has requested that INTERA evaluate mitigation and management options and develop BMPs for the seeps. INTERA has achieved this through review of the existing data, collection of additional data and consideration of options for mitigation and control.

2.0 TASK 1 – MONITORING WELL INSTALLATION AND SAMPLING

During a recent field event (August 15th-18th, 2007), INTERA installed three monitoring wells in the vicinity of the Dugout Creek and Pharaoh and O'Ryan Seeps (Figure 2). After installation the well locations were surveyed using a sub-meter GPS unit. Monitoring well MW-07-1 was installed approximately 75 feet north of the Citation 71 production-water injection well. In the March 2006 investigation, chloride concentrations in excess of 16,000 parts per million were measured in MW-21. From the limited potentiometric data collected in the northwest portion of the O'Ryan Seep area, INTERA located MW-07-1 north of Citation 71 for the purposes of providing upgradient information. This well was installed to determine if chloride contributions from sources other than Citation 71 exist in the area. Refer to Appendix A and B for boring logs and monitoring well construction diagrams, respectively.

Monitoring well MW-07-2 was installed approximately 730 feet up the O'Ryan Seep drainage channel from the confluence of the O'Ryan Seep channel and Dugout Creek (this well was not installed closer to the confluence due to the presence of a pipeline of unknown size and orientation and numerous blocks of concrete that made access difficult). Monitoring well MW-07-3 was installed approximately 154 feet up the Pharaoh Seep drainage channel from the confluence of the Pharaoh Seep channel and Dugout Creek. Both of these wells were installed to investigate groundwater in this area and to determine the chloride concentration immediately upgradient/up-channel of the confluence of each channel with Dugout Creek.

The working hypothesis for the process by which chloride moves from the seeps to Dugout Creek in the absence of continuous surface water flow or groundwater flow is as follows. Groundwater-bearing alluvium is limited in the channels to the area just downstream of the seeps and to the area just up-channel of the confluences with Dugout Creek. Groundwater in the alluvium just downgradient of the seeps receives chloride-contaminated recharge directly from the seeps. As the groundwater moves downgradient through the alluvium it becomes concentrated as water is removed through evapotranspiration (i.e. at MW-7). Evapotranspiration not only works to concentrate chloride in the groundwater, but as the process continues, the chloride-laden groundwater is drawn to the surface where the water evaporates and chloride salts are left behind on the soil surface. The chloride salt deposits on the soil surface are then available to be dissolved and carried downstream by surface water during precipitation events. Depending on the amount of surface water runoff, the chloride may be carried all the way to Dugout Creek or only down the channel until the surface water dries up and the process starts again. In this way, chloride would migrate in slugs down the channel until reaching the alluvium just upstream of the confluence where it may be returned to groundwater in the alluvium and then move on into Dugout Creek. If this hypothesis is correct, groundwater in MW-07-2 and MW-07-3 should exhibit elevated concentrations of chloride and will provide some indication as to the magnitude of the contribution of chloride from each seep to Dugout Creek.

The wells were developed and sampled for total dissolved solids and anion analyses, specifically chloride, bromide and sulfate, in accordance with the Project QAPP (RRC, 2007). Although a thin lens of saturated clayey sand was encountered in MW-07-2, groundwater did not enter the well and a sample was not obtained at this location.

2.1 Analytical Results

Groundwater analytical results from samples collected August 15th-18th, 2007 are presented in Table 1. The chloride concentration in MW-07-1 is elevated at 8,840 mg/L but is still well below the March 2006 concentration in MW-21 of 16,200 mg/L. The chloride concentration is very high in MW-07-03 at 38,800 mg/L, which supports the hypothesis described above and indicates that Pharaoh Seep is contributing a significant amount of chloride to Dugout Creek. Despite the lack of a groundwater sample from the O'Ryan Seep drainage channel upgradient of Dugout Creek, it is likely that similar chloride concentrations also exist in the alluvium in the O'Ryan Seep drainage channel immediately upgradient of its confluence with Dugout Creek. The laboratory data package from DHL Analytical along with a data usability review conducted by INTERA is included in Appendix C. The data usability review was conducted in accordance with the Project QAPP (RRC, 2007).

2.2 Waste Management

Soil cuttings from well installation and purge water from sampling was drummed separately and staged adjacent to each well location. The drums were labeled with the contents, date, and source of the materials. Composite soil cutting samples from each well location were submitted to the lab for chloride analysis. The cuttings were drummed pending the results of the chloride analyses. According to Project QAPP guidelines, the cuttings may be spread out at the site if they are below background levels; if they exceed background levels, the cuttings will need to be disposed of in a permitted landfill. Refer to Table 2 for waste characterization analytical results.

3.0 TASK 2 – OPTION EVALUATION AND BMP DEVELOPMENT

Once the additional analytical data was collected from the well installation and sampling activities, that data was used to help focus the BMPs that may be used to manage the chloride impacts to Dugout Creek and downstream. Crespo has provided INTERA with a BMP evaluation of the Dugout Creek project site, included in Appendix D. Crespo has provided a list of possible BMPs that can now be used as discussion points for INTERA and RRC moving forward with implementation of a remedy. Meetings including Crespo, INTERA and RRC will be required to determine scope of work and budgetary restraints on the project. The team will work to refine the site conceptual model and to define the

process for which additional data needed for the design will be collected for final BMP implementation.

4.0 REFERENCES

DE&S 2001a. Environmental Assessment Report for the Pharaoh Seep Investigation, Coahoma, Texas. August 2001.

DE&S 2001b. Environmental Assessment Report for the O'Ryan Seep Investigation, Coahoma, Texas. August 2001.

INTERA 2002a. Supplemental Investigation Report for the Pharaoh Seep Investigation, Coahoma, Texas. August 2002.

INTERA 2002b. Supplemental Investigation Report for the O'Ryan Seep Investigation, Coahoma, Texas. August 2002.

INTERA 2003a. Second Supplemental Investigation Report for the O'Ryan Seep Investigation, Coahoma, Texas. August 2003.

INTERA 2006a. Third Supplemental Investigation Report for the O'Ryan Seep Investigation, Coahoma, Texas. August 2006.

INTERA 2006b. Second Supplemental Investigation Report for the Pharaoh Seep Investigation, Coahoma, Texas. August 2006.

INTERA 2006c. Environmental Assessment of Dugout Creek, Howard and Mitchell Counties, Texas. August 2006.

RCC, 2007. Investigations and Abatement of Produced Water Impacts and Seeps to Surface Water in the Upper Colorado River Basin Upstream of Spence Reservoir (Segment 1411) Quality Assurance Project Plan. Prepared for the Railroad Commission of Texas Oil and Gas Division. Effective Period: July 2007 to May 2008.

Tables

Table 1. Groundwater Analytical Results

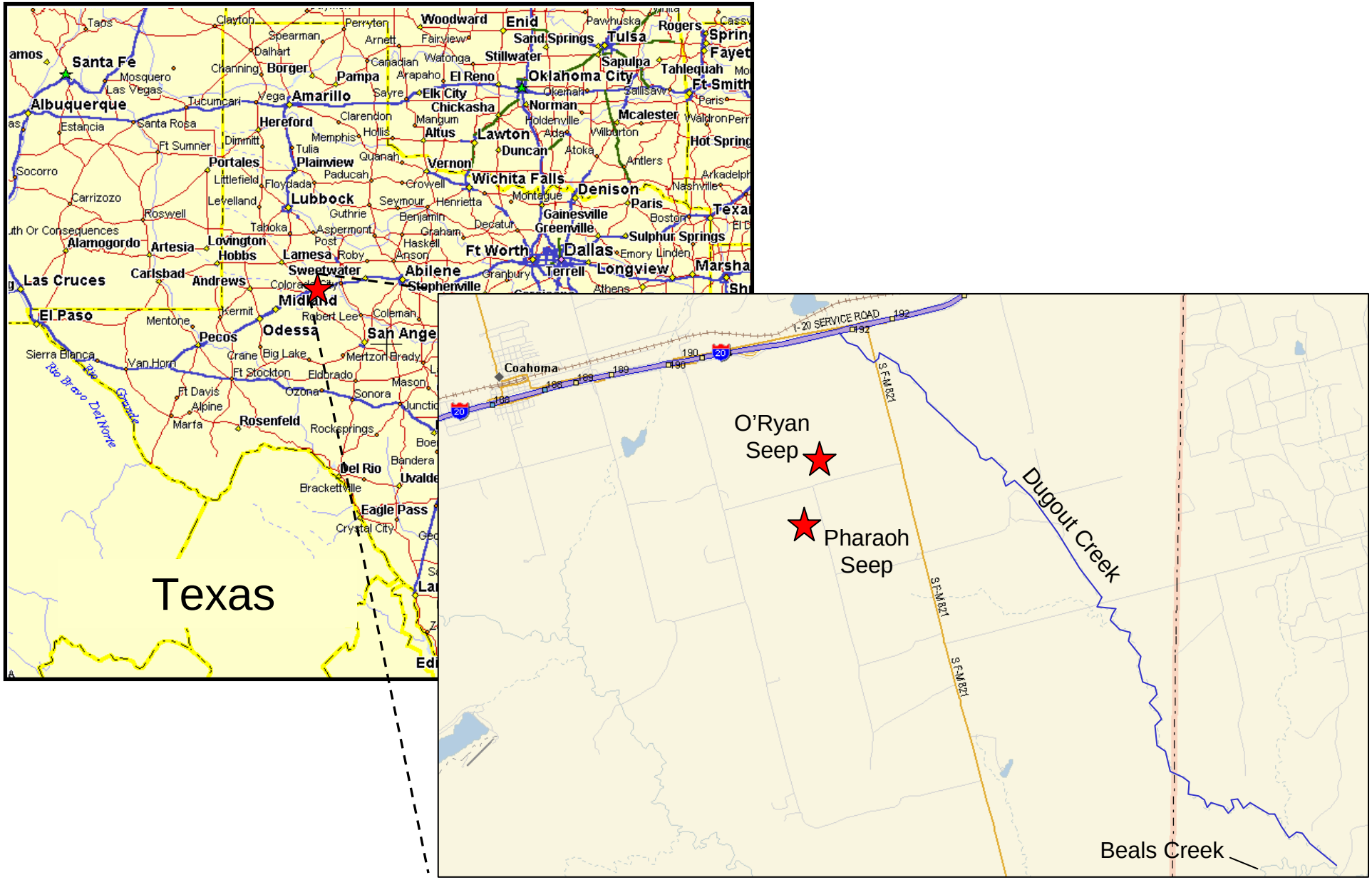
Sample ID	Collection Date	Bromide (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (TDS) (mg/L)
MW-07-1	8/18/2007	58	8840	586	19000
MW-07-2	--	dry	dry	dry	dry
MW-07-3	8/17/2007	112	38800	3760	62800
MW-07-4	8/17/2007	114	38700	3820	63100

MW-07-4 = Replicate Sample

Table 2. Waste Characterization Analytical Results for Soil Cuttings

Sample ID	Collection Date	Chloride (mg/kg-dry)
MW-07-1-S	8/17/2007	582
MW-07-2-S	8/16/2007	591
MW-07-3-S	8/15/2007	4860

Figures



DATE: 08/23/07	
REF: 01098.01.0001.03.00001	Site Location Map
FILE: Location-map.ppt	
1812 Centre Creek Dr Ste. 300 Austin, TX 78754	Dugout Creek, Coahoma, Texas
	Figure 1

Legend

- Monitoring Well
- Saltwater Injection Well
- Seep
- Creek
- Interstate Highway
- State Highway

μ

0 1,000 2,000 3,000 4,000 Feet

Date: 8/23/07	**Well Location Map**	
File: Fig2_well_locations.mxd		
Projection: NAD83, UTM Zone 14N		
INTERA	Dugout Creek Near Coahoma, TX	FIGURE 2

Appendix A

Boring Logs

INTERA INCORPORATED
1812 Centre Creek Dr., Suite 300
Austin, TX 78754

BORING NO: MW-07-1

PROJECT: **DUGOUT CREEK**
LOCATION: **HOWARD / MITCHELL COUNTIES, TX** sheet: 1 of 3

DATE:	8/20/2007	NORTHING:	N/A
DRILLER AND COMPANY:	Oscar Garcia - JEDI	EASTING:	N/A
LOGGED BY:	S. Pierson	ELEVATION:	N/A
DRILLING EQUIPMENT:	CME 75	TOTAL DEPTH:	31.5 ft.
DRILLING METHOD:	Hollow Stem Auger / Air Rotary (switch @ 9')	SAMPLING METHOD:	Split Spoon

SURFACE CONDITIONS: grass, other vegetation

DRILLING: START TIME 1430 DATE 8/16/07; FINISH TIME 2015 DATE 8/16/07

DEPTH IN FEET (BLS)	SYMBOL	USCS	MATERIAL CHANGE DEPTH	STRATUM DESCRIPTION	SAMPLE INTER.	SAMPLE NO.	RECOVERY %	FIELD SCREENING	REMARKS
1–2				SAND, fine grained, light brown, dry, very loose, subrounded, poorly sorted.			50%		
2–3				SAND, fine grained, dark brown, damp, very loose, subrounded, poorly sorted			80%		
3			3	becoming orange					
3–4			3.5	becoming tan, silty					
4–5							25%		
5–6									
6–7				SAND, silty, light tan, fine grained, subrounded, loose, very slightly damp			80%		
7–8									
8–9				becoming cemented					
9–10				Tan SAND					
10–11									
11–12									

INTERA INCORPORATED
1812 Centre Creek Dr., Suite 300
Austin, TX 78754

BORING NO: MW-07-1

PROJECT: **DUGOUT CREEK**
LOCATION: **HOWARD / MITCHELL COUNTIES, TX** sheet: 2 of 3

DATE:	8/20/2007	NORTHING:	N/A
DRILLER AND COMPANY:	Oscar Garcia - JEDI	EASTING:	N/A
LOGGED BY:	S. Pierson	ELEVATION:	N/A
DRILLING EQUIPMENT:	CME 75	TOTAL DEPTH:	31.5 ft.
DRILLING METHOD:	Hollow Stem Auger / Air Rotary (switch @ 9')	SAMPLING METHOD:	Split Spoon

SURFACE CONDITIONS: grass, other vegetation

DRILLING: START TIME 1430 DATE 8/16/07; FINISH TIME 2015 DATE 8/16/07

DEPTH IN FEET (BLS)	SYMBOL	USCS	MATERIAL CHANGE DEPTH	STRATUM DESCRIPTION	SAMPLE INTER.	SAMPLE NO.	RECOVERY %	FIELD SCREENING	REMARKS
12									
19				becoming pinkish tan					
21				SAND, silty, very fine grained to coarse grained, orange, subrounded, damp, poorly sorted					

INTERA INCORPORATED
1812 Centre Creek Dr., Suite 300
Austin, TX 78754

BORING NO: MW-07-1

PROJECT: **DUGOUT CREEK**
LOCATION: **HOWARD / MITCHELL COUNTIES, TX** sheet: 3 of 3

DATE:	8/20/2007	NORTHING:	N/A
DRILLER AND COMPANY:	Oscar Garcia - JEDI	EASTING:	N/A
LOGGED BY:	S. Pierson	ELEVATION:	N/A
DRILLING EQUIPMENT:	CME 75	TOTAL DEPTH:	31.5 ft.
DRILLING METHOD:	Hollow Stem Auger / Air Rotary (switch @ 9')	SAMPLING METHOD:	Split Spoon

SURFACE CONDITIONS: grass, other vegetation

DRILLING: START TIME 1430 DATE 8/16/07; FINISH TIME 2015 DATE 8/16/07

DEPTH IN FEET (BLS)	SYMBOL	USCS	MATERIAL CHANGE DEPTH	STRATUM DESCRIPTION	SAMPLE INTER.	SAMPLE NO.	RECOVERY %	FIELD SCREENING	REMARKS
24–31									
32				EOB @ 31.5 ft					Switch to Hollow Stem Auger @ 31.5' to ream out bit stuck down hole. Finished @ 0830 8/17.
33–35									

INTERA INCORPORATED
1812 Centre Creek Dr., Suite 300
Austin, TX 78754

BORING NO: MW-07-2

PROJECT: **DUGOUT CREEK**
LOCATION: **HOWARD / MITCHELL COUNTIES, TX** sheet: 1 of 2

DATE:	8/20/2007	NORTHING:	N/A
DRILLER AND COMPANY:	Oscar Garcia - JEDI	EASTING:	N/A
LOGGED BY:	S. Pierson	ELEVATION:	N/A
DRILLING EQUIPMENT:	CME 75	TOTAL DEPTH:	20 ft.
DRILLING METHOD:	Hollow Stem Auger / Air Rotary (switch @ 9')	SAMPLING METHOD:	Split Spoon

SURFACE CONDITIONS: dry creek bed, red dirt, surrounding vegetation = grass, mesquite, sunflowers

DRILLING: START TIME 0910 DATE 8/16/07; FINISH TIME 1030 DATE 8/16/07

DEPTH IN FEET (BLS)	SYMBOL	USCS	MATERIAL CHANGE DEPTH	STRATUM DESCRIPTION	SAMPLE INTER.	SAMPLE NO.	RECOVERY %	FIELD SCREENING	REMARKS
1–4				CLAY, sandy (fine grain), red-orange, damp, medium stiff, slightly plastic, little organic content			50%		
5–6			5	4 inch bed of SAND, clayey, fine grained, red-orange, subrounded, well sorted, homogenous, loose			50%		
6–8				CLAY and SAND, clay supported, red-orange, damp, fine grained, medium stiff, plastic			90%		
8–10				CLAY, sandy (fine grained), red-orange, damp, medium stiff, slightly plastic, little organic content			100%		
			8.8	soft, wet					
			9.2						
			9.7	soft, wet, 2 inches					
10–12				CLAY and silty SAND, red-orange, damp, fine grained to medium grained, stiff, highly plastic			90%		

INTERA INCORPORATED
1812 Centre Creek Dr., Suite 300
Austin, TX 78754

BORING NO: MW-07-2

PROJECT: **DUGOUT CREEK**
LOCATION: **HOWARD / MITCHELL COUNTIES, TX** sheet: 2 of 2

DATE:	8/20/2007	NORTHING:	N/A
DRILLER AND COMPANY:	Oscar Garcia - JEDI	EASTING:	N/A
LOGGED BY:	S. Pierson	ELEVATION:	N/A
DRILLING EQUIPMENT:	CME 75	TOTAL DEPTH:	20 ft.
DRILLING METHOD:	Hollow Stem Auger / Air Rotary (switch @ 9')	SAMPLING METHOD:	Split Spoon

SURFACE CONDITIONS: grass, other vegetation

DRILLING: START TIME 0910 DATE 8/16/07; FINISH TIME 1030 DATE 8/16/07

DEPTH IN FEET (BLS)	SYMBOL	USCS	MATERIAL CHANGE DEPTH	STRATUM DESCRIPTION	SAMPLE INTER.	SAMPLE NO.	RECOVERY %	FIELD SCREENING	REMARKS
12									
13			12.8 13.2	6 inches, SAND, clayey, medium grained, subrounded, well sorted, saturated			100%		
14			13.8	CLAY, red and green mottled					
15				CLAY, red with some green mottling throughout, very dense, highly plastic			100%		
16									
17				CLAY, red-orange, stiff, non-plastic, dry, slickensided			95%		
18				some mottling in last 4 inches					
19							60%		
20				EOB @ 20 ft					
21									
22									
23									
24									

INTERA INCORPORATED
1812 Centre Creek Dr., Suite 300
Austin, TX 78754

BORING NO: MW-07-3

PROJECT: **DUGOUT CREEK**
LOCATION: **HOWARD / MITCHELL COUNTIES, TX** sheet: 1 of 2

DATE:	8/20/2007	NORTHING:	N/A
DRILLER AND COMPANY:	Oscar Garcia - JEDI	EASTING:	N/A
LOGGED BY:	S. Pierson	ELEVATION:	N/A
DRILLING EQUIPMENT:	CME 75	TOTAL DEPTH:	20 ft.
DRILLING METHOD:	Hollow Stem Auger / Air Rotary (switch @ 9')	SAMPLING METHOD:	Split Spoon

SURFACE CONDITIONS: dry creek channel, mud cracks, red dirt, surrounding Veg. = grass & mesquite

DRILLING START: TIME 1634, DATE 8/15/07
DRILLING FINISH: TIME 1730, DATE 8/15/07

DEPTH IN FEET (BLS)	SYMBOL	USCS	MATERIAL CHANGE DEPTH	STRATUM DESCRIPTION	SAMPLE INTER.	SAMPLE NO.	RECOVERY %	FIELD SCREENING	REMARKS
1–10				0-10 no recovery red-orange clay w/black organic rich layer near the top			0%		
10–12				CLAY, red-orange, very stiff, very plastic, homogenous			80%		

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Austin, TX 78754

BORING NO: MW-07-3

PROJECT: **DUGOUT CREEK**
LOCATION: **HOWARD / MITCHELL COUNTIES, TX** sheet: 2 of 2

DATE:	8/20/2007	NORTHING:	N/A
DRILLER AND COMPANY:	Oscar Garcia - JEDI	EASTING:	N/A
LOGGED BY:	S. Pierson	ELEVATION:	N/A
DRILLING EQUIPMENT:	CME 75	TOTAL DEPTH:	20 ft.
DRILLING METHOD:	Hollow Stem Auger / Air Rotary (switch @ 9')	SAMPLING METHOD:	Split Spoon

SURFACE CONDITIONS: dry creek channel, mud cracks, red dirt, surrounding Veg. = grass & mesquite

DRILLING START: TIME 1634, DATE 8/15/07
DRILLING FINISH: TIME 1740, DATE 8/15/07

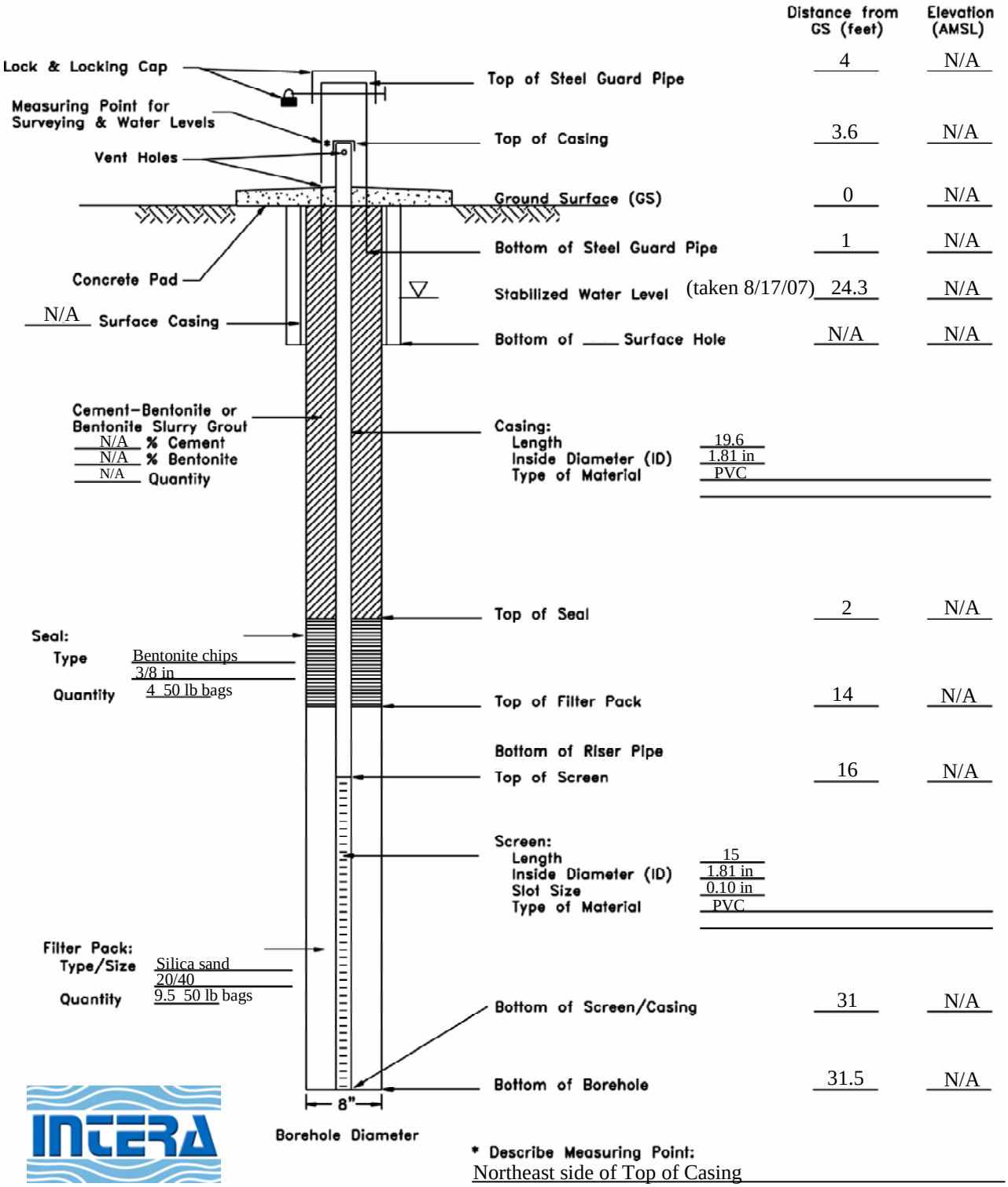
DEPTH IN FEET (BLS)	SYMBOL	USCS	MATERIAL CHANGE DEPTH	STRATUM DESCRIPTION	SAMPLE INTER.	SAMPLE NO.	RECOVERY %	FIELD SCREENING	REMARKS
12				CLAY, as above					
13							100%		
14			13.8	1 inch thick, softer, wet, becoming silty					
				SAND, clayey, red-orange, fine grained to medium grained, subrounded, moist, dense, moderately sorted					
15							100%		
16				same as above, fine grained					
17							100%		
			17.5	same as above, coarse grained to pebbles, saturated					
18				interbedded sandy CLAY with clayey SAND to pebbles, clay is moderately dense and wet, sand is coarse grained to pebbles and saturated, red-orange					
19							100%		
20				EOB @ 20 ft					
21									
22									
23									
24									

Appendix B

Monitoring Well Construction Diagrams

Project No. RRC-DUG 02-01 **Client:** Texas Railroad Commission **Site:** Dugout Creek **Well Location:** NW of saltwater injection well "Citation 71" and MW-21 **Contractor:** Jedi **Method:** Hollow-Stem Auger/ Air Rotary	**Well No.** MW-07-1 **Date Installed:** 8/17/07

MONITORING WELL CONSTRUCTION DETAIL



	Distance from GS (feet)	Elevation (AMSL)
Top of Steel Guard Pipe	4	N/A
Top of Casing	3.6	N/A
Ground Surface (GS)	0	N/A
Bottom of Steel Guard Pipe	1	N/A
Stabilized Water Level (taken 8/17/07)	24.3	N/A
Bottom of ___ Surface Hole	N/A	N/A
Top of Seal	2	N/A
Top of Filter Pack	14	N/A
Bottom of Riser Pipe Top of Screen	16	N/A
Bottom of Screen/Casing	31	N/A
Bottom of Borehole	31.5	N/A

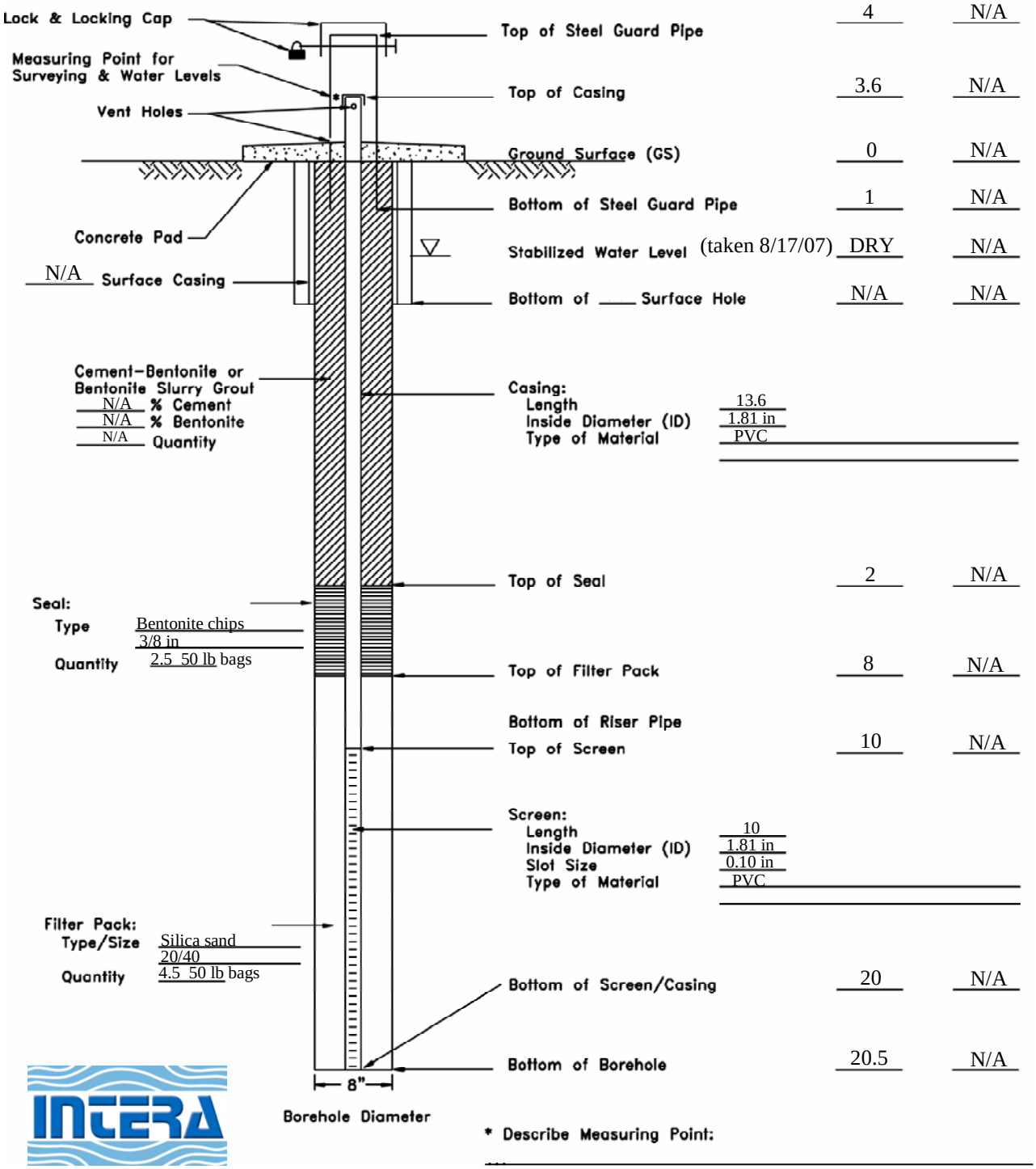
Casing:
Length 19.6
Inside Diameter (ID) 1.81 in
Type of Material PVC

Screen:
Length 15
Inside Diameter (ID) 1.81 in
Slot Size 0.10 in
Type of Material PVC

* Describe Measuring Point:
Northeast side of Top of Casing

Project No. RRC-DUG 02-01 Client: Texas Railroad Commission Site: Dugout Creek Well Location: Near confluence of O'Ryan Seep and Dugout Creek Contractor: Jedi Method: Hollow-Stem Auger	Well No. MW-07-2 Date Installed: 8/16/07

MONITORING WELL CONSTRUCTION DETAIL



	Distance from GS (feet)	Elevation (AMSL)
Top of Steel Guard Pipe	4	N/A
Top of Casing	3.6	N/A
Ground Surface (GS)	0	N/A
Bottom of Steel Guard Pipe	1	N/A
Stabilized Water Level (taken 8/17/07)	DRY	N/A
Bottom of ___ Surface Hole	N/A	N/A
Top of Seal	2	N/A
Top of Filter Pack	8	N/A
Bottom of Riser Pipe Top of Screen	10	N/A
Bottom of Screen/Casing	20	N/A
Bottom of Borehole	20.5	N/A

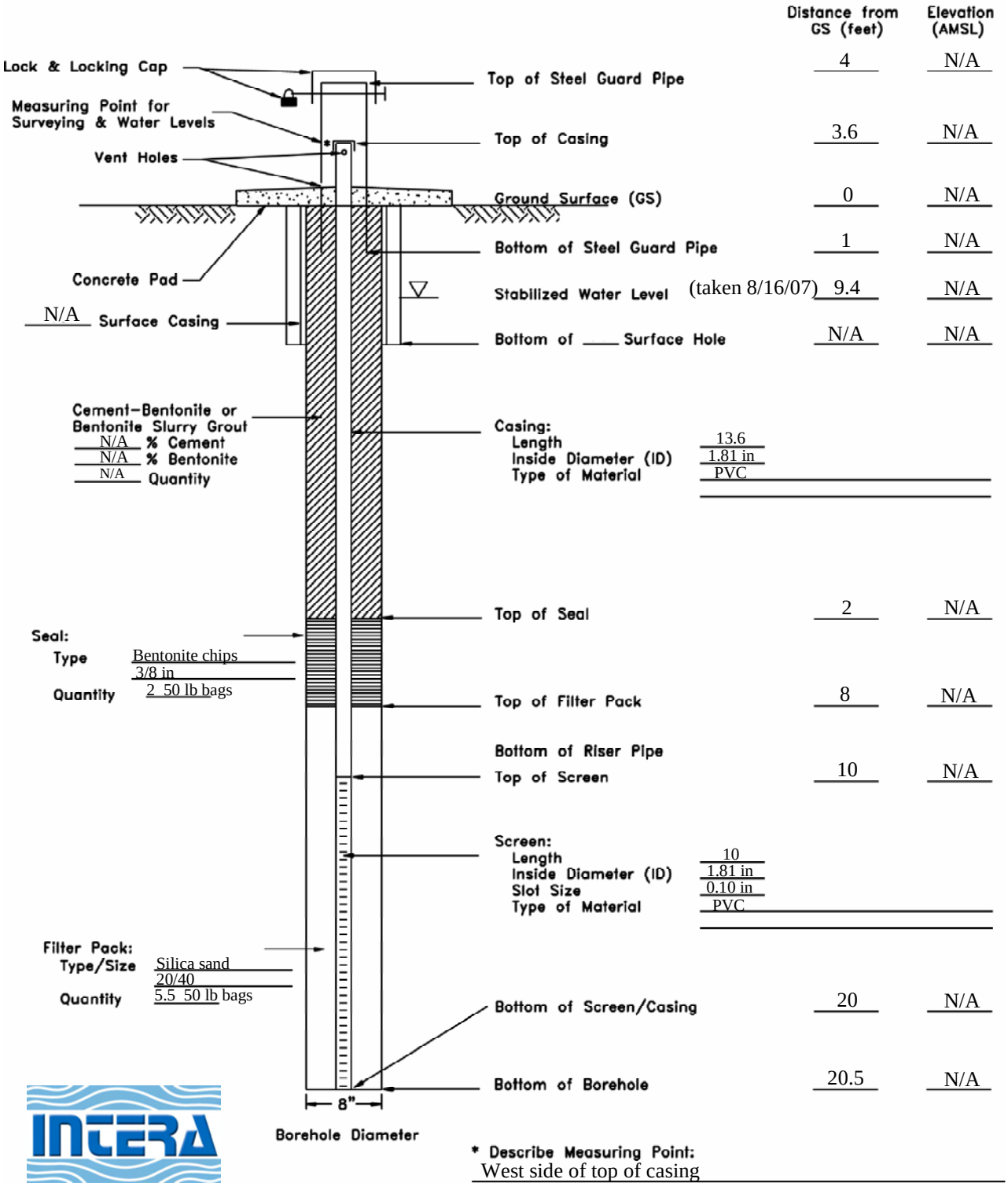
Casing: Length 13.6; Inside Diameter (ID) 1.81 in; Type of Material PVC

Screen: Length 10; Inside Diameter (ID) 1.81 in; Slot Size 0.10 in; Type of Material PVC

* Describe Measuring Point:

Project No. RRC-DUG 02-01 Client: Texas Railroad Commission Site: Dugout Creek Well Location: Near confluence of Pharaoh Seep and Dugout Creek Contractor: Jedi Method: Hollow-Stem Auger	Well No. MW-07-3 Date Installed: 8/15/07

MONITORING WELL CONSTRUCTION DETAIL



	Distance from GS (feet)	Elevation (AMSL)
Top of Steel Guard Pipe	4	N/A
Top of Casing	3.6	N/A
Ground Surface (GS)	0	N/A
Bottom of Steel Guard Pipe	1	N/A
Stabilized Water Level (taken 8/16/07)	9.4	N/A
Bottom of ___ Surface Hole	N/A	N/A
Top of Seal	2	N/A
Top of Filter Pack	8	N/A
Bottom of Riser Pipe / Top of Screen	10	N/A
Bottom of Screen/Casing	20	N/A
Bottom of Borehole	20.5	N/A

* Describe Measuring Point: West side of top of casing

Appendix C

Laboratory Data Package and Data Usability Review

August 2007

Table D2.1 Data Review Checklist

Client/Project: Dugout Creek	Reviewer: Barbara Ligney	Review Date: 8/23/07
Laboratory: DHL Work Order No.: 0708171	Analytical Method: SW846 EPA 300 + TDS 160.1	Matrix: Soil + Water

#	Review Item or Question	Yes	No	Comments (List Exceptions, Explanations, etc.)
Sample Preservation and Integrity				
1	Did samples arrive at the laboratory appropriately preserved (e.g., 4°C, correct acid added to sample)?	✓		
2	Were holding times met?	✓		
Data Completeness				
3	Are results reported for all target analytes, with no additional analytes?	✓		
4	Was the requested analytical method followed?	✓		
5	Do reported detection limits (or reporting limits/MDL) agree with the project specifications (QAPP)?		✓	Water sample RLs elevated due to dilution. MDL's ok
6	Are results reported for all samples submitted for analysis?	✓		
Calibration and QC Sample Frequency				
7	Were initial and continuing instrument calibration analyses performed? And reported? [a]	✓		
8	For each analytical batch, are results provided for a method blank?	✓		
9	For each analytical batch, are results provided for an LCS/LCSD pair?	✓		
10	For each analytical/preparation batch, are results provided for an MS/MSD pair? Alternately, are results for MS/MSD pairs provided for every 20 field samples analyzed?	✓		
11	Are field duplicate results provided at the project-specified (QAPP) frequency?	✓		

Table D2.1 Data Review Checklist (continued)

Client/Project: Nuccount Creek	Reviewer: BARBARA Kipp		Review Date: 8/29/07
Laboratory: DHL Work Order No.: 070817	Analytical Method: SW 846 EPA 300 V TDS 160.1		Matrix: Soil + Water
# Review Item or Question	Yes	No	Comments (List Exceptions, Explanations, etc.)
12 Organic Analyses Only: For each sample (field and QC), are surrogate spike results provided?	/	/	NA
QC Results			
13 Do method blank results show **no** detectable concentrations of target analytes (i.e., results = ND)?	✓		
14 Are LCS/LCSD recoveries and RPDs within limits?	✓		
15 Are MS/MSD recoveries and RPDs within limits?	✓		
16 Are surrogate recoveries within limits (organic analyses only)?	/	/	NA
Other Data Quality-Related Issues			
17 The laboratory did not issue any CARs. If this is not true (a CAR was issued), describe impact on sample results.	✓		No CARs issued
18 The analyst did not describe any analytical anomalies. If this is not true, describe potential impact to sample results.	✓		
19 No other potential data quality issues were identified. If this is not true, describe issues.		✓	labels on sample lids + bottles did not match *

[a] The laboratory will not be required to report all calibration results. Data validation efforts for this project will assume that the laboratory performed the method-specified calibration analyses.

CAR = Corrective Action Report

LCS/LCSD = Laboratory Control Sample/Duplicate Laboratory Control Sample

MS/MSD = Matrix Spike/Matrix Spike Duplicate

QAPP = Quality Assurance Project Plan

RPD = Relative Percent Difference

Further Comments:

* Sampling team lead was contacted and confirmed lid are correct

Dedicated equipment used - no equipment blanks necessary

DHL ANALYTICAL

August 30, 2007

Daniel Krause
INTERA Inc.
1812 Centre Creek Dr. #300
Austin, Texas 78754

TEL: (512) 425-2000
FAX: (512) 425-2099

RE: Dugout Creek
Revision Number 1 for Work Order 0708171

Dear Daniel Krause,

DHL Analytical received 6 samples on 8/20/07 for the analyses presented in the following REVISED report. This revision consists of changing the report to a TRRP report. Please replace the original report with this revised report.

There were no problems with the analyses and all data met requirements of NELAC except where noted in the Case Narrative. All non-NELAC methods will be identified accordingly in the case narrative and all estimated uncertainties of test results are within method or EPA specifications.

If you have any questions regarding these test results, please feel free to call. Thank you for using DHL Analytical.

Sincerely,

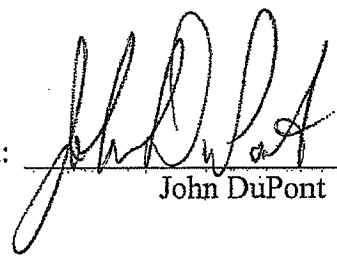
John Dupont
General Manager

DHL ANALYTICAL

TABLE OF CONTENTS

This report for Intera, Inc.: Dugout Creek (DHL Work Order 0708171) contains the following information:

August 30, 2007

Approved: 
John DuPont

2300 Double Creek Drive • Round Rock, TX 78664 • Phone (512) 388-8222 • FAX (512) 388-8229
www.dhlanalytical.com

DHL ANALYTICAL

2300 Double Creek Drive • Round Rock, TX 78664
Phone (512) 388-8222 • FAX (512) 388-8229

№ 29786

CHAIN-OF-CUSTODY

CLIENT: INTERA, INC.
ADDRESS: 1812 CENTRE CREEK DR, SUITE 200
PHONE: 425-2000 FAX 425-2099
DATA REPORTED TO: dkrause@intera.com
ADDITIONAL REPORT COPIES TO:

DATE: 8/18/07 PAGE ___ OF ___
PO #: ___ DHL WORK ORDER #: 0708174
PROJECT LOCATION OR NAME: DUWAMISH CREEK
CLIENT PROJECT #: 2006101-01 COLLECTOR: DK

Authorize 5% surcharge for TRRP report? ☐ Yes ☒ No

S=SOIL W=WATER A=AIR P=PAINT SL=SLUDGE OT=OTHER

Field Sample I.D.	DHL Lab #	Date	Time	Matrix	Container Type	# of Containers	PRESERVATION: HCl	HNO_3	H_2SO_4 ☐ NaOH ☐	ICE	UNPRESERVED	ANALYSES	FIELD NOTES
MW-07-1-S	01	8-17-07	2015	S	6-4oz	1				X	X		SOIL SAMPLES
MW-07-2-S	02	8-16-07	1145	S	6-4oz	1				X	X		ANIONS →
MW-07-3-S	03	8-15-07	1735	S	6-4oz	1				X	X		CHLORIDE ONLY
MW-07-1	04	8-18-07	0755	W	P	2				X	X		WATER SAMPLES
MW-07-3	05	8-17-07	0905	W	P	2				X	X		ANIONS →
MW-07-4	06	8-16-07	1110	W	P	2				X	X		Cl, SO_4, Br
TOTAL													

ANALYSES: BTEX ☐ MTBE ☐ | TPH 418.1 ☐ | TPH 1005 ☐ TPH 1006 ☐ | GASOLINE MOD 8015 ☐ | DIESEL MOD 8015 ☐ | VOC 8260 ☐ | SVOC 8270 ☐ PAH 8270 ☐ HOLDPAH ☐ | 8081 PESTICIDES ☐ 8151 HERBICIDES ☐ | 8082 PCBS ☐ | TCLP - METALS (RCRA) ☐ TCLP VOC ☐ | TCLP - PEST ☐ HERB ☐ Semi-VOC ☐ | TOTAL METALS (RCRA) ☐ OTHER LIST ☐ | LEAD - TOTAL ☐ D.W. 200.8 ☐ TCLP ☐ | RCI ☐ TOX ☐ FLASHPOINT ☐ | TDS ☒ TSS ☐ % MOISTURE ☐ CYANIDE ☐ | pH ☐ HEXAVALENT CHROMIUM ☐ | EXPLOSIVES ☐ PECHLORATE ☐ | CHLORIDE ☐ ANIONS ☒ ALKALINITY ☐

RELINQUISHED BY: (Signature) DANIEL KRAUSE — DATE/TIME 8/20/07 1535 — RECEIVED BY: (Signature)
RELINQUISHED BY: (Signature) — DATE/TIME — RECEIVED BY: (Signature)
RELINQUISHED BY: (Signature) — DATE/TIME — RECEIVED BY: (Signature)

☐ DHL DISPOSAL @ $5.00 each ☐ Return

TURN AROUND TIME
RUSH ☒ CALL FIRST
1 DAY ☐ CALL FIRST
2 DAY ☐
NORMAL ☐
OTHER ☐ ___

LABORATORY USE ONLY:
RECEIVING TEMP: 5.2°C THERM #: 54
CUSTODY SEALS - ☐ BROKEN ☐ INTACT ☒ NOT USED
☐ CARRIER BILL # ___
☐ APC DELIVERY
☒ HAND DELIVERED

DHL Analytical

Sample Receipt Checklist

Client Name INTERA Inc. Date Received: 8/20/2007

Work Order Number 0708171 Received by DU

Checklist completed by: [signature] 8.20.07 (Signature / Date) Reviewed by JD 08/20/07 (Initials / Date)

Carrier name: Hand Delivered

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shippping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☐	No ☑	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐	
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	Not Applicable ☑

Adjusted? _____ Checked by _____

Any No response must be detailed in the comments section below.

Client contacted Intera Date contacted: 8.20.07 Person contacted Daniel Krause

Contacted by: Debbiell. Regarding: Sample IDs

Comments: ① lid ID = MW07-2 label ID = MW-07-1

② lid ID = MW-07-1 label ID = MW-07-2

Corrective Action Lid IDs are correct

Laboratory Data Package Signature Page

This data package consists of:

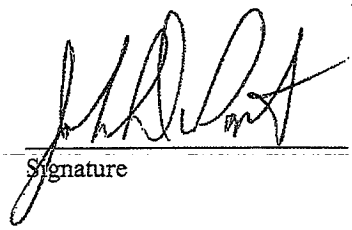
This signature page, the laboratory review checklist, and the following reportable data:

- R1 Field chain-of-custody documentation;
- R2 Sample identification cross-reference;
- R3 Test reports (analytical data sheets) for each environmental sample that includes:
  - a) Items consistent with NELAC 5.13
  - b) dilution factors,
  - c) preparation methods,
  - d) cleanup methods, and
  - e) if required for the project, tentatively identified compounds (TICs).
- R4 Surrogate recovery data including:
  - a) Calculated recovery (%R), and
  - b) The laboratory's surrogate QC limits.
- R5 Test reports/summary forms for blank samples;
- R6 Test reports/summary forms for laboratory control samples (LCSs) including:
  - a) LCS spiking amounts,
  - b) Calculated %R for each analyte, and
  - c) The laboratory's LCS QC limits.
- R7 Test reports for project matrix spike/matrix spike duplicates (MS/MSDs) including:
  - a) Samples associated with the MS/MSD clearly identified,
  - b) MS/MSD spiking amounts,
  - c) Concentration of each MS/MSD analyte measured in the parent and spiked samples,
  - d) Calculated %Rs and relative percent differences (RPDs), and
  - e) The laboratory's MS/MSD QC limits
- R8 Laboratory analytical duplicate (if applicable) recovery and precision:
  - a) the amount of analyte measured in the duplicate,
  - b) the calculated RPD, and
  - c) the laboratory's QC limits for analytical duplicates.
- R9 List of method quantitation limits (MQLs) for each analyte for each method and matrix;
- R10 Other problems or anomalies.

The Exception Report for every "No" or "Not Reviewed (NR)" item in laboratory review checklist.

Release Statement: I am responsible for the release of this laboratory data package. This data package has been reviewed by the laboratory and is complete and technically compliant with the requirements of the methods used, except where noted by the laboratory in the attached exception reports. By me signature below, I affirm to the best of my knowledge, all problems/anomalies, observed by the laboratory as having the potential to affect the quality of the data, have been identified by the laboratory in the Laboratory Review Checklist, and no information or data have been knowingly withheld that would affect the quality of the data.

Scott Schroeder – Project Manager
John DuPont – General / QA Manager



Signature

08/30/07
Date

DHL Analytical, Inc.

Laboratory Review Checklist: Reportable Data

Project Name: Dugout Creek	Date: 8/30/07
Reviewer Name: Laura Flowers	Laboratory Work Order: 0708171
Prep Batch Number(s): See Prep Dates Report	Run Batch: See Analytical Dates Report

#[1]	A[2]	Description	Yes	No	NA[3]	NR[4]	ER#[5]
		Chain-of-Custody (C-O-C)					
R1	OI	1) Did samples meet the laboratory's standard conditions of sample acceptability upon receipt?	✓				R1-01
		2) Were all departures from standard conditions described in an exception report?	✓				
R2	OI	**Sample and Quality Control (QC) Identification**					
		1) Are all field sample ID numbers cross-referenced to the laboratory ID numbers?	✓				
		2) Are all laboratory ID numbers cross-referenced to the corresponding QC data?	✓				
R3	OI	**Test Reports**					
		1) Were all samples prepared and analyzed within holding times?	✓				
		2) Other than those results < MQL, were all other raw values bracketed by calibration standards?	✓				
		3) Were calculations checked by a peer or supervisor?	✓				
		4) Were all analyte identifications checked by a peer or supervisor?	✓				
		5) Were sample quantitation limits reported for all analytes not detected?	✓				
		6) Were all results for soil and sediment samples reported on a dry weight basis?	✓				
		7) Were % moisture (or solids) reported for all soil and sediment samples?	✓				
		8) If required for the project, TICs reported?			✓		
R4	O	**Surrogate Recovery Data**					
		1) Were surrogates added prior to extraction?			✓		
		2) Were surrogate percent recoveries in all samples within the laboratory QC limits?			✓		
R5	OI	**Test Reports/Summary Forms for Blank Samples**					
		1) Were appropriate type(s) of blanks analyzed?	✓				
		2) Were blanks analyzed at the appropriate frequency?	✓				
		3) Where method blanks taken through the entire analytical process, including preparation and, if applicable, cleanup procedures?	✓				
		4) Were blank concentrations < MQL?	✓				
R6	OI	**Laboratory Control Samples (LCS):**					
		1) Were all COCs included in the LCS?	✓				
		2) Was each LCS taken through the entire analytical procedure, including prep and cleanup steps?	✓				
		3) Were LCSs analyzed at the required frequency?	✓				
		4) Were LCS (and LCSD, if applicable) %Rs within the laboratory QC limits?	✓				
		5) Does the detectability data document the laboratory's capability to detect the COCs at the MDL used to calculate the SQLs?	✓				
		6) Was the LCSD RPD within QC limits (if applicable)?	✓				
R7	OI	**Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Data**					
		1) Were the project/method specified analytes included in the MS and MSD?	✓				
		2) Were MS/MSD analyzed at the appropriate frequency?	✓				
		3) Were MS (and MSD, if applicable) %Rs within the laboratory QC limits?	✓				
		4) Were MS/MSD RPDs within laboratory QC limits?	✓				
R8	OI	**Analytical Duplicate Data**					
		1) Were appropriate analytical duplicates analyzed for each matrix?	✓				
		2) Were analytical duplicates analyzed at the appropriate frequency?	✓				
		3) Were RPDs or relative standard deviations within the laboratory QC limits?	✓				
R9	OI	**Method Quantitation Limits (MQLs):**					
		1) Are the MQLs for each method analyte included in the laboratory data package?	✓				
		2) Do the MQLs correspond to the concentration of the lowest non-zero calibration standard?	✓				
		3) Are unadjusted MQLs included in the laboratory data package?	✓				
R10	OI	**Other Problems/Anomalies**					
		1) Are all known problems/anomalies/special conditions noted in this LRC and ER?	✓				
		2) Were all necessary corrective actions performed for the reported data?	✓				
		3) Was applicable and available technology used to lower the SQL minimize the matrix interference affects on the sample results?	✓				

1 Items identified by the letter "R" should be included in the laboratory data package submitted to the TCEQ in the TRRP-required report(s). Items identified by the letter "S" should be retained and made available upon request for the appropriate retention period.
2 O = organic analyses; I = inorganic analyses (and general chemistry, when applicable).
3 NA = Not applicable.
4 NR = Not Reviewed.
5 ER# = Exception Report identification number (an Exception Report should be completed for an item if "NR" or "No" is checked).

DHL Analytical, Inc.

Laboratory Review Checklist (continued): Supporting Data

Project Name: Dugout Creek	Date: 8/30/07
Reviewer Name: Laura Flowers	Laboratory Work Order: 0708171

#[1]	A[2]	Description	Yes	No	NA[3]	NR[4]	ER#[5]
S1	OI	**Initial Calibration (ICAL)**					
		1) Were response factors and/or relative response factors for each analyte within QC limits?	✓				
		2) Were percent RSDs or correlation coefficient criteria met?	✓				
		3) Was the number of standards recommended in the method used for all analytes?	✓				
		4) Were all points generated between the lowest and highest standard used to calculate the curve?	✓				
		5) Are ICAL data available for all instruments used?	✓				
		6) Has the initial calibration curve been verified using an appropriate second source standard?	✓				
S2	OI	**Initial and Continuing calibration Verification (ICCV and CCV) and Continuing Calibration blank (CCB):**					
		1) Was the CCV analyzed at the method-required frequency?	✓				
		2) Were percent differences for each analyte within the method-required QC limits?	✓				
		3) Was the ICAL curve verified for each analyte?	✓				
		4) Was the absolute value of the analyte concentration in the inorganic CCB < MDL?	✓				
S3	O	**Mass Spectral Tuning:**					
		1) Was the appropriate compound for the method used for tuning?			✓		
		2) Were ion abundance data within the method-required QC limits?			✓		
S4	O	**Internal Standards (IS):**					
		1) Were IS area counts and retention times within the method-required QC limits?			✓		
S5	OI	**Raw Data (NELAC section 1 appendix A glossary, and section 5.12)**					
		1) Were the raw data (for example, chromatograms, spectral data) reviewed by an analyst?	✓				
		2) Were data associated with manual integrations flagged on the raw data?	✓				
S6	O	**Dual Column Confirmation**					
		1) Did dual column confirmation results meet the method-required QC?			✓		
S7	O	**Tentatively Identified Compounds (TICs):**					
		1) If TICs were requested, were the mass spectra and TIC data subject to appropriate checks?			✓		
S8	I	**Interference Check Sample (ICS) Results:**					
		1) Were percent recoveries within method QC limits?			✓		
S9	I	**Serial Dilutions, Post Digestion Spikes, and Method of Standard Additions**					
		1) Were percent differences, recoveries, and the linearity within the QC limits specified in the method?			✓		
S10	OI	**Method Detection Limit (MDL) Studies**					
		1) Was a MDL study performed for each reported analyte?	✓				
		2) Is the MDL either adjusted or supported by the analysis of DCSs?	✓				
S11	OI	**Proficiency Test Reports:**					
		1) Was the lab's performance acceptable on the applicable proficiency tests or evaluation studies?	✓				
S12	OI	**Standards Documentation**					
		1) Are all standards used in the analyses NIST-traceable or obtained from other appropriate sources?	✓				
S13	OI	**Compound/Analyte Identification Procedures**					
		1) Are the procedures for compound/analyte identification documented?	✓				
S14	OI	**Demonstration of Analyst Competency (DOC)**					
		1) Was DOC conducted consistent with NELAC Chapter 5C?	✓				
		2) Is documentation of the analyst's competency up-to-date and on file?	✓				
S15	OI	**Verification/Validation Documentation for Methods** (NELAC Chap 5)					
		1) Are all the methods used to generate the data documented, verified, and validated, where applicable?	✓				
S16	OI	**Laboratory Standard Operating Procedures (SOPs):**					
		1) Are laboratory SOPs current and on file for each method performed?	✓				

1 Items identified by the letter "R" should be included in the laboratory data package submitted to the TCEQ in the TRRP-required report(s). Items identified by the letter "S" should be retained and made available upon request for the appropriate retention period.
2 O = organic analyses; I = inorganic analyses (and general chemistry, when applicable).
3 NA = Not applicable.
4 NR = Not Reviewed.
5 ER# = Exception Report identification number (an Exception Report should be completed for an item if "NR" or "No" is checked).

CLIENT: INTERA Inc.
Project: Dugout Creek
Lab Order: 0708171

CASE NARRATIVE

Samples were analyzed using the methods outlined in the following references:

Method SW9056 - Anions by IC Method
Method E300 - Anions Analysis
Method E160.1 - TDS Analysis
Method D2216 - Percent Moisture (Parameter Not NELAC Certified)

Exception Report R1-01

Samples were received and log-in performed on 8/20/07. A total of 6 samples were received. The samples arrived in good condition and were properly packaged. There were a couple discrepancies with the sample IDs between the sample lids and the sample container labels. The correct sample IDs are on the sample lids as per client.

DHL Analytical

Date: *30-Aug-07*

CLIENT: INTERA Inc.
Project: Dugout Creek
Lab Order: 0708171

Work Order Sample Summary

Lab Smp ID	Client Sample ID	Tag Number	Date Collected	Date Recved
0708171-01	MW-07-1-S		08/17/07 08:15 PM	8/20/2007
0708171-02	MW-07-2-S		08/16/07 10:45 AM	8/20/2007
0708171-03	MW-07-3-S		08/15/07 05:35 PM	8/20/2007
0708171-04	MW-07-1		08/18/07 07:50 AM	8/20/2007
0708171-05	MW-07-3		08/17/07 08:05 AM	8/20/2007
0708171-06	MW-07-4		08/16/07 12:10 PM	8/20/2007

Lab Order: 0708171
Client: INTERA Inc.
Project: Dugout Creek

PREP DATES REPORT

Sample ID	Client Sample ID	Collection Date	Matrix	Test Number	Test Name	Prep Date	Batch ID
0708171-01A	MW-07-1-S	08/17/07 08:15 PM	Soil	SW9056	Anion Prep	08/21/07 01:32 PM	26958
	MW-07-1-S	08/17/07 08:15 PM	Soil	D2216	Percent Moisture	08/21/07 03:50 PM	PMOIST_070821C
0708171-02A	MW-07-2-S	08/16/07 10:45 AM	Soil	SW9056	Anion Prep	08/21/07 01:32 PM	26958
	MW-07-2-S	08/16/07 10:45 AM	Soil	SW9056	Anion Prep	08/21/07 01:32 PM	26958
	MW-07-2-S	08/16/07 10:45 AM	Soil	D2216	Percent Moisture	08/21/07 03:50 PM	PMOIST_070821C
0708171-03A	MW-07-3-S	08/15/07 05:35 PM	Soil	SW9056	Anion Prep	08/21/07 01:32 PM	26958
	MW-07-3-S	08/15/07 05:35 PM	Soil	D2216	Percent Moisture	08/21/07 03:50 PM	PMOIST_070821C
0708171-04A	MW-07-1	08/18/07 07:50 AM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
	MW-07-1	08/18/07 07:50 AM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
	MW-07-1	08/18/07 07:50 AM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
	MW-07-1	08/18/07 07:50 AM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
0708171-04B	MW-07-1	08/18/07 07:50 AM	Aqueous	M2540C	Total Dissolved Solids	08/22/07	TDS_W-08/22/07
0708171-05A	MW-07-3	08/17/07 08:05 AM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
	MW-07-3	08/17/07 08:05 AM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
	MW-07-3	08/17/07 08:05 AM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
0708171-05B	MW-07-3	08/17/07 08:05 AM	Aqueous	M2540C	Total Dissolved Solids	08/22/07	TDS_W-08/22/07
0708171-06A	MW-07-4	08/16/07 12:10 PM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
	MW-07-4	08/16/07 12:10 PM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
	MW-07-4	08/16/07 12:10 PM	Aqueous	E300	Anions by IC method - Water	08/21/07	R33218
0708171-06B	MW-07-4	08/16/07 12:10 PM	Aqueous	M2540C	Total Dissolved Solids	08/22/07	TDS_W-08/22/07

Lab Order: 0708171
Client: INTERA Inc.
Project: Dugout Creek

ANALYTICAL DATES REPORT

Sample ID	Client Sample ID	Matrix	Test Number	Test Name	Batch ID	Dilution	Analysis Date	Run ID
0708171-01A	MW-07-1-S	Soil	SW9056	Anions by IC method - Soil	26958	5	08/23/07 12:30 PM	IC2_070823A
	MW-07-1-S	Soil	D2216	Percent Moisture	PMOIST_070821C	1	08/22/07 09:40 AM	PMOIST_070821C
0708171-02A	MW-07-2-S	Soil	SW9056	Anions by IC method - Soil	26958	20	08/23/07 12:00 PM	IC2_070823A
	MW-07-2-S	Soil	SW9056	Anions by IC method - Soil	26958	5	08/23/07 05:24 PM	IC2_070823A
	MW-07-2-S	Soil	D2216	Percent Moisture	PMOIST_070821C	1	08/22/07 09:40 AM	PMOIST_070821C
0708171-03A	MW-07-3-S	Soil	SW9056	Anions by IC method - Soil	26958	20	08/23/07 12:15 PM	IC2_070823A
	MW-07-3-S	Soil	D2216	Percent Moisture	PMOIST_070821C	1	08/22/07 09:40 AM	PMOIST_070821C
0708171-04A	MW-07-1	Aqueous	E300	Anions by IC method - Water	R33218	5	08/21/07 06:05 PM	IC2_070821A
	MW-07-1	Aqueous	E300	Anions by IC method - Water	R33218	500	08/21/07 03:51 PM	IC2_070821A
	MW-07-1	Aqueous	E300	Anions by IC method - Water	R33218	200	08/21/07 05:51 PM	IC2_070821A
	MW-07-1	Aqueous	E300	Anions by IC method - Water	R33218	100	08/21/07 04:36 PM	IC2_070821A
0708171-04B	MW-07-1	Aqueous	M2540C	Total Dissolved Solids	TDS_W-08/22/07	1	08/22/07 09:00 AM	WC_070822D
0708171-05A	MW-07-3	Aqueous	E300	Anions by IC method - Water	R33218	500	08/21/07 04:05 PM	IC2_070821A
	MW-07-3	Aqueous	E300	Anions by IC method - Water	R33218	1000	08/21/07 04:51 PM	IC2_070821A
	MW-07-3	Aqueous	E300	Anions by IC method - Water	R33218	50	08/21/07 06:20 PM	IC2_070821A
0708171-05B	MW-07-3	Aqueous	M2540C	Total Dissolved Solids	TDS_W-08/22/07	1	08/22/07 09:00 AM	WC_070822D
0708171-06A	MW-07-4	Aqueous	E300	Anions by IC method - Water	R33218	500	08/21/07 04:20 PM	IC2_070821A
	MW-07-4	Aqueous	E300	Anions by IC method - Water	R33218	1000	08/21/07 05:36 PM	IC2_070821A
	MW-07-4	Aqueous	E300	Anions by IC method - Water	R33218	50	08/21/07 06:35 PM	IC2_070821A
0708171-06B	MW-07-4	Aqueous	M2540C	Total Dissolved Solids	TDS_W-08/22/07	1	08/22/07 09:00 AM	WC_070822D

DHL Analytical

Date: *30-Aug-07*

CLIENT:	INTERA Inc.	**Client Sample ID:**	MW-07-1-S
Project:	Dugout Creek	**Lab ID:**	0708171-01
Project No:	RRC-DUG-01-01	**Collection Date:**	08/17/07 08:15 PM
Lab Order:	0708171	**Matrix:**	SOIL

Analyses	Result	SDL	RL	Qual	Units	DF	Date Analyzed
ANIONS BY IC METHOD - SOIL		**SW9056**					Analyst: **JBC**
Chloride	582	26.3	26.3		mg/Kg-dry	5	08/23/07 12:30 PM
PERCENT MOISTURE		**D2216**					Analyst: **TPO**
Percent Moisture	4.83	0	0	N	WT%	1	08/22/07 09:40 AM

Qualifiers:

ND - Not Detected at the SDL
J - Analyte detected between SDL and RL
B - Analyte detected in the associated Method Blank
DF- Dilution Factor
N - Parameter not NELAC certified
See Final Page of Report for MQLs and MDLs
S - Spike Recovery outside control limits
C - Sample Result or QC discussed in Case Narrative
RL - Reporting Limit (MQL adjusted for moisture and sample size)
SDL - Sample Detection Limit
E - TPH pattern not Gas or Diesel Range Pattern

DHL Analytical

Date: *30-Aug-07*

CLIENT:	INTERA Inc.	**Client Sample ID:**	MW-07-2-S
Project:	Dugout Creek	**Lab ID:**	0708171-02
Project No:	RRC-DUG-01-01	**Collection Date:**	08/16/07 10:45 AM
Lab Order:	0708171	**Matrix:**	SOIL

Analyses	Result	SDL	RL	Qual	Units	DF	Date Analyzed
ANIONS BY IC METHOD - SOIL		**SW9056**					Analyst: **JBC**
Chloride	591	29.1	29.1		mg/Kg-dry	5	08/23/07 05:24 PM
PERCENT MOISTURE		**D2216**					Analyst: **TPO**
Percent Moisture	14.8	0	0	N	WT%	1	08/22/07 09:40 AM

Qualifiers:

- ND - Not Detected at the SDL
- J - Analyte detected between SDL and RL
- B - Analyte detected in the associated Method Blank
- DF- Dilution Factor
- N - Parameter not NELAC certified
- See Final Page of Report for MQLs and MDLs
- S - Spike Recovery outside control limits
- C - Sample Result or QC discussed in Case Narrative
- RL - Reporting Limit (MQL adjusted for moisture and sample size)
- SDL - Sample Detection Limit
- E - TPH pattern not Gas or Diesel Range Pattern

DHL Analytical

Date: *30-Aug-07*

CLIENT:	INTERA Inc.	**Client Sample ID:**	MW-07-3-S
Project:	Dugout Creek	**Lab ID:**	0708171-03
Project No:	RRC-DUG-01-01	**Collection Date:**	08/15/07 05:35 PM
Lab Order:	0708171	**Matrix:**	SOIL

Analyses	Result	SDL	RL	Qual	Units	DF	Date Analyzed
ANIONS BY IC METHOD - SOIL		**SW9056**					Analyst: **JBC**
Chloride	4860	115	115		mg/Kg-dry	20	08/23/07 12:15 PM
PERCENT MOISTURE		**D2216**					Analyst: **TPO**
Percent Moisture	15.8	0	0	N	WT%	1	08/22/07 09:40 AM

Qualifiers:

ND - Not Detected at the SDL
J - Analyte detected between SDL and RL
B - Analyte detected in the associated Method Blank
DF- Dilution Factor
N - Parameter not NELAC certified
See Final Page of Report for MQLs and MDLs
S - Spike Recovery outside control limits
C - Sample Result or QC discussed in Case Narrative
RL - Reporting Limit (MQL adjusted for moisture and sample size)
SDL - Sample Detection Limit
E - TPH pattern not Gas or Diesel Range Pattern

CLIENT:	INTERA Inc.	**Client Sample ID:**	MW-07-1
Project:	Dugout Creek	**Lab ID:**	0708171-04
Project No:	RRC-DUG-01-01	**Collection Date:**	08/18/07 07:50 AM
Lab Order:	0708171	**Matrix:**	AQUEOUS

Analyses	Result	SDL	RL	Qual	Units	DF	Date Analyzed
ANIONS BY IC METHOD - WATER		**E300**					Analyst: **JBC**
Bromide	58.0	1.50	5.00		mg/L	5	08/21/07 06:05 PM
Chloride	8840	60.0	200		mg/L	200	08/21/07 05:51 PM
Sulfate	586	5.00	15.0		mg/L	5	08/21/07 06:05 PM
TOTAL DISSOLVED SOLIDS		**M2540C**					Analyst: **JBC**
Total Dissolved Solids (Residue, Filterable)	19000	10.0	10.0		mg/L	1	08/22/07 09:00 AM

Qualifiers:

ND - Not Detected at the SDL
J - Analyte detected between SDL and RL
B - Analyte detected in the associated Method Blank
DF- Dilution Factor
N - Parameter not NELAC certified
See Final Page of Report for MQLs and MDLs
S - Spike Recovery outside control limits
C - Sample Result or QC discussed in Case Narrative
RL - Reporting Limit (MQL adjusted for moisture and sample size)
SDL - Sample Detection Limit
E - TPH pattern not Gas or Diesel Range Pattern

CLIENT:	INTERA Inc.	**Client Sample ID:**	MW-07-3
Project:	Dugout Creek	**Lab ID:**	0708171-05
Project No:	RRC-DUG-01-01	**Collection Date:**	08/17/07 08:05 AM
Lab Order:	0708171	**Matrix:**	AQUEOUS

Analyses	Result	SDL	RL	Qual	Units	DF	Date Analyzed
ANIONS BY IC METHOD - WATER		**E300**					Analyst: **JBC**
Bromide	112	15.0	50.0		mg/L	50	08/21/07 06:20 PM
Chloride	38800	300	1000		mg/L	1000	08/21/07 04:51 PM
Sulfate	3760	50.0	150		mg/L	50	08/21/07 06:20 PM
TOTAL DISSOLVED SOLIDS		**M2540C**					Analyst: **JBC**
Total Dissolved Solids (Residue, Filterable)	62800	10.0	10.0		mg/L	1	08/22/07 09:00 AM

Qualifiers:

ND - Not Detected at the SDL
J - Analyte detected between SDL and RL
B - Analyte detected in the associated Method Blank
DF- Dilution Factor
N - Parameter not NELAC certified
See Final Page of Report for MQLs and MDLs
S - Spike Recovery outside control limits
C - Sample Result or QC discussed in Case Narrative
RL - Reporting Limit (MQL adjusted for moisture and sample size)
SDL - Sample Detection Limit
E - TPH pattern not Gas or Diesel Range Pattern

DHL Analytical **Date:** *30-Aug-07*

CLIENT:	INTERA Inc.	**Client Sample ID:**	MW-07-4
Project:	Dugout Creek	**Lab ID:**	0708171-06
Project No:	RRC-DUG-01-01	**Collection Date:**	08/16/07 12:10 PM
Lab Order:	0708171	**Matrix:**	AQUEOUS

Analyses	Result	SDL	RL	Qual	Units	DF	Date Analyzed
ANIONS BY IC METHOD - WATER		**E300**					Analyst: **JBC**
Bromide	114	15.0	50.0		mg/L	50	08/21/07 06:35 PM
Chloride	38700	300	1000		mg/L	1000	08/21/07 05:36 PM
Sulfate	3820	50.0	150		mg/L	50	08/21/07 06:35 PM
TOTAL DISSOLVED SOLIDS		**M2540C**					Analyst: **JBC**
Total Dissolved Solids (Residue, Filterable)	63100	10.0	10.0		mg/L	1	08/22/07 09:00 AM

Qualifiers:

ND - Not Detected at the SDL
J - Analyte detected between SDL and RL
B - Analyte detected in the associated Method Blank
DF- Dilution Factor
N - Parameter not NELAC certified
See Final Page of Report for MQLs and MDLs
S - Spike Recovery outside control limits
C - Sample Result or QC discussed in Case Narrative
RL - Reporting Limit (MQL adjusted for moisture and sample size)
SDL - Sample Detection Limit
E - TPH pattern not Gas or Diesel Range Pattern

CLIENT: INTERA Inc.
Work Order: 0708171
Project: Dugout Creek

ANALYTICAL QC SUMMARY REPORT

RunID: IC2_070821A

Sample ID: ICV-070821	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: ICV	Run ID: IC2_070821A	Analysis Date: 8/21/2007 9:48:53 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	50.9	1.00	50.00	0	102	90	110			
Chloride	25.3	1.00	25.00	0	101	90	110			
Sulfate	76.3	3.00	75.00	0	102	90	110			

Sample ID: MB-070821	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: MBLK	Run ID: IC2_070821A	Analysis Date: 8/21/2007 10:06:20 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	ND	1.00								
Chloride	ND	1.00								
Sulfate	ND	3.00								

Sample ID: LCS-070821	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: LCS	Run ID: IC2_070821A	Analysis Date: 8/21/2007 10:21:00 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	20.1	1.00	20.00	0	100	90	110			
Chloride	10.0	1.00	10.00	0	100	90	110			
Sulfate	29.8	3.00	30.00	0	99.3	90	110			

Sample ID: LCSD-070821	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: LCSD	Run ID: IC2_070821A	Analysis Date: 8/21/2007 10:35:41 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	20.1	1.00	20.00	0	100	90	110	0.0811	20	
Chloride	9.99	1.00	10.00	0	99.9	90	110	0.0640	20	
Sulfate	29.8	3.00	30.00	0	99.2	90	110	0.109	20	

Sample ID: CCV1-070821	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: CCV	Run ID: IC2_070821A	Analysis Date: 8/21/2007 12:57:37 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	20.0	1.00	20.00	0	100	90	110			
Chloride	10.1	1.00	10.00	0	101	90	110			
Sulfate	29.7	3.00	30.00	0	99.0	90	110			

Qualifiers:

B	Analyte detected in the associated Method Blank	DF	Dilution Factor
J	Analyte detected between MDL and RL	MDL	Method Detection Limit
ND	Not Detected at the Method Detection Limit	R	RPD outside accepted control limits
RL	Reporting Limit	S	Spike Recovery outside control limits
N	Parameter not NELAC certified		

CLIENT: INTERA Inc.
Work Order: 0708171
Project: Dugout Creek

ANALYTICAL QC SUMMARY REPORT

RunID: IC2_070821A

Sample ID: 0708174-01E MS	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: MS	Run ID: IC2_070821A	Analysis Date: 8/21/2007 1:20:57 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	131	5.00	50.00	80.24	101	90	110			

Sample ID: 0708174-01E MSD	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: MSD	Run ID: IC2_070821A	Analysis Date: 8/21/2007 1:35:37 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	131	5.00	50.00	80.24	102	90	110	0.194	20	

Sample ID: 0708174-01E MS	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: MS	Run ID: IC2_070821A	Analysis Date: 8/21/2007 1:50:18 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	18.6	1.00	20.00	0	92.9	90	110			
Sulfate	42.5	3.00	30.00	12.33	101	90	110			

Sample ID: 0708174-01E MSD	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: MSD	Run ID: IC2_070821A	Analysis Date: 8/21/2007 2:04:58 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	18.5	1.00	20.00	0	92.6	90	110	0.254	20	
Sulfate	42.5	3.00	30.00	12.33	100	90	110	0.0275	20	

Sample ID: CCV2-070821	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: CCV	Run ID: IC2_070821A	Analysis Date: 8/21/2007 5:05:52 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	20.6	1.00	20.00	0	103	90	110			
Chloride	10.6	1.00	10.00	0	106	90	110			
Sulfate	30.5	3.00	30.00	0	102	90	110			

Sample ID: CCV3-070821	Batch ID: R33218	TestNo: E300	Units: mg/L
SampType: CCV	Run ID: IC2_070821A	Analysis Date: 8/21/2007 8:32:42 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Bromide	20.2	1.00	20.00	0	101	90	110			
Chloride	10.2	1.00	10.00	0	102	90	110			
Sulfate	30.0	3.00	30.00	0	100	90	110			

Qualifiers:

B	Analyte detected in the associated Method Blank	DF	Dilution Factor
J	Analyte detected between MDL and RL	MDL	Method Detection Limit
ND	Not Detected at the Method Detection Limit	R	RPD outside accepted control limits
RL	Reporting Limit	S	Spike Recovery outside control limits
N	Parameter not NELAC certified		

CLIENT: INTERA Inc.
Work Order: 0708171
Project: Dugout Creek

ANALYTICAL QC SUMMARY REPORT

RunID: IC2_070823A

Sample ID: MB-26958	Batch ID: 26958	TestNo: SW9056	Units: mg/Kg
SampType: MBLK	Run ID: IC2_070823A	Analysis Date: 8/23/2007 10:01:33 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	ND	5.00								

Sample ID: LCS-26958	Batch ID: 26958	TestNo: SW9056	Units: mg/Kg
SampType: LCS	Run ID: IC2_070823A	Analysis Date: 8/23/2007 10:16:13 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	50.6	5.00	50.00	0	101	80	120			

Sample ID: LCSD-26958	Batch ID: 26958	TestNo: SW9056	Units: mg/Kg
SampType: LCSD	Run ID: IC2_070823A	Analysis Date: 8/23/2007 10:30:54 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	50.6	5.00	50.00	0	101	80	120	0.0138	20	

Sample ID: 0708171-01A DUP	Batch ID: 26958	TestNo: SW9056	Units: mg/Kg-dry
SampType: DUP	Run ID: IC2_070823A	Analysis Date: 8/23/2007 11:16:56 AM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	536	26.1	0	581.7				8.11	25	

Sample ID: 0708171-01A MS	Batch ID: 26958	TestNo: SW9056	Units: mg/Kg-dry
SampType: MS	Run ID: IC2_070823A	Analysis Date: 8/23/2007 12:44:56 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	604	26.3	262.7	349.0	97.1	80	120			

Sample ID: 0708171-01A MSD	Batch ID: 26958	TestNo: SW9056	Units: mg/Kg-dry
SampType: MSD	Run ID: IC2_070823A	Analysis Date: 8/23/2007 12:59:37 PM	Prep Date: 8/21/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	604	26.3	262.7	349.0	97.2	80	120	0.0222	20	

Qualifiers:

B	Analyte detected in the associated Method Blank	DF	Dilution Factor
J	Analyte detected between MDL and RL	MDL	Method Detection Limit
ND	Not Detected at the Method Detection Limit	R	RPD outside accepted control limits
RL	Reporting Limit	S	Spike Recovery outside control limits
N	Parameter not NELAC certified		

CLIENT: INTERA Inc.
Work Order: 0708171
Project: Dugout Creek

ANALYTICAL QC SUMMARY REPORT

RunID: IC2_070823A

Sample ID: ICV-070823	Batch ID: R33264	TestNo: SW9056	Units: mg/Kg
SampType: ICV	Run ID: IC2_070823A	Analysis Date: 8/23/2007 9:42:28 AM	Prep Date: 8/23/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	25.5	5.00	25.00	0	102	90	110			

Sample ID: CCV1-070823	Batch ID: R33264	TestNo: SW9056	Units: mg/Kg
SampType: CCV	Run ID: IC2_070823A	Analysis Date: 8/23/2007 1:14:16 PM	Prep Date: 8/23/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	10.1	5.00	10.00	0	101	90	110			

Sample ID: CCV3-070823	Batch ID: R33264	TestNo: SW9056	Units: mg/Kg
SampType: CCV	Run ID: IC2_070823A	Analysis Date: 8/23/2007 5:56:59 PM	Prep Date: 8/23/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	10.3	5.00	10.00	0	103	90	110			

Sample ID: CCV2-070823	Batch ID: R33264	TestNo: SW9056	Units: mg/Kg
SampType: CCV	Run ID: IC2_070823A	Analysis Date: 8/23/2007 4:40:34 PM	Prep Date: 8/23/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Chloride	10.1	5.00	10.00	0	101	90	110			

Qualifiers:

B	Analyte detected in the associated Method Blank	DF	Dilution Factor
J	Analyte detected between MDL and RL	MDL	Method Detection Limit
ND	Not Detected at the Method Detection Limit	R	RPD outside accepted control limits
RL	Reporting Limit	S	Spike Recovery outside control limits
N	Parameter not NELAC certified		

CLIENT: INTERA Inc.
Work Order: 0708171
Project: Dugout Creek

ANALYTICAL QC SUMMARY REPORT

RunID: PMOIST_070821C

Sample ID: **0708171-03A DUP**	Batch ID: **PMOIST_070821C**	TestNo: **D2216**		Units: **WT%**	
SampType: **DUP**	Run ID: **PMOIST_070821C**	Analysis Date: **8/22/2007 9:40:00 AM**		Prep Date: **8/21/2007**	

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Percent Moisture	16.1	0	0	15.75				1.96	30	N

Qualifiers:

B	Analyte detected in the associated Method Blank	DF	Dilution Factor
J	Analyte detected between MDL and RL	MDL	Method Detection Limit
ND	Not Detected at the Method Detection Limit	R	RPD outside accepted control limits
RL	Reporting Limit	S	Spike Recovery outside control limits
N	Parameter not NELAC certified		

CLIENT: INTERA Inc.
Work Order: 0708171
Project: Dugout Creek

ANALYTICAL QC SUMMARY REPORT

RunID: WC_070822D

Sample ID: MB-070822	Batch ID: TDS_W-08/22/07	TestNo: M2540C	Units: mg/L
SampType: MBLK	Run ID: WC_070822D	Analysis Date: 8/22/2007 9:00:00 AM	Prep Date: 8/22/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Total Dissolved Solids (Residue, Filtera	ND	10.0								

Sample ID: LCS-070822	Batch ID: TDS_W-08/22/07	TestNo: M2540C	Units: mg/L
SampType: LCS	Run ID: WC_070822D	Analysis Date: 8/22/2007 9:00:00 AM	Prep Date: 8/22/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Total Dissolved Solids (Residue, Filtera	737	10.0	745.6	0	98.8	70	126			

Sample ID: 0708151-01B DUP	Batch ID: TDS_W-08/22/07	TestNo: M2540C	Units: mg/L
SampType: DUP	Run ID: WC_070822D	Analysis Date: 8/22/2007 9:00:00 AM	Prep Date: 8/22/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Total Dissolved Solids (Residue, Filtera	5440	10.0	0	5590				2.63	5	

Sample ID: 0708173-04B DUP	Batch ID: TDS_W-08/22/07	TestNo: M2540C	Units: mg/L
SampType: DUP	Run ID: WC_070822D	Analysis Date: 8/22/2007 9:00:00 AM	Prep Date: 8/22/2007

Analyte	Result	RL	SPK value	Ref Val	%REC	LowLimit	HighLimit	%RPD	RPDLimit	Qual
Total Dissolved Solids (Residue, Filtera	1300	10.0	0	1288				0.542	5	

Qualifiers:

B	Analyte detected in the associated Method Blank	DF	Dilution Factor
J	Analyte detected between MDL and RL	MDL	Method Detection Limit
ND	Not Detected at the Method Detection Limit	R	RPD outside accepted control limits
RL	Reporting Limit	S	Spike Recovery outside control limits
N	Parameter not NELAC certified		

CLIENT: INTERA Inc.
Work Order: 0708171
Project: Dugout Creek

MQL SUMMARY REPORT

TestNo: E300	MDL	MQL
Analyte	**mg/L**	**mg/L**
Bromide	0.300	1.00
Chloride	0.300	1.00
Sulfate	1.00	3.00

TestNo: SW9056	MDL	MQL
Analyte	**mg/Kg**	**mg/Kg**
Chloride	5.00	5.00

TestNo: M2540C	MDL	MQL
Analyte	**mg/L**	**mg/L**
Total Dissolved Solids (Residue, Filt	10.0	10.0

Qualifiers: MQL -Method Quantitation Limit as defined by TRRP
MDL -Method Detection Limit as defined by TRRP

Appendix D

BMP Evaluation - Crespo Consulting Services, Inc.

August 2007

Engineering Summary Letter

Dugout Creek

Best Management Practice Development

Prepared for:

INTERA, Inc.

August 30, 2007

Prepared by:

Crespo Consulting Services, Inc.
4131 Spicewood Springs Road, B-2
Austin, TX 78759
Tel: (512) 343-6404 Fax: (512) 343-8120

1. Executive Summary

This scope of this project is to compile known site conditions, evaluate mitigation options, and develop BMPs to address the saltwater contamination at O'Ryan and Pharaoh Seeps and potential impacts to Dugout Creek. Crespo compiled available information for O'Ryan Seep, Pharaoh Seep and Dugout Creek and performed site reconnaissance of the seeps and creek. Based on the available data, the site reconnaissance, and discussions with INTERA staff geologists, Crespo recommends placement of a low-flow diversion at or very near all three of the seeps to capture the seep water before it combines with stormwater and route it to an evaporation pond. In addition, a first-flush stormwater diversion to an evaporation pond is recommended downstream of the O'Ryan Seep. Some additional surveying, engineering, and surface water sampling is required to develop a preliminary engineering plan for these BMPs. Two monitoring stations are recommended on Dugout Creek and one monitoring station on the O'Ryan Seep tributary, along with additional flow and quality monitoring at the seeps.

2. Previous Studies

The overall Dugout Creek area, monitoring wells, Dugout Creek and its tributaries and seeps are shown in Appendix A. The O'Ryan Seep and Pharaoh Seep areas including seeps, wells, and monitoring wells is shown in Appendix B and Appendix C, respectively.

Pharaoh Seep

Based on INTERA staff observations, Pharaoh Seep appears to flow only after significant rainfall events and stops flowing within a short time (INTERA 2006a). Flow was estimated at approximately 0.5 liters per minute in March 2006, the only flow observed between 2000 and 2006. Subsequent observations by INTERA staff support the intermittent behavior of the seep (INTERA 2006b). Information from Railroad Commission field staff obtained during the June 2007 site visit also supports these observations.

A sample collected by INTERA from the seep contained chloride concentrations of 13,800 mg/L. INTERA concluded that the seep was impacted by produced water from the Saga #2 well (INTERA 2006a). INTERA also concluded that the chloride plume in the Pharaoh Seep area has been flushed down gradient, presumably in the direction of Dugout Creek (INTERA 2006a). INTERA investigations do not conclusively demonstrate that Pharaoh Seep contributes to chloride levels in Dugout Creek at this time (INTERA 2006b).

O'Ryan Seep

Previous studies do not contain historical flow data from O'Ryan Seep. Information from Railroad Commission field staff indicates that O'Ryan Seep flows only after significant rainfall.

One potential source of the chloride is believed to be the Citation 71 injection well. The chloride level in O'Ryan Seep (North) is 1210 mg/L (INTERA 2006c). Chloride concentrations are not available for the O'Ryan South seep.

Dugout Creek

INTERA investigations do not conclusively demonstrate that Pharaoh Seep contributes to chloride levels in Dugout Creek (INTERA 2006b). O'Ryan Seep appears to contribute chloride to the groundwater entering Dugout Creek at the Dugout/O'Ryan confluence. Chloride levels of between 10,200 mg/L and 12,000 mg/L were detected in the segment between the confluence of the O'Ryan Seep and Pharaoh Seep tributaries (INTERA 2006b).

3. Site Visit

A June 2007 site visit by Crespo and INTERA staff took place during a period of above average rainfall for the region and one day after a rainfall of approximately 0.5 inches.

Pharaoh Seep

Observations were made at the SAGA #2 well and Pit #1 site, and several sites where the Pharaoh Seep channel crossed roadways. The actual seep (downstream from the Saga #2 well) was not visited due to access limitations and time constraints. At the Saga #2 site, no surface water was observed, however a very small seep to the south of the main drainage area was observed. The water from this small seep made a small pool and appeared to soak back into the ground, or to evaporate. There was an oily sheen in the water and some surface salt deposition was present in the area. Salt Cedar (Tamarix) shrubs/trees were present in the overall seep drainage area, which was relatively flat and broad.

Standing water was present in the channel at various road crossings downstream from the seep. Little or no flow was observed, and no surface salt deposits were observed downstream from the SAGA #2 well and Pit #1 site. The Pharaoh Seep channel was not distinct at the SAGA #2 well and Pit #1 site, but the channel was visible at the County Road 53 crossing.

At the Dugout Creek/Pharaoh Seep confluence the flow appeared to fan out into a series of small channels. Salt Cedars were present at the SH 821 crossing but not observed at any other downstream crossings.

O'Ryan Seeps

The North and South O'Ryan seeps were located in dense brush and difficult terrain and the actual seeps were not observed. But there was a variety of plant life in the area

that indicated the presence of surface or subsurface water. Salt cedar trees were present in the seep area.

Flow was observed in the vicinity of MW-7 and MW-15, downstream from the seeps. Flow was also observed in a cut in a berm located just upstream from MW-15. Flow was estimated to be approximately 1L/min. Numerous surface salt deposits were observed in the area between MW-15 and MW-7. Salt cedar trees were present in the MW-7 and MW-15 areas. Surface salt deposits were observed in the area near SB-10A and SB-10B as well, although they were not as prevalent as in the MW-15 and MW-7 areas.

The O'Ryan tributary/Dugout Creek confluence is well defined. Little or no flow was observed in Dugout Creek or in the O'Ryan tributary channel at the confluence.

Dugout Creek

Standing water was observed in Dugout Creek, but little to no flow was observed at the locations visited. The only location where flow was observed was at the US81 crossing where a trickle was observed. The Dugout Creek channel width and depth varies widely along the reach visited. Some areas were completely dry. Debris lines from recent storm events were visible in several locations.

4. Conceptual Model

A conceptual model of the O'Ryan Seep and the associated chloride plume was developed by INTERA and Crespo based on the available data and the results of the site visit.

The two O'Ryan seeps are fed by groundwater from a disconnected section of the Ogallala Aquifer. The seep transports the dissolved chlorides to the surface and to the alluvium in the channel formed by surface drainage and the seep. The water table in the area downstream of the O'Ryan Seeps is relatively high and as a result, evapotranspiration by phreatophytes draws the water from the alluvium to the surface where it evaporates forming salt deposits. Surface water from rainfall-runoff events then dissolve the salt deposits and transport the salt downstream toward Dugout Creek in pulses.

Pharaoh Seep is assumed to be the primary source of chlorides in the Pharaoh Seep area. It is assumed that treating the water flowing from the seep will remove most of the chlorides being transported to Dugout Creek.

Flow Estimations

Since there is only one flow estimate (for Pharaoh Seep), several flow estimation methods were utilized to estimate the range in flows at the seeps. Even with these estimates, there is some significant uncertainty in the flows at the seeps.

INTERA provided an estimation of seep flow for the O'Ryan Seep based on generally accepted parameters for the Ogallala aquifer and the limited data available from the monitoring wells in the area.

Based on the groundwater contours upgradient of the seep there is about 3000- to 4000-feet length of aquifer that could be considered to be converging in the direction of the seep. Based on groundwater velocity, the second length dimension is estimated to be:

Groundwater Velocity $V = KI/n$

Where: K = hydraulic conductivity of the Ogallala aquifer (estimated at 10 ft/day)
I = hydraulic gradient, estimated from the groundwater elevation contours up gradient of the seep at 10ft/500ft = 0.02
n = porosity, estimated at 0.2

V = (10 ft/d X 10ft/500ft)/0.2 = 1ft/d, or 365 ft/year; or, in one year, the up gradient distance contributing to the seep is 365 ft.

The area contributing recharge to the seep on an annual basis is then 3,000ft X 365ft = 1,095,000 sq ft or 25 acres. The flow rate at the seep by taking a 10 foot thick saturated thickness, the 3,000 ft as the other length dimension in the flow rate calculation:

Flow rate Q = AKI = 3000ft X 10ft X 10ft/d X 0.02ft/d = 6,000 cu ft/d = 44,880 gal/d = 31 gal/min (117 liters/min). The Pharaoh Seep was expected to have similar flow characteristics as the O'Ryan Seep; however, this flow rate estimate is significantly higher than the observed rate of 0.5 Liters/min.

Another method of estimating seep flow is using recharge rates. The recharge rate as a percentage of precipitation can be estimated based on average annual rainfall and recharge estimates in inches per year:

- Precipitation Mitchell/Howard County border = 19 inches/year (Climatic Atlas of Texas, 1983)
- Recharge: Southern High Plains: estimated based on groundwater, 0.4 inches/year (Wood and Sanford, 1995); 0.31 inches/year (Reedy et al., 2003); 0.086 inches/year (USGS RASA model)

Annual recharge estimates as percent of precipitation then range from:

- 0.4 in/19 in = 2.1%
- 0.31 in/19 in = 1.6%
- 0.086 in/19in = 0.45%

For comparative purposes, a range of recharge rates were used to estimate seep flow based on average annual precipitation, recharge rates, and estimated drainage areas. INTERA's recommendation of 25 acres was rounded up to 30 acres to provide a conservative (high) estimate of the contributing area for both O'Ryan and Pharaoh Seeps. A recharge rate of 0.4 inches/year or 2.1% was also used as a conservative (high) estimate to determine a maximum seep flow rate. A recharge rate based on a USGS RASA model recharge rate of 0.086 in/yr (low end of the RASA model) was used to calculate the expected low end flow rate (TWDBb). The results were compared to the observed discharge rate estimate at Pharaoh Seep of 0.5 L/min. It was assumed that the combined O'Ryan North and South seeps had approximately the same flow rate as Pharaoh Seep. Results of this calculation are shown in Appendix F for O'Ryan Seep and Appendix G for Pharaoh Seep. A summary of flow rate calculations is provided in Table 1.

Table 1. Estimated Seep Flow Rates

Estimated Seep Flow Rate (Various Methods)				
	O'Ryan Seep		Pharaoh Seep	
Methods	Liters/min	Gallons/min	Liters/min	Gallons/min
Observed	x	x	0.50	0.13
Recharge Rate (low)	0.50	0.13	0.47	0.12
Recharge Rate (high)	2.37	0.63	2.19	0.6
Ground Water Velocity	117	31	x	x

These estimates are provided to illustrate the range of flows to be managed and the degree of uncertainty in the flow estimates. The recharge rate methods appear to approximate more closely the observed seep flow since these flows were utilized in the BMP sizing.

5. Proposed Corrective Actions and Monitoring

Rather than attempting to build a single BMP to treat the entire area, the strategy of utilizing two types of BMPs separates the capture of the low flow seep water and the higher flow rain/runoff water allowing more effective BMPs to be designed for the different flow regimes. Based on the observations and calculations, a proposed general strategy of capturing the surface runoff at Pharaoh and O'Ryan tributaries by:

1) Intercepting the seep water and storing it as close to the source as possible. This will require later disposal or evaporation. The reduced transport of additional salt into the area will prevent the formation of surface salt deposits in the drainage area downstream from the seep.

2) Placing a BMP downstream of the surface salt deposits to catch first flush (salt runoff) to store and treat (O'Ryan Seep only).

Specific BMP Recommendations

The BMPs in Table 2 were considered for use in the O'Ryan and Pharaoh Seep areas.

Table 2. BMP designs considered (Schueler 1987, LCRA 2007)

BMP Type	Comment
Dry Extended Detention	Not effective for dissolved constituent removal
Extended Detention with Marsh	Not suited for dry areas
Wet Extended Detention	Not suited for dry areas
Wet Pond	Not suited for dry areas
Water Quality Inlet	Not effective for dissolved constituent removal
Grassed Swale	Not effective for dissolved constituent removal
Vegetative Filter Strip	Not effective for dissolved constituent removal
Shallow Marsh	Not suited for dry areas
Sand Filtration Basins	Not effective for dissolved constituent removal
Retention Irrigation systems	Not effective for dissolved constituent removal
Porous Pavement	Not applicable
Infiltration Trench	Not effective for dissolved chloride removal
Infiltration Basin	Not effective for dissolved chloride removal
Storage and Disposal	**Alternate Recommendation**
Storage and Evaporation	**Recommended**

Most of the BMPs listed above are effective at removing suspended solids and particulates but are not effective at removing dissolved constituents. They are designed to treat the captured water and release it back into the drainage system. In the O'Ryan and Pharaoh systems the dissolved solids, in this case the chlorides would pass through these types of BMPs. Wet Ponds and other BMPs that utilize permanent water volumes are not practical for areas with low rainfall and high evaporation rates.

The infiltration BMPs typically involve return of the captured water into the groundwater system. In the case of the O'Ryan and Pharaoh Seeps, infiltration techniques would return most of the dissolved chlorides into the alluvium.

The two BMPs considered to be most effective are the Storage and Disposal, and the Storage and Evaporation BMPs. The Storage and Evaporation BMP is recommended

because of its effectiveness at removing salts and its lower cost compared to the Storage and Disposal BMP.

O'Ryan Seep - Low Flow Seep BMP.

The recommended BMP is a sump and evaporation pond for both the O'Ryan north and the O'Ryan south seeps. The evaporation ponds should be located above the O'Ryan seep channel. The sumps should be located as close to each seep as possible (see Appendix D). The sumps are sized to capture 1-day of the maximum estimated flow (60 cf), or approximately 4.5 days of the minimum flow. The sumps are used to isolate the seep flow from surface runoff, collect the seep water and pump it to either a holding tank or an evaporation pond. Based on the flow estimates (Appendix F), the sumps should be 3-feet high with a diameter of 5-feet. Sump sizing is shown in Table 3.

Table 3. O'Ryan Seep Low Flow BMP Sump Sizing

O'Ryan Sump Sizing			
Minimum Size			
	Volume (cf)	**height (ft)**	**diameter (ft)**
1 day	13	3	2.33
2 day	25.7	3	3.30
1 week	89.8	3	6.18
Maximum Size			
	Volume (cf)	**height (ft)**	**diameter (ft)**
1 day	60	3	5.05
2 day	120.4	3	7.15
1 week	421.4	3	13.37

The water collected in the sump is pumped to a 60-ft x 60-ft evaporation pond with a depth of 1-ft as shown in Table 4. The evaporation pond was sized using the calculated minimum and maximum flow rates and average precipitation and evaporation data (TWDBb). The evaporation pond should be lined with a corrosion and contamination resistant liner due to the high chloride levels in the seep water. Based on USGS rainfall depth-duration frequency data, the pond will hold one month's maximum seep flow plus the precipitation from the 25-year precipitation event (approximately 6-inches).

Table 4. O'Ryan Seep evaporation pond and holding tank sizing

O'Ryan Seep

	max	min
	1,831 cf/month	390 cf/month

Month	Mean Precip (in)	Mean Evap (in)	Max Inflow (in)	Max Level (in)	Min Inflow (in)	Min Level (in)
Jan	0.92	2.67	0.51	0.00	0.11	0.00
Feb	0.98	3.18	0.51	0.00	0.11	0.00
Mar	1.15	5.36	0.51	0.00	0.11	0.00
Apr	1.6	6.7	0.51	0.00	0.11	0.00
May	2.9	6.79	0.51	0.00	0.11	0.00
Jun	2.52	8.33	0.51	0.00	0.11	0.00
Jul	2.16	9.38	0.51	0.00	0.11	0.00
Aug	2.07	8.36	0.51	0.00	0.11	0.00
Sep	2.69	6.5	0.51	0.00	0.11	0.00
Oct	2.05	5.19	0.51	0.00	0.11	0.00
Nov	1.15	3.73	0.51	0.00	0.11	0.00
Dec	1.05	2.83	0.51	0.00	0.11	0.00
Total	21.24	69.02	6.10		1.30	

Evaporation Pond Dimensions

depth	1	ft
length	60	ft
width	60	ft
Volume	3,600	cubic feet

Holding Tank
One Month Capacity (max flow rate)
55,698 cf
416,646 gallons

4.7 months at min flow rate

0.51 max required depth from seep flow
0.11 min required depth from seep flow

A 55,698-cf (416,646 gallon) capacity tank would hold the one-month maximum flow and would require pumping and transport every month. If the minimum seep flow occurs, a much smaller holding tank would be required. The size of available holding tanks and tanker truck capacities suggests an evaporation pond approach would be more cost effective if the maximum seep flow estimate is accurate.

Based on chloride concentration level of 1210 mg/L and the minimum and maximum estimated flow rates, each evaporation pond will collect from 708-lbs to 3,320-lbs of salt per year (see Appendix F).

Based on site conditions, the following alternative designs could be considered for the low flow seep BMP.

- Construct a single evaporation pond for the combined flow from both seeps.
- Construct a single holding tank
- Construct a single pond downstream from confluence of two seeps

O'Ryan Seep – First-Flush BMP

The recommended BMP is to divert the first 0.1 inches of runoff from the area downstream of the seeps and downstream of the area where the surface salt deposits are located. The drainage area is approximately 200 acres. The approximate location of this BMP is shown in Appendix D.

The BMP is designed to divert the first-flush of runoff that contains the highest load of chloride dissolved from the surface salt deposits and minor seeps. The surface salt deposits are located far enough downstream from the seeps that several additional tributaries are part of the drainage area at the proposed BMP location. The 200 acre drainage area does not include the relatively flat area above the escarpment. Runoff from this flat area will not reach the area of surface salt deposits until the deposits have already been dissolved and transported to the BMP.

The first flush BMP is relatively large due to the increased drainage area. Based on annual rainfall and infiltration rates it is assumed that approximately 1-inch runoff per year flows over the drainage area. The proposed first-flush BMP will capture half of the annual runoff volume with an assumed chloride concentration of 1210 mg/l (the same as the chloride concentration at the O'Ryan seep). Since the chlorides are dissolved easily, only a small depth of capture is required. Table 5 provides an estimated BMP sizing for the first flush BMP.

Table 5. First-Flush BMP Sizing

Drainage Area	
Drainage Area (acres)	200.0
DA (sf)	8,712,000
capture (inches)	0.1
Pond Volume (cf)	72,600
Capture Volume Size	
height (ft)	1
length (ft)	270
width (ft)	270
total volume (cf)	72,900
Chloride Captured	
Concentration (mg/L)	1210
Captured per storm (lbs)	6.8
# storms/year	10
Capture per year (lbs)	68.4

Due to the high concentrations of chloride in the runoff it is assumed that the BMP will need to be sized as an evaporation pond. The evaporation pond should be lined with a corrosion resistant liner due to the high chloride levels in the seep water.

Prior to beginning the detailed design and implementation of the recommended BMPs, additional data will be required as outlined below:

1. Measure the precipitation and flow rate at each seep to validate the flow rate estimates used to size the BMPs. The flow rates at each seep should be measured after significant rainfall events.
2. Measure the chloride concentration and conductivity at each seep to establish the chloride concentration and the correlation between chloride concentration and conductivity. Once the correlation is established, ongoing conductivity measurements can be used to monitor BMP performance.
3. Measure the precipitation and flow rate at the proposed location of the first-flush BMP after a significant rainfall event.
4. Measure the chloride concentration and conductivity at the proposed first-flush BMP location to establish the chloride concentration and the correlation between chloride concentration and conductivity.
5. Develop a more refined precipitation/evaporation runoff model in order to size the BMPs accurately.
6. Perform a topographic survey of the seep areas and the proposed BMP locations to accurately determine the final BMP placement.
7. Perform a geotechnical survey of the proposed BMP locations. The survey will identify local geologic features that could impact the pond location and design.
8. Develop a preliminary BMP design, including the specification for the flow containment/liners to be used in the BMPs
9. Develop a cost estimate for the proposed BMPS
10. Develop sampling plans to monitor the performance of the BMPs. The sampling plan includes periodic samples from the seeps, as well as samples downstream of the seeps near proposed location of the first-flush BMP.

Pharaoh Seep – Low-Flow Seep BMP.

A sump and evaporation pond are recommended for the Pharaoh seep. The evaporation pond should be located above the Pharaoh Seep channel. The sump should be located as close to the seep as possible (see Appendix B). The sump is sized to capture 1-day of the maximum estimated flow (120 cfs), or approximately 4.5 days of the minimum flow. The sump will be used to isolate the seep flow from surface runoff, collect the seep water and pump it to either a holding tank or an evaporation pond. Based on the flow estimates (Appendix G), the sump should be 3-feet high with a diameter of 7.2-feet. Sump sizing is shown in Table 6.

Table 6. Pharaoh Seep Low Flow BMP Sump Sizing

Sump Sizing			
Minimum Size			
	Volume (cf)	**height (ft)**	**diameter (ft)**
1 day	26	3	3.30
2 day	51.3	3	4.67
1 week	179.7	3	8.73
Maximum Size			
	Volume (cf)	**height (ft)**	**diameter (ft)**
1 day	120	3	7.15
2 day	240.8	3	10.11
1 week	842.8	3	18.91

The water collected in the sump is pumped to an 85-ft x 85-ft evaporation pond with a depth of 1-ft as shown in Table 7. The evaporation pond was sized using the calculated minimum and maximum flow rates, and average precipitation and evaporation data (TWDBb). The evaporation pond should be lined with a corrosion and contamination resistant liner due to the high chloride levels in the seep water. Based on USGS rainfall depth-duration frequency data, the pond will hold one month's maximum seep flow plus the precipitation from the 25-year precipitation event (approximately 6-inches).

Table 7. Pharaoh Seep Evaporation pond and holding tank sizing

Pharaoh Seep

max 3,662 cf/month

min 781 cf/month

Month	Mean Precip (in)	Mean Evap (in)	Max Inflow (in)	Max Level (in)	Min Inflow (in)	Min Level (in)
Jan	0.92	2.67	0.51	0.00	0.11	0.00
Feb	0.98	3.18	0.51	0.00	0.11	0.00
Mar	1.15	5.36	0.51	0.00	0.11	0.00
Apr	1.6	6.7	0.51	0.00	0.11	0.00
May	2.9	6.79	0.51	0.00	0.11	0.00
Jun	2.52	8.33	0.51	0.00	0.11	0.00
Jul	2.16	9.38	0.51	0.00	0.11	0.00
Aug	2.07	8.36	0.51	0.00	0.11	0.00
Sep	2.69	6.5	0.51	0.00	0.11	0.00
Oct	2.05	5.19	0.51	0.00	0.11	0.00
Nov	1.15	3.73	0.51	0.00	0.11	0.00
Dec	1.05	2.83	0.51	0.00	0.11	0.00
Total	21.24	69.02	6.10		1.30	

Evaporation Pond Dimensions

depth	1	ft
length	85	ft
width	85	ft
Volume	7,225	cubic feet
	54,047	gallons

Holding Tank
One Month Capacity (max flow rate)
111,395 cf
833,292 gallons

4.7 months at min flow rate

0.51 max required depth from seep flow
0.11 min required depth from seep flow

An 111,395-cf (833,292 gallon) capacity tank would hold the one-month maximum flow and would require pumping and transport every month. If the minimum seep flow occurs, a much smaller holding tank would be required. The size of available holding tanks and tanker truck capacities suggests an evaporation pond approach would be more cost effective if the maximum seep flow estimate is accurate.

Based on chloride concentration level of 13,800 mg/L and the minimum and maximum estimated flow rates, each evaporation pond will collect from 8,072-lbs to 37,862-lbs of salt per year (Appendix G).

No data exists, and no observations were made confirming the presence of salt deposits downstream from the Pharaoh Seep. Preliminary data suggests that if present, surface and subsurface salt deposits may be similar to those observed downstream from the O' Ryan Seeps. If additional seeps and/or surface and subsurface salt deposits are present downstream from Pharaoh Seep, a first-flush BMP similar to that recommended for the O'Ryan Seeps could be developed for Pharaoh Seep at a later time.

Prior to beginning the detailed design and implementation of the recommended BMPs, additional data will be required as outlined below:

1. Measure the flow rate at the seep to validate the flow rate estimates used to size the BMPs. The flow rates at the seep should be measured after significant rainfall events.
2. Measure the chloride concentration and conductivity at the seep to establish the chloride concentration and the correlation between chloride concentration and conductivity. Once the correlation is established, ongoing conductivity measurements can be used to monitor BMP performance.
3. Develop a more refined precipitation/evaporation runoff model in order to size the BMPs accurately.
4. Perform a topographic survey of the seep area to accurately determine the final BMP locations.
5. Perform a geotechnical survey of the proposed BMP locations. The survey will identify local geologic features that could impact the pond location and design.
6. Develop a preliminary BMP design, including the specification for the flow containment/liners to be used in the BMP.
7. Develop a cost estimate for the proposed BMP.
8. Develop sampling plans to monitor the performance of the BMP by performing periodic sampling of the seep.

6. Proposed Permanent Monitoring Stations

In order to establish baseline surface water flows and conductivity measurements, as well as to monitor the effectiveness of the proposed BMPs, four permanent monitoring stations are recommended. A sufficient number of chloride samples at each seep should be taken to correlate chloride concentrations with conductivity. Flow and conductivity measurements at the following locations are recommended.

1. MS-1: Dugout Creek, upstream from the O'Ryan Seep tributary/Dugout Creek confluence. Monitoring data at this location will establish a baseline for flow and chlorides entering the O'Ryan/Pharaoh/Dugout Creek area.

2. MS-2: O'Ryan Creek tributary, slightly upstream from the O'Ryan Seep tributary/Dugout Creek confluence. Monitoring this location will provide data on the current flow and chloride levels entering Dugout Creek from the O'Ryan Seep tributary.

3. MS-3: Dugout Creek, downstream from the Pharaoh Seep tributary/Dugout Creek confluence. Monitoring this location will provide flow and chloride concentrations leaving the O'Ryan/Pharaoh/Dugout Creek area.

4. Annual conductivity measurements at each seep to monitor flow and chloride concentrations.

The proposed permanent monitoring station locations are shown in Appendix E.

7. References

INTERA 2006a. Second Supplemental Investigation Report for the Pharaoh Seep Investigation, Coahoma, Texas. August 2006.

INTERA 2006b. Environmental Assessment of Dugout Creek, Howard and Mitchell Counties, Texas. August 2006.

INTERA 2006c. Third Supplemental Investigation Report for the O'Ryan Seep Investigation, Coahoma, Texas. August 2006.

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Schueler, Thomas. Controlling Urban Runoff: A practical Manual for Planning and Designing Urban BMPs. Washington Metropolitan Water Resources Planning Board, July 1987.

TWDB1, Texas Water Development Board, Groundwater Availability of the Southern Ogallala Aquifer in Texas and New Mexico: Numerical Simulations Through 2050, http://www.twdb.state.tx.us/gam/GAM_documents/documents.htm, February 2003.

TWDB2, Texas Water Development Board, Evaporation/Precipitation Data for Texas, accessed August 2007, http://hyper20.twdb.state.tx.us/Evaporation/evap.html

Appendix A

Dugout Creek Area Map (INTERA 2006b)

Appendix B

O'Ryan Seep Area Map (INTERA 2006c)

Appendix C

Pharaoh Seep Area Map (INTERA 2006a)

Appendix D

Dugout Creek – Proposed BMP Locations

Appendix E

Dugout Creek – Proposed Permanent Monitoring Stations

Appendix F. O'Ryan Seep Flow Calculations

O'Ryan Seeps (North or South) Date modified: 8/30/07

Chloride level (mg/l)	1,210	based on groundwater concentration near seeps

Minimum flow estimation based on contributing aquifer area and recharge rate from USGS RASA Model

Aquifer DA (acres)	30.0	
DA (sf)	1,306,800	
Avg annual rainfall (in)	21.24	
Recharge Rate (in/year)	0.086	recharge rate from USGS RASA Model
% to seep	0.405%	

Seep Flow	units		units		units		units
9,370	cf/year	265,329	Liters/year	70,092	gal/year	321,047,511	mg chloride/year
781	cf/month	22,111	Liters/month	5,841	gal/month	321	kg chloride/year
26	cf/day	727	Liters/day	192	gal/day	708	lbs chloride/year
0.018	cf/min	0.50	Liters/min	0.13	gal/min		
0.00030	cfs	0.008	Liters/sec	0.002	gal/sec		

Maximum flow estimation based on contributing aquifer area and recharge rate from INTERA

Aquifer DA (acres)	30.0	
DA (sf)	1,306,800	
Avg annual rainfall (in)	21.24	
Recharge Rate (in/year)	0.404	recharge rate from INTERA calculations
% to seep	1.900%	

Seep Flow	units		units		units		units
43,948	cf/year	1,244,483	Liters/year	328,758	gal/year	1,505,824,818	mg chloride/year
3,662	cf/month	103,707	Liters/month	27,396	gal/month	1,506	kg chloride/year
120	cf/day	3,410	Liters/day	901	gal/day	3,320	lbs chloride/year
0.084	cf/min	2.37	Liters/min	0.63	gal/min		
0.00139	cfs	0.039	Liters/sec	0.010	gal/sec		

Flow estimation based on observed flow at Pharaoh seep (0.5 L/min), assumes O'Ryan North and South flow equals Pharaoh flow (double observed flow rate to get maximum)

cf/year	10,054	Liters/year	284,700	gal/yr	75,210	344,487,000	mg chloride/year
cf/month	838	Liters/month	23725	gal/month	6267	344	kg chloride/year
cf/day	28	Liters/day	780	gal/day	206	759	lbs chloride/year
cf/min	0.019	Liters/min	**0.50**	gal/min	0.13		
cfs	0.00032	L/s	0.008	gal/s	0.002		

Appendix G. Pharaoh Seep Flow Calculations

Pharaoh Seep Date modified: 8/14/07

Chloride level (mg/l)	13,800

Minumun flow estimation based on contributing aquifer area and recharge rate from USGS RASA Model

Aquifer DA (acres)	30.0						
DA (sf)	1,306,800						
Avg annual rainfall (in)	21.24						
Recharge Rate (in/year)	0.086	recharge rate from USGS RASA Model					
% to seep	0.405%						
Seep Flow							
	9,370	cf/year	265,329	Liters/year	70,092	gal/yr	
	781	cf/month	22,111	Liters/month	5,841	gal/month	3,661,533,593 mg chloride/year
	26	cf/day	727	Liters/day	192	gal/day	3,662 kg chloride/year
	0.018	cf/min	0.47	Liters/min	0.12	gal/min	8,072 lbs chloride/year
	0.000	cfs	0.01	L/sec	0.002	gal/sec	

Maximum flow estimation based on contributing aquifer area and recharge rate from INTERA

Aquifer DA (acres)	30.0					
DA (sf)	1,306,800					
Avg annual rainfall (in)	21.24					
Recharge Rate (in/year)	0.404	recharge rate from INTERA calculations				
% to seep	1.9%					
Seep Flow						
cf/year	43,948	Liters/year	1,244,483	gal/yr	328,758	
cf/month	3,662	Liters/month	103,707	gal/month	3,945,093	17,173,869,831 mg chloride/year
cf/day	120	Liters/day	3,410	gal/day	901	17,174 kg chloride/year
cf/min	0.084	Liters/min	2.19	gal/min	0.58	37,862 lbs chloride/year
cfs	0.001	L/s	0.04	gal/s	0.010	

Flow estimation based on observed flow rate at seep (0.5 L/min)
(assumes max flow rate is double the observed flow rate)

cf/year	20,108	Liters/year	569,400	gal/yr	150,420	
cf/month	1,676	Liters/month	47,450	gal/month	12,535	7,857,720,000 mg chloride/year
cf/day	55	Liters/day	1,560	gal/day	412	7,858 kg chloride/year
cf/min	0.038	Liters/min	**1.00**	gal/min	0.26	17,323 lbs chloride/year
cfs	0.00064	L/s	0.017	gal/s	0.004	