



MEMO

TO: Marc Seguin, Chief Administrative Office
Jeff Sibley, Superintendent, Public Works,

COMPANY: Town of Stewiacke

FROM: Gil Violette, WSP Canada Inc.

DATE: 14 February 2025

CC: Molly Noseworthy, Simon Gautrey, Collin Fogerty, WSP Canada Inc.

PROJECT NO.: CA0001941.4259.99-202

SUBJECT: FINAL MEMO: Source Analysis – Proposed Groundwater Supply from PW21-01,
Town of Stewiacke, NS

WSP Canada Inc. (WSP) is pleased to submit the results of a source analysis review conducted on existing pumping test data from PW21-01 and using the groundwater flow model previously constructed for this project. The PW21-01 well location appears to have ample water supply, however, the source of the water reaching the new well needs to be better understood, in terms of potential groundwater under the direct influence of surface water (GUDI) and in terms of the Town of Stewiacke's (Town) objective of limiting its reliance on the St Andrews River. Specific technical objectives for this review include aquifer characteristics and hydraulic connectivity assessment as described in Section 1. In addition, a GUDI analysis was completed to the extent it could be completed until the well is put into operation. Details are presented in Section 3.

This work is also necessary prior to completing the Groundwater Withdrawal Application to the Nova Scotia Environment and Climate Change (NSECC) and to assist with the water treatment plant design, should the source of water be GUDI. Presently, the project is at Phase 4, which consists of groundwater withdrawal permit application and pre-design of the required municipal infrastructure to support the groundwater distribution system. This memo should be read in conjunction with the June 2022 Groundwater Supply Investigation Phase 3 Report prepared by WSP¹.

1 BACKGROUND

The Town currently uses the St. Andrews River as a potable water supply, however, the range of available volumes and fluctuating turbidity in the river present persistent challenges in managing and delivering a reliable water supply. The Town would like to develop a groundwater supply to limit the reliance on the St. Andrews River as a surface water source.

¹ WSP.2022. Town of Stewiacke Groundwater Supply Investigation – Phase 3 Report. Report submitted to the Town of Stewiacke in June 2022. WSP Project Number 191-03686. 100 pp.

Groundwater exploration and water well drilling within the Town limits has led to the identification of the presence of a high yield aquifer unit consisting of sand and gravel and fractured bedrock (sedimentary – siltstone/limestone with gypsum). In October 2020, WSP installed a 150 mm (6-inch) diameter test well (TW20-01) to assess the production capacity of the aquifer unit and a 72-hour pumping test was conducted at a rate of 589 m³/day (90 Imperial gallons per minute (igpm)), resulting in a maximum drawdown of 0.13 metre (m). In December 2021, a 250 mm diameter (10-inch) production well was drilled and tested in January 2022. The 2022 testing program produced a 10-day constant rate test at a well discharge of 2440 m³/day (448 USgpm) (gpm) with an observed drawdown of 1.02 m at the well head; a drawdown of 0.55 m (668 Hwy 2) at a distance of 1.9 km west of the new well; and a drawdown of 0.68 m (925 Stewiacke Road) at a distance of 2 km east from the new well. Figure 1-1 shows the location of the pumping and the monitoring wells.

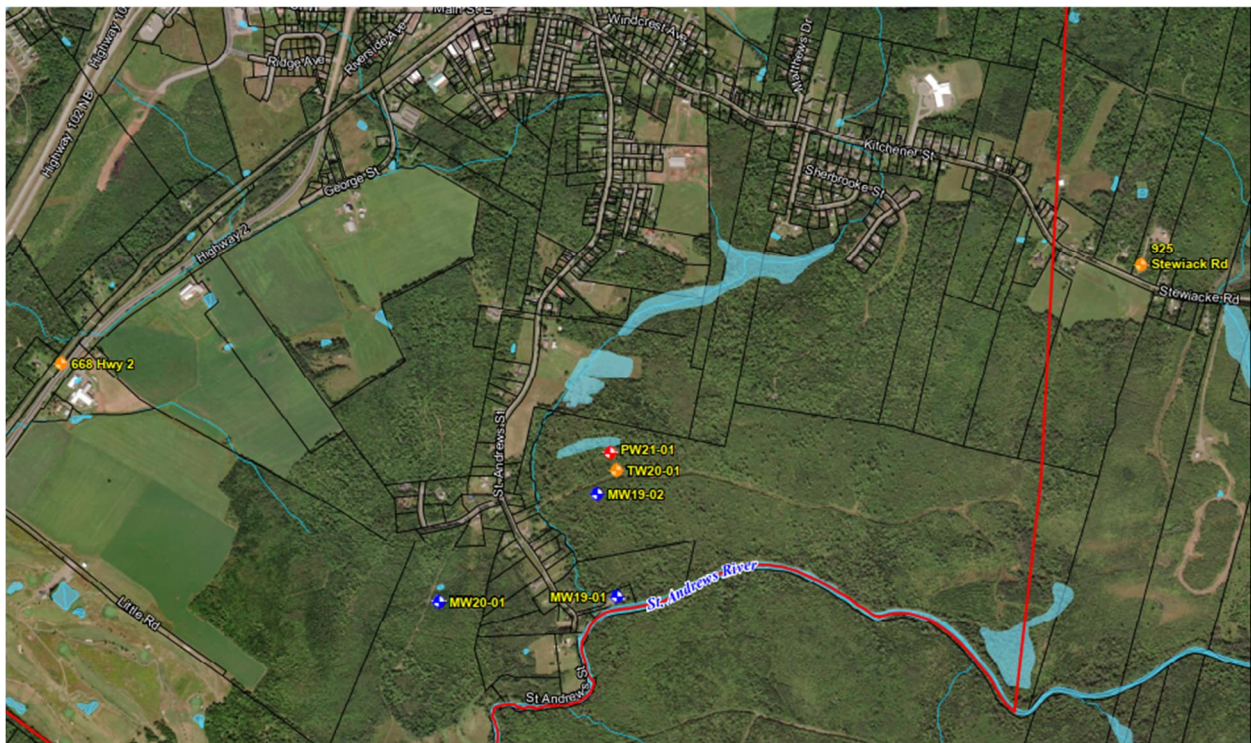


Figure 1-1 Location Plan of Proposed Production Well PW21-01, Town of Stewiacke, NS

The results of the pumping test are promising; however, a source analysis has been conducted to assist in providing clarity to the following technical aspects:

- Groundwater storage in sedimentary bedrock formations.
- Hydraulic connection between PW21-01 and a surface water body.
- Effect of rainfall on the aquifer.
- Effect of a confining layer above the aquifer.

2 SOURCE ANALYSIS AND FINDINGS

As described in our 12 July 2024 Change Order Scope of Work, the source analysis was primarily conducted by analyzing existing data and by applying the existing groundwater flow model to evaluate groundwater time of travel within the aquifer. From the review, the following general findings are of interest:

- The stratigraphy at the well location includes a sequence of thick clay-rich overburden material (till) overlying a 5m thick sand and gravel layer which overlies fractured bedrock.
- The fractured bedrock consists of limestone, which can be subjected to dissolution and erosion and hence, the limestone bedrock will be considered as “karstic”.
- The well PW21-01 is situated on a local high at about elevation 45 m and is slightly over 500 m to the north of the St Andrews River.

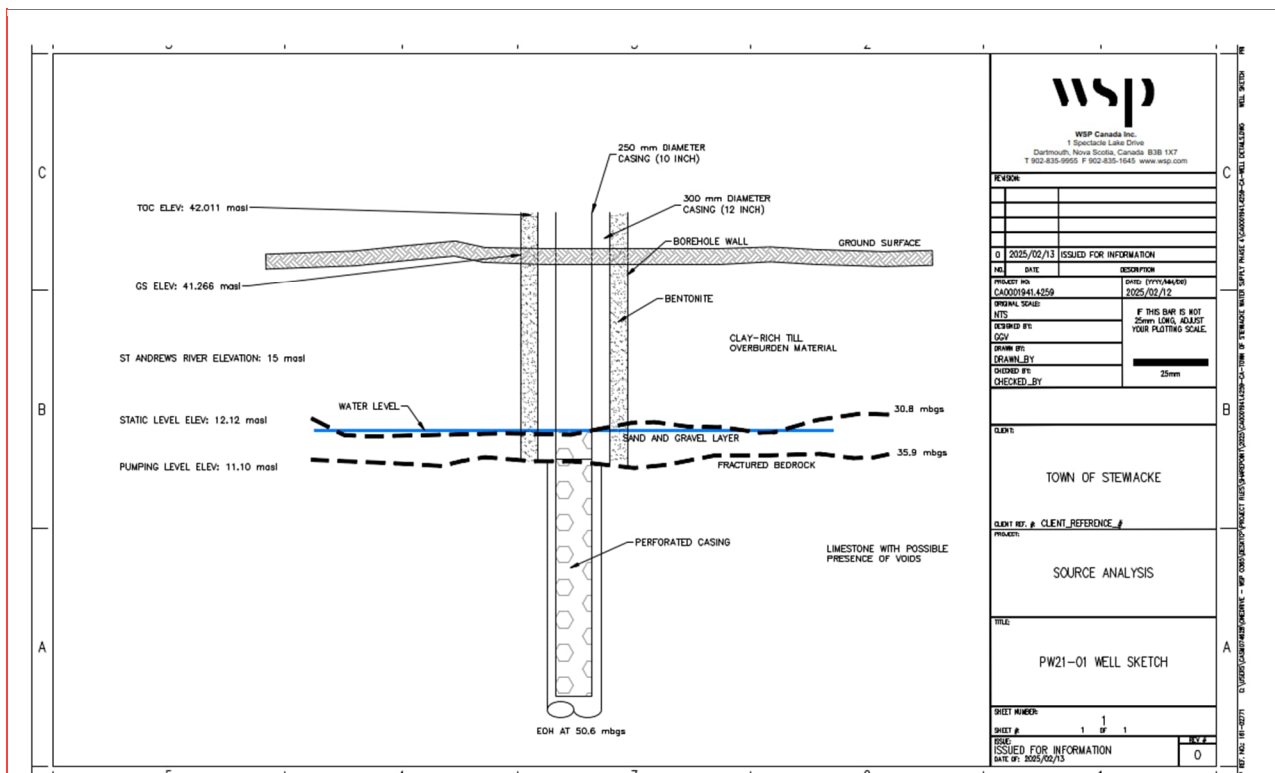


Figure 2-1 Schematic of the Well Construction for Pw21-01 and the Adjoining Geologic Formations

Figure 2-1 shows the well construction for PW21-01 along with important elevations and geologic formations adjacent to the well. The well has a total depth of 50.6 m below ground surface (mbgs) and has a 250 mm diameter (10-inch) pipe size casing for its entire depth, that has been perforated for the bottom 21 m. Perforations are 64 mm² (0.1 in²) with 24 perforations per foot of casing. The 250 mm diameter (10-inch) casing was installed within a 350 mm (12-inch) solid casing and open bedrock hole. The space between the 10-inch and 12-inch casings was filled with bentonite. The top of casing elevation is 42.011 m elevation, while the ground surface is at 41.266 m elevation. The static groundwater elevation at the time of the 10-day pumping test was 12.12 m elevation. The pumping level was at 11.10 m elevation for most of the pumping test. The St. Andrews River elevation was at approximately 15 m

elevation. The sand and gravel layer were encountered at a depth of 30.8 mbgs and bedrock (sandstone, limestone with gypsum) was encountered at 35.9 mbgs.

- The well has a 300 mm diameter (12-inch) metal casing that extends into bedrock, preventing surface water and groundwater from within the till layer from entering the supply well, as shown in Figure 2-1. This construction meets the Nova Scotia Well Construction Regulations². Also, the driller certified the well meets the Regulations in the submission of his well log (WSP 2022). Because of that construction, it is possible that groundwater within the sand and gravel layer at the well interface may be prevented from entering the well. However, it is likely that groundwater within the sand and gravel layer can also travel within the upper bedrock a distance away from the well, originating from a combined sand and gravel / fractured bedrock aquifer. Should any changes to the existing well construction be necessary, such as grouting the annular space between the two casings, the changes can be performed during the final stages of well infrastructure construction.
- The well intake construction is a series of perforations in a 250 mm (10-inch) diameter metal casing, extending from the water level (top of sand and gravel layer) to the bottom of hole – see Figure 2-1. Each perforation has an area of 0.1 in² and there are 24 perforations per foot of casing. A casing length of 70 ft was perforated for a total of 166 in² of area from the perforations.
- Review of the stratigraphy, local geology and curve fitting pumping test analysis suggests the sand and gravel / bedrock system behaves as a confined aquifer.
- The sand and gravel deposits are typically discontinuous³ (Rivera 2014).
- The groundwater pathway to the well is likely via the sand and gravel and through the fractured bedrock, then into the well. Should there be locations where the sand and gravel are absent, then the groundwater travels through the fractured bedrock.
- Groundwater contours of groundwater levels indicate groundwater flow is toward the St Andrews River. See Figure 2-2 for groundwater elevations at four locations at the start of the pumping test and at MW19-01 where the water level represents the elevation obtained shortly after drilling in 2019. Figure 2-3 shows the well log for this monitoring well, located approximately 30 m north of the St Andrews River. The presence of the clay-rich till to a thickness of approximately 13 m adjacent to the river and a water level partially within the till layer, suggests that the potentiometric level at that location was approximately 9 m above the base of the till or the top of bedrock. Although taken at a time other than the 10-day pumping test, it is WSP's opinion that the water level in MW19-01 would not normally change significantly and would remain close to the level observed shortly after drilling.
- Based on the log for monitoring well MW19-01, there is a thickness of approximately 13 m of the clay-rich overburden (till). This well is approximately 30 m north of the St Andrews River. Based on the description of

² Well Construction Regulations made under Sections 66 and 110 of the Environmental Act, S.N.S., 1994-95, c.1 – O.I.C. 2007-483 (September 7, 2007), N.S. Reg. 382/2007.

³ Rivera, Alphonso. 2014. Canada's Groundwater Resources. Compiled and Edited by Alphonso Rivera, Chief Hydrogeologist, Geological Survey of Canada. 2014. ISBN 978-1-55455-292-4 (HC).

the regional geology in Rivera 2014, it is expected that the clay-rich overburden till layer extends under the St Andrews River.

- The water quality results of seven samples taken from PW21-01 during the 10-day pumping test indicate a hard water with turbidity ranging between 5.7 and 12.4 NTUs, a dissolved sulphate between 800 and 1270 mg/L, a calculated TDS between 1410 and 1890 mg/L and iron and manganese concentrations just above the aesthetic guidelines. The range in concentration for selected chemical parameters is shown in Table 2-1.
- Water quality results from a sample from the St Andrews River taken in June of 2022 showed a turbidity of 5.8 NTU, a dissolved sulphate of 30 mg/L, a calculated TDS of 83 mg/L and iron and manganese concentrations below the aesthetic guidelines. The concentration of selected parameters is shown in Table 2-1.
- The proposed water treatment of the groundwater source (WSP 2024)⁴ will include a two-stage process with the initial stage for the treatment of iron (Fe), manganese (Mn) and sulphates (SO₄) while the second stage will handle total dissolved solids (TDS), turbidity and hardness.

Building on these findings, WSP reviewed and analyzed the pumping test data and adjusted properties in the previously constructed groundwater flow model. These results are described in this section.

It should be noted that an unnamed stream (shown in Figure 1-1) to the west of PW21-01 flows southerly and discharges to the St Andrews River. On average, this stream is approximately 10 m lower in elevation than the ground surface at the PW21-01 wellhead. It is therefore unlikely that surface water from the stream would enter the wellhead. With the stream at least 250 m away from the wellhead, it is also unlikely that surface water recharge to groundwater would travel to the well due to the presence of the thick clay rich overburden material. Figure 1-1 also shows the presence of a wet area just north of the PW21-01 wellhead. This area is 3 to 5 m lower in elevation than the wellhead and for similar reasons as just described, it is unlikely that surface water would reach the wellhead or be within the well capture zone, which is at the sand and gravel / bedrock level (depth of about 30 m).

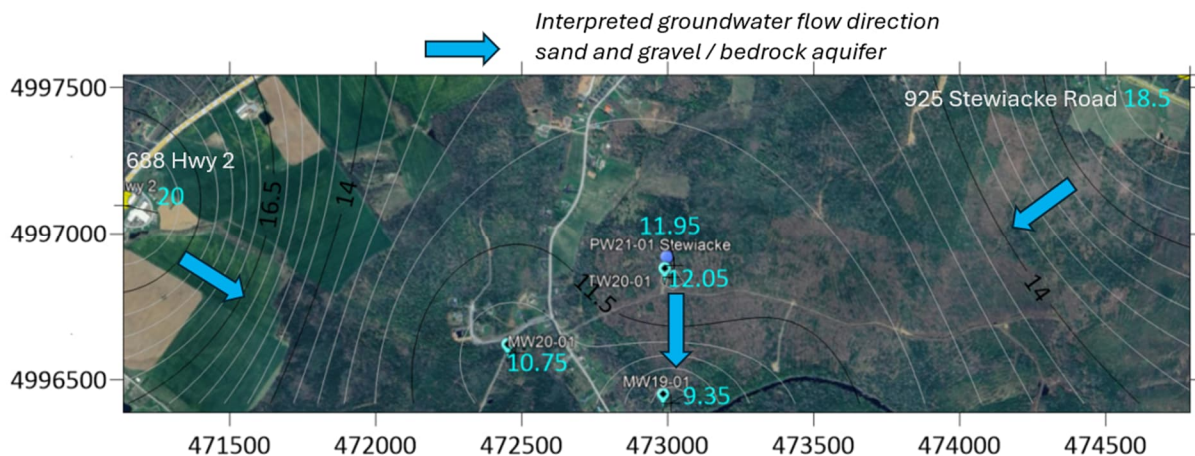


Figure 2-2 Groundwater Elevations (m) and Interpreted Groundwater Flow Direction in Sand and Gravel / Bedrock Aquifer

⁴ WSP Canada Inc. 2024. Phase 4 Concept Design Report for the Town of Stewiacke Water Supply System. Confidential Report submitted to the Town of Stewiacke, 22 February 2024. 46 pp.

Table 2-1 Select Water Quality Parameters from PW21-01 and St Andrews River

Parameter	Units	CDWQ ¹	Water Source	
			Groundwater Range during 10-day pumping test Feb-22	St Andrews River Value from sample taken Jun-22
General Chemistry				
pH		7 - 10.5 OG	7.6 to 7.88	7.59
Reactive Silica as SiO ₂	mg/L	-	7.1 to 9.9	3.6
Chloride	mg/L	250 AO	27 to 34	7.2
Sulphate	mg/L	500 AO	800 to 1270	30
Alkalinity	mg/L		113 to 115	30
True Color	TCU	15 AO	<5.00 to 17.3	50
Turbidity	NTU	1	5.7 to 12.4	5.8
Electrical Conductivity	µS/cm	-	2010 to 2070	150
Total Organic Carbon	mg/L	-	0.8 to 1.6	5.7
Dissolved Sodium	mg/L	200 AO	36.8 to 42.6	5.02
Dissolved Potassium	mg/L	-	0.1 to 1.7	0.48
Dissolved Calcium	mg/L	-	403 to 507	18.5
Dissolved Magnesium	mg/L	-	21.3 to 30.8	2.12
Calculated TDS	mg/L	500 AO	1410 to 1890	83
Hardness	mg/L	-	1120 to 1360	55
Anion Sum	me/L	-	19.9 to 29.5	1.36
Cation sum	me/L	-	24.1 to 29.1	1.34
Metals - Dissolved Metals for Groundwater and Total Metals for Surface Water				
Dissolved Iron	µg/L	300	59 to 1040	424
Dissolved Manganese	µg/L	120	66 to 85	80.7
Dissolved Zinc	µg/L	5000 AO	6.00 to 22.00	33.5
Bacteria				
<i>E.coli</i> (MPN)	CFU/100 mL	ND/100 mL	<1	
Total Coliforms (MPN)	CFU/100 mL	ND/100 mL	<1	

Notes:

- ¹ Health Canada Guidelines for Canadian Drinking Water Quality, September 2020.
 shading denotes a guideline
 exceedance
*italics denotes an exceedance in
 aesthetic guidelines (AO) or operation
 guidelines (OG)*

2.1 TASK 1 – BOUNDARY CONDITION EVALUATION

The use of specialized computer software (Aqtesolv and Aquifer Test and custom Excel spreadsheets) was made to generate graphical and computational solutions of estimates of aquifer properties such as transmissivity and storativity. Overall hydraulic conditions such as confined, unconfined or semi-confined conditions were evaluated to provide further insight on potential best-fit solutions. The effect of rainfall was evaluated to determine if rainfall recharge during the test was via ground surface run-off, or surface water and/or via a boundary (such as a surface water body). The following observations / findings were made during the review:

- Prior to the rainfall, the well drawdown was at a constant rate and did not stabilize (although a minimal drawdown of ~ 1 m) – see downward trend in purple dots in Figure 2-4.
- The heavy rainfall near the end of the 10-day test triggered an increase in the stage of the St Andrews River (see gray line in Figure 2-4). A short time later (perhaps a day), a pressure response can be seen in the pumping well PW21-01 (upward trend of purple dots), which suggests the well has a hydraulic connection with the nearby St Andrews River. It should be noted that the pressure response does not mean that river water entered the well that quickly but rather suggests that pressure within the confined aquifer propagated to the well in that time frame (see Figure 2-5).
- During the 10-day pumping test, the pumping rate for the well ranged between 2220 and 2769 m³/day (407 and 507 gpm) with an average of 2440 m³/day (448 gpm) and a standard deviation of 55 m³/day (10 gpm) - see Figure 2-5.
- The re-analysis of the data, with focus on the period prior to the heavy rainfall, and using Theis and Cooper-Jacob solutions for confined aquifers, provides an interpreted transmissivity of the confined aquifer system ranging from $6.9 \times 10^{-3} \text{ m}^2/\text{s}$ to $7.8 \times 10^{-2} \text{ m}^2/\text{s}$. The storativity of the confined aquifer system ranges from 8.7×10^{-3} to 1.3×10^{-2} . See drawdown versus time graph and interpretations in Figure 2-6.
- Assuming the aquifer is a combination of the sand and gravel layer and fractured bedrock with an overall thickness (also the saturated thickness of the pumped aquifer) of 20 m, then the hydraulic conductivity (K) is $3.9 \times 10^{-3} \text{ m/s}$.

The overburden material shown in Figure 2-1 and Figure 2-3 consists of a till material described as a “compact to very dense reddish brown silty clay with some cobble” in WSP 2022. At PW21-01, the till layer is 30.5 m thick. In the WSP 2021 report⁵, the till layer is described from the examination of split spoon samples retrieved from MW19-01 and MW19-02, as a clay rich glacial till, between 25 and 40 m in thickness and blankets the general Stewiacke area as shown in Figure 2 in WSP 2021. The report also states that localized sand lenses can exist within the till. The till layer provides a protective layer, isolating the underlying confined aquifer from surficial man-made activities. In other words, this layer should provide a good barrier against downward vertical migration of surface contaminants generated from day-to-day activities occurring at ground surface.

⁵ WSP. 2021. Town of Stewiacke Groundwater Supply Investigation. Draft Report submitted to the Town of Stewiacke on March 12, 2021. WSP project 191-03686. 115 pp.

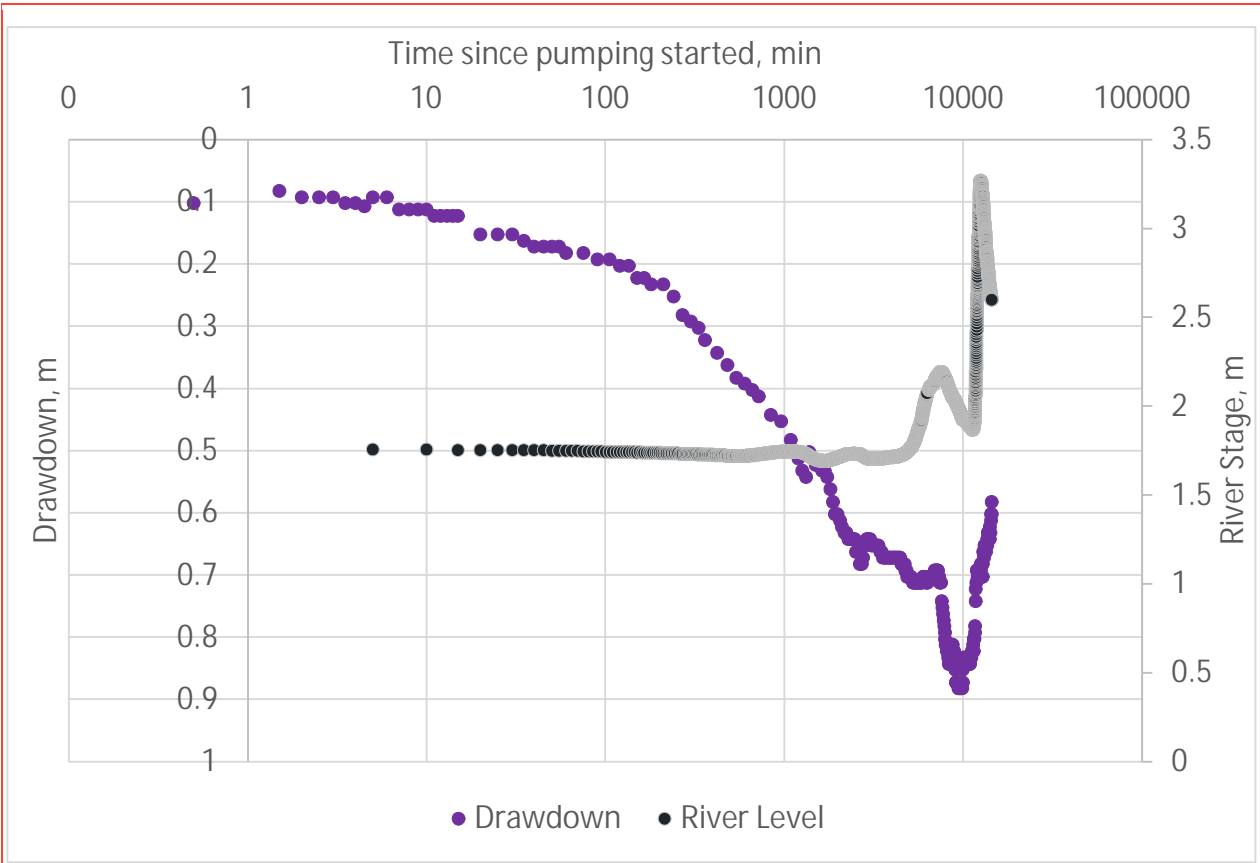


Figure 2-4 Drawdown at PW21-01 and St Andrews River Stage During 10-Day Pumping Test

Figure 2-4 shows drawdown at the pumping well and the river stage for the St Andrews River versus time for the duration of the 10-day pumping test (14400 minutes). The purple dots correspond to the drawdown at the well while the gray line corresponds to the river stage. The well is still pumping at the latter stages of the test, however, the rise in river stage creates a reversal in the trend of the drawdown within the pumping well, with a decreasing drawdown (rise of water level) at same time of the stage rise in the St Andrews River.

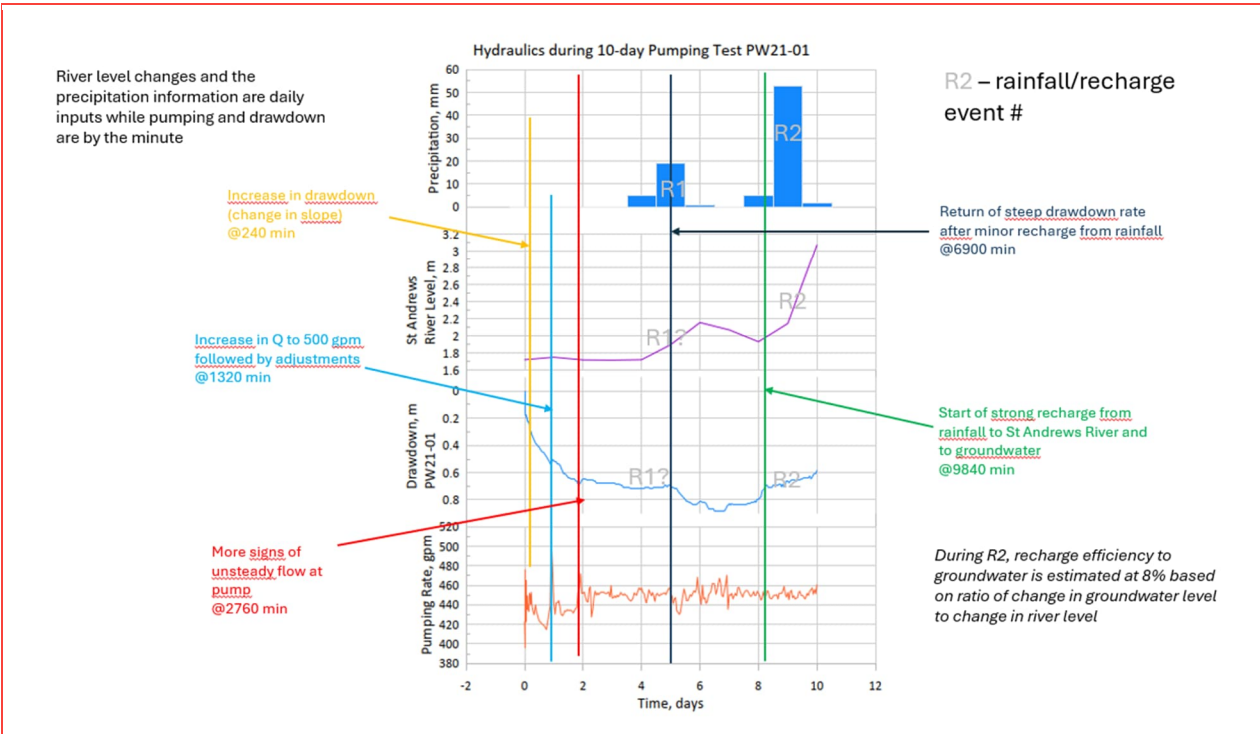
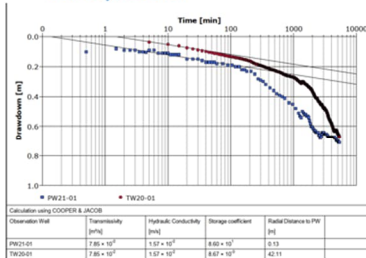


Figure 2-5 Hydraulic Events during the 10-Day Pumping Test on PW21-01

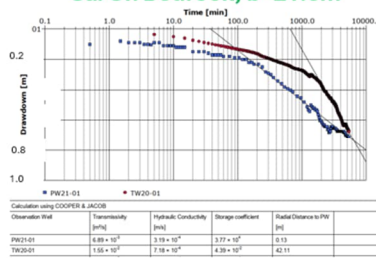
Figure 2-5 shows four hydraulic events occurring simultaneously during the 10-day pumping test. The value of each hydraulic parameter is plotted versus time. As can be seen, the pumping rate of PW21-01, the drawdown at the well, the stage of the St Andrews River (Station 01DG043) and precipitation were monitored within that same 10-day period. While the pumping rate is more or less constant at an average of 2440 m³/day (448 gpm), the drawdown increases initially, appears to stabilize at about 4 days, then increases, then decreases at the end of the pumping. The top two charts show the river level increasing with the rainfall events. A time lag exists between the rainfall events and the river stage / pumping level – but is difficult to ascertain the exact length of time between rainfall starting and the corresponding change in stage or well water level.

Aquifer Parameter Estimates for 10-day Pumping Test Data, PW21-01

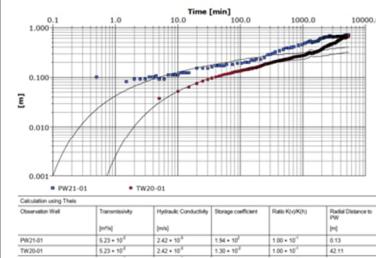
**Cooper-Jacob confined – early data
Sa/Gr, b=5 m**



**Cooper-Jacob confined – late data
Sa/Gr/Bedrock, b=21.6m**



**Theis confined – best fit
Sa/Gr/Bedrock, b=21.6m**



Well	T (m ² /s)	K (m/s)	S	T (m ² /s)	K (m/s)	S	T (m ² /s)	K (m/s)	S
PW21-01	7.8x10 ⁻²	1.6x10 ⁻²		6.9x10 ⁻³	3.2x10 ⁻⁴		5.2x10 ⁻²	2.4x10 ⁻³	
TW20-01	7.8x10 ⁻²	1.6x10 ⁻²	8.7x10 ⁻³	1.6x10 ⁻²	7.2x10 ⁻⁴	4.4x10 ⁻²	5.2x10 ⁻²	2.4x10 ⁻³	1.3x10 ⁻²

Figure 2-6 Drawdown versus Time for Pumping Well PW21-01 Data prior Tt Heavy Rainfall Data

The analysis of the pumping test for the data prior to the rainfall events correspond to approximately 4 days (96 hours) of pumping, which is sufficient time to allow for drawdown response to pumping at a well. The regular time frame for analysis of a municipal well is 72 hours. Fortunately, precipitation was not occurring in the first 96 hours of the pumping test, which provides a window of time for isolating solely the aquifer response to the stress of pumping from PW21-01. The aquifer analysis presented in WSP 2022 focused on the use of the double porosity method for bedrock aquifers. Noting that drill logs show the presence of a 5 m thick sand and gravel layer that is supported by regional mapping of the surficial geology (Rivera 2014) and minimal details for bedrock characterization of fractures provided in WSP 2021, the pumping data was analyzed for the combined porous media and upper bedrock fractures. It is assumed that the combined geologic layers behave as a porous media. Hence, the Theis and the Cooper-Jacob methods were applied to the data prior to rainfall. The re-analysis provides results of transmissivity similar to the double porosity method ($6.3 \times 10^{-3} \text{ m}^2/\text{s}$) but has the benefit to provide storage values for the aquifer. The Storativity values are within the range of confined aquifer⁶s.

⁶ Freeze, Ralph A. and John A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

2.2 TASK 2 – WELL EFFICIENCY

The theoretical and true drawdown values for well PW21-01 was estimated to provide an overall well efficiency. This will be important for the design of a backup well in this wellfield. For example, should the backup well be constructed in same manner (perforated casing) or be fitted with a machine-wound continuous wire screen well? Well performance typically degrades with time although alleviated through maintenance programs. This information will assist in developing a long-term well operation and well maintenance program for PW21-01 and the backup well.

- The well intake construction is a series of perforations in a 250 mm diameter (10 inches) metal casing, extending from the water level (top of sand and gravel layer) to the bottom of hole (see figure below).
- A well efficiency check reveals a Walton's C factor of $0.014 \text{ min}^2/\text{m}^5$, which is in the range of a properly designed well ($0.5 \text{ min}^2/\text{m}^5$), so the perforated casing appears to be properly designed.
- The diameter of the perforations within the casing were estimated to provide an open surface area for groundwater intake of $1,550 \text{ mm}^2$ (2.4 in^2) per foot of perforated casing. The open area for a 250 mm diameter (10-inch) diameter machine-wound well screen with a slot size 50 mils/inch would provide an open area of $69,670 \text{ mm}^2$ (108 in^2). A machine-wound well screen would provide approximately 45 times the intake area that the perforations on PW21-01 provides - however, the "properly designed" rating of this well indicates the existing design to be suitable for the operation of the well.
- It is understood that the intent of the perforated casing is to stabilize the borehole wall, to perform as a permanent stabilizing liner. Although the Atlantic Canada Water Supply Guidelines (ACWS)⁷, mentions slotted casing for the purpose, the well efficiency analysis in this memo suggest that the well is "properly designed". From the analysis, it appears that the perforated casing does not interfere with the movement of groundwater from the geological formations into the well.
- The turbidity in PW21-01 ranged between 5.7 and 12.4 NTUs during the 10-day pumping test. This represents a range of turbidity that will require treatment (which is being considered in WSP 2024) and is likely related to the size of the perforations in the casing. To avoid treatment of turbidity, a different well construction could include the installation of a pipe-size machine-wound continuous wire screen surrounded by a sand and gravel pack.

2.3 TASK 3 – APPLICATION OF EXISTING GROUNDWATER MODEL

Based on the findings from the boundary conditions, it is now assumed that the sand and gravel / bedrock formations make up the aquifer and that the aquifer is under confined conditions. The raise in groundwater levels within the pumping well, as a result of a rainfall, suggests that the groundwater criteria "rapid recharge" should be examined for this well, e.g. the recharge from the St Andrews River and the Time of Travel (TOT) from the river to the well should be investigated. The groundwater flow model was used to further explore the assumption of confined aquifer to provide estimates for the groundwater time of travel to the well PW21-01. The scenario evaluated to explore the groundwater flow path between the St Andrews River and the well is for:

- The sand and gravel / bedrock formations (aquifer) act as primary pathway between the river and the well.

⁷ Atlantic Canada Water & Wastewater Association. 2022. Atlantic Canada Water Supply Guidelines. Published May 2022 and revised April 13, 2023. 256 pp.

Revisions to the hydrogeological properties of the layers within the groundwater included increasing the hydraulic conductivity of the sand and gravel layer to 1×10^{-3} m/s, from a previous value of 3×10^{-4} m/s. As a result, the model is no longer calibrated and will require re-calibration in the future, once the well is put in operation and groundwater level observations can be collected over a period of time. However, it is considered that the results from the adjusted (non-calibrated) model are useful in forecasting the conditions near the well. The results of the groundwater flow modelling for purposes of GUDI analysis are presented in the following section. It should be noted that the groundwater flow modelling was performed for Equivalent Porous Media (EPM) conditions and should be evaluated for fractured rock conditions as well.

3 GUDI ANALYSIS

3.1 THE GUDI PROCESS IN NOVA SCOTIA

For determining water supply treatment requirements, a classification process has been put in place for municipalities in Nova Scotia. The classification is used to determine if groundwater is under the direct influence of surface water (GUDI) or is non-GUDI. All municipal water well sources in Nova Scotia must be initially assessed for their GUDI classification. The Nova Scotia GUDI assessment process is guided by the Nova Scotia Treatment Standards for Municipal Drinking Water Systems Appendix A of the reference⁸ (Nova Scotia 2022) and consists of three steps:

- Step 1 is a screening step used to rapidly identify obvious non-GUDI water wells based on available information.
- Step 2 is used to determine if there is a hydraulic connection throughout the aquifer that could allow rapid recharge of the well by water directly influenced by surface water. Rapid recharge means recharge that occurs between the well and surface water with a time of travel (TOT) of 90 days or less. In addition, Step 2 includes a review of available hydrogeologic information and one year of water quality monitoring at the wellhead and a nearby surface water body.
- Step 3 is used to determine if there are surface water particulates or pathogens present in the well that indicate it has been influenced by surface water. This is done using the Microscopic Particulate Analysis (MPA). The travel time results from Step 2 are needed to determine when the MPA samples are to be collected.

The completion of the process results in a GUDI classification of low, medium or high or a non-GUDI classification.

3.2 RESULTS OF THE GUDI ANALYSIS FOR PW21-01

3.2.1 STEP 1 SCREENING EVALUATION

The Step 1 screening evaluation indicates the following:

Sensitive Settings: The following considerations would rule out the well from this category:

- The well is constructed within a confined aquifer; and
- The well is approximately 450 m north of the St Andrews River, which is greater than the 60 m criteria.

⁸ Nova Scotia. 2022. Nova Scotia Treatment Standards for Municipal Drinking Water Systems. Approved by Lora MacEachern, Deputy Minister. June 15 2022. 193 pp.

However, the limestone bedrock is karstic which therefore suggests the potential for a karst aquifer. As a result, the aquifer will be considered as being within a “sensitive setting”.

Well Construction: The well has a solid outer protective casing that extends to 35.9 m below ground surface, exceeding the criteria of 12 m. The well has an inner casing that is perforated from 35.9 m to 50.6 m below ground surface. The area between the outer and inner casing is filled with bentonite and the annular seal is fully grouted. The well construction is certified by the driller as meeting the Nova Scotia Well Construction Regulation. The well also meets the ACWS well construction guidelines.

Water Quality: Three samples were taken during the 10-day pumping test and returned “absent” results for E.Coli and total coliform.

The results of the screening evaluation indicate the well is within a sensitive setting and should be further considered for GUDI. In addition, the rise in groundwater levels at the well and monitoring wells during the 10-day pumping test, as a result of precipitation suggests that the possibility of rapid recharge to the well which requires further assessment.

3.2.2 STEP 2 SCREENING EVALUATION

A Step 2 assessment was initiated, however, there are aspects of the Step 2 assessment that can only be carried out once the well is in operation, i.e. the one-year sampling requirement from the well. The portion of the assessment that was completed is the TOT portion and the results are presented below.

The previously calibrated groundwater flow model was adjusted to reflect higher transmissivities in the sand and gravel layer that would appear to hydraulically connect well PW21-01 and the St Andrews River. The preliminary simulation results indicate a response in the well from the precipitation event during the pumping test as can be seen in Figure 3-1. The figure shows a simulated increase in water level in the pumping well of about 1 m – this value is higher than the field observed increase of approximately 0.3 m. The higher response suggests a conservative response to the hydraulic connection between the well and the St Andrews River from the groundwater flow model. The model was subsequently used to assess the TOT between the river and the well.

The TOT results are helpful in determining the potential for the well to be GUDI as they were applied against the criteria provided in Appendix A of the reference Nova Scotia 2022: In the Step 2 of the GUDI analysis, the well is considered rapidly recharged if the TOT is less than 90 days.

The groundwater simulation shows that the TOT between the St Andrews River and PW21-01 operating at a discharge rate of 2440 m³/day (448 gpm) is 520 days for EPM conditions. Therefore, based on this preliminary analysis, PW21-01 is not a GUDI well. Another simulation was carried out with PW21-01 pumping at a rate of 650 m³/day (120 gpm), which is closer to the discharge rate the well will be initially operating at. At this pumping rate, there is no TOT as the influence of the well is not sufficient to initiate travel from the river to the well.

As stated in the assessment guidelines, the well should be sampled for a period of one year once the well is in operation. At that time, the water quality will be re-assessed as well as the TOT be re-evaluated with a re-calibrated model (and also consider fractured rock conditions). At that time, to be prudent, the Town of Stewiacke may select to carry out the MPA testing as a confirmation of the GUDI assessment.

Based on the screening evaluation and the preliminary results from the TOT evaluation, the well is considered non-GUDI, however, monitoring for a period of one year and re-assessment with a calibrated groundwater flow model is necessary to confirm this rating. It should also be noted that preliminary interpreted groundwater flow direction suggests groundwater flows towards the St Andrews River (i.e. groundwater recharges the river). Monitoring of water levels once the well is in operation will assist in providing supporting information on the direction of groundwater flow in the vicinity of PW21-01 and the St Andrews River.

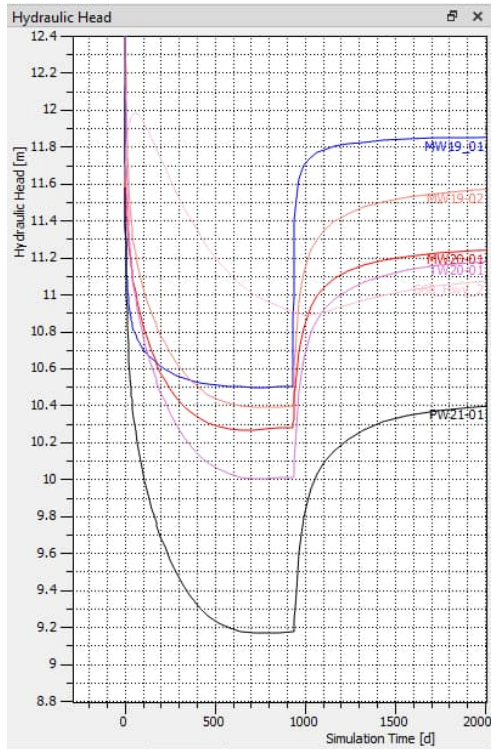


Figure 3-1 Preliminary Simulation Results from the Precipitation Event

4 CONCLUSIONS AND SUMMARY STATEMENT

Based on the information presented regarding the source analysis for groundwater supply at PW21-01, the following conclusions and summary statements have been developed by WSP.

- 1 The primary aquifer that supplies PW21-01 includes a thin sand and gravel layer, approximately 5 m in thickness, and the upper portion of limestone bedrock that is fractured and may be karstic.
- 2 PW21-01 was certified by well driller that it was constructed as per the Nova Scotia Well Construction Regulations.
- 3 The drawdown at the well, when pumped at a rate of 2440 m³/day (448 gpm), was 1.02 m.
- 4 The re-analyzed properties of the aquifer show a transmissivity ranging from 6.9 x10⁻³ m²/s to 7.8x10⁻² m²/s. The Storativity of the confined aquifer system ranges from 8.7x10⁻³ to 1.3x10⁻².
- 5 The presence of a thick clay-rich till layer (~30 m) acts as a confining layer and will minimize downward vertical migration of surface contaminants.

- 6 A precipitation event late in the 10-day pumping test of PW21-01 increased the stage of the St Andrews River and consequently, caused a rise in the water level (decrease in drawdown) in the pumping well and monitoring wells constructed in the aquifer.
- 7 The noticeable decrease in drawdown from the precipitation event suggests well PW21-01 has a hydraulic connection with the St Andrews River.
- 8 The water quality of the well PW21-01 does not resemble the water quality from the St Andrews River.
- 9 A two-stage treatment process is proposed to treat the groundwater source for: 1) iron, manganese, sulphates; and 2) total dissolved solids, turbidity and hardness.
- 10 Application of the GUDI screening guidelines suggests that the presence of a karstic limestone provides a sensitive setting for the well PW21-01.
- 11 The hydraulic connection between well PW21-01 and the St Andrews River is not a rapid recharge as defined by the GUDI assessment guidelines. An estimated time of travel (TOT) of 520 days was generated by the revised groundwater flow model previously constructed for the project and with PW21-01 operating at a pumping rate of 2440 m³/day (448 gpm). The estimated TOT is greater than the criteria of 90 days. Therefore, PW21-01 is not a GUDI well.
- 12 It is anticipated that upon start-up, well PW21-01 will operate at a much lower rate than the discharge rate used during the 10-day pumping test. Assuming a pumping rate of 120 gpm, then groundwater modelling simulations indicate river water does reach the well, hence has no TOT.
- 13 There are other portions of the GUDI assessment that can only be completed once the well is in operation e.g., sampling of groundwater over a period of one year.
- 14 The GUDI assessment indicates that the well PW21-01 is non-GUDI, however, confirmation will be required via monitoring and re-assessment.
- 15 The estimated TOTs provided herein should be re-evaluated with data acquired during the operation of the pumping well and from monitoring wells. Considerations should also be given for TOT within fractured rock.

5 RECOMMENDATIONS


Based on the findings presented in this memo, the following recommendations have been developed by WSP:


- 1 Submit an application to withdraw groundwater from PW21-01.
- 2 Make provisions for the implementation of a groundwater level and groundwater chemistry monitoring program, that meets the Step 2 requirements, as soon as the well is put into operation.
- 3 Re-evaluate the TOT for EPM and fractured rock scenarios and compare to the NS GUDI assessment criteria.
- 4 Carry out Microscopic Particulate Analysis (MPA) on the source (a minimum of 2 samples), once the system is in operation.
- 5 Construct a second well within the aquifer to provide backup/redundancy for PW21-01.

6 CLOSURE

This memo was prepared as documentation for the source analysis for PW21-01 for the Town of Stewiacke and is presented for the sole use of the Town of Stewiacke. The 10-day pumping test and pre-feasibility water treatment study have provided results that are promising for the development of a groundwater supply at PW21-01. It should be noted, however, that the period over which testing occurred remains a short snapshot in comparison to the proposed long-term operation of the system (decades). It is imperative that appropriate monitoring of water levels, discharge rates and water quality be implemented and maintained plus the results reviewed on a regular basis to determine the performance of the system and to allow necessary adjustments, as required. This memo was written by Gil Violette, M.Sc.E., P.Eng and reviewed by Simon Gautrey, P.Geo.

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