

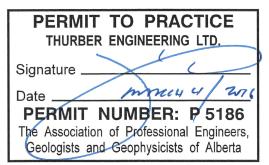
## HYDROGEOLOGICAL ASSESSMENT VILLAGE OF BAWLF SEWAGE LAGOON

Report

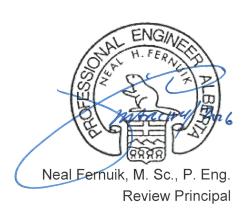
to

Village of Bawlf





Date: March 4, 2016 File: 19-6835-1





## **TABLE OF CONTENTS**

1.	INTRO	DDUCTI	ON	1
2.	OBJE	CTIVE A	AND SCOPE OF WORK	1
3.	PHAS	E I - HY	DROGEOLOGICAL DESKTOP STUDY & SITE RECONNAISSANCE	Ξ1
4.	LAGO	ON SIT	E	2
5.	METH	IOD OF	INVESTIGATION	2
	5.1	Ground	d Disturbance	2
	5.2	Drilling	]	2
	5.3	Insitu I	Hydraulic Conductivity Testing	3
	5.4	Ground	dwater Sampling	3
		6.	GEOLOGY	4
		6.1	Regional Geology	4
		6.2	Site Stratigraphy	4
		7.	HYDROGEOLOGY	4
	7.1	Region	nal Hydrogeology	4
	7.2	Site Hy	ydrogeology	5
8.	GUIDI	ELINES		5
9.	GROU	JNDWAI	ER ANALYTICAL RESULTS	5
10.	ASSE	SSEME	NT AND CONCLUSIONS	6
	10.1	Assess	sment	6
	10.2	Conclu	usions	7

STATEMENT OF LIMITATIONS AND CONDITIONS



## TABLE OF CONTENTS CONTINUED...

## APPENDIX A

- Drawing No. 19-6835-1-1H Site Location Map
- Drawing No. 19-6835-1-2H Lagoons Map
- Drawing No. 19-6835-1-3H— Cross Section WE
- Drawing No. 19-6835-1-4H Cross Section NS
- Drawing No. 19-6835-1-5 Piper Plot a
- Drawing No. 19-6835-1-6 Piper Plot

## APPENDIX B

Monitoring Well Logs

### APPENDIX C

- Table 1 Monitoring Wells Measurements and Summary in Situ Testing
- Table 2 Lagoon and Monitoring Wells Water Chemistry
- Table 3 Summary of Water Wells Chemistry from ERCB Database

## APPENDIX D

In Situ Hydraulic Conductivity Testing Graphs

## APPENDIX E

Selected Water Well Records

### APPENDIX F

Exova Analytical Report



### 1. INTRODUCTION

At the request of the Village of Bawlf, Thurber Engineering Ltd. (Thurber) conducted a hydrogeological investigation to assess if the existing wastewater lagoon ("Site") is leaking. The Site is located within NE  $\frac{1}{4}$  25-45-18 W4M approximately one kilometer southwest of the Village of Bawlf, Alberta. The approximate Site location is shown on Drawing 19-6835-1-1H in Appendix A .

Authorization to conduct the assessment if the lagoon was leaking was provided by Ms. Tracy M Stewart, Finance Officer of the Village of Bawlf.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

## 2. OBJECTIVE AND SCOPE OF WORK

The objective of the hydrogeological investigation, as outlined in Thurber's May 11 2015 proposal to the Village of Bawlf, was to assess if the waste water lagoon was leaking. The proposal was organized for the project to be conducted in two Phases;

- Phase 1 Hydrogeological Desktop Study and Site Reconnaissance
- Phase 2 Hydrogeological Program

The Phase 2 assessment comprised of two components; 2-1 assess if the lagoon was leaking and 2-2 establish a long term groundwater monitoring program. This report addresses the Phase 2-1 component as the long term monitoring program (Phase 2-2) was not authorized.

## 3. PHASE I - HYDROGEOLOGICAL DESKTOP STUDY & SITE RECONNAISSANCE

The Phase 1 desktop assessment and site reconnaissance was addressed in Thurber's December 2014 report¹. In summary, there was no major visible evidence of leakage trough the wastewater lagoon. However, as the native soil construction material consisted of moraine sandy clay till and the wastewater lagoon does not have a compacted clay liner, leakage would likely be occurring through the base of the wastewater lagoon. This assessment was further supported by the low water levels in the deep pond north of the Site in that there is a significant vertical downward groundwater gradient. The deep pond also did not show visible

 Client
 Village of Bawlf
 Date: March 4, 2016

 File:
 19-6835-1
 Page: 1 of 7

<sup>&</sup>lt;sup>1</sup> Thurber Engineering Ltd., December 9 2014, *Bawlf Existing Sewage Treatment Plant Assessment of the Existing Lagoon Conditions*.



evidence of groundwater seepage from the wastewater lagoon to the pond which indicates low hydraulic conductivity value of the soil. The Phase 2-1 was therefore recommended in order to assess leakage.

#### 4. LAGOON SITE

The wastewater lagoon comprises of two anaerobic cells (cells 1 and 2), primary cell (cell 5) and a secondary cell (cell 6) as shown on Drawing 19-6835-1-2H in Appendix A. The deep and shallow pond are located just to the north of the wastewater lagoon. The depths of the cells from top of the berm to the bottom were approximately 4 m for Cells 1 and 2, 2.3 m for Cell 5 and 3 m for Cell 6. The berms slide slopes were inclined at approximately 3H:1V. Along the south berm of the wastewater lagoon there is an unnamed creek were the treated water is discharged once a year.

### 5. METHOD OF INVESTIGATION

## 5.1 Ground Disturbance

Prior to the drilling program, Thurber arranged Alberta One-Call public utility locates for the Site. In addition to Alberta One-Call Thurber conducted a private utility locate to assess the underground utilities at the proposed test hole locations. The private utility locator Tierra Geomatic Services Inc. from Edmonton completed underground locates prior to drilling the test holes.

## 5.2 Drilling

On December 1, 2015 five test holes (TH15-1 through TH15-5) were advanced under full time observation of Thurber personnel. The test holes were advanced by Mobile Augers and Research Ltd. of Edmonton, Alberta using a track mounted drill rig. The test holes were drilled to depths ranging between approximately 5.3 m to 10.7 m below ground surface (bgs).

The test hole location coordinates were surveyed by Thurber using Total Station and are in NAD 83 UTM 12 coordinates. The approximate test hole locations are shown on Drawing 19-6835-1-2H in Appendix A.

Groundwater seepage and soil sloughing from test hole walls were noted during and after completion of the drilling and are recorded on the test hole logs in Appendix B. Groundwater monitoring wells, 50 mm diameter polyvinyl chloride (PVC) pipe, with machine slotted screens and solid casing were installed in all test holes. Silica sand was placed around the screened

Client Village of Bawlf Date: March 4, 2016
File: 19-6835-1 Page: 2 of 7



portion of the well and the well casing was sealed above the sand pack with bentonite chips. A lockable metal casing stick-up protector was installed at ground surface at each well location. Monitoring well completion details are shown on the respective test hole logs in Appendix B.

Topsoil was intermixed in the clay fill within the lagoon berms with the exception of test hole TH15-5 drilled within the middle of the lagoon whereby there was a 0.6 m layer of topsoil/clay fill at a depth of 2.3 m within the berm. Seepage within the berms was only encountered in test hole TH15-3 on the western berm. Seepage was otherwise encountered at depths of between 5.5 m and 5.8 m or approximately 701.5 m bgs.

## 5.3 Insitu Hydraulic Conductivity Testing

The insitu hydrogeological testing was completed on January 11, 2016 in conjunction with measuring static water levels in wells TH15-1 through TH15-5. The insitu bail test was completed by bailing out 10 liter of water and measuring recovery of water level in the well. Measuring of water level was conducted using pressure transducer recorders. Interpretation of the bail data was completed using the Bouwer & Rice and Cooper-Bredehoeft-Papadopulos methods.

Water seepage and water levels measured in open test holes on completion of drilling are summarized on the test-hole logs in Appendix B. The results of water level measurements and interpretation of insitu hydraulic conductivity tests are presented in Table 1 in Appendix C. The graphs of the test data and interpretation generated by the Bower & Rice and Copper-Bredehoeft-Papadopulos methods are shown in Appendix D. Calculated insitu hydrogeological conductivity values are in range from 1.02 E-9m/s to 1.00E-6m/s with a geometric mean of 1.90E-08m/s.

## 5.4 Groundwater Sampling

Water samples were collected on January 14, 2016 from monitoring wells TH15-1 through TH15-5 and from Cell's 1, 5 and 6. The water samples were placed in laboratory supplied containers and then in an ice-chilled cooler for transport to Exova for chemical analyses. The approximate locations of where the cell samples were taken are shown on Drawing 19-6853-1-2H. Water samples were attempted to be collected from the creek and two ponds but the surface water was completely frozen. Water samples were collected from the monitoring wells using dedicated bailers approximately three days after each well was purged.

 Client
 Village of Bawlf
 Date: March 4, 2016

 File:
 19-6835-1
 Page: 3 of 7



### 6. GEOLOGY

## 6.1 Regional Geology

The underlying bedrock in the project area consists of the lower Horseshoe Canyon Formation portion that is composed of sandstone, shale and coal layers. Horseshoe Canyon Formation is underlain by marine shale of the Bearpaw Formation. Bedrock topography in the general area around the Site is a plateau with no signs of significant buried valley. The average top of bedrock elevation is between 670m and 690m. The bedrock is overlain by stagnant ice moraine which are, in general area approximately from 15m to 40m thick. The stagnant ice moraine are composed of mixture of clay, silt and sand with locally included stratified glaciolacustrine and glaciofluvial silt and sand.

## 6.2 Site Stratigraphy

The test holes shows that subsurface stratigraphy is predominantly composed of clay till with traces and lenses of silt, sand and gravel. Based on water well data (Appendix E) in the surrounding area the clay till is underlain by bedrock composed of sandstone, shale and some coal. Approximate depth to the top of bedrock is 22 m bgs.

The lagoon berms are constructed from native compacted clay till. Total depth of berms is between 3 m and 3.5 m. According to the water well records we can expect the clay till unit is present from ground surface to the top of the bedrock.

Bedrock is significant aquifer in the area and it is source for domestic water supply nearby communities.

#### 7. HYDROGEOLOGY

## 7.1 Regional Hydrogeology

The major groundwater aquifer in the study area is formed in the bedrock within Horseshoe Canyon Formation. Water levels in water wells completed in the uppermost portion of the bedrock, as shown in selected water well logs (Appendix E) is between 3m and 11m bgs. Upper bedrock aquifer is major source for water supply in the region.

The bedrock aquifer is overlain by surficial deposits (clay till) which has a very low permeable and could be classified as an aquitard. These surficial deposits contain groundwater but groundwater movement is very slow. Groundwater origin in the surficial deposits is from

Client Village of Bawlf Date: March 4, 2016
File: 19-6835-1 Page: 4 of 7



precipitation, and groundwater movement in the surficial deposits is very slow downward toward the bedrock aguifer as further described in Section 7.2.

## 7.2 Site Hydrogeology

Table 1 in Appendix C summarizes water level measurements taken on January 11, 2016 approximately five weeks after completion of the well installations. Depth to groundwater ranged between 2.82 m below ground surface (bgs) and 7.25 m bgs. Calculated hydrogeological conductivity values are in range from 1.0E-9m/sec to 1.0E-6m/sec and that indicates significant heterogeneity of the clay till.

Hydrogeological cross sections north – south and east – west, Drawing 19-6835-1-3H and Drawing 19-6835-1-4H respectively in Appendix A, show that main drainage direction from the wastewater lagoon is through the berms toward the surrounding trenches and creek and below the lagoon generally downward toward the bedrock.

Based on water level in the lagoon (706 masl), approximate water level in the bedrock (698 masl), estimated thickness of clay till (22m) and a geometric mean of the hydraulic conductivity of clay till (1.9E-8m/sec) a calculated velocity of groundwater is 0.23 m/year. Based on above values a water particle would take more than 90 years to flow from the lagoon to the bedrock aquifer.

#### 8. GUIDELINES

Thurber used the Canadian Drinking Water Quality (CDWQ) guidelines, Health Canada, October 2014 and Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, part 3 published by Alberta Government 2013 (SGMW).

#### 9. GROUNDWAER ANALYTICAL RESULTS

Table 2 in Appendix C presents results of the analyses in relation to the CDWQ guidelines. Total coliforms analysis shows that waters collected in the lagoon cells are more than a million CFU/100ml while water collected from monitoring wells shows total coliforms in range from 0 CFU/100ml to 7000 CFU/100ml. The guideline for total coliforms is SGMW. The analyses also shows that lagoon water has significantly less total dissolved (TDS) content. Most of other chemical parameters are distinctively different for water in lagoon and groundwater in the monitoring wells.

 Client
 Village of Bawlf
 Date: March 4, 2016

 File:
 19-6835-1
 Page: 5 of 7



Table 3 in Appendix C presents a summary of water chemistry analysis for Village of Bawlf as obtained from Alberta Environment and Parks groundwater database. Two Piper plots "a" and "b" in Appendix A shows water types. Piper plot "a" is from water samples collected from water wells within the project area (bedrock aquifer) while Piper plot "b" is from monitoring wells installed around the lagoon (clay till) and from the lagoon. The Piper plots shows that the water from the bedrock aquifer, surficial deposits (clay till) and lagoon belong to different types of water. The water types are sodium-potassium-bicarbonate, sodium-calcium-sulfate and sodium-bicarbonate respectively.

### 10. ASSESSEMENT AND CONCLUSIONS

## 10.1 Assessment

Results of the hydrogeological investigation shows that the lagoon is located at a flat to gently rolling terrain one kilometer southwest from the Village of Bawlf. The lagoon is built over clay till surficial deposits compound of native compacted, clay till and silt material. There were no recorded visible leakage of water from lagoon to surrounding area especially into the deep and shallow ponds directly north of the lagoon.

Surficial deposits in the surrounding area is stagnant ice moraine composed of clay till which is mixture of clay and silt with some lances and pockets of sand and gravel. Surficial deposits (clay till) is approximately 22m thick at the site and it is underlain by bedrock sandstone, shale and some coal. Bedrock is a significant aquifer for the area and this aquifer is in use for water supply for nearby communities.

Insitu hydraulic conductivity tests shows that hydrogeological conductivity of the clay till is in range between 1.0E-9m/s to 1.0E-6m/s with geometrical mean as 1.9 E-8m/s. Groundwater flow in the study area is generally downward. An estimated time for lagoon water to reach the top of bedrock is more than 90 years. Due to the very slow movement of groundwater through the lagoon berms and base the zone of infiltration is limited. The front of infiltrated zone could be measured in meters or tens of metres in lateral surrounding around the lagoon, and metres downwards below the lagoon.

The Piper Plots and most of the chemical parameters show strong difference of water quality between lagoon water and groundwater even though the completion interval of the monitoring wells are only a few meters deeper than the lagoon base. The presence of total coliforms in the monitoring wells completed in the lagoon berms (TH15-1, TH15-2 and TH15-3) indicates that water from lagoon has not been released as a preferred leakage pathway but as

Client Village of Bawlf
File: 19-6835-1

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Date: March 4, 2016 Page: 6 of 7



infiltration. Absence of total coliforms in the deepest monitoring well TH15-5 which is located in the middle of the lagoon indicates very slow vertical advance of water infiltration from the lagoon towards the bedrock aquifer. Total coliforms were not present in well TH15-4 and this well had a higher hydraulic conductivity than wells TH15-1 and TH15-2.

#### 10.2 Conclusions

Based on the groundwater data within the lagoon berm and surrounding area, lack of preferential seepage pathways within the berms and low berm and native clay till hydraulic conductivities Thurber has concluded that water from the lagoon is infiltrating at a very slow rate in a lateral and downward direction from the lagoon but is not leaking via a preferential pathway.

Thurber recommends a continuation of monitoring water levels and doing water chemistry analysis from the monitoring wells as outlined in Standards and Guidelines for Municipal Waterworks and Code of Practice for Wastewater Systems Using a Wastewater Lagoon. We do not recommend the installation of additional monitoring wells as additional wells would not significantly improve the monitoring program. The groundwater analytical testing should be comprised of the following parameters that have been outlined in Code of Practice for Wastewater Systems Using a Wastewater Lagoon;

- Aggregate Organic Constituents (Chemical Oxygen Demands)
- Inorganic Nonmetallic Parameters (Ammonium, Kjeldahl Nitrogen)
- Metals Dissolved
- Routine Water
- Microbiological Analysis.

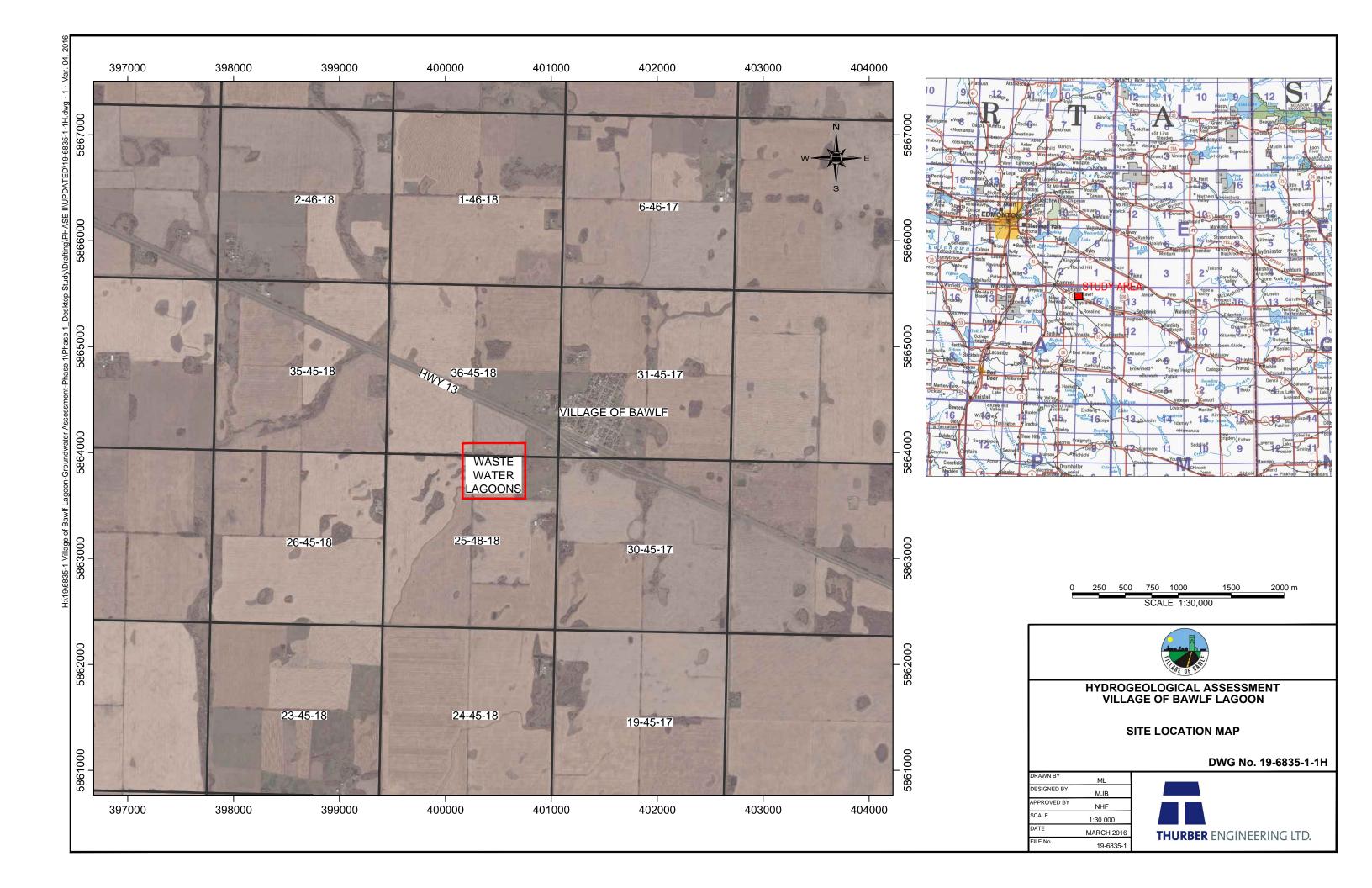
 Client
 Village of Bawlf
 Date: March 4, 2016

 File:
 19-6835-1
 Page: 7 of 7



## **APPENDIX A**

Drawings





## LEGEND



WETLAND



CREEK TRENCH

FENCE



TEST-HOLES DRILLED BEFORE THE LAGOON WAS BUILT

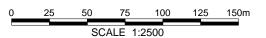


2015 MONITORING WELLS

×

SURFACE WATER SAMPLING LOCATION

Monitorin g Well ID	x (utm 12)	y (utm 12)	z (mbgs)
TH15-1	400272.04	5863873.46	707.56
TH15-2	400337.97	5863959.58	707.65
TH15-3	400646.36	5863906.07	707.34
TH15-4	400395.03	5863724.27	707.42
TH15-5	400440.19	5863856.88	707.93





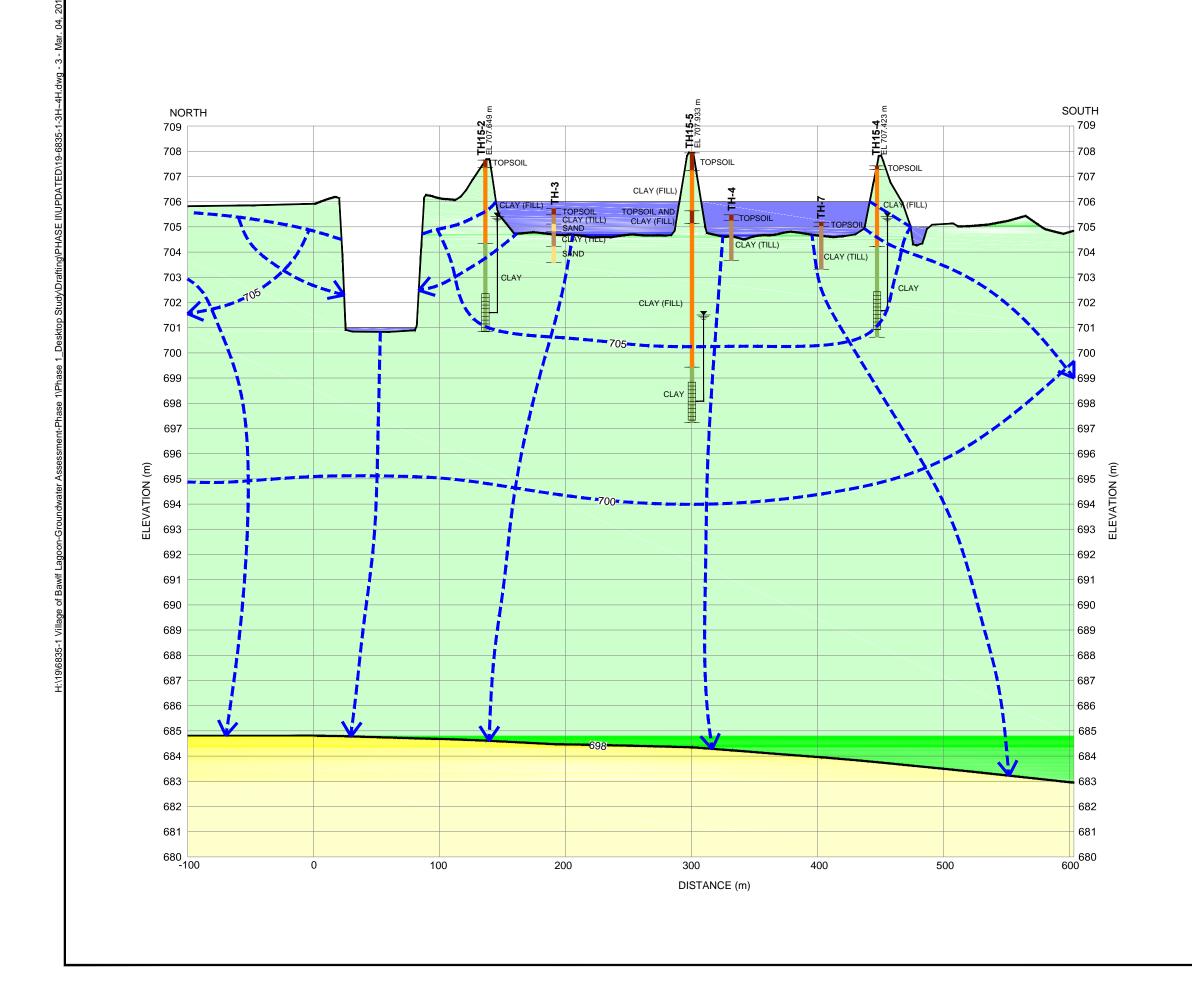
## HYDROGEOLOGICAL ASSESSMENT VILLAGE OF BAWLF LAGOON

## **LAGOON MAP**

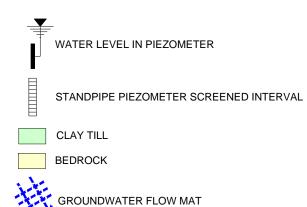
DWG No. 19-6835-1-2H

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DESIGNED BY	MJB
APPROVED BY	NHF
SCALE	1:2500
DATE	MARCH 201
FILE No.	19-6835-





## **LEGEND**



## NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT THE TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.



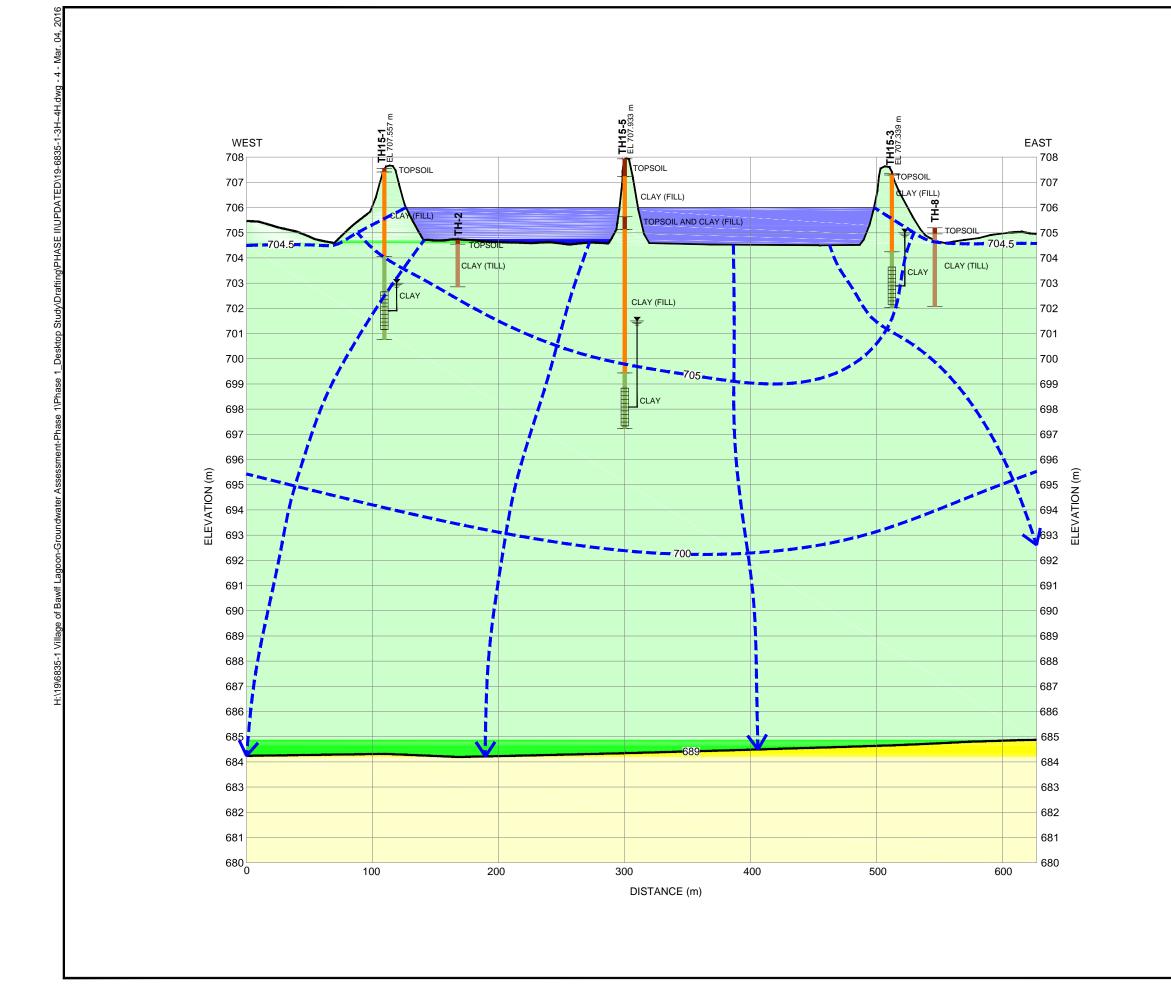
HYDROGEOLOGICAL ASSESSMENT VILLAGE OF BAWLF LAGOON

HYDROGEOLOGICAL CROSS - SECTION NORTH TO SOUTH

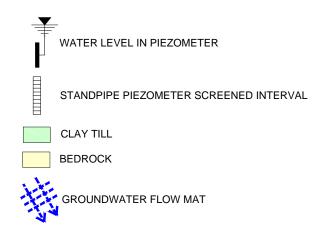
DWG No. 19-6835-1-3H

DRAWN BY	ML
DESIGNED BY	MJB
APPROVED BY	NHF
SCALE	H 1:3000 V 1:15
DATE	MARCH 201
FILE No.	19-6835-





## **LEGEND**



## NOTE

DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT THE TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND SO MAY VARY FROM THAT SHOWN.



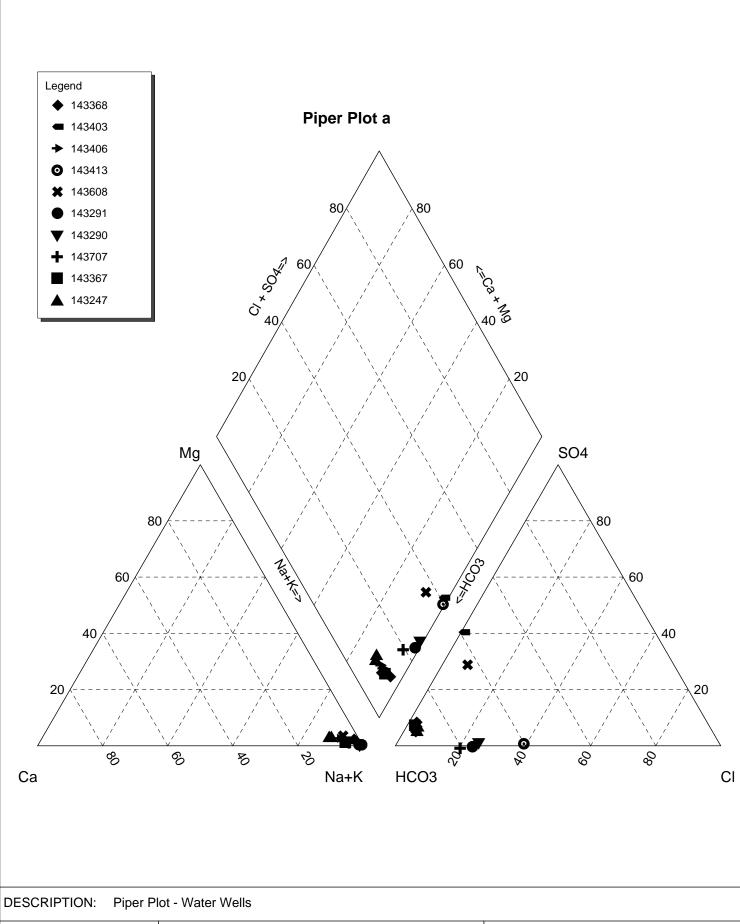
HYDROGEOLOGICAL ASSESSMENT VILLAGE OF BAWLF LAGOON

HYDROGEOLOGICAL CROSS - SECTION WEST TO EAST

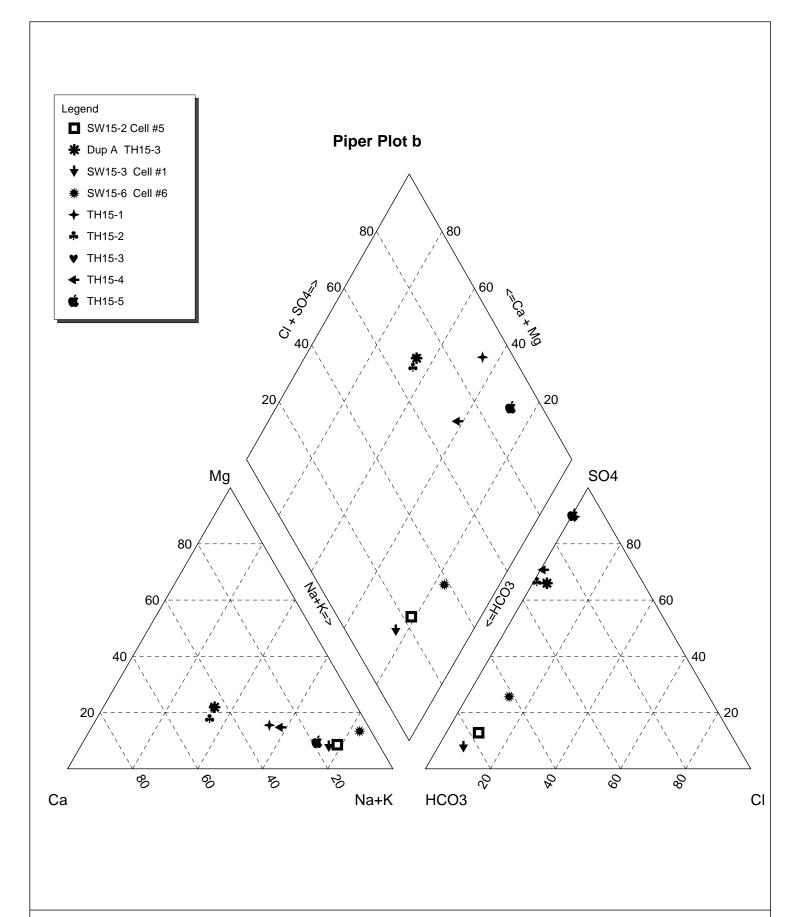
DWG No. 19-6835-1-4H

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DESIGNED BY	MJB
APPROVED BY	NHF
SCALE	H 1:3000 V 1:150
DATE	MARCH 2016
FILE No.	19-6835-1





******* \ \ \ \ \ \	Company	PROJECT: Village of Bawlf	PROJECT NO: 19-6835-1
5	Logo	CLIENT: Village of Bawlf	DATE: January 14, 2016



DESCRIPTION:	Piper Plot - Lagoon	and Monitoring Wells

Ţ.	Company	PROJECT:	Village of Bawlf	PROJECT NO:	19-6835-1
<b>□</b>	Logo	CLIENT:	Village of Bawlf	DATE:	January 14, 2016



## **APPENDIX B**

Well Logs

	IT: VILLAGE OF	BAWLF  Mobile Augers & Resea	rch I td		ECT: Village of Bawlf Lagoon-Groundwater Assessment-Phase 1 DRILLED: December 1, 2015	BOREHOLE NO:	
		k / Solid Stem Augers	IOII LIU.	_	TION: N5863873.46, E400272.04	ELEVATION: 7	
	LE TYPE	on otom ragoro		LOOM	1014.110000010.10, E 100272.01	LLEW MION. 7	07.00 (17)
	FILL TYPE	BENTONITE	SAND		[[]] SLOUGH		
DEPTH (m)	SAMPLE TYPE	REMARKS			SOIL DESCRIPTION		
0					TOPSOIL, brown, silty clay, roots to 0.1m		7
-1					CLAY (FILL) dark brown, silty, trace topsoil and silt lenses		
-2							
3							
4					CLAY mottled grey - brown, silty, trace silt lenses and gravel		
5					-grey	•	-
6	-Seepage						
7					END OF TEST HOLE AT 6.8m UPON COMPLETION: (Below ground surface) -Slough at 6.5m -No water Stondarios piczometer installed		
8					Standpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE: -December 1, 2015 = Dry		
9							-
10							
						N DEPTH: 6.8 m	
		THURBER ENGINEERIN			PREPARED BY: MJB COMPLETIC REVIEWED BY:	N DATE: 12/1/15	Page 1

		E OF BAWLF		CT: Village of Bawlf Lagoon-Groundwater Assessment-Phase 1		
		ANY: Mobile Augers & Research Ltd.		DRILLED: December 1, 2015 TION: N5863959.58, E400337.97	PROJECT NO: 19- ELEVATION: 707.0	
	LE TYPE	Track / Solid Stem Augers	LUCAT	ION: IN0003909.00, E400037.97	ELEVATION. 707.	JJ (111)
_	FILL TYPE	BENTONITE	SAND			
DEPTH (m)	SAMPLE TYPE	REMARKS	ī	SOIL DESCRIPTION	4:	
0				TOPSOIL, brown, silty clay, roots to 0.2m		-
-1				CLAY (FILL) brown, silty, trace silt lenses and topsoil, occasional gra	vel	-7 -7
2						-7
3				× .	12	-
4				CLAY mottled grey - brown, silty, trace oxides, coal, and grave		-
5			vi s			- - - - - - - -
6 +	-Seepa	ge	V	-fine sand lenses		
7			-	END OF TEST HOLE AT 6.8m UPON COMPLETION: (Below ground surface) -No slough		
8				-Water at 6.6m Standpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE: -December 1, 2015 = 6.06m		
9						
10					TION DEDTI- AC	-
					ETION DEPTH: 6.8 m ETION DATE: 12/1/15	
		THURBER ENGINEERING LTD.		REVIEWED BY:		Page 1

CLIE	NT: VILLAC	GE OF BAWLF	PROJEC	CT: Village of Bawlf Lagoon-Groundwater Assessment-Phase 1	BOREHOLE NO: TH15-	-3
		PANY: Mobile Augers & Research Ltd.		RILLED: December 1, 2015	PROJECT NO: 19-6835	
		: Track / Solid Stem Augers	LOCATIO	DN: N5863906.07, E400646.36	ELEVATION: 707.34 (m	1)
	PLE TYPE	OS UZOUZE	0.110	TH a quar		
BACK	FILL TYPE	BENTONITE	SAND	SLOUGH		
DEPTH (m)	SAMPLE TYPE	REMARKS	7	SOIL DESCRIPTION		i i
0			3 8	TOPSOIL, dark brown, silty clay CLAY (FILL) dark brown, silty, roots, trace topsoil and gravel		-7
-2			4			-7
3	-Seepa	age ,		CLAY mottled grey - brown, silty, trace gravel and silt lenses		
-5				-brown, sandy		
-6			13111	END OF TEST HOLE AT 5.3m  UPON COMPLETION: (Below ground surface) -Slough at 3.8m -Water at 4.4m  Standpipe piezometer installed		
-7				WATER LEVEL BELOW GROUND SURFACE: -December 1, 2015 = 2.79m		
8						
9						-(
10						-
					ON DEPTH: 5.3 m ON DATE: 12/1/15	
		THURBER ENGINEERING LTD.		REVIEWED BY:	Page	_

DRILLING COMPANY: Mobile Augers & Research Ltd.  DRILLINGTHOD: Track / Solid Stem Augers  SAMPLE TYPE  BACKFILL TYPE  BENTONITE  SAND  TOPSOIL, brown, silty clay  CLAY (FILL)  dark brown, silty, trace topsoil and gravel  CLAY mottled grey - brown, silty, trace gravel, silt lenses  - silt lenses  - grey	DN	F NO: 19-6835-1 DN: 707.42 (m)
SAMPLE TYPE BACKFILL TYPE BACKFILL TYPE REMARKS  REMARKS  SOIL DESCRIPTI  TOPSOIL, brown, silty clay CLAY (FILL) dark brown, silty, trace topsoil and gravel  CLAY mottled grey - brown, silty, trace gravel, silt lense	DN	
REMARKS  REMARKS  TOPSOIL, brown, sitty clay CLAY (FILL) dark brown, silty, trace topsoil and gravel  CLAY mottled grey - brown, silty, trace gravel, silt lenses		
REMARKS  TOPSOIL, brown, silty clay CLAY (FILL) dark brown, silty, trace topsoil and gravel  CLAY mottled grey - brown, silty, trace gravel, silt lense  -silt lenses		
TOPSOIL, brown, silty clay CLAY (FILL) dark brown, silty, trace topsoil and gravel  CLAY TOPSOIL, brown, silty clay CLAY (FILL) dark brown, silty, trace topsoil and gravel  CLAY mottled grey - brown, silty, trace gravel, silt lense  silt lenses		
CLAY (FILL) dark brown, silty, trace topsoil and gravel  CLAY mottled grey - brown, silty, trace gravel, silt lense  -silt lenses	s, oxides, and gypsum	
CLAY mottled grey - brown, silty, trace gravel, silt lense  -4 -5 -5	s, oxides, and gypsum	
CLAY mottled grey - brown, silty, trace gravel, silt lenses  -silt lenses	s, oxides, and gypsum	- - - - - - -
	•	F
-G -grey		- - - -
		- - - - - - - - -
END OF TEST HOLE AT 6.8m UPON COMPLETION: (Below ground surface) -Slough at 6.5m -No water Standpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE: -December 1, 2015 = 3.26m		
9		- - - - - - - - -
10		- - - - - - -
	OMPLETION DEPTH: 6.8 n	m
PREPARED BY: MJB		15

CLIENT: VILLAGE		PROJECT: Village of Bawlf Lagoon-Groundwater Assessment-Pha	
	ANY: Mobile Augers & Research Ltd.	DATE DRILLED: December 1, 2015  LOCATION: N5863856.88, E400440.19	PROJECT NO: 19-6835-1 ELEVATION: 707.93 (m)
SAMPLE TYPE	Track / Solid Stem Augers	LOCATION: N3003030.00, E400440.19	ELEVATION. 101.93 (III)
BACKFILL TYPE	BENTONITE	NND []] SLOUGH	
DEPTH (m) SAMPLE TYPE	REMARKS	SOIL DESCRIPTION	N
0		TOPSOIL, brown, silty clay, roots to 0.2m, occasion	ial gravel
2		CLAY (FILL) mottled light brown - dark brown, silty, occasional g	ravel and silt lenses
		TOPSOIL AND CLAY (FILL), black, occasional grav	-
3		CLAY (FILL) mottled light brown - dark brown, silty, occasional g	ravel and silt lenses
4		-dark brown	
5 -Seepag	ie		-
6		-grey, occasional dark brown, trace gravel and silt le	enses -
7			
8		√-grey	
9		CLAY grey, sandy, trace gravel	- - - - - - - - - -
10		TET	Ė.
		PREPARED BY: MJB CO	MPLETION DEPTH: 10.7 m MPLETION DATE: 12/1/15
	THURBER ENGINEERING LTD.	REVIEWED BY:	Page 1

DRILLMENTON: TOXA: / Solid Stem Augest SAMPLE TYPE BACKFILL TYPE REMARKS REMAR	CLIEN	NT: VILLAGE (	OF BAWLF	PROJE	CT: Village of Bawlf Lagoon-Groundwater Assessment-Phase 1	BOREHOLE NO: TH15-5
SAMPLE TYPE  REMARKS						PROJECT NO: 19-6835-1
REMARKS  SOIL  DESCRIPTION  REMARKS  REMARKS  SOIL  REMORT (Remover installed warrance)  Salvage personner installed warrance i			rack / Solid Stem Augers	LOCAT	TON: N5863856.88, E400440.19	ELEVATION: 707.93 (m)
REMARKS   SE				=	(III e. e. e.	
10  END OF TEST HOLE AT 10.7m UPON COMPLETION: (Below ground surface) - Sloudy #9.7m - Slandpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE: - December 1, 2015 = 9.20m  13  14  16  17  18	BACK	TILL TYPE	BENTONITE LI S.	AND	SLOUGH	
11	DEPTH (m)	SAMPLE TYPE	REMARKS	SLOTTED PIEZOMETER	SOIL DESCRIPTION	
11	10					
-13 -13 -14 -15	±11				UPON COMPLETION: (Below ground surface) -Slough at 9.7m Standpipe piezometer installed WATER LEVEL BELOW GROUND SURFACE:	
-14 -15 -16 -17 -18	-12				5.25m	-
-15 -16 -17 -18 -19 -19 -19 -19 -19 -19 -19 -19 -19 -19	13					
-16 -17 -18 -19	-14		*			
-17 -18 -19	-15					
-18	-16					
-19	-17					
	-18					
20	-19					- 6 - 6 - 7
	20					
FIELD LOGGED BY: JLM COMPLETION DEPTH: 10.7 m PREPARED BY: MJB COMPLETION DATE: 12/1/15					PREPARED BY: MJB COMPLETIO	N DEPTH: 10.7 m



## **APPENDIX C**

Tables



Table 1 - Monitoring Wells Measurements and Summary of In Situ Testing

Monitoring Well ID	x (utm 12)	y (utm 12)	Ground Surface Elevation	Top of Casing Elevation	Stickout (m)	Water Level Depth-btc- (Jan 11, 2016)	Water Level Elevation-(Jan 11, 2016)	Conductivity- Bouwer & Rice (m/sec)	Conductivity- Cooper & others (m/sec)	Conductivity- Average (m/sec)
TH15-1	400272.04	5863873.46	707.56	708.40	0.84	5.35	703.05	1.19E-09	1.62E-09	1.41E-09
TH15-2	400337.97	5863959.58	707.65	708.49	0.84	3.06	705.43	1.02E-09	1.01E-09	1.02E-09
TH15-3	400646.36	5863906.07	707.34	708.10	0.76	3.10	705.00	8.63E-07	1.14E-06	1.00E-06
TH15-4	400395.03	5863724.27	707.42	708.24	0.82	2.82	705.42	7.66E-07	6.03E-07	6.85E-07
TH15-5	400440.19	5863856.88	707.93	708.74	0.81	7.25	701.49	3.37E-09	1.72E-09	2.55E-09
		_							Geomean	1.90E-08



Table 2 Lagoon and Monitoring Wells Water Chemistry

						1	<u> </u>	1		1		<u> </u>	
Sample Description				Guideline Limit	TH15-1	TH15-2	TH15-3	Dup A TH15- 3	TH15-4	TH15-5	SW15-2 Cell #5	SW15-3 Cell #1	SW15-6 Cell #6
Analyte	Parameter Description	Unit	Detection Limit	0	Result	Result	Result	Result	Result	Result	Result	Result	Result
					ate Organic C								
Chemical Oxygen Demand	0	mg/L	5	0 Increase	193 ic Nonmetallio	308	96	100	35	59	656	17100	2710
Kjeldahl Nitrogen	Total	mg/L	0.07	0	2.97	2.74	2.16	2.67	1.56	3.89	62.5	320	30.4
ryordam rua ogon	Total	mg/L	0.07	·	Metals Disso		2.10	2.07	1.00	0.00	02.0	020	- 00.4
Silicon	Dissolved	mg/L	0.05		5.32	11.1	15	14.8	10.4	9.65	8.31	7.73	7.38
Sulfur	Dissolved	mg/L	0.3		975	539	856	849	456	1600	53	28.4	239
Mercury	Dissolved	mg/L	0.000005	0.001*	0.000008	<0.000005	<0.000005	<0.000005	<0.00005	<0.000005	<0.00005	<0.000005	0.000019
Aluminum	Dissolved	mg/L	0.002	0.1***	0.051	0.009	<0.01	<0.01	<0.004	<0.01	0.01	0.021	<0.01
Antimony Arsenic	Dissolved Dissolved	mg/L mg/L	0.0002 0.0002	0.006* 0.01*	<0.001 0.002	<0.0004 0.0007	<0.001 <0.001	<0.001 <0.001	<0.0004 0.002	<0.001 0.0079	<0.0004 0.0036	<0.0004 0.0024	0.002 <b>0.0756</b>
Barium	Dissolved	mg/L	0.0002	1*	0.002	0.0007	0.001	0.02	0.002	< 0.0079	0.0036	0.0024	0.0736
Beryllium	Dissolved	mg/L	0.0001		<0.0005	<0.0002	<0.0005	<0.0005	<0.0002	<0.0005	<0.0002	<0.0002	<0.0005
Bismuth	Dissolved	mg/L	0.0005		<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	0.001	<0.002
Boron	Dissolved	mg/L	0.002	5*	0.19	0.225	0.15	0.16	0.339	0.524	0.405	0.331	1.01
Cadmium	Dissolved	mg/L	0.00001	0.005*	0.0001	0.0002	0.00026	0.00023	<0.00002	<0.00005	<0.00002	0.00003	<0.00005
Chromium	Dissolved	mg/L	0.0005	0.05*	<0.002	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001	<0.001	<0.002
Cobalt	Dissolved	mg/L	0.0001	4++	0.004	0.006	0.007	0.0069	0.0069	<0.0005	0.0004	0.0009	0.0008
Copper Lead	Dissolved Dissolved	mg/L mg/L	0.001 0.0001	1** 0.01*	0.006 <0.0005	0.002 0.0004	<0.005 <0.0005	<0.005 <0.0005	<0.002 <0.0002	<0.005 <0.0005	0.006 <0.0002	0.003 <0.0002	<0.005 <0.0005
Lithium	Dissolved	mg/L	0.0001	0.01	0.49	0.319	0.48	0.47	0.294	0.589	0.0002	0.0002	0.3
Molybdenum	Dissolved	mg/L	0.001		<0.005	<0.002	<0.005	<0.005	<0.002	<0.005	<0.002	<0.002	<0.005
Nickel	Dissolved	mg/L	0.0005		0.019	0.0318	0.036	0.037	0.0062	0.003	0.0023	0.0031	0.013
Selenium	Dissolved	mg/L	0.0002	0.05*	0.001	0.0005	<0.001	<0.001	<0.0004	<0.001	0.0005	0.0005	<0.001
Silver	Dissolved	mg/L	0.00001		<0.00005	<0.00002	<0.00005	<0.00005	<0.00002	<0.00005	<0.00002	<0.00002	<0.00005
Strontium	Dissolved	mg/L	0.001		3.99	2.9	5.47	5.57	2.62	6.82	0.561	0.5	1.01
Thallium	Dissolved	mg/L	0.00005		<0.0003	0.0001	<0.0003	<0.0003	<0.0001	<0.0003	<0.0001	<0.0001	<0.0003
Tin Titanium	Dissolved Dissolved	mg/L mg/L	0.001 0.0005		<0.005 <0.002	<0.002 <0.001	<0.005 <0.002	<0.005 <0.002	<0.002 <0.001	<0.005 <0.002	<0.002 <0.001	<0.002 <0.001	<0.005 0.003
Uranium	Dissolved	mg/L	0.0005	0.02*	0.032	0.0208	0.103	0.0974	0.0033	0.002	0.0054	0.0048	0.0051
Vanadium	Dissolved	mg/L	0.0001	0.02	<0.0005	0.0003	<0.0005	<0.0005	<0.0002	<0.0005	0.0004	<0.0002	0.0069
Zinc	Dissolved	mg/L	0.001	5**	0.02	0.02	0.005	0.006	0.007	0.01	0.008	0.009	0.006
Subsample	Field Filtered	0	0		Lab Filtered	Lab Filtered	Lab Filtered	Lab Filtered	Lab Filtered	Lab Filtered	Lab Filtered	Lab Filtered	Lab Filtered
			T		robiological A								
Total Coliforms	Membrane Filtration	CFU/100 mL	1	0*	7000	300	1300	900	0	0	1100000	1600000	100
Fecal Coliforms	Membrane Filtration	CFU/100 mL	1	0*	0	0	0	0	0	0	200000	1600000	100
Fecal Coliforms	MPN	MPN/100 mL	1.8		<1.8 Routine	<1.8	<1.8	<1.8	<1.8	<1.8	0	0	0
pH	0	0	0	6.5-8.5**	7.78	7.39	7.63	7.45	7.75	7.75	8.15	7.89	8.63
Temperature of observed pH	0	°C	0	0.0 0.0	18.8	18.5	18.7	18.6	19.6	19.1	18.5	21.3	18.7
Electrical Conductivity	at 25 °C	uS/cm	1		5080	3630	5380	5280	3230	8330	2190	2130	4670
Calcium	Dissolved	mg/L	0.2		446	499	750	739	226	440	61.2	65	45
Magnesium	Dissolved	mg/L	0.2	005**	137	112	225	222	74.2	136	24.5	20	97.9
Sodium	Dissolved	mg/L	0.4	200**	905	412	654	648	543	1940	411	346	1120
Potassium Iron	Dissolved Dissolved	mg/L mg/L	0.4 0.01	0.3**	16 <0.05	14 <0.02	13 <0.05	13 <0.05	17 <0.02	18 <b>2.28</b>	20.4 0.03	19 0.08	47 0.05
Manganese	Dissolved	mg/L	0.005	0.05**	1.04	4.32	1.95	1.92	1.7	0.26	0.404	0.428	0.03
Chloride	Dissolved	mg/L	0.4	250**	23.2	19.9	122	121	11.5	9	89.8	60.6	265
Nitrate - N	0	mg/L	0.01	10*	< 0.05	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05	< 0.05	<0.05
Nitrite - N	0	mg/L	0.005	1*	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.027	0.073	<0.025
Nitrate and Nitrite - N	0	mg/L	0.01	10*	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	0.03	0.07	<0.07
Sulfate (SO4)	Dissolved	mg/L	0.9	500**	2920	1620	2570	2550	1370	4790	159	85	718
Hydroxide	0	mg/L	5		<5	<5 <6	<5 <6	<5	<5 <6	<5	<5	<5	<5
Carbonate Bicarbonate	0	mg/L	6 5		<6 387	<6 1010	<6 1470	<6 1470	<6 696	<6 649	<6 1230	<6 1170	119 2210
P-Alkalinity	as CaCO3	mg/L mg/L	5		<5	<5	<5	<5	<5	<5	<5	<5	99
T-Alkalinity	as CaCO3	mg/L	5		317	829	1200	1210	571	532	1010	957	2010
Total Dissolved Solids	Calculated	mg/L	1	500	4640	3170	5050	5010	2580	7660	1370	1170	3500
Hardness	Dissolved as CaCO3	mg/L	0		1680	1710	2800	2760	869	1660	254	245	520
Ionic Balance	Dissolved	%	0		108	103	105	104	103	107	91	90	96

Guideline; Health Canada GCDWQ. Guidelines for Canadian Drinking Water Quality. Health Canada.October 2014

\* = MAC = Maximum Acceptable Concentration

\*\* = AO = Aesthetic Objective

\*\*\* = OG = Operational Guideline for Water Treatment Plants

BOLD Does not meet applicable guidelines



Table 3 Summary of Water Well Chemistry from ERCB water well database

WeiiID	Legal Location	SampleDate	Water Level (m)	Depth(m)	EC	F I	PH IONBAL	нсоз	CA	SIO2	F_EC	F_EH	PHEN	тн	К	SO4	NO2_NO3_N	MG	TA	CL	F_FE	NA	TDS	CO3	NO2	NO3
143247	NE-13-045-18W4M	FEB-19-1976	10	15	1200	0.33	0	829.0809	26.9999	0	0	0	0	94	3.172	39.0572	0.7994	7.0054	680	21.0302	0	341.0003	848	0	0.7	0
143247	NE-13-045-18W4M	JAN-9-1979	15	20	1292	0.29	0	795.0772	24.9999	13.5	0	0	0	87	2.66	50.0721	-0.0504	6.0046	662	17.0222	0	290.0001	788	6	-0.0504	0
143290	NW-34-045-18W4M	JUN-26-1979	10	17	2230	0.58	0	1097.1071	4	10	0	0	0	15	1.328	15.0216	-0.0504	1.0008	15	215.304	0	549.999	1338	11.001	-0.0504	0
143291	NW-34-045-18W4M	DEC-2-1986	17	0	2190	0.62	0	1111.1065	5	10	0	0	0	17	1.536	-5.0072	-0.0504	-1.0008	911	200.2804	0	520.0001	1279	0	-0.0504	0
143367	SW-19-045-17W4M	DEC-5-1984	9	0	1163	0.29	0	730.0723	12.9999	12	0	0	0	41	2.66	46.0654	-0.0504	2.0015	599	11.0156	0	290.0001	724	0	-0.0504	0
143368	SW-19-045-17W4M	AUG-5-1981	27	12	1100	0.32	0	709.0672	4	13	0	0	0	22	2.864	52.0779	-0.0504	3.0023	581	10.0146	0	242.9996	663	0	-0.0504	0
143368	SW-19-045-17W4M	DEC-5-1984	9	0	1350	0.27	0	859.0874	16.9999	12.7	0	0	0	59	2.66	37.0562	-0.0504	4.0031	705	19.028	0	334.9996	838	0	-0.0504	0
143394	NW-30-045-17W4M	MAR-3-1959	14	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	1040	150.2112	0	0	1422	0	0	0
143394	NW-30-045-17W4M	JUN-3-1959	8	0	0	0	0	0 0	0	0	0	0	0	15	0	0	0	0	690	325.4569	0	0	1236	0	0	0
143400	04-31-045-17W4M	MAR-19-1965	29	0	0	0	0	0 0	0	0	0	0	0	30	0	25.036	0	0	400	1101.5508	0	0	2584	0	0	0
143401	SW-31-045-17W4M	MAR-29-1958	9	0	0	0	0	0 0	0	0	0	0	0	35	0	20.0288	0	0	420	1055.486	0	0	2256	0	0	0
143402	SW-31-045-17W4M	OCT-25-1960	1	0	0	0	0	0 0	0	0	0	0	0	45	0	0	0	0	410	986.3888	0	0	2160	0	0	0
143403	SW-31-045-17W4M	FEB-20-1981	0	0	2220	0.2	0	921.0898	6	8.3	0	0	0	18	1.74	497.7244	-0.0504	-1.0008	778	7.0112	0	576.0005	1555	12.999	-0.0504	0
143406	SW-31-045-17W4M	FEB-3-1978	10	0	1350	0.28	0	832.0834	14.9999	13	0	0	0	58	2.66	49.0716	0.7	5.0038	687	17.0222	0	319.999	824	-5.001	-0.0994	0
143406	SW-31-045-17W4M	NOV-16-1978	30	0	1324	0.25	0	847.0836	17.9999	13.6	0	0	0	64	2.252	52.0779	0.749	5.0038	695	15.02	0	311.9996	825	0	-0.0504	0
143409	04-31-045-17W4M	AUG-17-1957	0	0	0	0	0	0 0	0	0	0	0	0	30	0	37.0562	0	0	870	54.0772	0	0	1108	0	0	0
143409	04-31-045-17W4M	MAR-13-1952	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	445	846.1922	0	0	1896	0	0	0
143410	04-31-045-17W4M	AUG-17-1957	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	535	658.9297	0	0	1696	0	0	0
143413	NE-31-045-17W4M	OCT-4-1984	0	0	2160	0.82	0	809.0766	-1	7.5	0	0	0	-5	1.636	7.0082	-0.0504	-1.0008	664	305.4314	0	509.9997	1224	0	-0.0504	0
143414	SW-33-045-17W4M	AUG-17-1966	0	0	0	0	0	0 0	0	0	0	0	0	190	0	195.286	0	0	690	22.0313	0	0	1174	0	0	0
143415	05-33-045-17W4M	MAY-2-1966	0	0	0	0	0	0	0	0	0	0	0	200	0	145.2091	0	0	710	17.0222	0	0	1156	0	0	0
143608	SW-06-046-17W4M	OCT-19-1972	6	86	2000	0.52	0	0	9	0	0	0	0	42	0	53.0784	-0.0994	0	908	64.0917	0	0	1320	0	0	0
143608	SW-06-046-17W4M	JUN-13-1973	27	80	2570	0.4	0	1113.1081	23.9999	0	0	0	0	109	3.172	398.5806	0	12.0104	918	78.1106	0	577.9992	2191	0	-0.0504	0.0798
143702	SE-01-046-18W4M	JUN-25-1963	28	160	0	0	0	0	0	0	0	0	0	15	0	32.049	0	0	810	45.0637	0	0	1074	0	0	0
143707	SE-03-046-18W4M	FEB-13-1976	3	60	2050	0.42	0	1261.1267	18.9999	0	0	0	0	58	2.66	-10.0144	-0.0994	3.0023	1035	184.2592	0	554.001	1382	0	-0.0994	0
143709	SW-03-046-18W4M	DEC-3-1969	18	65	0	0	0	0	0	0	0	0	0	52	0	589.8599	0	0	723	40.0546	0	0	1764	0	0	0.6202



## APPENDIX D

In Situ Hydraulic Conductivity Testing Graphs



## Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

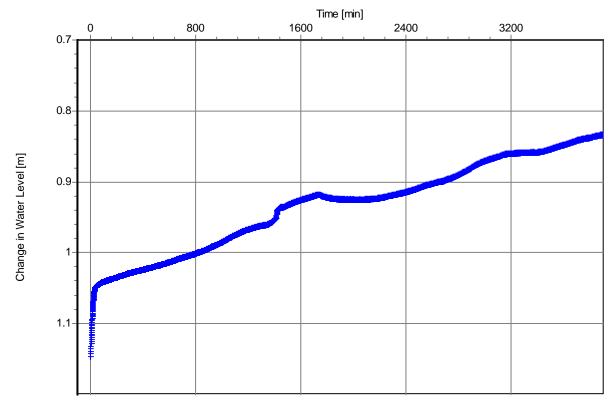
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

## TH15-1 [Time vs. Change in Water Level Plot]



+ TH15-1

Slug Test: TH15-1

Analysis Method: Time vs. Change in Water Level Plot

Analysis Results:

<u>Test parameters:</u> Test Well: TH15-1 Aquifer Thickness:

Casing radius: 0.025 [m]

Screen length: 1.2 [m]

Boring radius: 0.08 [m]

Comments:

Evaluated by: Milan B
Evaluation Date: 1/20/2016

1.2 [m]



h/h0

## Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

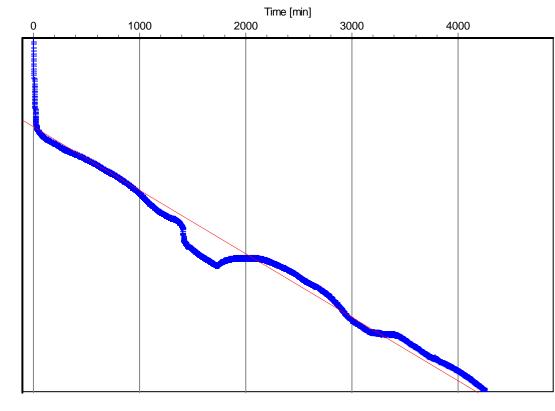
**Slug Test Analysis Report** 

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Village of Bawlf Client:





+ TH15-1

Slug Test: TH15-1

Analysis Method: **Bouwer & Rice** 

Analysis Results: Conductivity: 1.19E-9 [m/s]

Test parameters: Test Well: TH15-1

Aquifer Thickness: 1.2 [m]

Gravel Pack Porosity (%)

0.025 [m] Casing radius:

Screen length: 1.2 [m]

Boring radius: 0.08 [m]

r(eff): 0.035 [m]

Comments:

Evaluated by: Milan B 1/20/2016 Evaluation Date:

10

# A

## Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

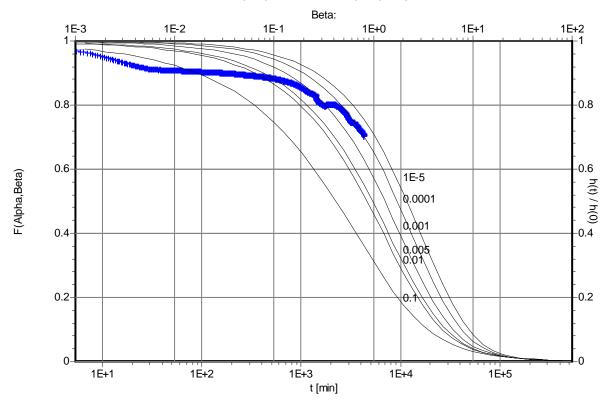
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

## TH15-1 [Cooper-Bredehoeft-Papadopulos]



+ TH15-1

Slug Test: TH15-1

Analysis Method: Cooper-Bredehoeft-Papadopulos

Analysis Results: Transmissivity: 1.95E-9 [m²/s] Conductivity: 1.62E-9 [m/s]

Storativity: 4.88E-4

<u>Test parameters:</u> Test Well: TH15-1 Aquifer Thickness: 1.2 [m]

Casing radius: 0.025 [m] Alpha: 0.005

Screen length: 1.2 [m]

Boring radius: 0.08 [m]

r(c): 0.08 [m]

Comments:

Evaluated by: Milan B
Evaluation Date: 1/26/2016



## Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

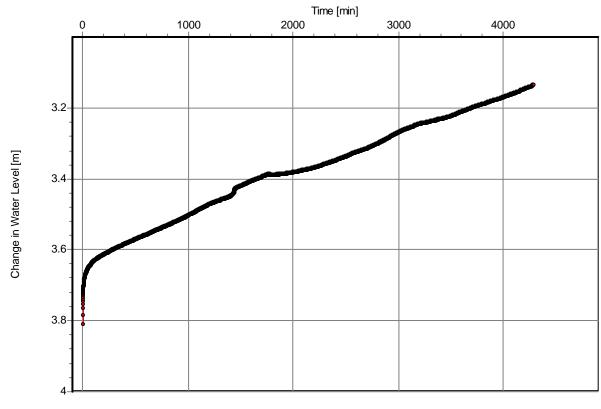
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

## TH15-2 [Time vs. Change in Water Level Plot]



**--** TH15-2

Slug Test: TH15-2

Analysis Method: Time vs. Change in Water Level Plot

Analysis Results:

<u>Test parameters:</u> Test Well: TH15-2 Aquifer Thickness: 1.68 [m]

Casing radius: 0.025 [m]

Screen length: 1.68 [m]

Boring radius: 0.08 [m]

Comments:

Evaluated by: Milan B
Evaluation Date: 1/20/2016



h/h0

## Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

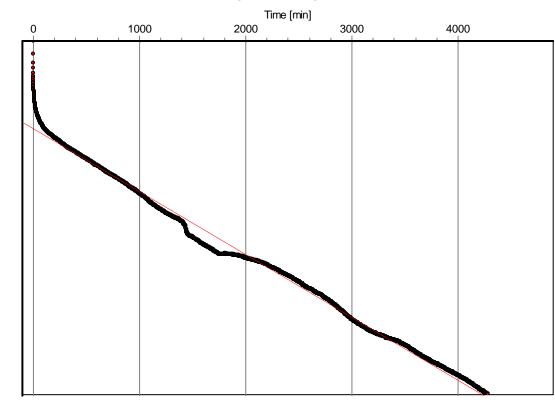
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf





• TH15-2

Slug Test: TH15-2

Analysis Method: Bouwer & Rice

Analysis Results: Conductivity: 1.02E-9 [m/s]

<u>Test parameters:</u> Test Well: TH15-2 Aquifer Thickness: 1.68 [m]

1.68 [m]

Casing radius: 0.025 [m] Gravel Pack Porosity (%) 25

Boring radius: 0.08 [m]

Screen length:

r(eff): 0.045 [m]

Comments:

Evaluated by: Milan B
Evaluation Date: 1/20/2016

## $\pi$

## Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

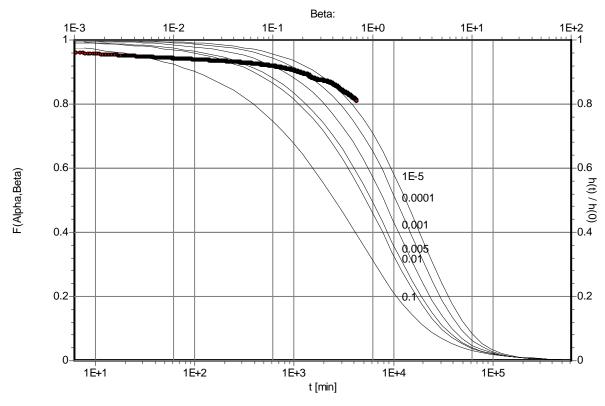
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

## TH15-2 [Cooper-Bredehoeft-Papadopulos]



• TH15-2

Slug Test: TH15-2

Analysis Method: Cooper-Bredehoeft-Papadopulos

Analysis Results: Transmissivity: 1.69E-9 [m²/s] Conductivity: 1.01E-9 [m/s]

Storativity: 4.88E-4

<u>Test parameters:</u> Test Well: TH15-2 Aquifer Thickness: 1.68 [m]

Casing radius: 0.025 [m] Alpha: 0.005

Screen length: 1.68 [m]

Boring radius: 0.08 [m]

r(c): 0.08 [m]

Comments:

Evaluated by: Milan B
Evaluation Date: 1/26/2016



## Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

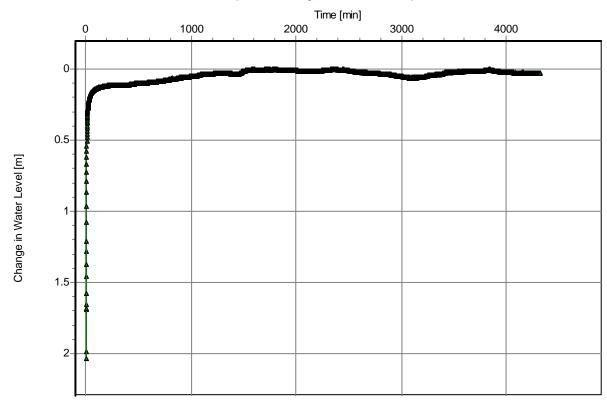
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

## TH15-3 [Time vs. Change in Water Level Plot]



-**▲** TH15-3

Slug Test: TH15-3

Analysis Method: Time vs. Change in Water Level Plot

Analysis Results:

<u>Test parameters:</u> Test Well: TH15-3 Aquifer Thickness: 1.85 [m]

Casing radius: 0.025 [m]

Screen length: 1.85 [m]

Boring radius: 0.08 [m]

Comments:

Evaluated by: Milan B
Evaluation Date: 1/21/2016



h/h0

### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

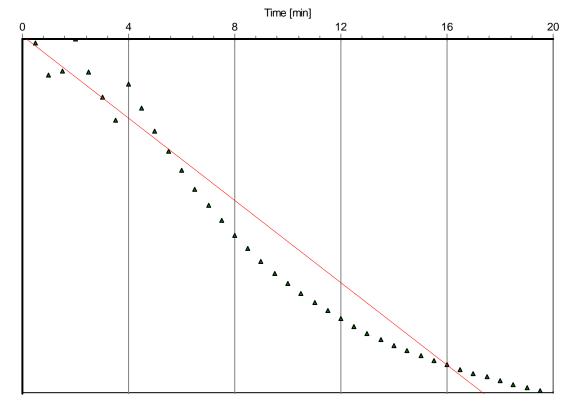
**Slug Test Analysis Report** 

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Village of Bawlf Client:





▲ TH15-3

Slug Test: TH15-3

**Bouwer & Rice** Analysis Method:

Analysis Results: Conductivity: 8.63E-7 [m/s]

Test parameters: Test Well: TH15-3 Aquifer Thickness: 1.85 [m]

> 0.025 [m] Gravel Pack Porosity (%) Casing radius: 25

1.85 [m] Boring radius: 0.08 [m]

r(eff): 0.045 [m]

Screen length:

Comments:

Evaluated by: Milan B 1/26/2016 Evaluation Date:

### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

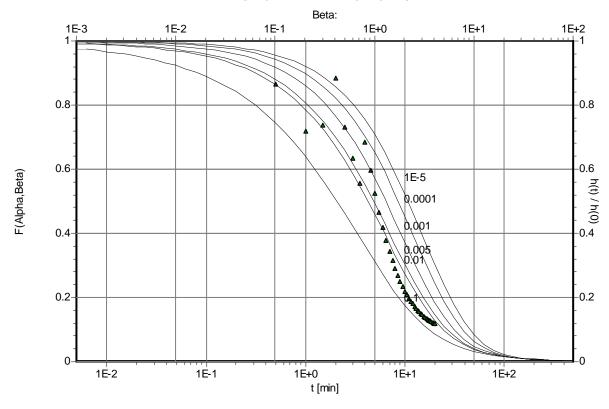
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

### TH15-3 [Cooper-Bredehoeft-Papadopulos]



▲ TH15-3

Slug Test: TH15-3

Analysis Method: Cooper-Bredehoeft-Papadopulos

Analysis Results: Transmissivity: 2.11E-6 [m²/s] Conductivity: 1.14E-6 [m/s]

Storativity: 4.88E-4

<u>Test parameters:</u> Test Well: TH15-3 Aquifer Thickness: 1.85 [m]

Casing radius: 0.025 [m] Alpha: 0.005

Screen length: 1.85 [m]

Boring radius: 0.08 [m]

r(c): 0.08 [m]

Comments:



### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

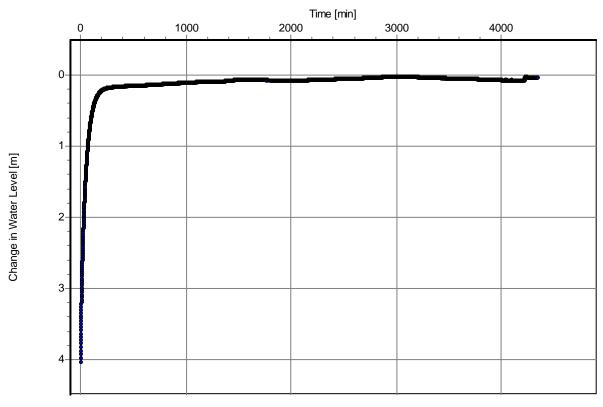
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

### TH15-4 [Time vs. Change in Water Level Plot]



**⊸** TH15-4

Slug Test: TH15-4

Analysis Method: Time vs. Change in Water Level Plot

Analysis Results:

<u>Test parameters:</u> Test Well: TH15-4 Aquifer Thickness: 1.22 [m]

Casing radius: 0.025 [m]

Screen length: 1.22 [m]

Boring radius: 0.08 [m]

Comments:



h/h0

### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

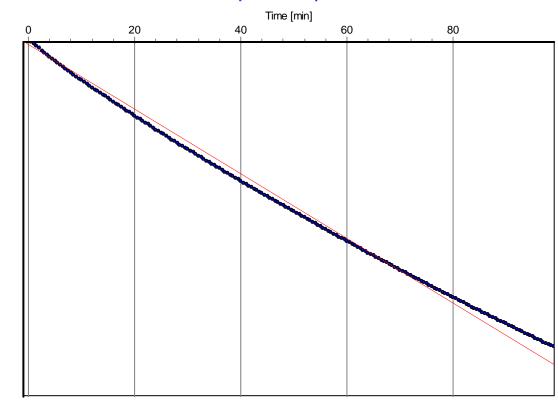
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf





• TH15-4

Slug Test: TH15-4

Analysis Method: Bouwer & Rice

Analysis Results: Conductivity: 7.66E-7 [m/s]

<u>Test parameters:</u> Test Well: TH15-4 Aquifer Thickness: 1.22 [m]

1.22 [m]

Casing radius: 0.025 [m] Gravel Pack Porosity (%) 25

Boring radius: 0.08 [m]

Screen length:

r(eff): 0.045 [m]

Comments:

# $\pi$

### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

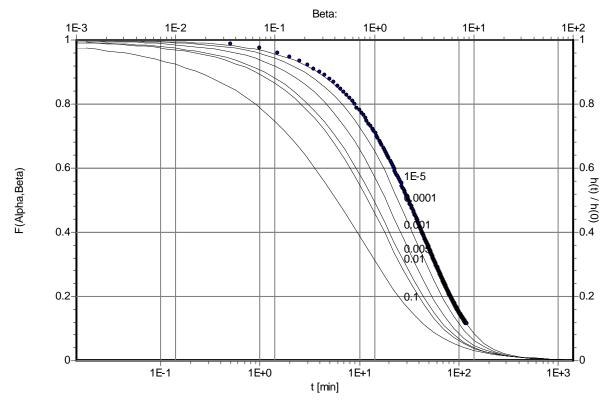
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

### TH15-4 [Cooper-Bredehoeft-Papadopulos]



• TH15-4

Slug Test: TH15-4

Analysis Method: Cooper-Bredehoeft-Papadopulos

Analysis Results:	Transmissivity:	7.36E-7 [m <sup>2</sup> /s]	Conductivity:	6.03E-7 [m/s]
-------------------	-----------------	-----------------------------	---------------	---------------

Storativity: 4.88E-4

<u>Test parameters:</u> Test Well: TH15-4 Aquifer Thickness: 1.22 [m]

Casing radius: 0.025 [m] Alpha: 0.005

Screen length: 1.22 [m]

Boring radius: 0.08 [m]

r(c): 0.08 [m]

Comments:



### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

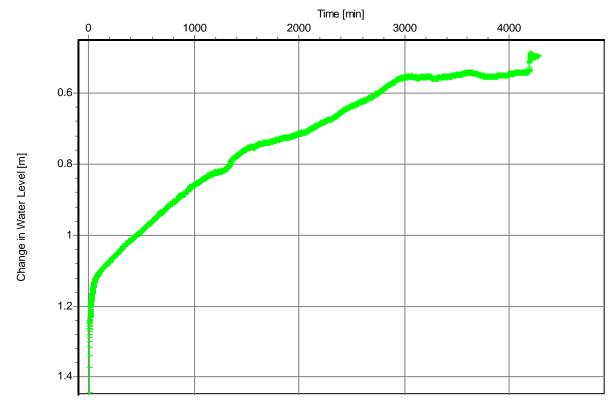
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

### TH15-5 [Time vs. Change in Water Level Plot]



+ TH15-5

Slug Test: TH15-5

Analysis Method: Time vs. Change in Water Level Plot

Analysis Results:

<u>Test parameters:</u> Test Well: TH15-5 Aquifer Thickness: 1.27 [m]

Casing radius: 0.025 [m]

Screen length: 1.27 [m]

Boring radius: 0.08 [m]

Comments:



h/h0

### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

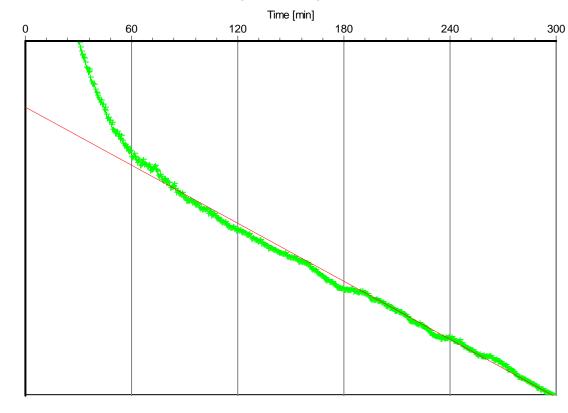
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf





+ TH15-5

Slug Test: TH15-5

Analysis Method: Bouwer & Rice

Analysis Results: Conductivity: 3.37E-9 [m/s]

<u>Test parameters:</u> Test Well: TH15-5 Aquifer Thickness: 1.27 [m]

1.27 [m]

Casing radius: 0.025 [m] Gravel Pack Porosity (%) 25

Boring radius: 0.08 [m]

Screen length:

r(eff): 0.045 [m]

Comments:

# A

### Thurber Engineering Ltd.

4127 Roper Road

Edmonton, Alberta, T6B 3S5

Phone: 780 438-1460

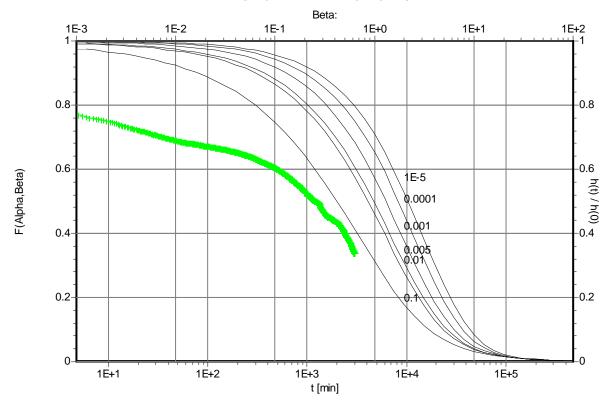
Slug Test Analysis Report

Project: Sewage Lagoon Groundwater Assessment

Number: 19-6835-1

Client: Village of Bawlf

### TH15-5 [Cooper-Bredehoeft-Papadopulos]



+ TH15-5

Slug Test: TH15-5

Analysis Method: Cooper-Bredehoeft-Papadopulos

Analysis Results: Transmissivity: 2.19E-9 [m²/s] Conductivity: 1.72E-9 [m/s]

Storativity: 4.88E-4

<u>Test parameters:</u> Test Well: TH15-5 Aquifer Thickness: 1.27 [m]

Casing radius: 0.025 [m] Alpha: 0.005

Screen length: 1.27 [m]

Boring radius: 0.08 [m]

r(c): 0.08 [m]

Comments:



### **APPENDIX E**

Selected Water Well Records



Domestic & Stock

### **Water Well Drilling Report**

The driller supplies the data contained in this report. The Province disclaims responsibility for its accuracy. The information on this report will be retained in a public database.

**View in Imperial Export to Excel** 

GIC Well ID GoA Well Tag No. Drilling Company Well ID Date Report Received

134795

**GOWN ID** Well Identification and Location Measurement in Metric Address Postal Code Town Owner Name Province Country P.O. BOX 64 BAWLF LEIREN, MORRIS T0B 0J0 1/4 or LSD SEC TWP W of MER Block RGE Plan Additional Description Location Lot

V: 11.T

Drilling Information

Method of Drilling
Drilled
Proposed Well Use

Type of Work
New Well

Formation Log			Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description	
32.00		Clay	
33.53	Yes	Water Bearing Coal	
35.05		Coal	

	iary					rement in ivi
Recommended Pu	mp Rate	0.0	00 L/min	_		
Test Date \	Nater Remo	val Rate (	L/min)	St	atic Wat	er Level (m)
1955/07/07					4	.57
Well Completion					Measu	rement in M
Total Depth Drilled	Finished V	n Start	Date	Е	End Date	
35.05 m		1955/	07/04	1	955/07/07	
Borehole						
Diameter (cm	1)	Fron			-	
		0.				35.05
Surface Casing (in Steel		•	Well Ca			
	10.16					0.00 cm
Wall Thickness:			Wall 7	hickness	3 :	0.000 cm
Bottom at : 32.00 m						0.00 m
			E	Bottom a	t :	0.00 m
Perforations	Diam	neter or				
From (m) To	Slot	Width	Slot Le	ength n)		or Slot rval(cm)
Perforated by						
Perforated by  Annular Seal Dri Placed from Amount Other Seals	0.00 m		0.00	) m_		
Annular Seal Dri Placed from Amount Other Seals	0.00 m		0.00	) m_	At (m)	
Annular Seal Placed from Amount Other Seals  Screen Type	0.00 m		0.00	) m_	At (m)	
Annular Seal Placed from Amount Other Seals  Screen Type	0.00 m		0.00	) m_	At (m)	
Annular Seal Placed from Amount Other Seals  Screen Type	0.00 m	cm	0.00	) m_		Size (cm)
Annular Seal Dri Placed from Amount Other Seals  T  Screen Type Size OD: From (m)	0.00 m	<u>cm</u> To	(m)	) m_		
Annular Seal Dri Placed from Amount Other Seals  T  Screen Type Size OD:	0.00 m	<u>cm</u> To	(m)	) m_	Slot	Size (cm)
Annular Seal Dri Placed from Amount Other Seals  T  Screen Type Size OD: From (m)	0.00 m	<u>cm</u> To	(m)		Slot	Size (cm)
Annular Seal Dri Placed from Amount Other Seals  Screen Type Size OD: From (m)  Attachment Top Fittings	0.00 m	<u>cm</u> To	(m)		Slot	Size (cm)

Contractor	Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name SERVOLD, HAROLD Certification No

1

Copy of Well report provided to owner Date approval holder signed

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### **View in Imperial Export to Excel**

124705

GIC Well ID GoA Well Tag No. Drilling Company Well ID Date Report Received

G	1	Λ.	N I	IL

Well Identification and Location	on					Measurement in Metric
Owner Name LEIREN, MORRIS	Address P.O. BOX 64 BAWLF		Town	Provii	nce Country	Postal Code T0B 0J0
Location 1/4 or LSD SEC SW 30	045 RGE	W of MER Los			ditional Description	
Measured from Boundary of m from m from		GPS Coordinates in Latitude 52.905: How Location Obtain	334 Longitu		Elevation  How Elevation Observation Observation	
Additional Information						Measurement in Metric
Distance From Top of Casing to Is Artesian Flow Rate		cm		ol Installed Describe		
Recommended Pump Rate		0.00 L/min			Depth	
Recommended Pump Intake Dep	oth (From TOC)	0.00 m	Туре	Make		Н.Р.
					Model (Output F	Rating)
Did you Encounter Saline Wate	er (>4000 ppm TDS) Gas			Geophysical		
Additional Comments on Well SEE VG CHEM SAMPLE #8713	467		Sample Colle	ected for Potability	Sub.	mitted to ESRD
Yield Test					m Ground Level Depth to water level	Measurement in Metric
Test Date Start 1955/07/07 12:00		Water Level 4.57 m	Drawdo	own (m)	Elapsed Time Minutes:Sec	Recovery (m)
Method of Water Removal Type Removal Rate Depth Withdrawn From  If water removal period was < 2 I	0.00 m		_			
Water Diverted for Drilling						
Water Source	Amo	ount Taken		Dive	ersion Date & Time	

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name SERVOLD, HAROLD Certification No

1

Copy of Well report provided to owner Date approval holder signed



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### **View in Imperial Export to Excel**

143264

GIC Well ID GoA Well Tag No.

Drilling Company Well ID

4000/04/00

JOWN ID						Da	ite Report Receiv	ed 1986/04/28
Well Identification and Lo	ocation							Measurement in Metr
Owner Name LARSON, TED	Address BAWLF		Town	n		Province	Country	Postal Code
Location 1/4 or LSD NW	SEC TWP 23 045	RGE 18	W of MER Lot	Block F	Plan	Additional	Description	
	f m from m from		GPS Coordinates in De Latitude 52.897914 How Location Obtained Map	Longitude	NAD 83) -112.513	— Н	levationlow Elevation Obtool Obtained	mtained
Drilling Information								
Method of Drilling Rotary Proposed Well Use			Type of Work New Well					
Stock Formation Log		I Me	easurement in Metric	Yield Test S	ummary			Measurement in Metri
Depth from Water	Lithology Description		susurement in wether	Recommende		ate 3	31.82 L/min	Wedstrement in Weth
ground level (m) Bearing	Elenology Description			Test Date		r Removal Ra	te (L/min)	Static Water Level (m)
12.19	Clay			1985/09/10		31.82		7.92
18.29	Sand			Well Comple				Measurement in Metri
				Total Depth D 18.29 m	rilled Fini	ished Well De	epth Start Date 1985/08/28	End Date 1985/09/10
				Borehole			1903/06/20	1903/09/10
				Diamete	er (cm)	F	rom (m)	To (m)
				0.0			0.00	18.29
				Surface Casi Steel			Well Casing Steel	
					OD :	16.51 cm		OD: 11.43 cm
				Wall Thickne		0.478 cm	Wall Thickn	
				Botton	ı al .	12.19 m	Bottor	n at : 10.67 m n at : 18.29 m
				Perforations			Dottor	10.20 111
				From (m) 12.19	To (m) 18.29	Diameter o Slot Width (cm) 0.000		Hole or Slot Interval(cm) 0.00
				Perforated by  Annular Seal  Placed from  Amour	Unknow		12.19 m	
				Other Seals	Type			At (m)
					Турс			AC (III)
				Screen Type		0.00 cm		
				From	(m)		To (m)	Slot Size (cm)
				Attachm Top Fittil			Bottom Fitt	ings
				Pack				
				Туре			Grain Size	
				Amount				

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name

GENETH CONSTRUCTION/DIVISION OF 305-137 ALBERTA LTD.

Certification No

1

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# **Water Well Drilling Report**

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### **View in Imperial Export to Excel**

143264

GIC Well ID GoA Well Tag No.

Drilling Company Well ID Date Report Received

1986/04/28

Well Identific	cation and L	ocation									Measurement in Metric
Owner Name LARSON, TEI	D		Address BAWLF			Town	)		Province	Country	Postal Code
	1/4 or LSD NW	SEC 23	<i>TWP</i> 045	<i>RGE</i> 18	W of MER 4			Plan		nal Description	
Measured from		m from m from			GPS Coordin Latitude 5: How Location Map	2.897914	Longi			Elevation How Elevation Ol	
Additional In	formation										Measurement in Metric
Distance Fro Is Artesian F		_	_				Is Flow Con	trol Installed Describe			
	ed Pump Rat				31.82 L/min	Pum	p Installed			Depth	m
Recommend	ed Pump Inta	ke Depth (F	rom TOC)		15.24 m	Тур	e		Make	Model (Output I	H.PRating)
	counter Salin Comments of			OS) Gas	Depth Depth		<u>m</u>	Geo	physical Log Submitted to	ESRD	mitted to ESRD
Yield Test								Tak		Ground Level	Measurement in Metric
Test Date 1985/09/10		Start Time 12:00 AM		Statio	7.92 m		Draw	down (m)	E	Elapsed Time Minutes:Sec	Recovery (m)
Rei	moval Rate Irawn From	3ailer 31	5.76 m	ly		_					
Water Diver	ted for Drillin	ng									
Water Source				Amo	ount Taken L				Diversio	n Date & Time	

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name

GENETH CONSTRUCTION/DIVISION OF 305-137 ALBERTA LTD.

Certification No

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**Drilling Information** Method of Drilling

39.01

39.62

Rotary

### **Water Well Drilling Report**

**View in Imperial Export to Excel** 

Data Papart Pagaiyad

GIC Well ID GoA Well Tag No.

143265

Drilling Company Well ID 1006/04/20

GOWN	ID
Cacavvia	ш

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> Type of Work New Well

COWITID										Date Report Receiv	60 1300/0 <del>4</del> /20
Well Iden	tification and L	ocation									Measurement in Metric
Owner Nar LARSON,			Address BAWLF			Town			Province	Country	Postal Code
Location	1/4 or LSD NW	SEC 23	<i>TWP</i> 045	RGE 18	W of MER 4	Lot	Block	Plan	Additio	nal Description	
Measured	from Boundary o	of			GPS Coordir	nates in Dec	imal Degre	es (NAD 83	3)		
		m from			Latitude 5	2.897914	Longi	itude <u>-112.5</u>	513541	Elevation	m
		m from			How Location	n Obtained				How Elevation Obt	ained
					Мар					Not Obtained	

Proposed Well Use Domestic Formation Log Measurement in Metric Water Lithology Description Depth from ground level (m) Bearing 18.29 Clay 21.34 Shale

Bentonitic Shale

Coal

Yield Test Sum	Yield Test Summary Measurement in Metric							
Recommended Pump Rate 4.55 L/min								
					tic Water Level (m)			
1985/08/27		5.00			3.05			
Well Completio	n			١	Measurement in Me	tric		
Total Depth Drille	ed Fini	shed Well Depth	Start	Date	End Date			
39.62 m			1985/	03/23	1985/08/27			
Borehole								
Diameter (d	cm)	From			To (m)			
0.00		0.0			39.62	_		
Surface Casing Steel	(if appl		Well Ca Steel	sing/Lin	er			
Size OD	:	16.51 cm		Size OD	: 11.43 cm			
Wall Thickness	:	0.478 cm	Wall T	: 0.318 cm				
Bottom at	:	21.34 m	Top at :		: <u>19.81 m</u>			
			Bottom at :		: 39.01 m			
Perforations								
From (m) To	o (m)	Diameter or Slot Width (cm)		ength n)	Hole or Slot Interval(cm)			
FIOIII (III)	J (111)	(CIII)	(()	11)	Interval(City)			
Perforated by  Annular Seal  Placed from	Jnknow	ł m						
Amount -								
Other Seals			-					
	Type				At (m)			

To (m)

Bottom Fittings

Grain Size

Slot Size (cm)

(	Contractor	Certification

Name of Journeyman responsible for drilling/construction of well  ${\tt UNKNOWN\ NA\ DRILLER}$ 

Company Name

GENETH CONSTRUCTION/DIVISION OF 305-137 ALBERTA LTD.

Certification No

Screen Type

Pack

Туре Amount

Size OD:

From (m) Attachment

Top Fittings

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#### **View in Imperial Export to Excel**

GIC Well ID

143265

GoA Well Tag No.

Drilling Company Well ID 1986/04/28

**GOWN ID** Date Report Received Well Identification and Location Measurement in Metric Address Owner Name Postal Code Town Province Country LARSON, TED **BAWLF** 1/4 or LSD SEC TWP RGE W of MER Block Plan Additional Description Location Lot NW 23 045 18 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of Elevation \_\_\_ Latitude 52.897914 Longitude -112.513541 m m from How Location Obtained How Elevation Obtained m from Not Obtained Additional Information Measurement in Metric Distance From Top of Casing to Ground Level cm Is Artesian Flow Is Flow Control Installed Rate Describe Recommended Pump Rate 4.55 L/min Pump Installed Depth m Recommended Pump Intake Depth (From TOC) 33.53 m H.P. Model (Output Rating) m Well Disinfected Upon Completion Did you Encounter Saline Water (>4000 ppm TDS) Depth m \_\_\_\_ Depth Geophysical Log Taken Gas \_\_\_\_\_ Submitted to ESRD Sample Collected for Potability Submitted to ESRD Additional Comments on Well Yield Test Taken From Ground Level Measurement in Metric Depth to water level Test Date Start Time Static Water Level Drawdown (m) Elapsed Time Recovery (m) 1985/08/27 12:00 AM 3.05 m Minutes:Sec Method of Water Removal Type Bailer Removal Rate 5.00 L/min Depth Withdrawn From 36.58 m If water removal period was < 2 hours, explain why

Water Diverted for Drilling		
Water Source	Amount Taken L	Diversion Date & Time

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name

GENETH CONSTRUCTION/DIVISION OF 305-137 ALBERTA LTD.

Certification No

Copy of Well report provided to owner Date approval holder signed

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### **View in Imperial Export to Excel**

GIC Well ID GoA Well Tag No.

143401

Drilling Company Well ID

GOWN	ID

OWN ID										Date Report Receive	1958/04/07	
Well Ident	ification and L	ocation									Measurement in M	letric
Owner Name Address HIWAY SVC BAWLF					Town				Province	e Country	Postal Cod	de
Location	1/4 or LSD SW	SEC 31	<i>TWP</i> 045	RGE 17	W of MER 4	Lot	Block	Plan	Additio	onal Description		
Measured from Boundary of m from			GPS Coordinates in Decimal Degrees (NAD 83)  Latitude 52.919817 Longitude -112.46				Elevation	m				
		m from			How Location	n Obtained				How Elevation Obtained	ained	

**Drilling Information** Method of Drilling Type of Work Cable Tool New Well Proposed Well Use Domestic Yield Test Summary

Formation Log			Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description	
18.29		Clay	
30.48		Clay	
48.77		Clay	
53.95	Yes	Water Bearing Sandstone	
56.39		Shale	

Tield Test Sui	-		00 1/		Wicas	urement in	IVICTIC
Recommended Tost Date	Pump Rat	e 0.0 Removal Rate (	JU L/MIN		atic \^/	ator Lovol (m	`
Test Date	vvater k	kemoval Kate (	L/1111(11)	51		ater Level (m	)
1955/06/27						10.97	
Well Completi					Meas	urement in	Metric
Total Depth Drill	led Finish	ned Well Depth	Start	Date		End Date	
56.39 m						1955/06/27	
Borehole							
Diameter (	(cm)	From	n (m)			To (m)	
0.00			00			56.39	
Surface Casing Steel			Well Ca	ising/Li	ner		
Size OL	) :	7.62 cm		Size O	D :	0.00 cm	_
Wall Thickness			Wall T	hicknes	s:	0.000 cm	_
Bottom a	t: 5	1.82 m		Тор а	at :	0.00 m	_
			E	Bottom a	at:	0.00 m	_
Perforations							
From (m)	Diameter of Slot Widt To (m) (cm)			Length cm)		le or Slot terval(cm)	
	0.0	e 10 m to		) m_	At (m	n)	
Screen Type							
	) :	0.00 cm					
From (n	n)	То	(m)		Slo	ot Size (cm)	
							_
Top Fitting				n Fitting	gs		_
Pack							
Туре			Grain	Size			
Amount							

Contractor	Certification

Name of Journeyman responsible for drilling/construction of well UNKNOWN NA DRILLER

Company Name SERVOLD, HAROLD Certification No

Copy of Well report provided to owner Date approval holder signed

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## **Water Well Drilling Report**

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**View in Imperial Export to Excel** 

GIC Well ID GoA Well Tag No. 143401

Drilling Company Well ID
Date Report Received

1958/04/07

	ification and								Measurement in Metric
Owner Nam HIWAY SV		Address BAWLF			Town		Province	Country	Postal Code
Location	1/4 or LSD SW	SEC TWP 31 045	RGE 17	4	Lot Block	Plan	Additional D	Description	
Measured t	from Boundary	of			es in Decimal Degree		5400		
		m from			019817 Longia	tuae <u>-112.46</u>		evation ow Elevation Obt	
		m from		How Location C	Diamed		<b>I</b> -	ow Elevation Obt ot Obtained	arried
Additional	Information		•				,		Measurement in Metric
Distance F	From Top of Ca	asing to Ground Level		cm					
Is Artesia	n Flow		_		Is Flow Con				
	Rate	L/min	_			Describe _			
Recomme	nded Pump Ra	ate		0.00 L/min	Pump Installed		De	pth	m
Recomme	nded Pump Int	take Depth (From TO	C)	0.00 m	Туре		Make		Н.Р.
							٨	/lodel (Output Ra	ating)
Did you	Encounter Sali	ine Water (>4000 ppn	n TDS)	Depth	m	Well Disinfe	ected Upon Con	npletion	
			Gas		m			ken	
						Geop		ken	
					<u>m</u>	Geop S	hysical Log Tak ubmitted to ES	ken RD	
Addition	nal Comments (				<u>m</u>	Geop S	hysical Log Tak	ken RD	
Addition					<u>m</u>	Geop S	hysical Log Tak ubmitted to ES	ken RD	
Addition	nal Comments (				<u>m</u>	Geop S Ollected for Po	hysical Log Tak ubmitted to ESI otability en From Grou	RD Subn	
Yield Test Test Date	nal Comments (	on Well Start Time	Gas	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESI otability en From Grou Depth to	Subn Subn Nd Level water level	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test	nal Comments (	on Well	Gas	Depth	m Sample Co	Geop S Ollected for Po	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	RD Subn	nitted to ESRD <u>Yes</u>
Yield Test Test Date 1955/06/2	nal Comments o	on Well  Start Time 12:00 AM	Gas	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	Subn Subn Nd Level water level ed Time	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test Test Date 1955/06/2	nal Comments of	on Well  Start Time 12:00 AM	Gas	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	Subn Subn Nd Level water level ed Time	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test Test Date 1955/06/2	nal Comments of Type	on Well  Start Time 12:00 AM	Gas	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	Subn Subn Nd Level water level ed Time	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test Test Date 1955/06/2	onal Comments of Type Removal Rate	on Well  Start Time 12:00 AM  val	GasStai	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	Subn Subn Nd Level water level ed Time	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test Test Date 1955/06/2  Method o	7  f Water Remo Type Removal Rate thdrawn From	Start Time 12:00 AM val L/m 0.00 m	Gas	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	Subn Subn Nd Level water level ed Time	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test Test Date 1955/06/2  Method o	7  f Water Remo Type Removal Rate thdrawn From	on Well  Start Time 12:00 AM  val	Gas	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	Subn Subn Nd Level water level ed Time	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test Test Date 1955/06/2'  Method of Formula Depth Win	7  f Water Remo Type Removal Rate thdrawn From	Start Time 12:00 AM  val  Um  0.00 m	Gas	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	Subn Subn Nd Level water level ed Time	nitted to ESRD <u>Yes</u> Measurement in Metric
Yield Test Test Date 1955/06/2'  Method of Formula Depth Win	7  f Water Remo Type Removal Rate thdrawn From moval period w	Start Time 12:00 AM  val  Um  0.00 m	State why	Depth	m Sample Co	Geop S Dillected for Po Take	hysical Log Tak ubmitted to ESi otability  en From Grou Depth to 1 Elapse	nd Level water level ed Time tes:Sec	nitted to ESRD <u>Yes</u> Measurement in Metric

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name SERVOLD, HAROLD Certification No

1

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# **Water Well Drilling Report**

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**View in Imperial Export to Excel** 

GIC Well ID GoA Well Tag No.

143407

Drilling Company Well ID Date Report Received

1982/01/27

tion and Lo	cation									Measurement in Metric
GE OF		Address BAWLF		Town Province			Country	Postal Code		
4 or LSD <b>V</b>	SEC 31	<i>TWP</i> 045	<i>RGE</i> 17	W of MER 4	Lot	Block	Plan	Additio	onal Description	
Boundary of				GPS Coordinates in Decimal Degrees (NAD 83)			)			
*					52.919817	Longi	tude -112.4	165188	Elevation	m
m from					How Location Obtained				How Elevation Obtained	
Map						Not Obtained				
-	SE OF f or LSD V Boundary of n	for LSD SEC V 31	Address BAWLF For LSD SEC TWP V 31 045 Boundary of m from	Address BAWLF  For LSD SEC TWP RGE V 31 045 17  Boundary of m from	Address   BAWLF	Address Town BE OF BAWLF  For LSD SEC TWP RGE W of MER Lot V 31 045 17 4  Boundary of GPS Coordinates in Dec. Latitude 52.919817 How Location Obtained	Address Town  BE OF BAWLF  For LSD SEC TWP RGE W of MER Lot Block  N 31 045 17 4  Boundary of GPS Coordinates in Decimal Degree  In from How Location Obtained	Address         Town           SE OF         BAWLF           # or LSD         SEC         TWP         RGE         W of MER         Lot         Block         Plan           W         31         045         17         4           GPS Coordinates in Decimal Degrees (NAD 83 Latitude         52.919817         Longitude         -112.4           How Location Obtained         How Location Obtained         -112.4         -112.4	Address Town Province BE OF BAWLF  For LSD SEC TWP RGE W of MER Lot Block Plan Addition  31 045 17 4  Boundary of GPS Coordinates in Decimal Degrees (NAD 83)  Latitude 52.919817 Longitude -112.465188  How Location Obtained	Address BAWLF  For LSD SEC TWP RGE W of MER Lot Block Plan Additional Description  31 045 17 4  Boundary of GPS Coordinates in Decimal Degrees (NAD 83) Latitude 52.919817 Longitude -112.465188 Elevation Obtained  How Elevation Obtained

**Drilling Information** Method of Drilling Type of Work Cable Tool New Well Proposed Well Use Municipal Yield Test Summary Measurement in Metric

Formation Log			Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description	
0.61		Topsoil	
5.79		Brown Clay & Rocks	
10.67		Black Sandy Clay	
19.51		Black Clay	
20.42		Light Sand & Gravel	
21.03		Clay & Shale	

Test Date   Water Removal Rate (L/min)   Static Water Level (m)     1981/09/25   272.77   3.35	Recommended	l Pump Ra	ate 0.0	0 L/min	_			
Well Completion         Measurement in Metric           Total Depth Drilled         Finished Well Depth         Start Date         End Date           21.03 m         1981/09/20         1981/09/25           Borehole           Diameter (cm)         From (m)         To (m)           0.00         0.00         21.03           Surface Casing (if applicable)           Steel         Size OD :         21.92 cm         Size OD :         0.00 cm           Wall Thickness :         0.650 cm         Wall Thickness :         0.000 cm           Bottom at :         19.20 m         Top at :         0.00 m           Perforations           Diameter or Slot Width (cm)         Slot Length (cm)         Hole or Slot Interval(cm)           Perforated by           Annular Seal Drive Shoe         0.00 m         19.20 m           Amount         19.20 m         19.20 m	Test Date	Water	Removal Rate (I	_/min)	St	atic Water Level (m)	)	
Total Depth Drilled   Finished Well Depth   Start Date   21.03 m   1981/09/20   1981/09/25	1981/09/25		272.77		3.35			
Diameter (cm)							Metric	
Diameter (cm)	,	lled Finis	shed Well Depth					
Diameter (cm)	21.03 m			1981/	09/20	1981/09/25		
0.00         0.00         21.03           Surface Casing (if applicable)           Steel         Size OD:         0.00 cm           Wall Thickness:         0.650 cm         Wall Thickness:         0.000 cm           Bottom at:         19.20 m         Top at:         0.00 m           Bottom at:         0.00 m         Bottom at:         0.00 m           Perforations         Slot Length (cm)         Hole or Slot Interval(cm)           Perforated by         Annular Seal Placed from 0.00 m to 19.20 m         19.20 m	Borehole							
Surface Casing (if applicable)   Steel   Size OD :   21.92 cm   Size OD :   0.00 cm								
Size OD :   21.92 cm   Size OD :   0.00 cm								
Wall Thickness :         0.650 cm         Wall Thickness :         0.000 cm           Bottom at :         19.20 m         Top at :         0.00 m           Bottom at :         0.00 m           Perforations           From (m)         To (m)         Slot Width (cm)         Hole or Slot Interval(cm)           Perforated by           Annular Seal Placed from 0.00 m to 19.20 m           Amount         19.20 m	,	g (if appli	cable)	Well Ca	asing/Li	ner		
Perforations   Diameter or   Slot Width   Cm   Interval(cm)	Size O							
Perforations    Diameter or Slot Width (cm)   Slot Length (cm)   Interval(cm)		ss:	0.650 cm	Wall T	hicknes	s: 0.000 cm		
Perforations  Diameter or Slot Width (cm) Slot Length Interval(cm)  Perforated by  Annular Seal Placed from 0.00 m to 19.20 m  Amount	Bottom a	at :	19.20 m		Тор а	at: 0.00 m		
Perforated by  Annular Seal Placed from Drive Shoe				E	Bottom a	at: 0.00 m		
From (m) To (m) Slot Width (cm) Hole or Slot Interval(cm)  Perforated by  Annular Seal Placed from 0.00 m to 19.20 m  Amount	Perforations							
From (m)         To (m)         (cm)         Interval(cm)           Perforated by           Annular Seal         Drive Shoe           Placed from         0.00 m         to         19.20 m           Amount						Holo or Clot		
Perforated by  Annular Seal Drive Shoe Placed from 0.00 m to 19.20 m Amount	From (m)							
Annular Seal Drive Shoe Placed from 0.00 m to 19.20 m Amount								
Placed from 0.00 m to 19.20 m  Amount	Perforated by							
Placed from 0.00 m to 19.20 m  Amount	Annular Seal	Drive Sho	ne.					
Amount				19.20 m				
Olite Seals	Other Seals			-				
Type At (m)		Type		At (m)				
				7.6 ()				
Screen Type Stainless Steel	Screen Type	Stainless	Steel					
Size OD: 19.05 cm								
From (m) To (m) Slot Size (cm)				m)		Slot Size (cm)		
19.20 20.73 0.051								
Attachment Telescoped	Attachme	nt Telesc	oped					
Top Fittings Packer Bottom Fittings Plug	Top Fitting	gs Packer		Bottom Fittings Plug				
Pack	Pack							
Type Grain Size	Туре			Grain	Size			
Amount 0.00								

Contractor	Certification

Name of Journeyman responsible for drilling/construction of well UNKNOWN NA DRILLER

Company Name

SERVOLD & SONS DRILLING

Certification No

Copy of Well report provided to owner Date approval holder signed

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## **Water Well Drilling Report**

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### **View in Imperial Export to Excel**

GIC Well ID

143407

GoA Well Tag No. Drilling Company Well ID

1982/01/27 Date Report Received

Well Identificati	ion and Lo	ocation									Measure	ement in Metric
Owner Name BAWLF, VILLAG	E OF		Address BAWLF			Town			Province	Country	′	Postal Code
Location 1/4	or LSD	SEC 31	<i>TWP</i> 045	RGE 17	W of MER 4	Lot	Block	Plan	Additio	nal Description		
Measured from E		f m from m from			GPS Coordin Latitude 5 How Location Map	52.919817	•	es (NAD 83) tude <u>-112.4</u>		Elevation How Elevation C		_
Additional Infor	mation										Measure	ement in Metric
Distance From T Is Artesian Flow Rate	v				cm	1	's Flow Con	trol Installed Describe				
Recommended					0.00 L/mir	n Pump	o Installed _			Depth	m	_
Recommended	Pump Intal	ke Depth (	(From TOC)		17.68 m	Туре	SUB		Make JA			
										Model (Output	Rating)	
Did you Encou	unter Saline	e Water (>		DS) Gas		1		Geo		Completion g Taken p ESRD		
Additional Co.			ATER, SEE	VG CHEM	SAMPLE #8865	599	Sample Co	ollected for F	Potability	Sui	bmitted to ESF	RD
Yield Test								Tak		Ground Level th to water level	Measure	ement in Metric
Test Date 1981/09/25		Start Tim 12:00 AM		Stati	c Water Level 3.35 m		Draw	down (m)		Elapsed Time Minutes:Sec	Recov	ery (m)
Method of Wate Remov Depth Withdrav	Type Power Provided P	ump 2				_						
Water Diverted	for Drillin	ng										
Water Source				Am	ount Taken				Diversio	on Date & Time		

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name

SERVOLD & SONS DRILLING

Certification No

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**Drilling Information** Method of Drilling

Proposed Well Use

30.48

Rotary

### **Water Well Drilling Report**

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Data Papart Pagaiyad

GIC Well ID

143408

1000/02/21

To (m)

30.48

0.00 cm

GoA Well Tag No.

Drilling Company Well ID

GOWN	

accuracy. The information on this report will be retained in a public database.

Type of Work

New Well

JOWNIN										Date Report Receive	eu 1900/03/21
Well Ident	ification and L	ocation									Measurement in Metric
Owner Nan ALTA WHE			Address DAYSLAN	D		Town			Province	Country	Postal Code
Location	1/4 or LSD SW	SEC 31	<i>TWP</i> 045	RGE 17	W of MER 4	Lot	Block	Plan	Additio	onal Description	
Measured t	from Boundary o	of			GPS Coordin	nates in Dec	imal Degre	es (NAD 83 <sub>)</sub>	)		
mododrod r		m from			Latitude 5	2.919817	Longi	tude -112.4	65188	Elevation	m
		m from			How Location	n Obtained				How Elevation Obt	ained
					Not Verified					Not Obtained	

Domestic Formation Log Measurement in Metric Water Lithology Description Depth from ground level (m) Bearing 10.67 Till & Clay 25.91 Brown Shale 27.43 Shale

Sandstone

Yield Test Sum	nmary	Measurement in Metric	
Recommended F	Pump Rate0.00	L/min_	
Test Date	Water Removal Rate (L/	/min)	Static Water Level (m)
1987/11/23	22.73		4.57
Well Completion	on		Measurement in Metric
Total Depth Drille	ed Finished Well Depth	Start Date	End Date
30.48 m			1987/11/23
Borehole			

From (m)

0.00

Well Casing/Liner

Size OD:

Wall Thickness : 0.000 cm Top at : \_\_\_\_\_0.00\_m

At (m)

Slot Size (cm)

		Bottom a	at:	0.00 m
To (m)	Diameter or Slot Width (cm)	Slot Length (cm)		ole or Slot nterval(cm)
	To (m)	Slot Width	Diameter or Slot Width Slot Length	Diameter or Slot Width Slot Length He

Perforated by

Other Seals

Diameter (cm) 0.00

Surface Casing (if applicable)

Size OD:

Wall Thickness : 0.000 cm

Bottom at : 25.91 m

Annular Seal Driven 0.00 m to Placed from \_ Amount

14.12 cm

Screen Type

Size OD: From (m)

Type

Attachment Top Fittings Bottom Fittings

Pack

Grain Size Туре Amount

### Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name

GENETH CONSTRUCTION/DIVISION OF 305-137 ALBERTA LTD.

Certification No

Copy of Well report provided to owner Date approval holder signed

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**View in Imperial Export to Excel** 

GIC Well ID 143408 GoA Well Tag No.

Drilling Company Well ID Date Report Received 1988/03/21

**GOWN ID** Well Identification and Location Measurement in Metric Address Owner Name Town Province Country Postal Code ALTA WHEAT POOL DAYSLAND 1/4 or LSD SEC TWP RGE W of MER Block Plan Additional Description Location Lot SW 31 045 17 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of Elevation \_\_\_ Latitude 52.919817 Longitude -112.465188 m m from How Location Obtained How Elevation Obtained m from Not Verified Not Obtained Additional Information Measurement in Metric Distance From Top of Casing to Ground Level cm Is Artesian Flow Is Flow Control Installed Rate Describe Recommended Pump Rate 0.00 L/min Pump Installed Depth m Recommended Pump Intake Depth (From TOC) 0.00 m H.P. Model (Output Rating) m Well Disinfected Upon Completion Did you Encounter Saline Water (>4000 ppm TDS) Depth m\_\_\_\_ Gas \_\_\_\_ Depth Geophysical Log Taken Submitted to ESRD Sample Collected for Potability Submitted to ESRD Additional Comments on Well Yield Test Taken From Ground Level Measurement in Metric Depth to water level Test Date Start Time Static Water Level Drawdown (m) Elapsed Time Recovery (m) 1987/11/23 12:00 AM 4.57 m Minutes:Sec Method of Water Removal Type Bailer Removal Rate 22.73 L/min Depth Withdrawn From 21.34 m If water removal period was < 2 hours, explain why Water Diverted for Drilling

Amount Taken

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name

Water Source

GENETH CONSTRUCTION/DIVISION OF 305-137 ALBERTA LTD.

Certification No

Copy of Well report provided to owner Date approval holder signed

Diversion Date & Time

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**View in Imperial Export to Excel** 

GIC Well ID GoA Well Tag No. Drilling Company Well ID Date Report Received

1685004

**GOWN ID** 

										and moperit modern	
Well Ident	ification and L	ocation									Measurement in Metric
Owner Nan FENSKE, E			Address P.O. BOX	56		Town BAWL			Province AB	Country CA	Postal Code T0B 0J0
Location	1/4 or LSD 16	SEC 24	<i>TWP</i> 045	<i>RGE</i> 18	W of MER 4	Lot	Block	Plan	Additiona	al Description	
Measured f		of m from No m from Ea			How Location	2.899710	Longi	es (NAD 83) tude <u>-112.4</u>	75190	Elevation How Elevation Obt	mtained
					Not Verified					Not Obtained	

**Drilling Information** Method of Drilling Type of Work Cable Tool New Well Proposed Well Use Domestic & Stock

Formation Log		Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description
0.15		Black Topsoil
1.83		Brown Hard Clay
4.27		Brown Sandy Clay
12.80		Black Clay
17.07	Yes	Brown Water Bearing Sand
26.52		Black Soft Clay & Sand
29.26		Clay & Shale
30.48		Dark Brown Clay
32.00		Brown Clay
33.53		Coal

Yield Test Summary Measurement in Metric								
Recommended Pump Rate15.91 L/min								
		Removal Rate (	L/min)	St				
2003/07/14		22.73			4.88			
Well Completion					Measurement in Me	tric		
Total Depth Drill	ed Finisi	hed Well Depth			End Date			
33.53 m			2003	/06/27	2003/07/03			
Borehole								
Diameter ( 12.70		From 0.0	(m) no		To (m) 33.53	-		
Surface Casing Steel		cable)	Well Ca Plastic	asing/Li				
	) :1	4.13 cm		Size O	D: 11.43 cm			
			Wall 7		ss: 0.635 cm			
		9.87 m			at: 26.82 m			
			I	Bottom a	at: 32.92 m			
Perforations								
		Diameter or Slot Width	Slot L	ength	Hole or Slot			
From (m) T	o (m)	(cm)		n)	Interval(cm)			
26.82	32.92	0.051						
Perforated by	Saw							
Annular Seal	Driven							
Placed from	26.8	2 m to	33.53	3 m				
Amount			_					
Other Seals								
	Type				At (m)			
Screen Type								
Size OD	:							
From (m	1)	То	(m)		Slot Size (cm)			
Attachmen	t Unknow	/n						
Top Fittings	Unknov	/n	Botto	m Fitting	gs Unknown			
Pack								
Type Silica S	and		Grain	Size 10	0/20			
Amount	Amount 80.00 Pounds							

#### Contractor Certification

Name of Journeyman responsible for drilling/construction of well

IRVIN SERVOLD

Company Name SERVOLD & SONS DRILLING Certification No

VA3263

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GIC Well ID GoA Well Tag No. Drilling Company Well ID Data Papart Pagaiyad

Model (Output Rating)

Submitted to ESRD

m Well Disinfected Upon Completion

Submitted to ESRD

Depth \_\_\_\_\_ m Geophysical Log Taken \_

1685004

GO	۱۸/	N	IГ

COWILID										Date Report Receiv	eu	
Well Ident	tification and L	ocation									Measureme	nt in Metric
Owner Name FENSKE, BLAINE			Address P.O. BOX 56		<i>Town</i> <b>BAWLF</b>			Province Coun AB CA			stal Code B 0J0	
Location	1/4 or LSD 16			RGE 18	W of MER 4	Lot	Block	Plan	Addition	nal Description		·
Measured i		of m from North m from East	_ _ 		GPS Coordin Latitude 5 How Location Not Verified	52.899710	U	es (NAD 83) itude <u>-112.47</u>	<u>′5190</u>	Elevation How Elevation Obt	mtained	
Additional	I Information										Measureme	nt in Metric
Distance I Is Artesia	From Top of Cas an Flow Rate		Level		45.72 cm	ı	's Flow Con	trol Installed Describe				
	Rate		<u>min</u>					Describe				
Recomme	ended Pump Rat	te	_		15.91 L/mir	<u>n</u> Pum <sub>l</sub>	o Installed			Depth	m	
Recomme	ended Pump Inte	ake Depth (Fror	n TOC)		12.19 m	Тур	e		Make		Н.Р.	

Sample Collected for Potability Additional Comments on Well Yield Test Taken From Ground Level Measurement in Metric Depth to water level Test Date Start Time Static Water Level Drawdown (m) Elapsed Time Recovery (m) 2003/07/14 12:00 AM 4.88 m Minutes:Sec 4.88 0:00 7.62 Method of Water Removal 5.79 1:00 6.10 Type Bailer 6.71 2:00 5.49 7.01 3:00 5.18 22.73 L/min Removal Rate 7.32 4:00 5.18 12.1<u>9 m</u> Depth Withdrawn From 5:00 5.03 7.62 5.03 7.62 6:00 If water removal period was < 2 hours, explain why 7.62 7:00 5.03 7.62 8:00 5.03 PUMP INSTALLED TO TEST ONLY 7.62 9:00 5.03 7.62 10:00 4.88 12:00 4.88 14:00 4.88 16:00 4.88 20:00 4.88

Water Diverted for Drilling		
9		
Water Source	Amount Taken	Diversion Date & Time
	1	
	L	

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

Did you Encounter Saline Water (>4000 ppm TDS) \_\_\_\_\_ Depth \_\_\_\_

Gas \_\_\_\_

IRVIN SERVOLD

Company Name SERVOLD & SONS DRILLING Certification No

VA3263

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1685014

GIC Well ID GoA Well Tag No. Drilling Company Well ID

**GOWN ID** 

Date Report Received Well Identification and Location Measurement in Metric Address Country Postal Code Town Province Owner Name BELLINGHAM, ROGER P.O. BOX 148 **BAWLF** AΒ CA T0B 0J0 1/4 or LSD SEC TWP W of MER Block Additional Description RGE Plan Location Lot 80 23 045 18 4 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of Elevation Latitude 52.892510 Longitude -112.500190 m 213.36 m from North How Location Obtained How Elevation Obtained 121.92 m from East Not Verified Not Obtained

**Drilling Information** Method of Drilling Type of Work New Well Cable Tool Proposed Well Use Domestic & Stock

Formation Log			Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description	
0.61		Topsoil	
4.57		Brown Clay	
13.72		Blue Sandy Clay & Rocks	
19.81		Blue Gray Firm Sand	
22.25		Fine Grained Sand & Grav	el

rieid Test Summa	ai y		Measurement in Metric		
Recommended Pun					
	later Removal Rate	(L/min)			
2003/08/13	68.19		5.18		
Well Completion			Measurement in Metric		
Total Depth Drilled	Finished Well Dept	h Start Date	End Date		
22.25 m		2003/08/13	3 2003/08/13		
Borehole					
Diameter (cm)		n (m)			
12.70		.00	22.25		
Surface Casing (if	аррисавіе)	Well Casing Unknown	y Liner		
Size OD:	14.13 cm	Size	e OD :		
Wall Thickness:	0.478 cm	Wall Thickr	ness: cm		
Bottom at :	21.79 m	To	op at :m		
		Botto	m at :m_		
Perforations					
From (m) To (r	Diameter or Slot Width m) (cm)	Slot Length (cm)			
			-		
Ту	ре		At (m)		
Screen Type Size OD: From (m)		(m)	Slot Size (cm)		
Attachment					
Top Fittings			tings		
Pack					
Type Unknown		Grain Size			
Amount	Unknown		<del></del>		

Contractor	Certification

Name of Journeyman responsible for drilling/construction of well

IRVIN SERVOLD

Company Name

SERVOLD & SONS DRILLING

Certification No

VA3263

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GIC Well ID GoA Well Tag No. Drilling Company Well ID Date Report Received

1685014

#### **GOWN ID**

Well Identi	fication and L	_ocation									Meas	surement in Metric
Owner Nam BELLINGHA			Address P.O. BOX	148		Town BAWLF			Province AB	Co. CA	untry	Postal Code T0B 0J0
Location	1/4 or LSD 08	SEC 23	<i>TWP</i> 045	<i>RGE</i> 18	W of MER 4	Lot	Block	Plan	Addition	nal Description	)	
Measured fr	-	of m from No m from Ea			GPS Coordina Latitude 52 How Location Not Verified	2.892510	•			Elevation How Elevation Not Obtained		m
Additional	Information										Meas	surement in Metric
	rom Top of Cas n Flow Rate				45.72 cm	Is	Flow Con	trol Installed Describe				
Recommen	nded Pump Rai	te			3.41 L/min	Pump	Installed	Yes		Depth	m	
Recommen	nded Pump Inta	ake Depth (	From TOC)		12.19 m	Туре	SUB		Make		H.P.	
										Model (Out	tput Rating)	
Did you E	Encounter Salir	ne Water (>		DS) Gas						Completion _ Taken _		
				-					Submitted to	ESRD		
							Sample C	ollected for P	otability		Submitted to	ESRD
Additiona	al Comments o	n Well										
45' - 65' AL	SO SOFT LAY	'ERS, 65' -	73' SMALL	GRAVEL	TO VARIOUS LA	RGER AT B	оттом,	WATER OF	GOOD QUA	LITY		
Yield Test								Tak	en From G	Fround Level	Meas	surement in Metric

/ield Test			Taken	From Ground Level	Measurement in Me
Test Date	Start Time	Static Water Level		Depth to water level	
2003/08/13	12:00 AM	5.18 m	Drawdown (m)	Elapsed Time Minutes:Sec	Recovery (m)
			5.18	0:00	7.01
Method of Water F	Removal		5.79	1:00	6.10
	Type Bailer & Pump		6.10	2:00	5.79
	Rate 68.19 L/m	in .	6.40	3:00	5.49
		<u></u>	7.01	4:00	5.49
Depth Withdrawn F	From 12.19 m	-	7.01	5:00	5.49
			7.01	6:00	5.49
lf water removal pe	riod was < 2 hours, explain	why	7.01	7:00	5.49
			7.01	8:00	5.49
			7.01	9:00	5.49
			7.01	10:00	5.18
			7.01	12:00	5.18
			7.01	14:00	5.18
			7.01	16:00	5.18
			7.01	20:00	5.18
			7.01	25:00	5.18
			7.01	30:00	5.18
			7.01	35:00	5.18
			7.01	40:00	5.18
			7.01	50:00	5.18
			7.01	60:00	5.18
			7.01	75:00	5.18
			7.01	90:00	5.18
			7.01	105:00	5.18
			7.01	120:00	5.18

Water Diverted for Drilling		
Water Source	Amount Taken	Diversion Date & Time

#### Contractor Certification

Name of Journeyman responsible for drilling/construction of well  $\ensuremath{\mathsf{IRVIN}}$  SERVOLD

Company Name SERVOLD & SONS DRILLING Certification No

VA3263

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GIC Well ID GoA Well Tag No.

197063

Drilling Company Well ID

GOWN ID										Date Report Receiv	ved 1986/02/17	*
Well Identi	ification and L	ocation.									Measurement	in Metric
Owner Name Address ARC# TH 32-75			Town			Province Country		Posta	al Code			
Location	1/4 or LSD 13	SEC 23	<i>TWP</i> 045	<i>RGE</i> 18	W of MER 4	Lot	Block	Plan	Additio	onal Description		
Measured fi	rom Boundary o	of m from			_	2.899722	U	es (NAD 83) tude112.5		Elevation	702.87 m	
	m from				How Location	How Location Obtained				How Elevation Obtained		
					Field				ı	Survey-Transit		

Drilling Information			
Method of Drilling	Type of Work	Plugged	1975/06/23
Unknown	Coal Test Hole	Plugged with	Unknown
Proposed Well Use Other		Amount	

Other		
Formation Log		Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description
1.52		Light Brown Sandy Clay
4.57		Light Brown Clay
7.62		Light Brown Sandy Clay
10.67		Gray Shale
12.19		Gray Silt
16.76		Gray Shale
18.29		Gray Shale
21.34		Gray Shale & Sandy Stringers
22.86		Gray Shale & Silt
27.43		Sandy Unknown
28.96		Light Gray Sandy Shale
32.00		Light Gray Shale
33.53		Brown Shale
35.05		Dark Brown Carbonaceous Shale & Coal
36.58		Light Brown Shale
38.10		Gray Shale
41.15		Dark Brown Carbonaceous Shale & Coal
42.67		Light Gray Shale
44.20		Light Gray Shale & Sandstone
45.72		Light Gray Fine Grained Sandstone
47.24		Gray Shale
48.77		Light Gray Fine Grained Shale & Sandstone
53.34		Greenish Gray Shale & Silt
57.91		Light Gray Fine Grained Sandstone
59.44		Gray Shale
60.96		Gray Sandy Shale
64.01		Greenish Gray Shale
65.53		Gray Shale
67.06		Light Gray Fine Grained Shale & Sandstone
68.58		Gray Shale
74.68		Gray Fine Grained Shale & Sandstone
77.72		Dark Gray Silty Shale

Yield Test S	Summary				Meas	urement in I	Metric
Recommend	led Pump R	ate	L/min	_			
Test Date	Removal Rate (	L/min)	min) Static Water Level (m)				
Well Compl						urement in I	Metric
	Drilled Fini	shed Well Depth	n Start	Date		End Date	
120.40 m						1975/06/23	
Borehole							
Diamet 0.	er (cm)	From 0.				To (m) 120.40	
		licable)		asing/Li	iner	120.40	
Size	OD :	0.00 cm		Size O	D :	0.00 cm	
Wall Thickr	ness :	0.000 cm	Wall 7	hicknes	ss:	0.000 cm	
Bottoi	m at :	0.00 m		Тор а	at :	0.00 m	
			L	Bottom a	at:	0.00 m	
Perforations	S						
		Diameter or Slot Width	Slot L	enath	Но	le or Slot	
From (m)	To (m)	(cm)	(cr			erval(cm)	
	al om <u>0</u>	.00 m_to		) m_			
	Type				At (m	)	
Screen Type		0.00 cm					
	n (m)	_	(m)		Slo	ot Size (cm)	
			,			,	
			Botto	m Fitting	ns.		-
			_01101				_
Pack			Grain	Sizo			
Amount			Gialli	Size			
Amount							

Contractor	Certification

Name of Journeyman responsible for drilling/construction of well UNKNOWN NA DRILLER

Company Name UNKNOWN DRILLER Certification No

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GIC Well ID GoA Well Tag No. 197063

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Drilling Company Well ID Date Report Received

1986/02/17

**GOWN ID** Well Identification and Location Measurement in Metric Owner Name Address Town Postal Code Province Country ARC# TH 32-75 1/4 or LSD SEC TWP RGE W of MER Block Plan Additional Description Location Lot 13 23 045 18 4 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of Elevation 702.87 m Latitude 52.899722 Longitude -112.516532 m from How Location Obtained How Elevation Obtained m from Field Survey-Transit

Depth from ground level (m)	Water Bearing	Lithology Description
79.25		Dark Gray Carbonaceous Shale & Coal
82.30		Gray Shale
83.82		Dark Gray Shale
85.34		Dark Gray Shale & Sandstone
86.87		Dark Gray Dirty Sandstone
88.39		Dark Gray Shale & Siltstone
89.92		Dark Gray Cemented Sandstone
91.44		Gray Silty Shale
94.49		Dark Gray Calcareous Shale
96.01		Gray Soft Shale
97.54		Gray Dirty Sandstone
99.06		Gray Sandstone
100.58		Gray Dirty Shale & Sandstone
102.11		Gray Shale
103.63		Gray Calcareous Shale
108.20		Gray Soft Shale
111.25		Dark Gray Soft Shale
114.30		Dark Gray Soft Shale & Gravel
115.82		Gray Calcareous Shale
120.40		Dark Gray Calcareous Shale & Sandstone Ledges

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

UNKNOWN NA DRILLER

Company Name UNKNOWN DRILLER Certification No

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### **Water Well Drilling Report**

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**View in Imperial Export to Excel** 

Date Report Received

197063

GIC Well ID GoA Well Tag No.

Drilling Company Well ID

1986/02/17

Well Identification and Location Measurement in Metric Postal Code Owner Name Address Town Province Country ARC# TH 32-75 1/4 or LSD SEC TWP W of MER RGE Block Plan Additional Description Location Lot 13 23 045 18 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of Elevation Latitude 52.899722 Longitude -112.516532 702.87 m m from How Location Obtained How Elevation Obtained m from Survey-Transit Additional Information Measurement in Metric Distance From Top of Casing to Ground Level cm Is Artesian Flow Is Flow Control Installed Rate Describe Recommended Pump Rate L/min Pump Installed Depth m Recommended Pump Intake Depth (From TOC) m H.P. Model (Output Rating) m Well Disinfected Upon Completion Did you Encounter Saline Water (>4000 ppm TDS) Depth m\_\_\_\_ Depth Geophysical Log Taken Gas Submitted to ESRD Sample Collected for Potability Submitted to ESRD Additional Comments on Well Yield Test Taken From Ground Level Test Date Start Time Static Water Level Method of Water Removal Type L/min Removal Rate Depth Withdrawn From m If water removal period was < 2 hours, explain why Water Diverted for Drilling Amount Taken Diversion Date & Time Water Source

Contractor Certification

UNKNOWN NA DRILLER

Company Name UNKNOWN DRILLER

Name of Journeyman responsible for drilling/construction of well

Certification No

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### **Water Well Drilling Report**

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GIC Well ID GoA Well Tag No.

1190090

Drilling Company Well ID Date Report Received

2009/12/10

Well Identification and Location Measurement in Metric Address Postal Code Town Province Country Owner Name CUNNINGHAM, SCOTT P.O. BOX 1264 CAMROSE **ALBERTA** CANADA T4Y 1X2 SEC TWP W of MER Additional Description 1/4 or LSD RGE Block Plan Location Lot NE 24 45 18 4 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of Elevation \_ Latitude 52.897922 Longitude -112.477377 m m from How Location Obtained How Elevation Obtained m from Not Verified Not Obtained

**Drilling Information** Method of Drilling Type of Work New Well Rotary - Mud Proposed Well Use Domestic

Formation Log			Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description	
3.96		Brown Clay	
19.51		Gray Clay	
20.73		Sand & Coal	
26.82		Gray Clay	
31.70	Yes	Sandy Shale	
32.92	Yes	Coal	
33.53	Yes	Gray Sand	
36.58		Gray Shale	

Yield Test Sum	mary				Measu	rement in N	/letric
Recommended P	ump Ra	te 4.5	5 L/min	_			
	Removal Rate (L	/min) Static Water Level (m)			er Level (m)		
2009/08/14 4.55 3.79							
Well Completion						rement in N	/letric
Total Depth Drille						End Date	
	33.53	3 m	2009/	/08/11	2	2009/08/12	
Borehole							
Diameter (c 17.15	m)	From 0.0				To (m) 33.53	
Surface Casing	(if applic	cable)		asing/Li		33.33	
Size OD	:	cm		Size OL	D :	12.70 cm	
Wall Thickness	:	cm	Wall 7	hicknes	s:	0.630 cm	
Bottom at	:	m		Тор а	nt :	0.00 m	
			E	Bottom a	at:	33.53 m	
Perforations From (m) To	o (m)	Diameter or Slot Width (cm)	Slot Le (cr	ength n)		e or Slot rval(cm)	
	0.0	00 m to	22.86	6 m			
Amount		4.00 Bags	_				
Other Seals							
	Туре		At (m)				
Screen Type P Size OD From (m) 24,38	:1	12.70 cm To (				Size (cm) 0.025	
	Attache	ed To Casing					
			Botto	m Fitting	s Plug		_
Pack							_
Type Artificial			Grain	Size 10	0/20		
Amount		Bags					

#### Contractor Certification

Name of Journeyman responsible for drilling/construction of well

ROBERT GROVE

Company Name

CHRIS'S WATERWELL SERVICING LTD.

Certification No

26857A

Copy of Well report provided to owner Yes

Date approval holder signed

2009/08/14

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1190090

GIC Well ID GoA Well Tag No.

**Drilling Company Well ID** 2009/12/10

**GOWN ID** Date Report Received Well Identification and Location Measurement in Metric Address Postal Code Town Province Owner Name Country CUNNINGHAM, SCOTT P.O. BOX 1264 CAMROSE **ALBERTA CANADA** T4Y 1X2 SEC TWP W of MER Additional Description 1/4 or LSD RGE Block Plan Location Lot NE 24 45 18 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of 52.897922 Longitude -112.477377 Latitude Elevation m m from How Location Obtained How Elevation Obtained m from

		l Not Verified		I Not Ob	tained
Additional Informa	ation				Measurement in Metric
Distance From Top Is Artesian Flow Rate	o of Casing to Ground Level	60.96 cm	Is Flow Control	Installed	
Recommended Pu	ımp Rate	4.55 L/min	Pump Installed Yes	Depth	33.22 m
Recommended Pu	mp Intake Depth (From TOC	33.22 m	Type Submersible	Make Grundfos	H.P. 0.5
				Mode	l (Output Rating)
Did you Encounte	er Saline Water (>4000 ppm	TDS) Depth _	m //	Vell Disinfected Upon Complet	ion Yes
		Gas Depth	m	Geophysical Log Taken	
				Submitted to ESRD	
			Sample Collec	cted for Potability	Submitted to ESRD
Additional Comn	ments on Well		,	´ <u></u>	
Yield Test				Taken From Top of Ca	
Test Date	Start Time	Static Water Level		Depth to water	
2009/08/14	10:00 AM	3.79 m	Drawdov	wn (m) Elapsed Ti	ime Recovery (m)

Held Test			Takeni	rioni rop or Casing	Measurement in Meti
Test Date	Start Time	Static Water Level		Depth to water level	
2009/08/14	10:00 AM	3.79 m	Drawdown (m)	Elapsed Time Minutes:Sec	Recovery (m)
			3.79	0:00	32.23
Method of Water F	Removal		4.31	1:00	31.91
	Type Pump		5.03	2:00	31.87
Removal			5.80	3:00	31.80
			6.48	4:00	31.70
Depth Withdrawn F	-rom 33.22 m		7.16	5:00	31.59
			7.84	6:00	31.53
If water removal per	riod was < 2 hours, explain why		8.53	7:00	31.43
			9.17	8:00	31.34
			9.82	9:00	31.25
			10.43	10:00	31.18
			11.69	12:00	31.01
			12.92	14:00	30.80
			14.15	16:00	30.64
			16.61	20:00	30.35
			19.64	25:00	29.93
			22.29	30:00	29.54
			24.98	35:00	29.16
			27.41	40:00	28.76
			30.90	50:00	28.03
			31.40	60:00	27.36
			31.87	75:00	26.89
			32.00	90:00	26.21
			32.21	105:00	25.03
			32.23	120:00	24.07

Water Diverted for Drilling				
Water Source DUG OUT	Amount Taken 9092.18	L	Diversion Date & Time 2009/08/12 12:00 AM	

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

ROBERT GROVE

Company Name CHRIS'S WATERWELL SERVICING LTD. Certification No

26857A

Yes

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Date approval holder signed 2009/08/14

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GIC Well ID

2029708

GoA Well Tag No. Drilling Company Well ID

2012/04/23

Measurement in Metric

**GOWN ID** 

Date Report Received Well Identification and Location Measurement in Metric Address Postal Code Town Owner Name Province Country MICIAK, RONALD P.O. BOX 102 **BAWLF ALBERTA CANADA** T0B 0J0 1/4 or LSD SEC TWP W of MER Block Additional Description RGE Plan Location Lot 1 36 45 18 4 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of Elevation Latitude 52.917340 Longitude -112.472690 708.05 m m from How Location Obtained How Elevation Obtained m from Hand held autonomous GPS 20-30m Hand held autonomous GPS 20-30m

**Drilling Information** Method of Drilling Type of Work New Well Combination Proposed Well Use Domestic

Yield Test Summary

Formation Log		Measurement in Metric
Depth from ground level (m)	Water Bearing	Lithology Description
4.88		Brown Till
19.81		Gray Till
26.52		Gray Shale
27.13		Coal
30.78		Gray Shale
31.70		Soft Coal
46.02		Brown Shale
55.78		Gray Shale & Sandstone Ledges
56.39	Yes	Gray Coarse Grained Sandstone
56.69	Yes	Hard Sandstone
59.74	Yes	Gray Coarse Grained Sandstone
60.66	Yes	Green Sandstone
61.26		Hard Ledges
63.40		Gray Shale
79.25		Gray Shale

Recommended	Pump Rai	te 45.4	6 L/min					
Test Date	Water F	Removal Rate (L	_/min)	St	atic W	ater Level (m	1)	
2012/01/06		45.46			8.66			
Well Completion	on				Meas	urement in	Metric	
Total Depth Drill	led Finisi	hed Well Depth	Start L	Date		End Date		
79.25 m	60.96	3 m	2012/0	01/02		2012/01/05		
Borehole								
Diameter (			(m)			To (m)		
20.00 13.02		0.0	)U 96	-		60.96 79.25		
Surface Casing			Well Ca	sina/l i	nor	73.23		
ourrace oasing	(п аррпс		Plastic	sirig/ El	iici			
Size OE	) :	cm		Size Ol	D :	12.70 cm	_	
Wall Thickness	3:	cm	Wall TI	nicknes	s:	0.800 cm	<u>.</u>	
Bottom a	t :	m		Тор а	at:	-0.61 m		
			В	ottom a	at:	60.96 m		
Perforations							_	
		Diameter or Slot Width	Slot Le		11-	le or Slot		
From (m)	o (m)	(cm)	Siot Le			terval(cm)		
		0.051	(0	,		5.08		
Perforated by	Machir	ne						
•								
Annular Seal Placed from		00 m to	50 29	m				
_		10.00 Bags	50.25					
Other Seals		10.00 Dago	-					
	Type				At (m	1)		
	71-					,		
Screen Type								
	) :	cm						
From (n		To (	m)		Sle	ot Size (cm)		
110111 (11	.,	10 (	,		JI.	oc oize (citi)		
Attachmen	nt						_	
Top Fitting	S		Botton	n Fitting	IS			
Pack								
Type Artificia	ıl		Grain	Size 10	)-20			
Amount		Bags						

Contractor	Certification

Name of Journeyman responsible for drilling/construction of well

LEONARD ODEGARD

Company Name LOSNESS DRILLING (2005) Certification No

42243A

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Date approval holder signed

2012/01/10 Yes

Printed on 9/23/2015 2:27:55 PM Page: 1 / 2



The driller supplies the data contained in this report. The Province disclaims responsibility for its

**View in Imperial Export to Excel** 

GIC Well ID 2029708 GoA Well Tag No.

Drilling Company Well ID

**GOWN ID** 

accuracy. The information on this report will be retained in a public database

Date Report Received 2012/04/23 Well Identification and Location Measurement in Metric Address Postal Code Owner Name Town Province Country MICIAK, RONALD P.O. BOX 102 **BAWLF ALBERTA** CANADA T0B 0J0 1/4 or LSD SEC TWP W of MER Additional Description RGE Block Plan Location Lot 1 36 45 18 4 GPS Coordinates in Decimal Degrees (NAD 83) Measured from Boundary of 708.05 m Latitude 52.917340 Longitude -112.472690 Elevation m from

III IIOIII		How Location O	How Location Obtained		How Elevation Obtained		
		omous GPS 20-30m	Hand held auton	omous GPS 20-30m			
Additional Informa	ation				Measurement in Metric		
Distance From Top	of Casing to Ground Level	60.96 cm					
Is Artesian Flow			Is Flow Control Installed				
Rate	L/min		Describe				
Recommended Pur	mp Rate	45.46 L/min	Pump Installed Yes		0.23 m		
Recommended Pur	mp Intake Depth (From TOC)	40.23 m	Type Submersible	Make 3" 10SQE07-240	H.P. 0.75		
			·· <u> </u>		Rating)		
Did you Encounte	er Saline Water (>4000 ppm TDS)	Depth	m Well Disinfe	ected Upon Completion Yes			
				hysical Log Taken			
	_			ubmitted to ESRD			
			Sample Collected for Pa	ntability Sul	hmittad to ESPD		
Additional Comm	nents on Well		Sample Collected for 1 c	- Sui			
	DTARY AIR & MUD DRILLING, 201	200' ALSO HADDLE	OCES ANNIH AB SEAL : ALSO	CUITTINGS TOS 1000 IDC	NI 0 01 DDM HADDNESS		
	, WATER DIVERTED FOR DRILLIN		JOLO, ANNOLAN SLAL . ALSO	COTTINGS, 123 1900, INC	ON O.OT FFIN, HANDINESS		
Violat To at			Tale	- F T( O'	Management to Market		
Yield Test			Take	n From Top of Casing  Depth to water level	Measurement in Metric		
Test Date		Static Water Level	Durandana (m)	·	D ()		
2012/01/06	10:30 AM	8.66 m	Drawdown (m)	Elapsed Time Minutes:Sec	Recovery (m)		
			8.66	0:00	22.92		
Method of Water F	Removal		14.20	1:00	20.15		
	Type Pump			2:00	18.19		
Removal	Rate 45.46 L/min			3:00	16.59		
				4:00	15.32		
Deptn witnarawn F	From 39.62 m		19.76	5:00	14.37		
			20.08	6:00	13.61		
It water removal pe	riod was < 2 hours, explain why		20.33	7:00	13.02		
	PM @ 145, 90% RECOVERY @ 50	MINUTES, SOUNDER	20.56	8:00	12.62		
STUCK FROM 2 TO	O 4 MINUTES DURING PUMPING		20.79	9:00	12.32		

Removal Rate 45.46 L/min		3:00	16.59
		4:00	15.32
Withdrawn From 39.62 m	19.76	5:00	14.37
	20.08	6:00	13.61
removal period was < 2 hours, explain why	20.33	7:00	13.02
ST @ 15 GPM @ 145, 90% RECOVERY @ 50 MINUTES, SOUNDER	20.56	8:00	12.62
FROM 2 TO 4 MINUTES DURING PUMPING	20.79	9:00	12.32
	20.91	10:00	11.96
	21.20	12:00	11.57
	21.43	14:00	11.22
	21.47	16:00	11.00
	21.55	18:00	10.54
	21.67	20:00	10.71
	21.93	25:00	10.48
	22.10	30:00	10.30
	22.22	35:00	10.16
	22.33	40:00	10.00
	22.47	50:00	
	22.54	60:00	
	22.60	75:00	
	22.69	90:00	
	22.82	105:00	
	22.92	120:00	

Water Diverted for Drilling

Water Source Amount Taken Diversion Date & Time LOSNESS SHOP 2012/01/02 8:00 AM 22730.46

Contractor Certification

Name of Journeyman responsible for drilling/construction of well

LEONARD ODEGARD

Company Name LOSNESS DRILLING (2005) Certification No

42243A

Yes

Copy of Well report provided to owner

Date approval holder signed 2012/01/10

Printed on 9/23/2015 2:27:55 PM Page: 2 / 2



### **APPENDIX F**

Exova Analytical Report

Exova 7217 Roper Road NW Edmonton, Alberta T6B 3J4, Canada

T: +1 (780) 438-5522 F: +1 (780) 434-8586 E: Edmonton@exova.com W: www.exova.com



Lot ID:

Control Number:

Date Received:

Date Reported:

Report Number:

1116288

Jan 14, 2016

Jan 20, 2016

2074893

C0078186

#### **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

ID: 19-6835-1 Bawlf Lagoon 4127 Roper Road Name: Edmonton, AB, Canada Location: Bawlf

T6B 3S5 LSD: Milan Butorac P.O.:

Attn: Sampled By: JLM Acct code:

Company: TEL

**Reference Number** 

1116288-1

Sample Date Sample Time January 14, 2016

NA

**Sample Location** Sample Description

TH15-1 / 4.1°C

Sample Matrix Water

**Nominal Detection** Guideline Guideline Limit Limit Comments Analyte Units Result **Aggregate Organic Constituents** 193 5 Chemical Oxygen Demand mg/L **Inorganic Nonmetallic Parameters** Kjeldahl Nitrogen Total 2.97 0.07 mg/L **Metals Dissolved** Silicon Dissolved 5.32 0.05 mg/L Sulfur Dissolved mg/L 975 0.3 0.000008 0.000005 0.001 Below MAC Dissolved Mercury mg/L Aluminum Dissolved 0.051 0.002 0.1 Below OG mg/L Below MAC Antimony Dissolved mg/L < 0.001 0.0002 0.006 Arsenic Dissolved mg/L 0.002 0.0002 0.01 Below MAC Barium 0.04 0.001 Below MAC Dissolved mg/L 1 Beryllium Dissolved < 0.0005 0.0001 mg/L **Bismuth** Dissolved mg/L < 0.002 0.0005 Below MAC Boron Dissolved mg/L 0.19 0.002 5 0.00010 Below MAC Cadmium Dissolved mg/L 0.00001 0.005 Chromium <0.002 0.0005 0.05 Below MAC Dissolved mg/L Cobalt Dissolved 0.004 0.0001 mg/L Below AO Copper Dissolved 0.006 0.001 mg/L 1 Lead Dissolved mg/L < 0.0005 0.0001 0.01 Below MAC Lithium Dissolved mg/L 0.49 0.001 Molybdenum Dissolved mg/L < 0.005 0.001 Nickel Dissolved 0.019 0.0005 mg/L 0.05 Below MAC Selenium Dissolved mg/L 0.001 0.0002 Silver Dissolved mg/L <0.00005 0.00001 Strontium Dissolved 3.99 0.001 mg/L Thallium Dissolved mg/L < 0.0003 0.00005 Tin Dissolved < 0.005 0.001 mg/L Titanium Dissolved < 0.002 0.0005 mg/L 0.0005 Uranium Dissolved mg/L 0.032 0.02 Above MAC Vanadium Dissolved < 0.0005 0.0001 mg/L 0.02 0.001 5 Below AO Zinc Dissolved mg/L Subsample Field Filtered Lab Filtered Microbiological Analysis 7000 0 **Total Coliforms** Membrane Filtration CFU/100 mL 1 Above MAC Fecal Coliforms MPN MPN/100 mL <1.8 1.8

Exova 7217 Roper Road NW Edmonton, Alberta T6B 3J4, Canada

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### **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

ID: Bawlf Lagoon Name:

Bawlf

Edmonton, AB, Canada T6B 3S5 LSD:

Attn: Milan Butorac P.O.: Sampled By: JLM Acct code:

Company: TEL

19-6835-1 Control Number: C0078186

> Date Received: Jan 14, 2016 Date Reported: Jan 20, 2016 Report Number: 2074893

Lot ID: 1116288

**Reference Number** 1116288-1

> Sample Date Sample Time

January 14, 2016

**Sample Location Sample Description** 

Location:

TH15-1 / 4.1°C

Sample Matrix Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water						
рН			7.78		6.5 - 8.5	Within AO
Temperature of observed pH	I	°C	18.8			
Electrical Conductivity	at 25 °C	uS/cm	5080	1		
Calcium	Dissolved	mg/L	446	0.2		
Magnesium	Dissolved	mg/L	137	0.2		
Sodium	Dissolved	mg/L	905	0.4	200	Above AO
Potassium	Dissolved	mg/L	16	0.4		
Iron	Dissolved	mg/L	< 0.05	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	1.04	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	23.2	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	< 0.025	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	< 0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	2920	0.9	500	Above AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	387	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	317	5		
Total Dissolved Solids	Calculated	mg/L	4640	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	1680			
Ionic Balance	Dissolved	%	108			

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#### **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

Edmonton, AB, Canada

ID: 19-6835-1
Name: Bawlf Lagoon
Location: Bawlf

T6B 3S5

Attn: Milan Butorac

LSD: P.O.:

Sampled By: JLM Company: TEL

Acct code:

Date Received: Jan 14, 2016 Date Reported: Jan 20, 2016

Control Number: C0078186

Lot ID: 1116288

Report Number: 2074893

Reference Number

**Sample Description** 

1116288-2

Sample Date Sample Time January 14, 2016

Time N

Sample Location

TH15-2 / 4.1°C

Sample Matrix

Water

		Outriple Matrix	Water			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Co	nstituents					
Chemical Oxygen Dem	and	mg/L	308	5		
Inorganic Nonmetallic	Parameters	-				
Kjeldahl Nitrogen	Total	mg/L	2.74	0.07		
Metals Dissolved						
Silicon	Dissolved	mg/L	11.1	0.05		
Sulfur	Dissolved	mg/L	539	0.3		
Mercury	Dissolved	mg/L	< 0.000005	0.000005	0.001	Below MAC
Aluminum	Dissolved	mg/L	0.009	0.002	0.1	Below OG
Antimony	Dissolved	mg/L	< 0.0004	0.0002	0.006	Below MAC
Arsenic	Dissolved	mg/L	0.0007	0.0002	0.01	Below MAC
Barium	Dissolved	mg/L	0.066	0.001	1	Below MAC
Beryllium	Dissolved	mg/L	< 0.0002	0.0001		
Bismuth	Dissolved	mg/L	< 0.001	0.0005		
Boron	Dissolved	mg/L	0.225	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	0.00020	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	< 0.001	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	0.0060	0.0001		
Copper	Dissolved	mg/L	0.002	0.001	1	Below AO
Lead	Dissolved	mg/L	0.0004	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.319	0.001		
Molybdenum	Dissolved	mg/L	< 0.002	0.001		
Nickel	Dissolved	mg/L	0.0318	0.0005		
Selenium	Dissolved	mg/L	0.0005	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	< 0.00002	0.00001		
Strontium	Dissolved	mg/L	2.90	0.001		
Thallium	Dissolved	mg/L	0.0001	0.00005		
Tin	Dissolved	mg/L	< 0.002	0.001		
Titanium	Dissolved	mg/L	<0.001	0.0005		
Uranium	Dissolved	mg/L	0.0208	0.0005	0.02	Above MAC
Vanadium	Dissolved	mg/L	0.0003	0.0001		
Zinc	Dissolved	mg/L	0.02	0.001	5	Below AO
Subsample	Field Filtered		Lab Filtered			
Microbiological Analys	sis					
Total Coliforms	Membrane Filtration	CFU/100 mL	300	1	0	Above MAC
Fecal Coliforms	MPN	MPN/100 mL	<1.8	1.8		

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## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

19-6835-1 ID: Name:

Bawlf

Edmonton, AB, Canada Location: T6B 3S5 LSD:

Attn: Milan Butorac P.O.: Sampled By: JLM Acct code:

Company: TEL

Control Number: C0078186 Bawlf Lagoon

Date Received: Jan 14, 2016 Date Reported: Jan 20, 2016 Report Number: 2074893

Lot ID: 1116288

**Reference Number** 

1116288-2

Sample Date Sample Time January 14, 2016

Sample Location **Sample Description** 

TH15-2 / 4.1°C

Sample Matrix

				Nominal Detection	Guideline	Guideline
Analyte		Units	Result	Limit	Limit	Comments
Routine Water						
pН			7.39		6.5 - 8.5	Within AO
Temperature of observed	[	°C	18.5			
рН						
Electrical Conductivity	at 25 °C	uS/cm	3630	1		
Calcium	Dissolved	mg/L	499	0.2		
Magnesium	Dissolved	mg/L	112	0.2		
Sodium	Dissolved	mg/L	412	0.4	200	Above AO
Potassium	Dissolved	mg/L	14	0.4		
Iron	Dissolved	mg/L	< 0.02	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	4.32	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	19.9	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	< 0.025	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	< 0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	1620	0.9	500	Above AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	1010	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	829	5		
Total Dissolved Solids	Calculated	mg/L	3170	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	1710			
Ionic Balance	Dissolved	%	103			

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## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

ID: 19-6835-1 Name: Bawlf Lagoon

Edmonton, AB, Canada Locat T6B 3S5 LSD:

Attn: Milan Butorac P.O.:
Sampled By: JLM Acct code:

Company: TEL

Name: Bawlf Lagoon Date Received: Jan 14, 2016
Location: Bawlf Date Reported: Jan 20, 2016

Date Reported: Jan 20, 2016 Report Number: 2074893

Control Number: C0078186

Lot ID: 1116288

Reference Number 1116288-3 Sample Date January 14, 2016

Sample Time
Sample Location

Sample Description TH15-3 / 4.1°C

Sample Matrix Water

		Sample Matrix	Water			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Con	nstituents					
Chemical Oxygen Dema	and	mg/L	96	5		
Inorganic Nonmetallic F	Parameters	-				
Kjeldahl Nitrogen	Total	mg/L	2.16	0.07		
Metals Dissolved						
Silicon	Dissolved	mg/L	15.0	0.05		
Sulfur	Dissolved	mg/L	856	0.3		
Mercury	Dissolved	mg/L	< 0.000005	0.000005	0.001	Below MAC
Aluminum	Dissolved	mg/L	<0.01	0.002	0.1	Below OG
Antimony	Dissolved	mg/L	< 0.001	0.0002	0.006	Below MAC
Arsenic	Dissolved	mg/L	< 0.001	0.0002	0.01	Below MAC
Barium	Dissolved	mg/L	0.02	0.001	1	Below MAC
Beryllium	Dissolved	mg/L	< 0.0005	0.0001		
Bismuth	Dissolved	mg/L	< 0.002	0.0005		
Boron	Dissolved	mg/L	0.15	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	0.00026	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	< 0.002	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	0.0070	0.0001		
Copper	Dissolved	mg/L	< 0.005	0.001	1	Below AO
Lead	Dissolved	mg/L	< 0.0005	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.48	0.001		
Molybdenum	Dissolved	mg/L	< 0.005	0.001		
Nickel	Dissolved	mg/L	0.036	0.0005		
Selenium	Dissolved	mg/L	< 0.001	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	< 0.00005	0.00001		
Strontium	Dissolved	mg/L	5.47	0.001		
Thallium	Dissolved	mg/L	<0.0003	0.00005		
Tin	Dissolved	mg/L	<0.005	0.001		
Titanium	Dissolved	mg/L	<0.002	0.0005		
Uranium	Dissolved	mg/L	0.103	0.0005	0.02	Above MAC
Vanadium	Dissolved	mg/L	< 0.0005	0.0001		
Zinc	Dissolved	mg/L	0.005	0.001	5	Below AO
Subsample	Field Filtered		Lab Filtered			
Microbiological Analysi	is					
Total Coliforms	Membrane Filtration	CFU/100 mL	1300	1	0	Above MAC
Fecal Coliforms	MPN	MPN/100 mL	<1.8	1.8		

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Lot ID: 1116288

C0078186

Jan 14, 2016

Jan 20, 2016

Control Number:

Date Received:

Date Reported:

Report Number: 2074893

## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

Edmonton, AB, Canada

ID: 19-6835-1 Name: Bawlf Lagoon Location: Bawlf

T6B 3S5 LSD:
Attn: Milan Butorac P.O.:

Sampled By: JLM Acct code:

Company: TEL

Reference Number

Sample Date Sample Time January 14, 2016

1116288-3

NA

Water

Sample Location Sample Description

TH15-3 / 4.1°C

Sample Matrix

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water						
рН			7.63		6.5 - 8.5	Within AO
Temperature of observed pH		°C	18.7			
Electrical Conductivity	at 25 °C	uS/cm	5380	1		
Calcium	Dissolved	mg/L	750	0.2		
Magnesium	Dissolved	mg/L	225	0.2		
Sodium	Dissolved	mg/L	654	0.4	200	Above AO
Potassium	Dissolved	mg/L	13	0.4		
Iron	Dissolved	mg/L	< 0.05	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	1.95	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	122	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	< 0.025	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	< 0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	2570	0.9	500	Above AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	1470	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	1200	5		
Total Dissolved Solids	Calculated	mg/L	5050	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	2800			
Ionic Balance	Dissolved	%	105			

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 7217 Roper Road NW
 F: +1 (780) 434-8586

 Edmonton, Alberta
 E: Edmonton@exova.com

 T6B 3J4, Canada
 W: www.exova.com



## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road Name: Bawlf Lagoon Edmonton, AB, Canada Location: Bawlf

Acct code:

T6B 3S5 LSD:
Attn: Milan Butorac P.O.:

Sampled By: JLM Company: TEL

Project: Lot ID: **1116288**ID: 19-6835-1 Control Number: C0078186

Date Received: Jan 14, 2016
Date Reported: Jan 20, 2016
Report Number: 2074893

Reference Number 1116288-4
Sample Date January 14, 2016
Sample Time NA

Sample Time
Sample Location

Sample Description TH15-4 / 4.1°C

Sample Matrix Water

		Sample Matrix	vvaler			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Co	onetituonte	Onits	Nesun			
Chemical Oxygen Den		mg/L	35	5		
Inorganic Nonmetallic		IIIg/∟	33	3		
Kjeldahl Nitrogen	Total	mg/L	1.56	0.07		
Metals Dissolved	Total	IIIg/∟	1.50	0.07		
Silicon	Dissolved	mg/L	10.4	0.05		
Sulfur	Dissolved	mg/L	456	0.3		
Mercury	Dissolved	mg/L	<0.000005	0.000005	0.001	Below MAC
Aluminum	Dissolved	mg/L	<0.004	0.002	0.1	Below OG
Antimony	Dissolved	mg/L	<0.004	0.0002	0.006	Below MAC
Arsenic	Dissolved	mg/L	0.002	0.0002	0.01	Below MAC
Barium	Dissolved	mg/L	0.050	0.001	1	Below MAC
Beryllium	Dissolved	mg/L	<0.0002	0.0001	,	Below Wirte
Bismuth	Dissolved	mg/L	<0.001	0.0005		
Boron	Dissolved	mg/L	0.339	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	<0.0002	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	<0.001	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	0.0069	0.0001	0.00	20.01.11.10
Copper	Dissolved	mg/L	<0.002	0.001	1	Below AO
Lead	Dissolved	mg/L	<0.0002	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.294	0.001		
Molybdenum	Dissolved	mg/L	<0.002	0.001		
Nickel	Dissolved	mg/L	0.0062	0.0005		
Selenium	Dissolved	mg/L	< 0.0004	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	< 0.00002	0.00001		
Strontium	Dissolved	mg/L	2.62	0.001		
Thallium	Dissolved	mg/L	< 0.0001	0.00005		
Tin	Dissolved	mg/L	< 0.002	0.001		
Titanium	Dissolved	mg/L	<0.001	0.0005		
Uranium	Dissolved	mg/L	0.0033	0.0005	0.02	Below MAC
Vanadium	Dissolved	mg/L	< 0.0002	0.0001		
Zinc	Dissolved	mg/L	0.007	0.001	5	Below AO
Subsample	Field Filtered	-	Lab Filtered			
Microbiological Analy	sis					
Total Coliforms	MPN	MPN/100 mL	79	1.8		
Fecal Coliforms	MPN	MPN/100 mL	<1.8	1.8		

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## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

ID: 19-6835-1 Name: Bawlf Lagoon

Edmonton, AB, Canada Location: T6B 3S5 LSD:

Attn: Milan Butorac P.O.:

Sampled By: JLM Company: TEL

Lot ID: **1116288**19-6835-1 Control Number: C0078186

Date Received: Jan 14, 2016
Date Reported: Jan 20, 2016
Report Number: 2074893

Reference Number 1116288-4

Sample Date January 14, 2016 Sample Time NA

Bawlf

Sample Location

Acct code:

Sample Description TH15-4 / 4.1°C

Sample Matrix Water

		Odinpic Matrix	vvalci			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water		Onits	Result			
pH			7.75		6.5 - 8.5	Within AO
Temperature of observed pH	I	°C	19.6			
Electrical Conductivity	at 25 °C	uS/cm	3230	1		
Calcium	Dissolved	mg/L	226	0.2		
Magnesium	Dissolved	mg/L	74.2	0.2		
Sodium	Dissolved	mg/L	543	0.4	200	Above AO
Potassium	Dissolved	mg/L	17	0.4		
Iron	Dissolved	mg/L	< 0.02	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	1.70	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	11.5	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	< 0.025	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	< 0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	1370	0.9	500	Above AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	696	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	571	5		
Total Dissolved Solids	Calculated	mg/L	2580	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	869			
Ionic Balance	Dissolved	%	103			

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## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

19-6835-1 ID: Bawlf Lagoon Name: Location: Bawlf

T6B 3S5

Edmonton, AB, Canada LSD: P.O.:

Attn: Milan Butorac Sampled By: JLM

Company: TEL

Date Received: Jan 14, 2016

Control Number: C0078186

Lot ID: 1116288

Date Reported: Jan 20, 2016 Report Number: 2074893

**Reference Number** 

Acct code:

1116288-5

Sample Date Sample Time January 14, 2016

Sample Location **Sample Description** 

TH15-5 / 4.1°C

Sample Matrix

		Sample Matrix	vvaler			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Co	netituente					
Chemical Oxygen Den		mg/L	59	5		
Inorganic Nonmetallic		mg/L	39	3		
Kjeldahl Nitrogen	Total	mg/L	3.89	0.07		
Metals Dissolved	Total	mg/L	0.00	0.01		
Silicon	Dissolved	mg/L	9.65	0.05		
Sulfur	Dissolved	mg/L	1600	0.3		
Mercury	Dissolved	mg/L	<0.000005	0.000005	0.001	Below MAC
Aluminum	Dissolved	mg/L	<0.01	0.002	0.1	Below OG
Antimony	Dissolved	mg/L	<0.001	0.0002	0.006	Below MAC
Arsenic	Dissolved	mg/L	0.0079	0.0002	0.01	Below MAC
Barium	Dissolved	mg/L	<0.005	0.001	1	Below MAC
Beryllium	Dissolved	mg/L	<0.0005	0.0001	•	20.011 1111 10
Bismuth	Dissolved	mg/L	<0.002	0.0005		
Boron	Dissolved	mg/L	0.524	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	<0.00005	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	<0.002	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	<0.0005	0.0001		
Copper	Dissolved	mg/L	<0.005	0.001	1	Below AO
Lead	Dissolved	mg/L	<0.0005	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.589	0.001		
Molybdenum	Dissolved	mg/L	<0.005	0.001		
Nickel	Dissolved	mg/L	0.003	0.0005		
Selenium	Dissolved	mg/L	<0.001	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	< 0.00005	0.00001		
Strontium	Dissolved	mg/L	6.82	0.001		
Thallium	Dissolved	mg/L	< 0.0003	0.00005		
Tin	Dissolved	mg/L	< 0.005	0.001		
Titanium	Dissolved	mg/L	< 0.002	0.0005		
Uranium	Dissolved	mg/L	0.003	0.0005	0.02	Below MAC
Vanadium	Dissolved	mg/L	< 0.0005	0.0001		
Zinc	Dissolved	mg/L	0.01	0.001	5	Below AO
Subsample	Field Filtered	-	Lab Filtered			
Microbiological Analy	sis					
Total Coliforms	MPN	MPN/100 mL	22	1.8		
Fecal Coliforms	MPN	MPN/100 mL	<1.8	1.8		

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Lot ID: 1116288

C0078186

Jan 14, 2016

Jan 20, 2016

Control Number:

Date Received:

Date Reported:

Report Number: 2074893

## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

ID: 19-6835-1 Name: Bawlf Lagoon

Bawlf

Edmonton, AB, Canada Location: T6B 3S5 LSD:

T6B 3S5 LSD:
Attn: Milan Butorac P.O.:

Sampled By: JLM Acct code:

Company: TEL

Reference Number

1116288-5

Sample Date Sample Time January 14, 2016

NA

Sample Location Sample Description

TH15-5 / 4.1°C

Sample Matrix

				Nominal Detection	Guideline	Guideline
Analyte		Units	Result	Limit	Limit	Comments
Routine Water						
рН			7.75		6.5 - 8.5	Within AO
Temperature of observed	I	°C	19.1			
pH		_,		_		
Electrical Conductivity	at 25 °C	uS/cm	8330	1		
Calcium	Dissolved	mg/L	440	0.2		
Magnesium	Dissolved	mg/L	136	0.2		
Sodium	Dissolved	mg/L	1940	0.4	200	Above AO
Potassium	Dissolved	mg/L	18	0.4		
Iron	Dissolved	mg/L	2.28	0.01	0.3	Above AO
Manganese	Dissolved	mg/L	0.26	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	9.0	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	< 0.025	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	< 0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	4790	0.9	500	Above AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	649	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	532	5		
Total Dissolved Solids	Calculated	mg/L	7660	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	1660			
Ionic Balance	Dissolved	%	107			

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Lot ID: 1116288

Jan 14, 2016

Control Number: C0078186

Report Number: 2074893

Date Reported: Jan 20, 2016

Date Received:

## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road Name: Edmonton, AB, Canada Location:

T6B 3S5 LSD:
Attn: Milan Butorac P.O.:

Sampled By: JLM Acct code:

Company: TEL

**Reference Number** 

ID:

1116288-6

Sample Date Sample Time January 14, 2016

NA

19-6835-1

Bawlf

Bawlf Lagoon

Sample Location Sample Description

SW15-2 / 4.1°C

Sample Matrix

		Sample Matrix	water			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Con	etituonte	Office	Nesuit			
		ma/l	656	5		
Chemical Oxygen Dema Inorganic Nonmetallic F		mg/L	636	5		
-	Total	∞ a/l	62.5	0.07		
Kjeldahl Nitrogen  Metals Dissolved	Total	mg/L	62.5	0.07		
Silicon	Dissolved	ma/l	8.31	0.05		
Sulfur	Dissolved	mg/L	53.0	0.03		
	Dissolved	mg/L mg/L	<0.000005	0.000005	0.001	Below MAC
Mercury	Dissolved	-	<0.000005 0.01	0.000	0.001	Below MAC
Aluminum	Dissolved	mg/L	<0.004	0.002	0.1	Below OG Below MAC
Antimony	Dissolved	mg/L			0.006	Below MAC
Arsenic		mg/L	0.0036 0.049	0.0002 0.001		
Barium	Dissolved	mg/L			1	Below MAC
Beryllium	Dissolved	mg/L	<0.0002	0.0001		
Bismuth	Dissolved	mg/L	<0.001	0.0005	_	Dalam MAG
Boron	Dissolved	mg/L	0.405	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	<0.00002	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	<0.001	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	0.0004	0.0001		5
Copper	Dissolved	mg/L	0.006	0.001	1	Below AO
Lead	Dissolved	mg/L	<0.0002	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.093	0.001		
Molybdenum	Dissolved	mg/L	<0.002	0.001		
Nickel	Dissolved	mg/L	0.0023	0.0005		
Selenium	Dissolved	mg/L	0.0005	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	<0.00002	0.00001		
Strontium	Dissolved	mg/L	0.561	0.001		
Thallium	Dissolved	mg/L	<0.0001	0.00005		
Tin	Dissolved	mg/L	<0.002	0.001		
Titanium	Dissolved	mg/L	<0.001	0.0005		
Uranium	Dissolved	mg/L	0.0054	0.0005	0.02	Below MAC
Vanadium	Dissolved	mg/L	0.0004	0.0001		
Zinc	Dissolved	mg/L	0.008	0.001	5	Below AO
Subsample	Field Filtered		Lab Filtered			
Microbiological Analysi	s					
Total Coliforms	Membrane Filtration	CFU/100 mL	1100000	1	0	Above MAC
Fecal Coliforms	Membrane Filtration	CFU/100 mL	200000	1		

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Lot ID: 1116288

Jan 14, 2016

Jan 20, 2016

Control Number: C0078186

Report Number: 2074893

Date Received:

Date Reported:

## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

19-6835-1 ID: Bawlf Lagoon Name: Edmonton, AB, Canada Location: Bawlf

T6B 3S5 LSD: P.O.:

Attn: Milan Butorac Sampled By: JLM Acct code:

Company: TEL

**Reference Number** 1116288-6

Sample Date January 14, 2016 Sample Time

Sample Location

**Sample Description** SW15-2 / 4.1°C

> Sample Matrix Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water						
рН			8.15		6.5 - 8.5	Within AO
Temperature of observed pH		°C	18.5			
Electrical Conductivity	at 25 °C	uS/cm	2190	1		
Calcium	Dissolved	mg/L	61.2	0.2		
Magnesium	Dissolved	mg/L	24.5	0.2		
Sodium	Dissolved	mg/L	411	0.4	200	Above AO
Potassium	Dissolved	mg/L	20.4	0.4		
Iron	Dissolved	mg/L	0.03	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	0.404	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	89.8	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	0.027	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	0.03	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	159	0.9	500	Below AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	1230	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	1010	5		
Total Dissolved Solids	Calculated	mg/L	1370	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	254			
Ionic Balance	Dissolved	%	91			

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## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Lot ID: 1116288 Report To: Thurber Engineering Ltd. 19-6835-1 ID: Control Number: C0078186

4127 Roper Road Bawlf Lagoon Name: Date Received: Jan 14, 2016 Edmonton, AB, Canada Location: Bawlf Date Reported: Jan 20, 2016 T6B 3S5 LSD: Report Number: 2074893

Attn: Milan Butorac P.O.: Sampled By: JLM Acct code:

Company: TEL

**Reference Number** 1116288-7 Sample Date January 14, 2016

Sample Time

Sample Location

**Sample Description** SW15-3 / 4.1°C

Sample Matrix Water

		Cample Matrix	· · · · · · · · · · · · · · · · · · ·			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Co	nstituents					
Chemical Oxygen Dem	and	mg/L	17100	5		
Inorganic Nonmetallic	Parameters	-				
Kjeldahl Nitrogen	Total	mg/L	320	0.07		
Metals Dissolved						
Silicon	Dissolved	mg/L	7.73	0.05		
Sulfur	Dissolved	mg/L	28.4	0.3		
Mercury	Dissolved	mg/L	< 0.000005	0.000005	0.001	Below MAC
Aluminum	Dissolved	mg/L	0.021	0.002	0.1	Below OG
Antimony	Dissolved	mg/L	< 0.0004	0.0002	0.006	Below MAC
Arsenic	Dissolved	mg/L	0.0024	0.0002	0.01	Below MAC
Barium	Dissolved	mg/L	0.059	0.001	1	Below MAC
Beryllium	Dissolved	mg/L	< 0.0002	0.0001		
Bismuth	Dissolved	mg/L	0.001	0.0005		
Boron	Dissolved	mg/L	0.331	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	0.00003	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	<0.001	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	0.0009	0.0001		
Copper	Dissolved	mg/L	0.003	0.001	1	Below AO
Lead	Dissolved	mg/L	< 0.0002	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.078	0.001		
Molybdenum	Dissolved	mg/L	< 0.002	0.001		
Nickel	Dissolved	mg/L	0.0031	0.0005		
Selenium	Dissolved	mg/L	0.0005	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	< 0.00002	0.00001		
Strontium	Dissolved	mg/L	0.500	0.001		
Thallium	Dissolved	mg/L	< 0.0001	0.00005		
Tin	Dissolved	mg/L	< 0.002	0.001		
Titanium	Dissolved	mg/L	<0.001	0.0005		
Uranium	Dissolved	mg/L	0.0048	0.0005	0.02	Below MAC
Vanadium	Dissolved	mg/L	< 0.0002	0.0001		
Zinc	Dissolved	mg/L	0.009	0.001	5	Below AO
Subsample	Field Filtered		Lab Filtered			
Microbiological Analys	sis					
Total Coliforms	Membrane Filtration	CFU/100 mL	1600000	1	0	Above MAC
Fecal Coliforms	Membrane Filtration	CFU/100 mL	1600000	1		

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## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

Edmonton, AB, Canada

19-6835-1 ID: Bawlf Lagoon Name:

Bawlf

Date Received: Jan 14, 2016

T6B 3S5

Location: LSD:

Date Reported: Jan 20, 2016 Report Number: 2074893

Control Number: C0078186

Lot ID: 1116288

Attn: Milan Butorac

P.O.:

Sampled By: JLM

Acct code:

Company: TEL

**Reference Number** 

1116288-7

Sample Date Sample Time January 14, 2016

Sample Location **Sample Description** 

SW15-3 / 4.1°C

Sample Matrix

		Sample Matrix	vvater			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water						
рН			7.89		6.5 - 8.5	Within AO
Temperature of observed	I	°C	21.3			
pH						
Electrical Conductivity	at 25 °C	uS/cm	2130	1		
Calcium	Dissolved	mg/L	65.0	0.2		
Magnesium	Dissolved	mg/L	20	0.2		
Sodium	Dissolved	mg/L	346	0.4	200	Above AO
Potassium	Dissolved	mg/L	19	0.4		
Iron	Dissolved	mg/L	80.0	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	0.428	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	60.6	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	0.073	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	85.0	0.9	500	Below AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	1170	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	957	5		
Total Dissolved Solids	Calculated	mg/L	1170	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	245			
Ionic Balance	Dissolved	%	90			

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Lot ID: 1116288

## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd. ID: 19-6835-1 Control Number: C0078186

4127 Roper RoadName:Bawlf LagoonDate Received:Jan 14, 2016Edmonton, AB, CanadaLocation:BawlfDate Reported:Jan 20, 2016T6B 3S5LSD:Report Number:2074893

Attn: Milan Butorac P.O.:
Sampled By: JLM Acct code:

Company: TEL

Reference Number 1116288-8

Sample Date January 14, 2016

Sample Time N

Sample Location

Sample Description SW15-6 / 4.1°C

Sample Matrix Water

		Sample Matrix	Water			
				Nominal Detection	Guideline	Guideline
Analyte		Units	Result	Limit	Limit	Comments
Aggregate Organic Con						
Chemical Oxygen Dema		mg/L	2710	5		
Inorganic Nonmetallic P	arameters					
Kjeldahl Nitrogen	Total	mg/L	30.4	0.07		
Metals Dissolved						
Silicon	Dissolved	mg/L	7.38	0.05		
Sulfur	Dissolved	mg/L	239	0.3		
Mercury	Dissolved	mg/L	0.000019	0.000005	0.001	Below MAC
Aluminum	Dissolved	mg/L	<0.01	0.002	0.1	Below OG
Antimony	Dissolved	mg/L	0.002	0.0002	0.006	Below MAC
Arsenic	Dissolved	mg/L	0.0756	0.0002	0.01	Above MAC
Barium	Dissolved	mg/L	0.12	0.001	1	Below MAC
Beryllium	Dissolved	mg/L	< 0.0005	0.0001		
Bismuth	Dissolved	mg/L	< 0.002	0.0005		
Boron	Dissolved	mg/L	1.01	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	< 0.00005	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	< 0.002	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	0.0008	0.0001		
Copper	Dissolved	mg/L	< 0.005	0.001	1	Below AO
Lead	Dissolved	mg/L	< 0.0005	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.30	0.001		
Molybdenum	Dissolved	mg/L	< 0.005	0.001		
Nickel	Dissolved	mg/L	0.013	0.0005		
Selenium	Dissolved	mg/L	<0.001	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	< 0.00005	0.00001		
Strontium	Dissolved	mg/L	1.01	0.001		
Thallium	Dissolved	mg/L	< 0.0003	0.00005		
Tin	Dissolved	mg/L	< 0.005	0.001		
Titanium	Dissolved	mg/L	0.003	0.0005		
Uranium	Dissolved	mg/L	0.0051	0.0005	0.02	Below MAC
Vanadium	Dissolved	mg/L	0.0069	0.0001		
Zinc	Dissolved	mg/L	0.006	0.001	5	Below AO
Subsample	Field Filtered	-	Lab Filtered			
Microbiological Analysis						
Total Coliforms	Membrane Filtration	CFU/100 mL	100	1	0	Above MAC
Fecal Coliforms	Membrane Filtration	CFU/100 mL	100	1		

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## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Lot ID: 1116288 Report To: Thurber Engineering Ltd. 19-6835-1 ID: Control Number:

C0078186 4127 Roper Road Bawlf Lagoon Name: Date Received: Jan 14, 2016 Edmonton, AB, Canada Location: Bawlf Date Reported: Jan 20, 2016 T6B 3S5 LSD: Report Number: 2074893

Attn: Milan Butorac P.O.: Sampled By: JLM Acct code:

Company: TEL

**Reference Number** 1116288-8

Sample Date January 14, 2016 Sample Time

Sample Location

**Sample Description** SW15-6 / 4.1°C

> Sample Matrix Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water						
рН			8.63		6.5 - 8.5	Above AO
Temperature of observed pH	i	°C	18.7			
Electrical Conductivity	at 25 °C	uS/cm	4670	1		
Calcium	Dissolved	mg/L	45	0.2		
Magnesium	Dissolved	mg/L	97.9	0.2		
Sodium	Dissolved	mg/L	1120	0.4	200	Above AO
Potassium	Dissolved	mg/L	47	0.4		
Iron	Dissolved	mg/L	0.05	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	0.27	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	265	0.4	250	Above AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	< 0.025	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	< 0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	718	0.9	500	Above AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	119	6		
Bicarbonate		mg/L	2210	5		
P-Alkalinity	as CaCO3	mg/L	99	5		
T-Alkalinity	as CaCO3	mg/L	2010	5		
Total Dissolved Solids	Calculated	mg/L	3500	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	520			
Ionic Balance	Dissolved	%	96			

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Lot ID: 1116288

Jan 14, 2016

Control Number: C0078186

Report Number: 2074893

Date Reported: Jan 20, 2016

Date Received:

## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

19-6835-1 ID: 4127 Roper Road Bawlf Lagoon Name: Edmonton, AB, Canada Location: Bawlf

T6B 3S5 LSD: Attn: Milan Butorac P.O.:

Sampled By: JLM Acct code:

Company: TEL

**Reference Number** 

1116288-9

Sample Date Sample Time January 14, 2016

Sample Location **Sample Description** 

Dup A / 4.1°C

Sample Matrix

		Sample Matrix	vvaler			
Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Aggregate Organic Con	actituanta	Onits	Nesun			
Chemical Oxygen Dema		ma/l	100	5		
Inorganic Nonmetallic F		mg/L	100	5		
-	Total	a/I	2.67	0.07		
Kjeldahl Nitrogen  Metals Dissolved	Total	mg/L	2.07	0.07		
Silicon	Dissolved	ma/l	14.8	0.05		
Sulfur	Dissolved	mg/L				
	Dissolved	mg/L	849 <0.000005	0.3 0.000005	0.004	Below MAC
Mercury		mg/L			0.001	
Aluminum	Dissolved	mg/L	<0.01	0.002	0.1	Below OG
Antimony	Dissolved	mg/L	<0.001	0.0002	0.006	Below MAC
Arsenic	Dissolved	mg/L	<0.001	0.0002	0.01	Below MAC
Barium	Dissolved	mg/L	0.02	0.001	1	Below MAC
Beryllium	Dissolved	mg/L	<0.0005	0.0001		
Bismuth	Dissolved	mg/L	<0.002	0.0005	_	
Boron	Dissolved	mg/L	0.16	0.002	5	Below MAC
Cadmium	Dissolved	mg/L	0.00023	0.00001	0.005	Below MAC
Chromium	Dissolved	mg/L	<0.002	0.0005	0.05	Below MAC
Cobalt	Dissolved	mg/L	0.0069	0.0001		
Copper	Dissolved	mg/L	<0.005	0.001	1	Below AO
Lead	Dissolved	mg/L	<0.0005	0.0001	0.01	Below MAC
Lithium	Dissolved	mg/L	0.47	0.001		
Molybdenum	Dissolved	mg/L	<0.005	0.001		
Nickel	Dissolved	mg/L	0.037	0.0005		
Selenium	Dissolved	mg/L	<0.001	0.0002	0.05	Below MAC
Silver	Dissolved	mg/L	<0.00005	0.00001		
Strontium	Dissolved	mg/L	5.57	0.001		
Thallium	Dissolved	mg/L	< 0.0003	0.00005		
Tin	Dissolved	mg/L	<0.005	0.001		
Titanium	Dissolved	mg/L	<0.002	0.0005		
Uranium	Dissolved	mg/L	0.0974	0.0005	0.02	Above MAC
Vanadium	Dissolved	mg/L	< 0.0005	0.0001		
Zinc	Dissolved	mg/L	0.006	0.001	5	Below AO
Subsample	Field Filtered		Lab Filtered			
Microbiological Analysi	is					
Total Coliforms	Membrane Filtration	CFU/100 mL	900	1	0	Above MAC
Fecal Coliforms	MPN	MPN/100 mL	<1.8	1.8		

Lot ID: 1116288

C0078186

Jan 14, 2016

Jan 20, 2016

Control Number:

Date Received:

Date Reported:

Report Number: 2074893

## **Analytical Report**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

4127 Roper Road

ID: 19-6835-1 Bawlf Lagoon Name:

Edmonton, AB, Canada Location: LSD: T6B 3S5

Attn: Milan Butorac P.O.: Sampled By: JLM Acct code:

Company: TEL

**Reference Number** 1116288-9 Sample Date January 14, 2016 Sample Time

Bawlf

Sample Location

**Sample Description** Dup A / 4.1°C Sample Matrix Water

Analyte		Units	Result	Nominal Detection Limit	Guideline Limit	Guideline Comments
Routine Water						
рН			7.45		6.5 - 8.5	Within AO
Temperature of observed pH	I	°C	18.6			
Electrical Conductivity	at 25 °C	uS/cm	5280	1		
Calcium	Dissolved	mg/L	739	0.2		
Magnesium	Dissolved	mg/L	222	0.2		
Sodium	Dissolved	mg/L	648	0.4	200	Above AO
Potassium	Dissolved	mg/L	13	0.4		
Iron	Dissolved	mg/L	< 0.05	0.01	0.3	Below AO
Manganese	Dissolved	mg/L	1.92	0.005	0.05	Above AO
Chloride	Dissolved	mg/L	121	0.4	250	Below AO
Nitrate - N		mg/L	< 0.05	0.01	10	Below MAC
Nitrite - N		mg/L	< 0.025	0.005	1	Below MAC
Nitrate and Nitrite - N		mg/L	< 0.07	0.01	10	Below MAC
Sulfate (SO4)	Dissolved	mg/L	2550	0.9	500	Above AO
Hydroxide		mg/L	<5	5		
Carbonate		mg/L	<6	6		
Bicarbonate		mg/L	1470	5		
P-Alkalinity	as CaCO3	mg/L	<5	5		
T-Alkalinity	as CaCO3	mg/L	1210	5		
Total Dissolved Solids	Calculated	mg/L	5010	1	500	Above AO
Hardness	Dissolved as CaCO3	mg/L	2760			
Ionic Balance	Dissolved	%	104			

Approved by:

Anthony Neumann, MSc

Anthony Weuman

7217 Roper Road NW Edmonton, Alberta T6B 3J4, Canada

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## **Quality Control**

Bill To: Thurber Engineering Ltd.

Report To: Thurber Engineering Ltd.

4127 Roper Road Edmonton, AB, Canada

T6B 3S5

Attn: Milan Butorac

Sampled By: .II М

ID:

Location:

LSD:

P.O.:

Jan 14, 2016 Jan 20, 2016

Control Number:

ampled By:	JLM	Acct code:
Company:	TEL	

• • • • • • • • • • • • • • • • • • •	

**Aggregate Organic Constituents** 

Chemical Oxygen Demand mg/L Date Acquired: January 15, 2016

**Client Sample Replicates** Units

Chemical Oxygen Demand mg/L Date Acquired: January 15, 2016

**Control Sample** Units Chemical Oxygen Demand mg/L Date Acquired: January 15, 2016

Chemical Oxygen Demand mg/L Date Acquired: January 15, 2016

Chemical Oxygen Demand mg/L

January 15, 2016 Date Acquired:

# **Inorganic Nonmetallic Parameters**

Dialiks	Onito
Nitrogen	mg/L
Date Acquired:	January 15, 2016

Date Acquired: January 15, 2016

**Client Sample Replicates** Units Nitrogen mg/L

January 15, 2016 Date Acquired: **Control Sample** Units

Nitrogen mg/L Date Acquired: January 15, 2016

Nitrogen mg/L Date Acquired: January 15, 2016

Date Acquired:

Project:

19-6835-1 **Bawlf Lagoon** Name:

Bawlf

Date Received: Date Reported: Report Number:

2074893

Lot ID: 1116288

C0078186

#### **Blanks** Units

Measured	Lower Limit	Upper Limit	
-1.88	-7	8	

Unite

mg/L

Replicate 1

2140

293

74

19

Measured

Replicate 2

**Lower Limit** 

286

Passed QC

yes

% RSD Criteria **Absolute Criteria** Passed QC 2170 10

yes

**Upper Limit** Passed QC 316 yes

67 85 yes

16 25 yes

Measured 0

**Lower Limit** -0.04

**Upper Limit** 

0.08

Passed QC

yes

Replicate 1 Replicate 2 % RSD Criteria **Absolute Criteria** Passed QC 3.78 3.79 10 0.06 yes

**Lower Limit Upper Limit Passed QC** Measured

116 103.74 137.28 yes 13.27 16.93 14.3

yes 0.89 1.25 1.07 yes

January 15, 2016

# Metals Dissolved

Nitrogen

Rlanke

Metals Dissolved					
Blanks	Units	Measured	Lower Limit	Upper Limit	Passed QC
Silicon	mg/L	-0.0176	-0.04	0.05	yes
Sulfur	mg/L	-0.024	-0.3	0.2	yes
Mercury	ug/L	0.0021	-0.038000	0.064000	yes
Aluminum	ug/L	0.244988	-2	2	yes
Antimony	ug/L	0.00974946	-0.2	0.2	yes
Arsenic	ug/L	0.00130268	-0.2	0.2	yes
Barium	ug/L	-0.0529903	-1	1	yes
Beryllium	ug/L	0.00341401	-0.0	0.1	yes
Bismuth	ug/L	0.00134404	-1.5	1.5	yes
Boron	ug/L	0.563677	-2	2	yes

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## **Quality Control**

Bill To: Thurber Engineering Ltd.

Report To: Thurber Engineering Ltd.

4127 Roper Road Edmonton, AB, Canada

T6B 3S5

Attn: Milan Butorac

Sampled By: JLM Company: TEL

Project:

19-6835-1 ID:

Name: Bawlf Lagoon Bawlf

Location:

LSD:

Acct code:

P.O.:

Lot ID: 1116288

Control Number: C0078186 Date Received: Jan 14, 2016 Jan 20, 2016 Date Reported:

Report Number: 2074893

Metals Dissolved	d - Continued					
Blanks	Units	Measured	Lower Limit	Upper Limit		Passed QC
Cadmium	ug/L	0.000925456	-0.01	0.01		yes
Chromium	ug/L	-0.000381963	-0.3	0.3		yes
Cobalt	ug/L	-5.5275e-005	-0.1	0.1		yes
Copper	ug/L	0.0185757	-1	1		yes
Lead	ug/L	0.00605492	-0.1	0.1		yes
Lithium	ug/L	0.0340441	-1	1		yes
Molybdenum	ug/L	0.0121069	-1	1		yes
Nickel	ug/L	0.0192031	-0.5	0.5		yes
Selenium	ug/L	-0.0223813	-0.2	0.2		yes
Silver	ug/L	0.000824007	-0.10	0.10		yes
Strontium	ug/L	0.0305279	-1	1		yes
Thallium	ug/L	9.17899e-005	-0.05	0.05		yes
Tin	ug/L	-0.00370881	-1	1		yes
Titanium	ug/L	0.0261145	-0.5	0.5		yes
Uranium	ug/L	0.000690339	-0.5	0.5		yes
Vanadium	ug/L	-0.00221815	-0.1	0.1		yes
Zinc	ug/L	0.189486	-0	2		yes
Date Acquired:	January 15, 2016					
Client Sample Rep	licates Units	Replicate 1	Replicate 2	% RSD Criteria	Absolute Criteria	Passed QC
Mercury	mg/L	< 0.000005	< 0.000005	10	0.000300	yes
Aluminum	ug/L	<4	<4	10	11	yes
Antimony	ug/L	<0.4	<0.4	10	0.4	yes
Arsenic	ug/L	0.7	0.6	10	0.4	yes
Barium	ug/L	24	24	10	2	yes
Boron	ug/L	341	338	10	4	yes
Cadmium	ug/L	0.33	0.33	10	0.02	yes
Chromium	ug/L	<1	<1	10	1.1	yes
Copper	ug/L	4	4	10	2	yes
Lead	ug/L	<0.2	<0.2	10	0.2	yes
Nickel	ug/L	45.7	45.7	10	1.1	yes
Selenium	ug/L	0.6	0.5	10	0.4	yes
Silver	ug/L	0.02	<0.02	10	0.22	yes
Uranium	ug/L	63.9	64.8	10	1.1	yes
Zinc	ug/L	10	10	10	2	yes
Date Acquired:	January 15, 2016					
Control Sample	Units	Measured	<b>Lower Limit</b>	<b>Upper Limit</b>		Passed QC
Mercury	mg/L	0.000757	0.000600	0.000960		yes
Date Acquired:	January 15, 2016					
Mercury	mg/L	0.00288	0.002610	0.003210		yes
Aluminum	ug/L	1020	938	1092		yes
Antimony	ug/L	37.8	35.2	43.0		yes

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## **Quality Control**

Bill To: Thurber Engineering Ltd.

Report To: Thurber Engineering Ltd.

4127 Roper Road Edmonton, AB, Canada

T6B 3S5

Attn: Milan Butorac Sampled By: JLM

Company: TEL

Project:

19-6835-1 ID:

Name: Bawlf Lagoon Location:

LSD:

Acct code:

P.O.:

Bawlf

Date Received:

Date Reported: Jan 20, 2016

Lot ID: 1116288

Jan 14, 2016

Report Number: 2074893

Control Number: C0078186

<b>Metals Dissolve</b>	d - Continued				
<b>Control Sample</b>	Units	Measured	Lower Limit	Upper Limit	Passed QC
Arsenic	ug/L	39.0	36.7	43.3	yes
Barium	ug/L	207	191	214	yes
Beryllium	ug/L	19.5	17.3	22.1	yes
Bismuth	ug/L	105	98.5	113.5	yes
Boron	ug/L	390	344	434	yes
Cadmium	ug/L	2.05	1.86	2.26	yes
Chromium	ug/L	99.4	92.2	110.2	yes
Cobalt	ug/L	19.3	18.0	21.2	yes
Copper	ug/L	196	184	208	yes
Lead	ug/L	20.4	18.4	22.0	yes
Lithium	ug/L	200	175	223	yes
Molybdenum	ug/L	200	187	226	yes
Nickel	ug/L	98.6	93.3	105.5	yes
Selenium	ug/L	39.6	35.8	43.0	yes
Silver	ug/L	20.2	18.40	22.00	yes
Strontium	ug/L	198	180	216	yes
Thallium	ug/L	10.1	9.40	11.20	yes
Tin	ug/L	206	180	220	yes
Titanium	ug/L	101	88.9	108.7	yes
Uranium	ug/L	99.1	92.7	107.5	yes
Vanadium	ug/L	19.9	18.0	22.0	yes
Zinc	ug/L	199	183	219	yes
Date Acquired:	January 15, 2016				
Mercury	mg/L	0.000784	0.000715	0.000865	yes
Date Acquired:	January 15, 2016				
Mercury	mg/L	0.000080	0.000065	0.000089	yes
Aluminum	ug/L	53	45	55	yes
Antimony	ug/L	2.0	1.8	2.3	yes
Arsenic	ug/L	2.0	1.8	2.2	yes
Barium	ug/L	10	9	11	yes
Beryllium	ug/L	1	0.9	1.1	yes
Bismuth	ug/L	4.3	4.1	5.5	yes
Boron	ug/L	20	18	22	yes
Cadmium	ug/L	0.10	0.09	0.11	yes
Chromium	ug/L	4.9	4.5	5.5	yes
Cobalt	ug/L	1	0.9	1.1	yes
Copper	ug/L	10	9	11	yes
Lead	ug/L	1.0	0.9	1.1	yes
Lithium	ug/L	10	9	11	yes
Molybdenum	ug/L	10	9	10	yes
Nickel	ug/L	4.9	4.4	5.5	yes
Selenium	ug/L	2.0	1.7	2.2	yes

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## **Quality Control**

Bill To: Thurber Engineering Ltd.

Report To: Thurber Engineering Ltd.

4127 Roper Road Edmonton, AB, Canada

T6B 3S5

Attn: Milan Butorac

Sampled By: JLM

Company: TEL

Project:

P.O.:

19-6835-1 ID:

Bawlf Lagoon Name:

Location:

LSD:

Acct code:

Bawlf

Date Received: Date Reported: Jan 20, 2016

Jan 14, 2016

Lot ID: 1116288

Report Number: 2074893

Control Number: C0078186

Metals Dissolved - Continued							
Control Sample	Units	Measured	Lower Limit	Upper Limit	Passed QC		
Silver	ug/L	1.06	0.84	1.08	yes		
Strontium	ug/L	10	9	11	yes		
Thallium	ug/L	0.51	0.47	0.56	yes		
Tin	ug/L	10	9	11	yes		
Titanium	ug/L	5.0	4.5	5.5	yes		
Uranium	ug/L	5.2	4.5	5.5	yes		
Vanadium	ug/L	1	0.9	1.1	yes		
Zinc	ug/L	10	9	11	yes		
Date Acquired:	January 15, 2016						
Silicon	mg/L	9.77	8.98	10.78	yes		
Sulfur	mg/L	143	138.5	155.3	yes		
Date Acquired:	January 15, 2016						
Silicon	mg/L	2.02	1.80	2.20	yes		
Sulfur	mg/L	9.5	9.2	11.0	yes		
Date Acquired:	January 15, 2016						
Silicon	mg/L	0.19	0.18	0.22	yes		
Sulfur	mg/L	3.1	2.7	3.2	yes		
Date Acquired:	January 15, 2016						

# **Routine Water**

Blanks	Units	Measured	Lower Limit	Upper Limit	Passed QC
Calcium	mg/L	-0.0543	-0.2	0.2	yes
Magnesium	mg/L	0.0463	-0.1	0.1	yes
Sodium	mg/L	0.0503	-0.4	0.4	yes
Potassium	mg/L	-0.0023	-0.4	0.4	yes
Iron	mg/L	-0.0057	-0.01	0.01	yes
Manganese	mg/L	-0.0006	-0.004	0.004	yes
Chloride	mg/L	0.19	-0.4	0.4	yes
Nitrate - N	mg/L	0	-0.01	0.01	yes
Nitrite - N	mg/L	0.00106322	-0.005	0.005	yes
Date Acquired:	January 15, 2016				

Client Sample Replicates	Units	Replicate 1	Replicate 2	% RSD Criteria	Absolute Criteria	Passed QC
рН		8.63	8.63	10	0.10	yes
Electrical Conductivity	dS/m	4.67	4.65	10	0.002	yes
Calcium	mg/L	13	12	10	0.6	yes
Magnesium	mg/L	3	3	10	0.7	yes
Sodium	mg/L	1590	1550	10	1.2	yes
Potassium	mg/L	5.2	5	10	1.2	yes
Iron	mg/L	0.11	0.08	10	0.05	yes
Chloride	mg/L	1150	1130	10	0.5	yes
Nitrate - N	mg/L	0.15	0.15	10	0.01	yes

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Lot ID: 1116288

C0078186

Jan 14, 2016

Jan 20, 2016

2074893

Control Number:

2.2

yes

1.8

## **Quality Control**

Bill To: Thurber Engineering Ltd.

Report To: Thurber Engineering Ltd.

> 4127 Roper Road Edmonton, AB, Canada

T6B 3S5

Attn: Milan Butorac JLM Sampled By:

Company: TEL Project:

ID: 19-6835-1

Name: **Bawlf Lagoon** Location:

LSD: P.O.:

Acct code:

Bawlf

Date Received: Date Reported: Report Number:

**Routine Water - Continued** % RSD Criteria **Client Sample Replicates** Units Replicate 1 Replicate 2 **Absolute Criteria Passed QC** Nitrite - N mg/L 0.061 0.061 10 0.010 yes Hydroxide mg/L <5 <5 10 yes 119 119 10 6 Carbonate mg/L yes Bicarbonate mg/L 2210 2220 10 6 yes 5 P-Alkalinity mg/L 99 99 10 yes T-Alkalinity mg/L 2010 2020 10 5 yes Date Acquired: January 15, 2016 Units Passed QC **Control Sample** Measured **Lower Limit Upper Limit** 1856.0 2126.0 Chloride mg/L 2060 yes Date Acquired: January 15, 2016 9.13 9.05 9.25 yes **Electrical Conductivity** dS/m 2.67 2.600 2.858 yes 228.0 Calcium mg/L 244 258.0 yes Magnesium mg/L 95.2 92.3 102.0 yes Sodium mg/L 245 233.3 257.3 yes Potassium mg/L 246 233.0 263.0 yes Iron mg/L 9.47 8.91 10.20 yes Manganese mg/L 2.36 2.240 2.540 yes Nitrate - N 9.58 10.58 mg/L 10.0 yes Nitrite - N mg/L 10.0 9.460 10.600 yes Nitrate and Nitrite - N 19.27 20.1 20.97 mg/L yes P-Alkalinity mg/L 434 423 549 ves 1010 956 T-Alkalinity mg/L 1056 yes Date Acquired: January 15, 2016 6.78 6.86 6.96 yes **Electrical Conductivity** dS/m 0.080 0.070 0.083 yes Calcium mg/L 51.5 44.9 56.9 yes Magnesium 22.0 mg/L 19.8 18.0 yes Sodium mg/L 51.4 47.7 55.5 yes 45.0 55.0 Potassium mg/L 51.9 yes 1.89 2.25 Iron mg/L 1.92 yes Manganese mg/L 0.493 0.488 0.572 yes Chloride mg/L 82.4 74.9 86.9 ves Nitrate - N 5.24 mg/L 4.87 4.48 yes Nitrite - N mg/L 5.02 4.488 5.292 yes 10.42 Nitrate and Nitrite - N mg/L 9.89 9.06 yes P-Alkalinity 27 22 67 mg/L yes T-Alkalinity mg/L 128 113 137 yes Date Acquired: January 15, 2016 Calcium 5.2 5.7 yes mg/L 4.6

2.0

mg/L

Magnesium

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## **Quality Control**

Bill To: Thurber Engineering Ltd.

Report To: Thurber Engineering Ltd.

4127 Roper Road Edmonton, AB, Canada

T6B 3S5

Attn: Milan Butorac

Sampled By: JLM Company: TEL

Project:

P.O.:

Acct code:

ID: 19-6835-1

Name:

Location: LSD:

Bawlf

Bawlf Lagoon

Date Received: Date Reported: Jan 20, 2016

Jan 14, 2016

Lot ID: 1116288

Report Number: 2074893

Control Number: C0078186

Control Sample	Units	Measured	Lower Limit	Upper Limit	Passed QC
Sodium	mg/L	5.2	4.7	5.7	yes
Potassium	mg/L	5.2	4.5	5.5	yes
Iron	mg/L	0.23	0.19	0.24	yes
Manganese	mg/L	0.052	0.046	0.056	yes
Chloride	mg/L	13.7	13.3	16.5	yes
Nitrate - N	mg/L	0.51	0.44	0.58	yes
Nitrite - N	mg/L	0.501	0.453	0.567	yes
Nitrate and Nitrite - N	mg/L	1.01	0.93	1.11	yes

# Page 25 of 26 **EXOVA**

Report Number: 2074893

## **Methodology and Notes**

Bill To: Thurber Engineering Ltd. Project: Lot ID: 1116288

Report To: Thurber Engineering Ltd. ID: 19-6835-1 Control Number: C0078186
4127 Roper Road Name: Bawlf Lagoon Date Received: Jan 14, 2016
Edmonton, AB, Canada Location: Bawlf Date Reported: Jan 20, 2016

T6B 3S5 LSD:
Attn: Milan Butorac P.O.:

Sampled By: JLM Acct code:

Company: TEL

Method of Analysis		
Method Name	Reference	Method Date Analysis Location Started
Alkalinity, pH, and EC in water	APHA	* Alkalinity - Titration Method, 2320 B 15-Jan-16 Exova Edmonton
Alkalinity, pH, and EC in water	APHA	* Conductivity, 2510 B 15-Jan-16 Exova Edmonton
Alkalinity, pH, and EC in water	APHA	* pH - Electrometric Method, 4500-H+ B 15-Jan-16 Exova Edmonton
Anions (Routine) by Ion Chromatography	APHA	* Ion Chromatography with Chemical 15-Jan-16 Exova Edmonton Suppression of Eluent Cond., 4110 B
pproval-Edmonton	APHA	Checking Correctness of Analyses, 1030 15-Jan-16 Exova Edmonton E
Chemical Oxygen Demand in water	APHA	<ul> <li>* Closed Reflux, Colorimetric Method, 5220 15-Jan-16 Exova Edmonton</li> <li>D</li> </ul>
chloride in Water	APHA	* Automated Ferricyanide Method, 4500-Cl- 15-Jan-16 Exova Edmonton E
coliforms - Membrane Filtration	APHA	Fecal Coliform Membrane Filter 15-Jan-16 Exova Calgary Procedure, 9222 D
coliforms - Membrane Filtration	APHA	Standard Total Coliform Membrane Filter 15-Jan-16 Exova Calgary Procedure, 9222 B
coliforms- MPN (Enviro)	APHA	Fecal Coliform Procedure, 9221 E 16-Jan-16 Exova Calgary
oliforms- MPN (Enviro)	APHA	Standard Total Coliform Fermentation 16-Jan-16 Exova Calgary Technique, 9221 B
fercury (Dissolved) in water	APHA	* Cold Vapour Atomic Absorption 15-Jan-16 Exova Edmonton Spectrometric Method, 3112 B
letals ICP-MS (Dissolved) in water	APHA/USEPA	* Metals By Inductively Coupled 15-Jan-16 Exova Edmonton Plasma/Mass Spectrometry, APHA 3125 B / USEPA 200.2, 200.8
letals Trace (Dissolved) in water	APHA	Hardness by Calculation, 2340 B 15-Jan-16 Exova Edmonton
letals Trace (Dissolved) in water	APHA	<ul> <li>* Inductively Coupled Plasma (ICP)</li> <li>Method, 3120 B</li> </ul>
otal and Kjeldahl Nitrogen (Total) in Vater	ISO	* Water Quality - Determination of nitrogen, 15-Jan-16 Exova Edmonton ISO/TR 11905-2
		+ Defending Adults of Mary 155 of

<sup>\*</sup> Reference Method Modified

## References

APHA Standard Methods for the Examination of Water and Wastewater

ISO International Organization for Standardization
US EPA US Environmental Protection Agency Test Methods

### Guidelines

Guideline Description Health Canada GCDWQ

Guideline Source Guidelines for Canadian Drinking Water Quality, Health Canada, October 2014

Guideline Comments MAC = Maximum Acceptable Concentration

AO = Aesthetic Objective

OG = Operational Guideline for Water Treatment Plants

Refer to Health Canada GCDWQ for complete guidelines and additional drinking water information at www.hc-sc.gc.ca

T: +1 (780) 438-5522 7217 Roper Road NW F: +1 (780) 434-8586 Edmonton, Alberta E: Edmonton@exova.com T6B 3J4, Canada W: www.exova.com



## **Methodology and Notes**

Bill To: Thurber Engineering Ltd. Project:

Report To: Thurber Engineering Ltd.

ID: 19-6835-1 4127 Roper Road Name: **Bawlf Lagoon** Edmonton, AB, Canada Location: Bawlf

Acct code:

T6B 3S5 LSD:

Attn: Milan Butorac P.O.:

Sampled By: JLM Company: TEL

Lot ID: 1116288

Control Number: C0078186 Date Received: Jan 14, 2016 Date Reported: Jan 20, 2016 Report Number: 2074893

#### Comments:

· Analysis for Total coliforms and Fecal coliforms was performed by both a membrane filtration method and a multi tube fermentation method as the samples contained sediment that affected volume of sample able to be filtered.

> The comparison of test results to guideline limits is provided for information purposes only. This is not to be taken as a statement of conformance / nonconformance to any guideline, regulation or limit. The data user is responsible for all conclusions drawn with respect to the data and is advised to consult official regulatory references when evaluating compliance.

Please direct any inquiries regarding this report to our Client Services group. Results relate only to samples as submitted.

The test report shall not be reproduced except in full, without the written approval of the laboratory.

Exovo	Testing, calibrating, advising	Invoice to:	Thurber Fran	neerina	Report T			SO	M	9	T.	7		= 1	I		eport esults		Regulatory Requirement
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Project ID:	19-6835-1	Attention:	Milan Buto	YOC	Attention:		12									-	nline		SPIGEC
Project Name:	BAWLF LAGOON	Phone:	780-438-14t	00	Phone:		G		-	0						Fa	IX.		BCCSR
Project Location	BANIF	Cell:	587-331-1	318	Cell:					5						PD	)F	V	Other (list below)
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Date Requi	red:	Signa	ture:			Š	ZES	70	又	0	. 1	1				Da	ate/Tin	ne st	amp:
	uctions/Comments (please include conta		ing ph. # if different from above			Ser (	TY.	10	百,	$\sum_{i}$	工	TOWN TOWN				1	Twee v		
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2	TH15-2		1	1	1	1	X	X	X	X	X	X						V	ere not packaged well
3	TH15-3						X	X	K	X	X	X						2	Indicate any samples not
4	TH15-4						X	X	X	X	X	X				I		re	ceived in Exova supplies
5	THIS-5		1	. 1			X	X	X	X	X	X						3	Indicate any samples that
6	SN15-2		+,				*	X	X	X	X	X						W	ere not clearly labeled
7	SN15-3						X	X	X.	X	X	X							Indicate any samples not
8	SN15-6		,				X	×	*	K	X	×							eceived within the required old time or temp.
9	DUPA			1	V	V	X	X	X	X	X	X						5	Indicate any missing or
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