Solutions today | Tomorrow IN mind

Maritime Centre, 1505 Barrington Street, Suite 901, Box 606, Halifax, NS, B3J 2R7 | 902-421-7241 | CBCL.ca | info@CBCL.ca

December 2, 2024

Alexander de Sousa, P.Eng.
Director of Engineering & Public Works
Town of Wolfville
359 Main Street
Wolfville, NS B4P 1A1

Dear Mr. de Sousa:

RE: ***Town of Wolfville Test Well Drilling and Step Testing Results Summary***

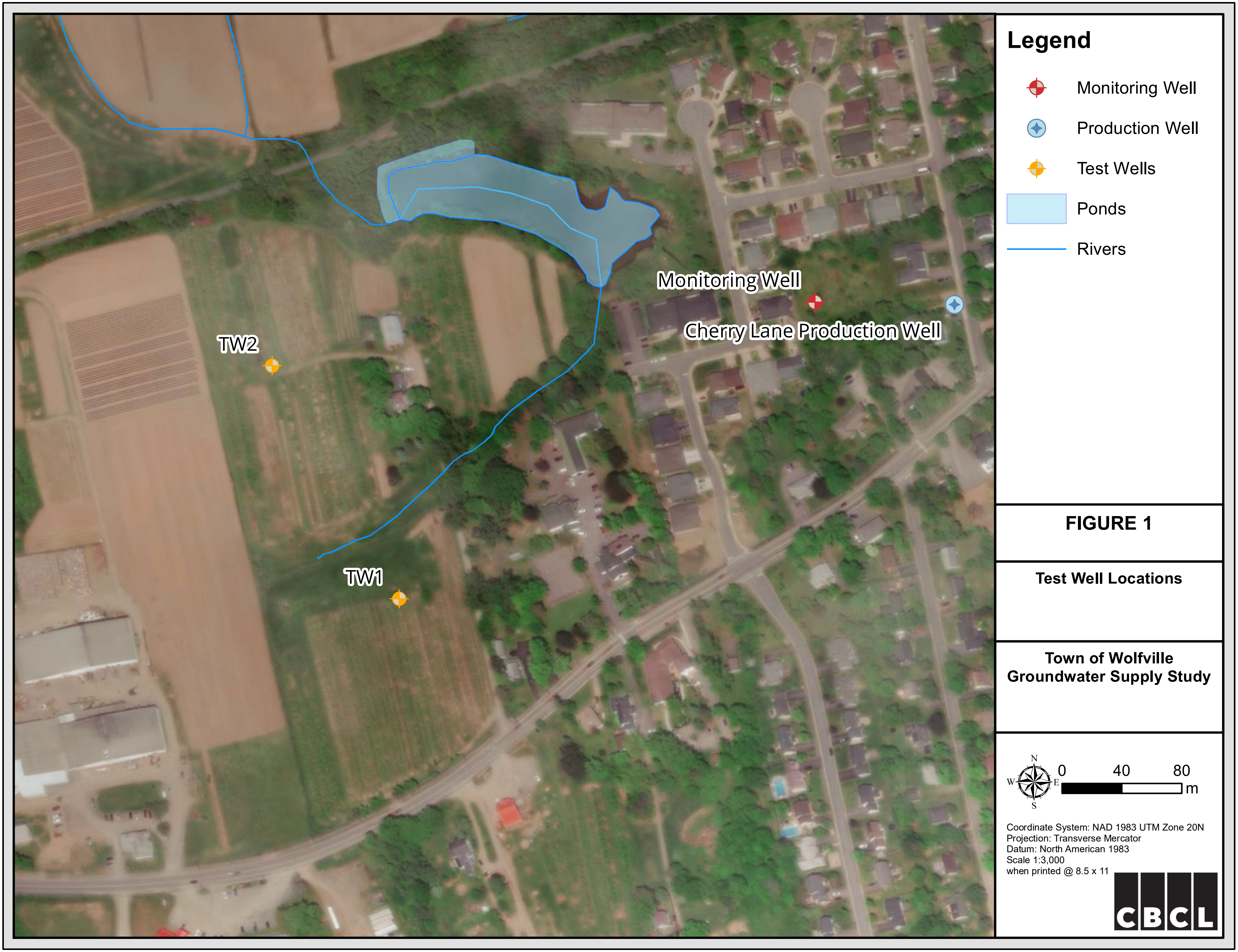
Physical Setting & Well Site Selection

A program of test well drilling and a step drawdown pumping test were completed on PID 55289524, adjacent to the western town boundary and north of Highway 1 (Figure 1). The property is occupied primarily by a fruit orchard and includes a house and barn on the eastern edge of the property. There is a ridge on the property oriented from west to east, following the approximate axis of the Annapolis Valley, and a stream that originates at the foot of the ridge, draining eastward. The northern edge of the property borders the flood plain / dikeland of the tidal Cornwallis River.

Conceptual mapping shown in the NSDNR online Groundwater Atlas shows the aquifer that services the Town's two existing production wells, oriented from west to east along the valley axis. Current conceptual models show the aquifer as a glacial outwash channel of sand and gravel, occupying a U-shaped buried glacial valley. New well site selection sought to target the thickest part of this deposit, with a separation distance from the existing production wells that should allow for simultaneous pumping of all three wells if needed.

The locations of the test wells are shown in Figure 1. TW1 was drilled in an area of low-relief, 30 m south of a small stream that drains the property. The property owner reported that standing water can be present in this general area during and immediately after snowmelt events. The low relief at the ground surface may be associated with the deepest part of the buried outwash valley aquifer that supplies Wolfville's current production wells.

TW2 was drilled on a local ridge, 175 m north of TW1. Following the axis of the Annapolis Valley and the NSDNR mapping of the outwash aquifer, this location is aligned with the existing Cherry Lane production well. Prior to drilling it was unknown if the ridge represented an additional thickness of sand and gravel, a confining unit of till, or ridge of the Wolfville Formation.


Monitoring Well
Cherry Lane Production Well
TW2
TW1
Legend
Monitoring Well
Production Well
Test Wells
Ponds
Rivers
FIGURE 1
Test Well Locations
Town of Wolfville
Groundwater Supply Study
N
W
E
S
0
40
80
m
Coordinate System: NAD 1983 UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983
Scale 1:3,000
when printed @ 8.5 x 11
CBCL

Test Well Drilling

CBCL provided onsite observation for the drilling of two new 6” test wells (TW1 and TW2). The wells were installed by Brewster Well Drilling during the week of June 1 – 5.

Test well drilling was completed as follows:

- A dual rotary drill rig was used to simultaneously advance the 6” well casing and the drill bit, until refusal was encountered at each location.
- Material cuttings were collected every 1.5 m and logged for the approximate grain size distribution, focusing on sequences that exhibited coarse-grained sand and gravel.
- A down-hole perforator was used to slot the well casing at depths where the content of well-sorted sand and gravel was observed to be highest.
- Each well was developed by surging with air and flushing for 2 hours following perforation. The turbidity of the water was evaluated visually at regular intervals to assess the progress of development.
- Cuttings samples from the intervals showing the highest content of sand and gravel were submitted to CBCL’s soil lab in Bedford for sieve analysis.
- The results of the sieve analysis were used to determine an appropriate slot size for a screened production well.

Well information is summarized in Table 1, and borehole logs are provided in Appendix A.

Table 1: Well Information

ID	Easting / Northing	NSE Well No.	Year Completed	Driller	Diameter (mm)	Casing Length (m)	Perforated Intervals (m)	Depth (m)
TW1	391293 / 4993574	Pending	2024	Brewster	152.4	45.7	30.5 - 33.5 36.6 - 39.6 42.7 - 44.2	45.7
TW2	391206 / 4993724	Pending	2024	Brewster	152.4	44.2	29.0 - 30.5 32.0 - 35.1 38.1 - 41.1	44.2

Cuttings sampled from TW1 showed significant sequences of well-sorted sand and gravel with minimal fine sand and silt content, primarily at depths below 30 m. The gravel sequences were overlain by layers of silty sand with clay and silty sand with gravel. The silty material may provide a degree of confinement of the target zone of the aquifer. Cuttings samples from TW2 contained red silt and fine sand throughout the borehole profile, and generally included clasts of sandy silt. The well-sorted coarse-grained sequences encountered in TW2 were associated with silty, red water in the cuttings, and were difficult to distinguish from the poorly consolidated sequences of the Wolfville Formation observed in previous work by CBCL.

Borehole refusal was encountered at 44 m, assumed to be associated with a harder bedrock unit. Airlifted water produced by TW2 after 2 hours of development did not show a reduction in turbidity. Drilling at TW2 also included a first attempt that was aborted at 12 m due to refusal of the drill bit. Minimal cuttings were produced at this depth, but chips of granitoid material indicated that the borehole had encountered a large glacial erratic.

Figure 2 shows a cross-section of the geologic sequence, interpolated between TW1 and TW2. The thickness of the deeper gravel unit appeared to increase from north to south, and the bedrock surface dipped slightly southward. A comparison of the cuttings and development water at both boreholes showed that conditions at TW1 are most favourable for well development.

Six samples collected from the following depths during drilling of TW1 were submitted to the laboratory for sieve analysis. The results of this analysis are attached in Appendix C.

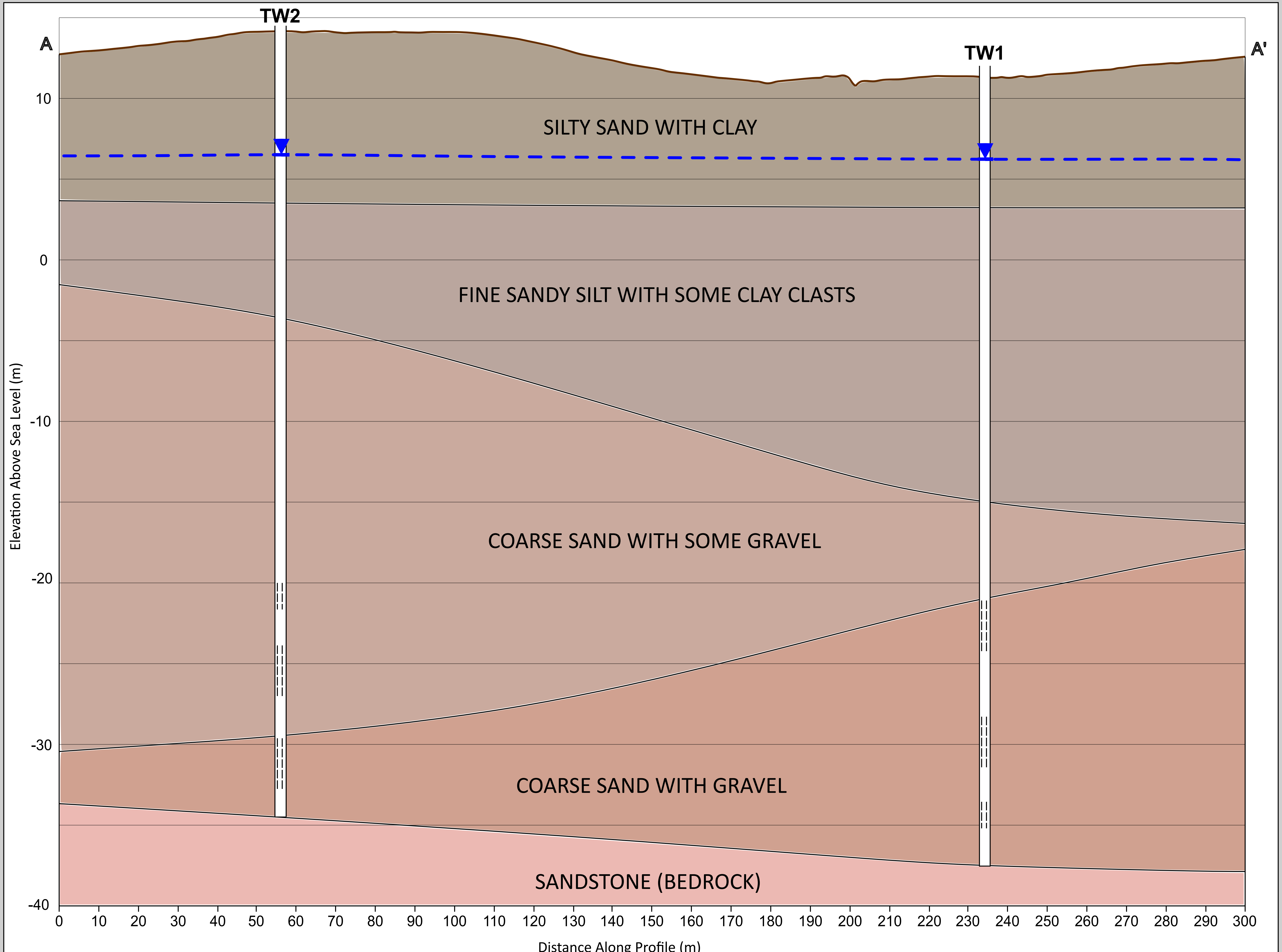
- 25.9 m – 27.4 m.
- 30.5 m.
- 33.5 m – 35.1 m.
- 35.1 m – 36.6 m.
- 41.1 m – 42.7 m.
- 42.7 m – 44.2 m.

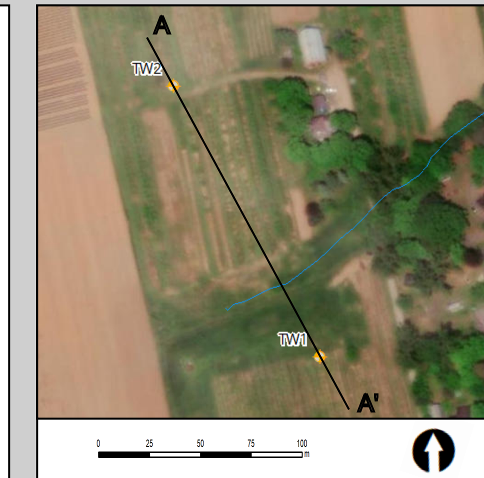
Sieve analysis is the primary method for determining the grain size distribution, by weight, of cuttings from drilling, providing a method to determine an appropriate well screen slot size and depth. All six samples confirmed observations from the field, containing majority fractions of sand or gravel, depending on depth. Little to no (< 3%) of silt and clay were identified in the samples. Samples retrieved at 30.5 m, and between 35.1 m – 36.6 m, showed the greatest presence of coarse sand and gravel, while the sample taken between 25.9 m – 27.4 m showed a higher presence of medium – fine sand. In general, coarser material presents the opportunity to design a screen with wider slot openings, resulting in a well with fewer well losses and better overall production and performance.

Step-Drawdown Test

A 4-hour step-drawdown test of TW1 was completed by Aquaterra Resources on June 13. Table 2 provides a summary of testing.

- An automated sensor was installed in the well to collect detailed water level and temperature data throughout the test and recovery period (Figure 3).
- The contractor measured water levels manually and maintained a record of the volume pumped using an inline totalizing flow meter.
- Pumped water was discharged directly to a drainage ditch to the north of TW1.





Legend

- Ground Surface
- Potentiometric Surface (static)
- Water Level (static)

Town of Wolfville Well Development

Figure 2 - Test Well Cross Section

Date: July 11, 2024
CBCL Project Number: 230830.00

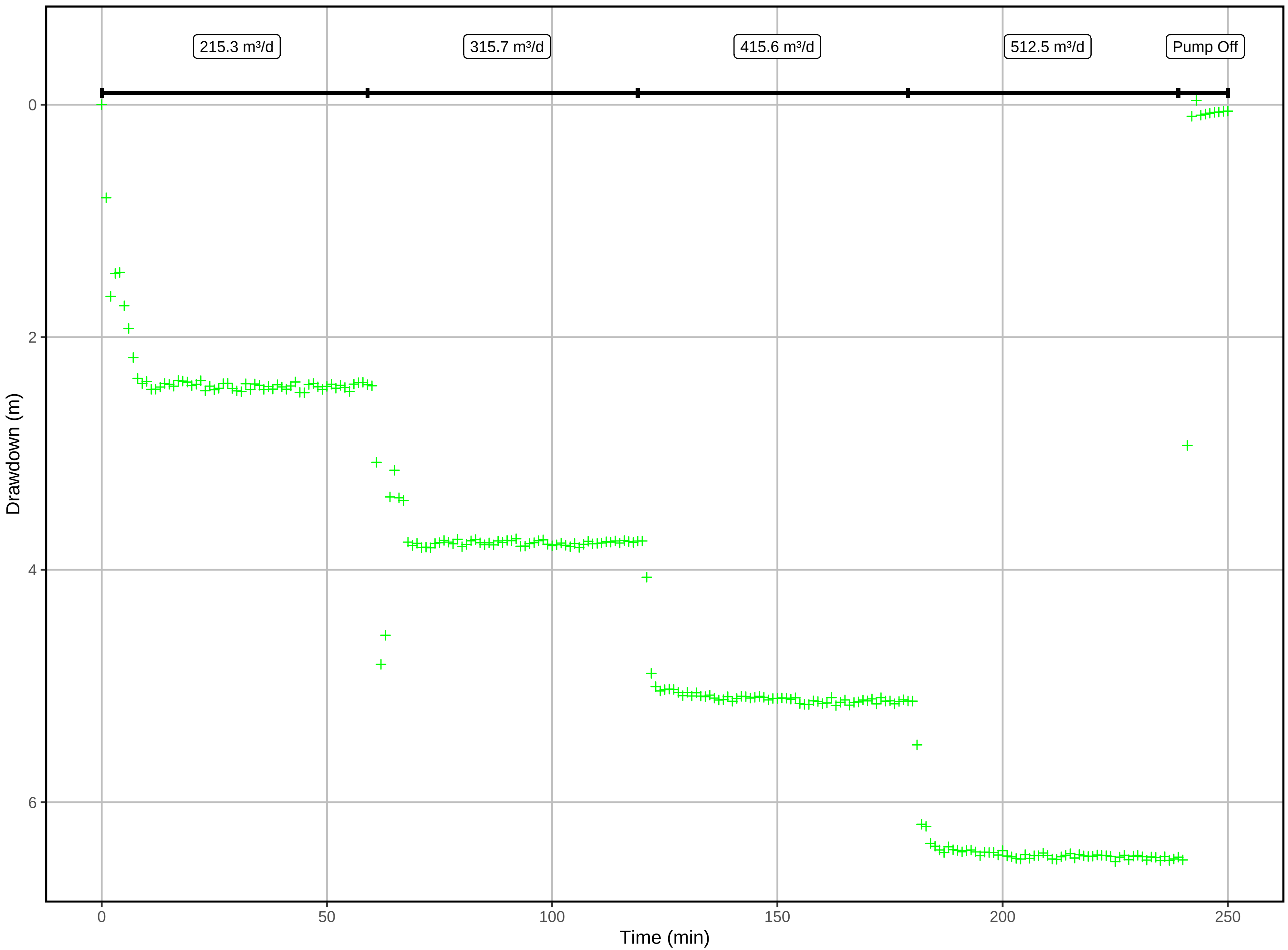


Figure 3: Aquifer Test Analysis, Step−Drawdown Test, Data Observed at Test Well 1, Wolfville

- The pumping rate was increased after each hour to provide preliminary indications of the well specific capacity and efficiency (Figure 4).
- The specific capacity is an indication of the yield provided per meter of drawdown.
- The well efficiency is an indication of how much drawdown is caused by losses within the well. Head losses within the well do not lead to drawdown in the surrounding aquifer, but they do affect the maximum sustainable pumping rate.
- Physical water quality parameters were recorded throughout the test (Table C2).
- A water quality sample was collected at the end of the step test, and analyzed for general chemistry and trace metals, including volatile organic compounds (VOCs) and microbiological quality (*E. coli* and total coliforms) (Table C1).

Table 2: Aquifer Testing Summary

Well ID	Test	Test Date	Pump Depth (m)	Pumping Rate (m^3/d)			
				Step 1	Step 2	Step 3	Step 4
TW1	Step-Drawdown	13-Jun-24	28.3	215	316	416	513

Test Well Performance

Table 3 provides a summary of step testing results. A component of the observed drawdown was related to losses within the well (< 20%). Well losses can be caused by turbulence near the borehole wall, friction in the pump and pump tubing, and a low-permeability 'skin-zone' at the borehole wall, caused by the drilling process. Well losses in this test well are likely affected by the limited intake area created by the down-hole perforator, and the limited amount of well development that can be accomplished with this type of installation. Well losses are expected to be substantially lower in the final production well with the use of a wire-wrapped well screen and sufficient development.

Table 3: Step Test Results

Well ID	Max. Drawdown (m)	Specific Capacity (m^2/d)	Well Efficiency			
			Step 1	Step 2	Step 3	Step 4
TW1	6.5	73	0.91	0.87	0.84	0.81

Preliminary indications of aquifer performance at TW1 were good. Qualitative analysis of the drawdown and recovery data (Figure 3) indicated the following:

- Drawdown during each step was rapid, stabilizing within 10 minutes of the new rate being established.
- Each increase in pumping rate caused an additional 1- 2.5 m of drawdown in the well. The magnitude of the increase in drawdown with each step decreased as the pumping rates increased (Figure 3).

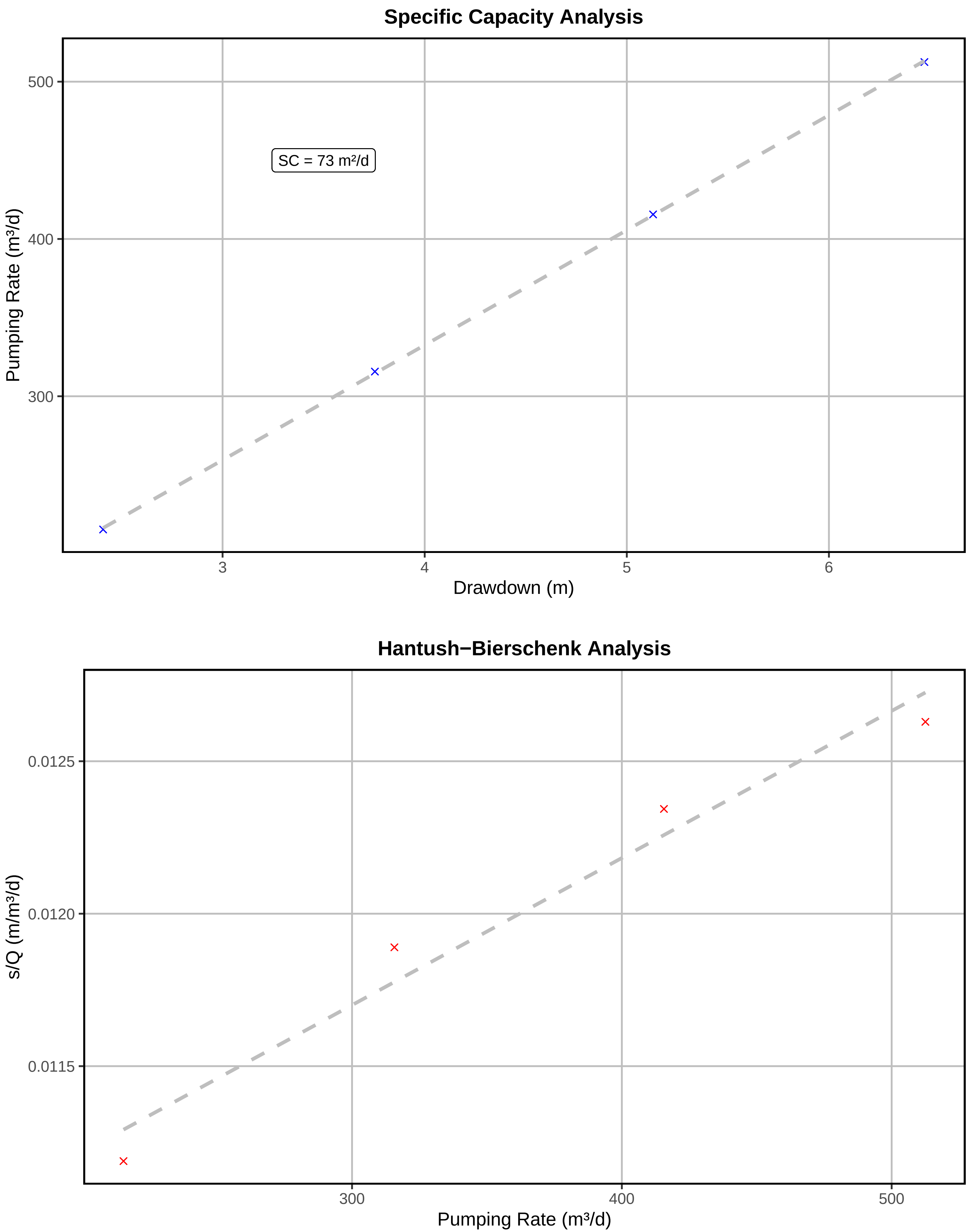


Figure 4: Aquifer Test Analysis, Step-Drawdown Analysis, Data Observed at Test Well 1, Wolfville

- Total drawdown at the end of the final step was 6.5 m. A production well of similar design to TW1 should have up to 25 m of available drawdown.
- Recovery following the pump shutting off was rapid, with >95% recovery within 2 minutes.
- This type of recovery indicates that a majority of drawdown observed was related to well losses and, and that the transmissivity of the aquifer is high.
- A residual analysis of the recovery data indicated a high aquifer transmissivity (generally associated with high well yields).
- Testing indicates that a higher pumping rate will be possible with a larger-diameter pump and well.

Water Quality

Water quality data are provided in Appendix C. Tables C1 and C2 provide a summary of drinking water parameters. The quality of water was good:

- Concentrations of trace metals were low.
- VOCs were not detected.
- *E. coli* and coliform bacteria were not detected.

As TW1 was drilled in the same aquifer as the Cherry Lane and Wickwire production wells, water quality data from all sources is provided in Table C1 for comparison purposes. The Cherry Lane and Wickwire data are from raw samples collected in 2021. Water quality between all three locations is similar, but minor differences were noted:

- The pH at TW1 was 5.74, which is more than 1 order of magnitude lower than the value measured at Cherry Lane in 2021 (6.82). pH adjustment will likely be required for water pumped from this location, as is currently the case with water from the Cherry Lane production well.
- The turbidity was slightly elevated at TW1 (3.43), associated with the slotted well casing and limited development. Turbidity is not expected to be an issue for a properly developed stainless steel well screen.
- The iron concentration in the filtered sample was slightly higher at TW1 compared to the Cherry Lane and Wickwire production wells (130 ug/L vs. 72 and 74 mg/L).

Summary

The results of the test well program indicate that TW1 is in a favourable location for development of a new production well. Cutting samples showed material of adequate grain size and sorting to support a high capacity municipal well and were consistent with logs from the system's existing production wells. Observed pumping rates and the calculated aquifer transmissivity indicate that the yield of a well in this location will be adequate to twin an existing well on an alternating basis. Pending the results of more comprehensive testing, a production well in this location should also be able to pump simultaneously with the existing wells, to provide additional water to the system when needed. Water quality results from TW1 were favorable and aligned closely with results from the Cherry Lane and Wickwire wells, indicating that there should be no compatibility issues in adding this source to the existing system. The low pH encountered during the step test indicates that chemical adjustment will be required, as is the case for the Cherry Lane source.

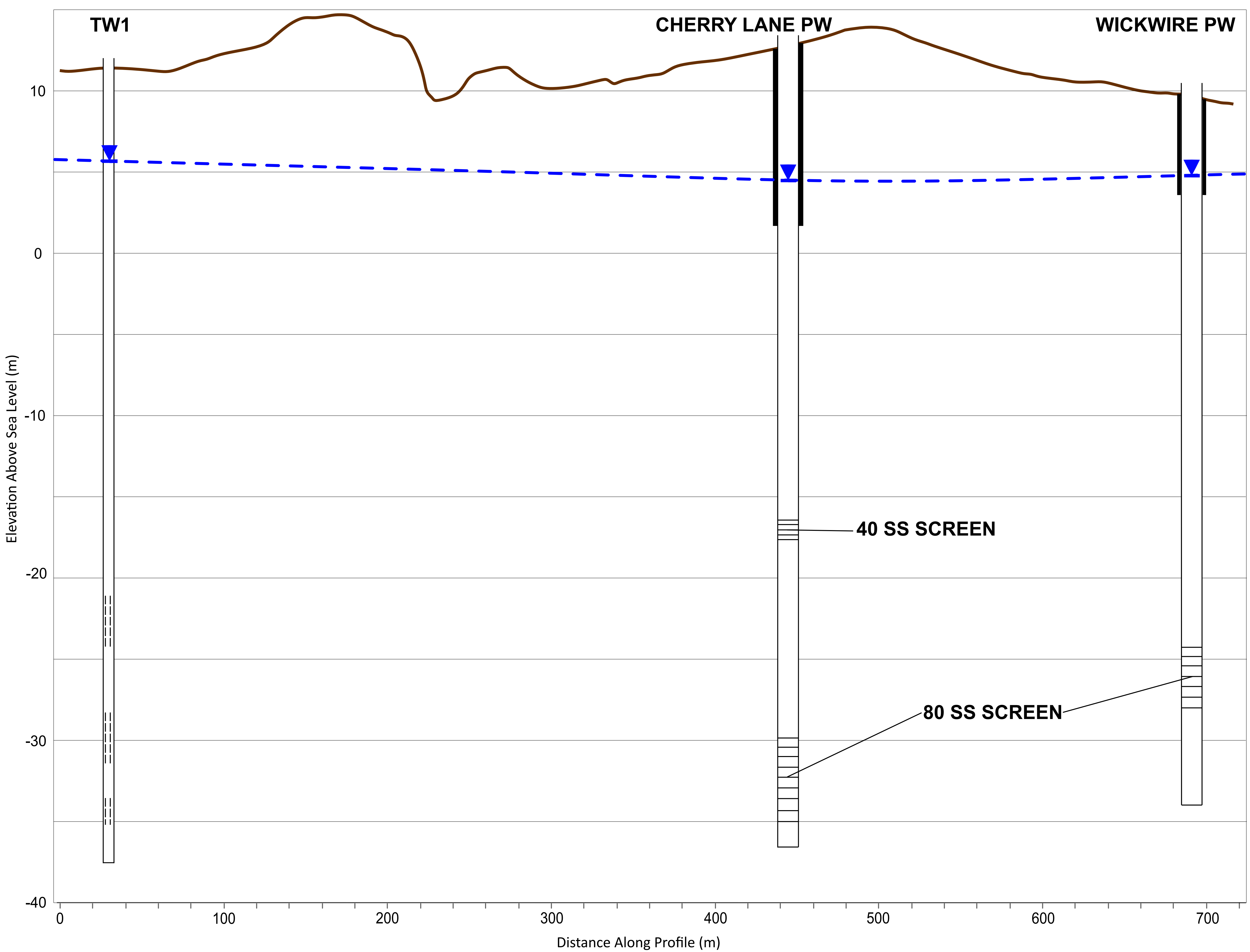
Well Design

A municipal production well can be drilled adjacent to TW1 (a minimum of 3 m away), constructed as follows:

- A 203 mm nominal steel well casing to a minimum depth of 30 m.
- A manufactured, stainless-steel wire-wrapped screen, with a slot size of 0.080 Inches (80-slot).
- A 6.1 m screened interval from 33.5 m – 39.6 m.
- A 1.5 m tight-wind / blank section at the top of the screen and a ~5 m blank section below the screen.
- A 1.5 m bail-bottom below the screen.
- A natural filter-pack, developed in place.

Figure 5 shows a cross-sectional profile along the valley axis, comparing the screen depths of the existing production wells and TW1. The recommended screen depths for the new well will be comparable to the existing wells.

As the new production well location is in an area that could flood during heavy rains and following spring melts, work will be required to alter and control surface water drainage. This is likely to require a system of drainage ditches around the well site and along the base of the field to the south of the well site. The well pad should incorporate drainage tile and filter stone and be graded/raised to provide up to 1 m of additional relief between the well and the surrounding landscape.



Legend

- Ground Surface
- Potentiometric Surface (static)
- Water Level (static)

CBCL

Town of Wolfville Well Development

Figure 5 - Production Well Cross Section

Date: July 11, 2024
CBCL Project Number: 230830.00

Yours very truly,

CBCL Limited

Prepared by:
Ryan Threndyle, M.A.Sc., M.I.T.
Hydrogeologist
Direct: 902-421-7241
E-Mail: rthrendyle@cbcl.ca

Reviewed by:
Colin Walker, M.Sc., P.Geo., FGC
Senior Hydrogeologist

Attachments:

A Borehole Logs
B Sieve Analysis Report
C Water Quality Data Tables

Report No: 230830.00

Appendix A

Borehole Logs

CBCL

Town of Wolfville Test Well 1

PROJECT NUMBER 230830.00
PROJECT NAME Wolfville Well Development
CLIENT Town of Wolfville
ADDRESS 10369 Nova Scotia Trunk 1

DRILLING DATE June 3 - 5 2024
TOTAL DEPTH 45.7 m
DIAMETER 6'
SCREENED INTERVALS
30.5 - 33.5 m; 36.6 - 39.6 m; 42.7 - 44.2 m

COORDINATES 4993574N 491293E
COORD SYS NAD 1983 UTM Zone 20N
COMPLETION June 5 2024
SURFACE ELEVATION (MASL) 11.4
WELL TOC (MASL) 12.1

COMMENTS

LOGGED BY Ryan Threndyle
CHECKED BY

Depth (feet)	Graphic Log	Material Description	Well Diagram	Elevation (masl)
0 - 20		Silty sand with clay.	Solid casing	
20 - 80		Silty sand with some fine gravel. Gravel diameter < 0.0254 m.	Solid casing	
80 - 100		Coarse sand with some gravel. Gravel diameter ~ 0.0254 m.	Solid casing	
100 - 150		Coarse sand with gravel. Gravel diameter 0.0254 - 0.0508 m.	Perforated casing	
150 - 160+		Sandstone bedrock.		

Depth (feet) scale: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160

Elevation (masl) scale: 5, 0, -5, -10, -15, -20, -25, -30, -35, -40

CBCL

Town of Wolfville Test Well 2

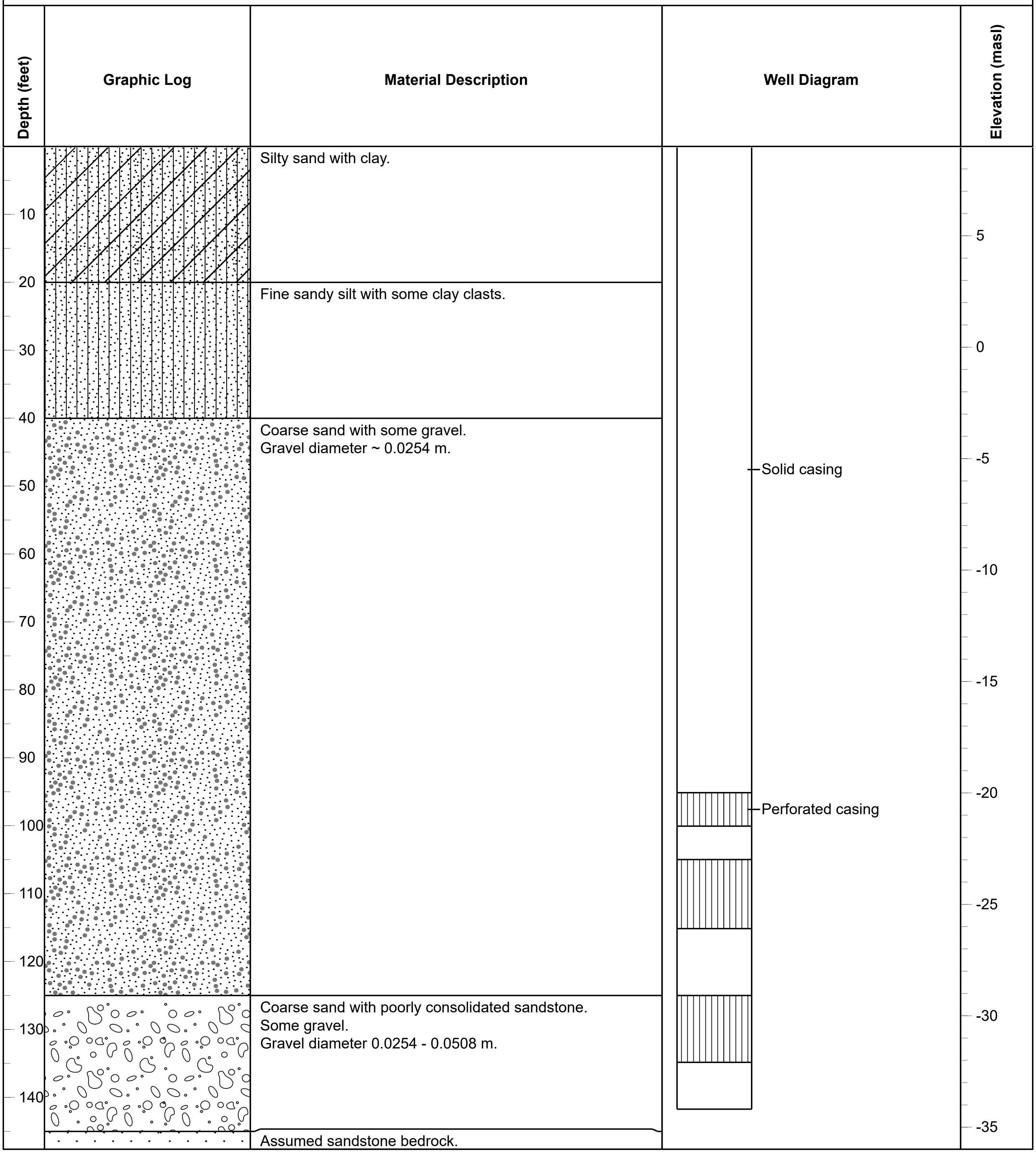
PROJECT NUMBER 230830.00
PROJECT NAME Wolfville Well Development
CLIENT Town of Wolfville
ADDRESS 10369 Nova Scotia Trunk 1

DRILLING DATE June 5 - 7 2024
TOTAL DEPTH 44.2 m
DIAMETER 6'
SCREENED INTERVALS
29.0 - 30.5 m; 32.0 - 35.1 m; 38.1 - 41.1 m

COORDINATES 4993724N 391206E
COORD SYS NAD 1983 UTM Zone 20N
COMPLETION June 7 2024
SURFACE ELEVATION (MASL) 14.2
WELL TOC (MASL) 14.9

COMMENTS

LOGGED BY Ryan Threndyle
CHECKED BY



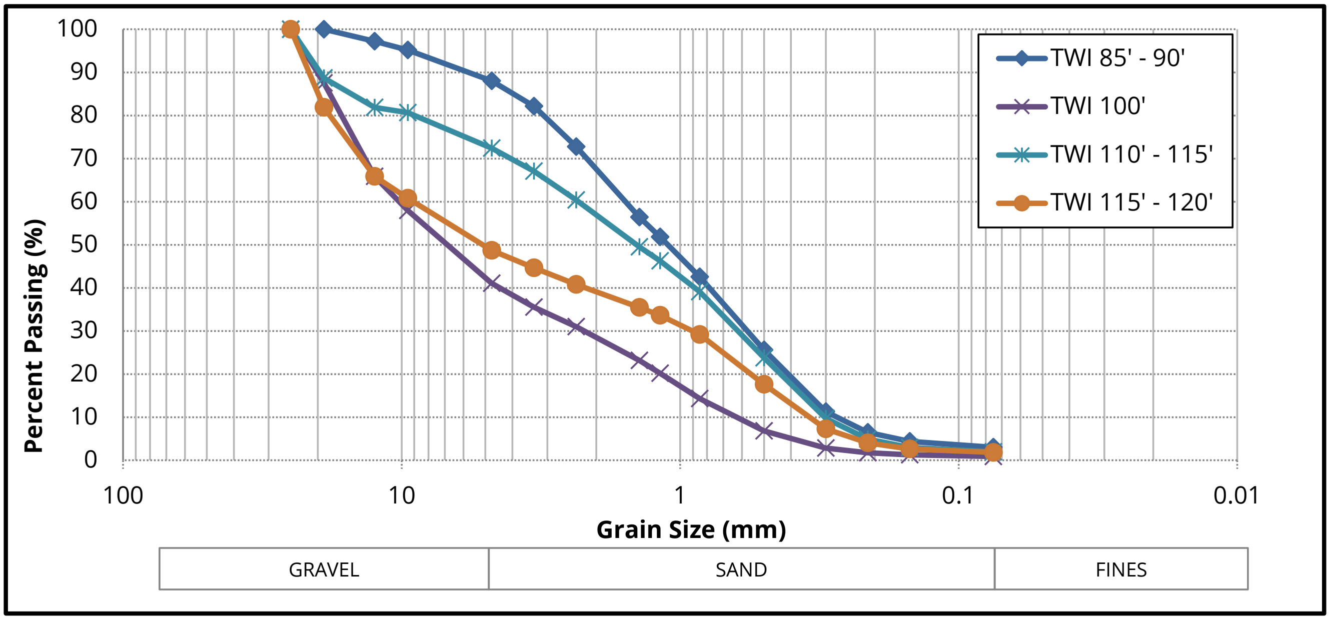
Appendix B

Sieve Analysis Report

CBCL
348 Bluewater Road
Bedford, NS, B4B 1J6
Phone: (902) 835-7313

SIEVE ANALYSIS

Project Name:	Wolfville Well Dev #3 Task 1	**Project #:**	230830.00
Client:	Town of Wolfville	**Date Sampled:**	June 24, 2024
Lab ID:	445	**Sampled By:**	Colin Walker
Sample Source:	Wolfville	**Date Tested:**	July 23, 2024
Standard:	Well Screens	**Tested By:**	JW/NS



Percent Passing:

Sieve Size (mm)	TWI 85' - 90'	TWI 100'	TWI 110' - 115'	TWI 115' - 120'	Specification: Well Screens
19	100.0	87.5	88.7	81.9	-
12.5	97.2	65.9	81.9	65.8	-
9.5	95.2	57.9	80.6	60.8	-
4.75	88.0	41.1	72.4	48.7	-
3.35	82.1	35.5	67.1	44.6	-
2.36	72.7	31.0	60.4	40.8	-
1.4	56.4	23.2	49.5	35.4	-
1.18	51.8	20.2	46.2	33.6	-
0.85	42.6	14.3	39.1	29.2	-
0.5	25.6	6.8	23.8	17.6	-
0.3	11.3	2.8	9.7	7.3	-
0.212	6.4	1.8	4.9	4.0	-
0.15	4.4	1.3	2.9	2.6	-
0.075	3.0	0.9	1.9	1.8	-

Grain Size Parameters:

	TWI 85' - 90'	TWI 100'	TWI 110' - 115'	TWI 115' - 120'
Cu	5.8	15.8	7.6	26.1
Cc	0.8	0.8	0.6	0.3
FM	3.5	5.5	4.2	5.1
D60	1.6	10.3	2.3	9.2
D30	0.6	2.2	0.6	0.9
D10	0.3	0.6	0.3	0.4

Remarks:

Reviewed By: Alex Gale (signature)
Alex Gale, CET

Date: July 24, 2024

Notice: Reporting of the results presented above constitutes a testing service only. Engineering interpretation and recommendations may be provided upon written request.

CBCL
348 Bluewater Road
Bedford, NS, B4B 1J6
Phone: (902) 835-7313

SIEVE ANALYSIS

Project Name:	Wolfville Well Dev #3 Task 1	**Project #:**	230830.00
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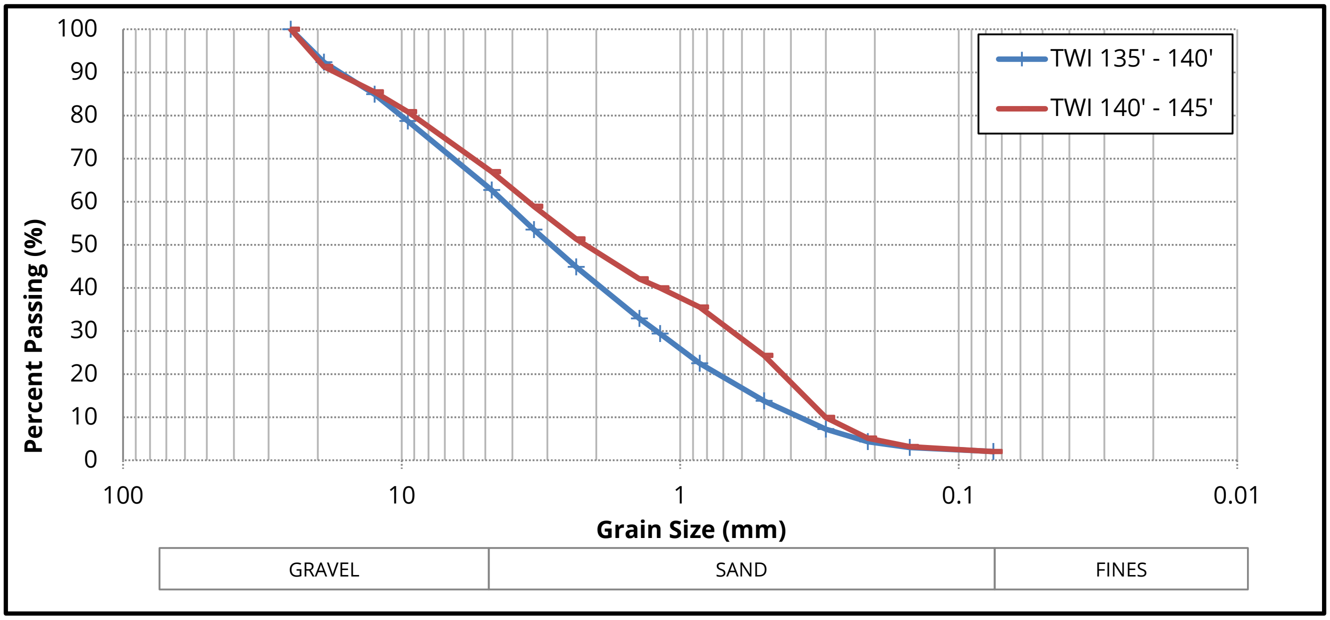

Percent Passing:

Sieve Size (mm)	TWI 135' - 140'	TWI 140' - 145'			Specification: Well Screens
19	92.3	91.3			-
12.5	84.9	85.4			-
9.5	78.7	80.9			-
4.75	62.7	66.9			-
3.35	53.5	58.9			-
2.36	44.8	51.3			-
1.4	32.9	42.1			-
1.18	29.3	40.0			-
0.85	22.5	35.5			-
0.5	13.7	24.3			-
0.3	7.2	9.9			-
0.212	4.3	5.1			-
0.15	3.0	3.2			-
0.075	2.0	2.0			-

Grain Size Parameters:

	TWI 135' - 140'	TWI 140' - 145'		
Cu	11.3	11.7		
Cc	0.9	0.4		
FM	5.1	5.1		
D60	4.3	3.5		
D30	1.2	0.7		
D10	0.4	0.3		

Remarks:

Reviewed By: Alex Gale
Alex Gale, CET

Date: July 24, 2024

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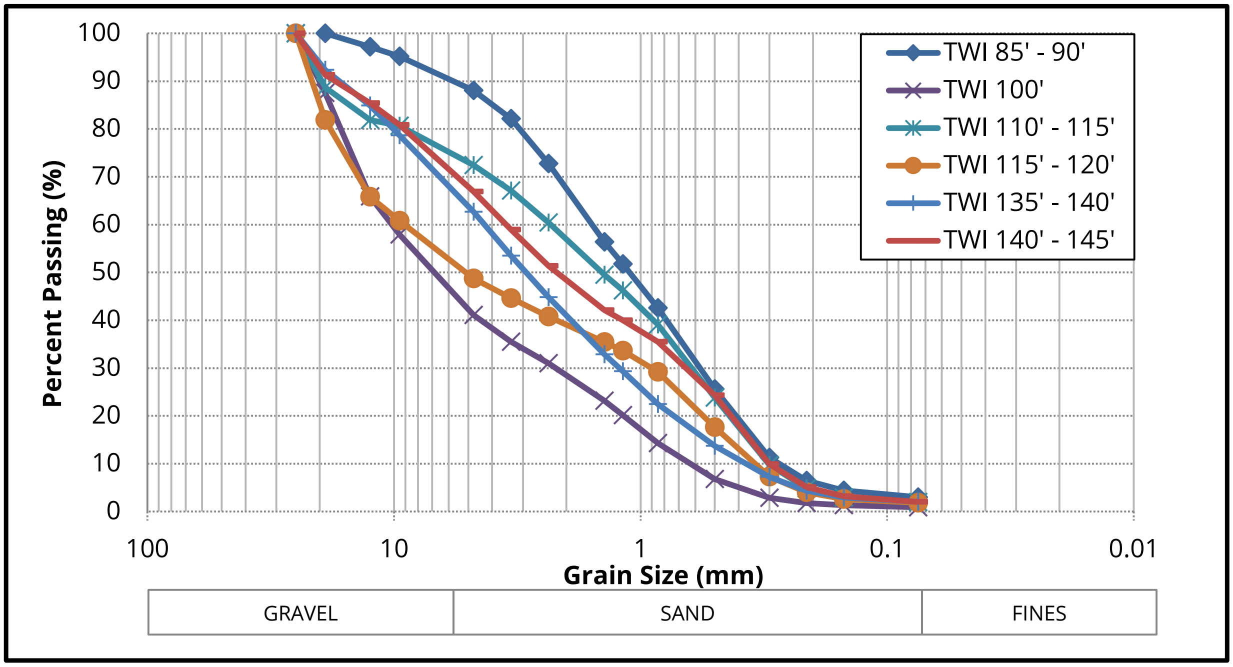

Sample ID	Depth (m)	Classification	Moisture (%)	Gravel (%)	Sand (%)	Silt & Clay (%)
TWI 85' - 90'	85' - 90'		14.2	12.0	85.0	3.0
TWI 100'	100'		7.7	58.9	40.2	0.9
TWI 110' - 115'	110' - 115'		12.4	27.6	70.5	1.9
TWI 115' - 120'	115' - 120'		8.8	51.3	46.9	1.8
TWI 135' - 140'	135' - 140'		8.5	37.3	60.6	2.0
TWI 140' - 145'	140' - 145'		10.9	33.1	64.9	2.0

Remarks:

Reviewed By: Alex Gale, CET **Date:** July 24, 2024

Notice: Reporting of the results presented above constitutes a testing service only. Engineering interpretation and recommendations may be provided upon written request.

Appendix C

Water Quality Data Tables

Table C1. Summary of Drinking Water Parameters

Parameter	Unit	GCDWQ	Type	TW1 Step Test June 13/24	Cherry Lane Sept 09/21	Wickwire Sept 09/21
Turbidity	NTU	<1	AO	*3.43*	<0.5	0.8
Colour	TCU	15	AO	<5	<5	6.17
pH	pH	6.5 - 8.5	AO	*5.74*	6.82	7.38
Chloride	mg/L	250	AO	90	130	101
Fluoride	mg/L	1.5	Health	<0.12	ND	ND
Sulphate	mg/L	500	AO	12	15	15
Total Dissolved Solids	mg/L	500	AO	198	243	237
Sodium	mg/L	200	Health	25.2	29.2	24.5
Nitrate	mg/L	10	Health	1.89	2.2	2.27
Nitrite	mg/L	1	Health	<0.05	-	-
Antimony	µg/L	6	Health	<2	6	ND
Arsenic	µg/L	10	Health	<2	3	ND
Barium	µg/L	2000	Health	54; 53[1]	48	53
Boron	µg/L	5000	Health	13; 5[1]	10	26
Cadmium	µg/L	5	Health	<0.09	0.1	ND
Chromium	µg/L	50	Health	<2	3	ND
Copper	µg/L	1000	Health	<1	29	ND
Iron	µg/L	300	AO	282; 130[1]	72	74
Lead	µg/L	5	Health	0.6; <0.5[1]	**5.3**	ND
Manganese	µg/L	20; 100	AO; Health	*34; 26*[1]	2	2.1
Selenium	µg/L	10	Health	<1	1	3
Strontium	µg/L	7000	Health	133; 132[1]	-	-
Uranium	µg/L	20	Health	<0.2	0.5	ND
Zinc	µg/L	5000	Health	<5	49	46

[1]Indicates filtered sample concentration

GCDWQ - Guidelines for Canadian Drinking Water Quality

AO - Aesthetic and/or Operational Guideline

Health - Human Health Guideline (Maximum Acceptable Concentration)

Parameter exceeds Health Guideline

Parameter exceeds AO

Table C1 (cont'd). Summary of Drinking Water Parameters

Parameter	Unit	GCDWQ	Type	TW Step Test Jun 13/24
E. coli	CFU/100 mL	<1	Health	<1
Total Coliforms	CFU/100 mL	<1	Health	<1
Vinyl Chloride	µg/L	2	Health	<0.6
1,1-Dichloroethylene	µg/L	14	Health	<0.6
Methylene Chloride	µg/L	50	Health	<2
Carbon Tetrachloride	µg/L	2	Health	<0.56
Benzene	µg/L	5	Health	<1
1,2-Dichloroethane	µg/L	5	Health	<2
Trichloroethylene	µg/L	5	Health	<1
Toluene	µg/L	24; 60	AO; Health	<2
Tetrachloroethylene	µg/L	10	Health	<2
Chlorobenzene	µg/L	30; 80	AO; Health	<1
Ethylbenzene	µg/L	1.6; 140	AO; Health	<2
1,4-Dichlorobenzene	µg/L	1; 5	AO; Health	<1
1,2-Dichlorobenzene	µg/L	3; 200	AO; Health	<0.7
Xylenes	µg/L	90; 20a	AO; Health	<1

GCDWQ - Guidelines for Canadian Drinking Water Quality

AO - Aesthetic and/or Operational Guideline

Health - Human Health Guideline (Maximum Acceptable Concentration)

Parameter exceeds Health Guideline

Parameter exceeds AO

Table C2. Summary of Physical Water Quality Parameters

Step	Date	Time	Temp (°C)	pH	ORP (mv)	Conductivity (µs/cm)
1	6/13/2024	11:45	7.99	5.95	83.0	254.5
1		12:00	7.99	5.59	104.5	251.8
2		12:25	7.99	5.52	114.1	253.7
2		12:45	7.99	5.53	122.1	250.4
2		1:00	7.99	5.53	127.7	247.8
2		1:10	7.99	5.53	126.5	249.9
3		1:25	7.99	5.50	133.3	246.8
3		2:00	7.99	5.52	131.3	247.2
4		2:15	7.99	5.54	137.0	247.2
4		2:25	7.99	5.54	137.0	244.4
4		2:45	7.99	5.55	153.1	245.6
4		3:00	7.99	5.56	163.2	246.5