TECHNICAL MEMORANDUM

Issue Date:	February 4, 2021	File:	2018-8012.030
To:	Kendra Kryszak, B.L.A., Manager, Parks Operations and Maintenance	Previous Issue Date:	
Cc:	Laurie Cordell, Manager, Long Range Planning and Sustainability		
From:	Carrie Nadeau, R.P.Bio., Mike Weldon, P.Geo.		
Client:	City of Vernon		
Project Name:	Polson Park Hydrogeology Analysis Update	Project No.:	2018-8012
Subject:	Polson Park Flooding		

1 INTRODUCTION

Associated Environmental Consultants Inc. (Associated) was retained by the City of Vernon (the City) in January 2018 to provide hydrogeology services for the collection and analysis of surface water and groundwater levels from 2018-2021 in Polson Park. The purpose of this study was to measure water level connections in the Park to help understand why permanent surface-water ponding has been occurring since 2017. The permanent surface-water ponding has created Park maintenance problems (mowing, die-off of lawn, an increase in weeds and sedges), aesthetic problems (muddy lawn areas creating unsanitary conditions for the pubic as a result of increased duck use) and has resulted in the shut-down of the spray park and the playground for parts of 2019 and all of 2020.

1.1 Background

Associated was originally retained by the City in 2018 to complete a groundwater investigation of the seepage and ponding of water in Polson Park (the study). The goal of the study was to help understand why long-term surface-ponding was occurring. The objectives of the study were to:

- Understand the subsurface lithology in the Park and associated aquifers;
- Identify groundwater and surface water (Vernon Creek) levels before and during freshet;
- Determine groundwater and surface water chemistry; and
- Determine the hydraulic connection between groundwater and surface water.

To meet these objectives, Associated completed the following scope of work in 2018:

- Installed a hydrometric station with a pressure-transducer data logger on Vernon Creek, to measure surface water level;
- Supervised the drilling and installation of three monitoring wells that were fitted with pressure-transducer data loggers (18MW01, 18MW02, and 18MW03) to collect groundwater level data;
- Completed a relative elevation survey of the hydrometric station and groundwater monitoring wells to a local elevation control point;
- Collected two sets of surface water and groundwater samples for chemistry analysis (i.e., pre-freshet and during freshet);
- Retrieved and processed surface water and groundwater data from the dataloggers; and

- Prepared two letter reports (a preliminary report dated April 5, 2018, and a final report dated August 1, 2018) summarizing the findings of the study and recommending options (Attachment A).

Following the 2018 reports, the City moved forward with Recommendation #4 (continue monitoring water levels in the monitoring wells and in Vernon Creek). Associated continued to maintain the dataloggers and monitor water levels throughout 2019 and 2020 (after a small pause in monitoring from October 2018-February 2019). In January 2020, Associated compiled the water level data for the City, delivered the dataset, and continued to monitor water levels to January 2021.

1.2 Objective and Scope of Work

The objective of the subsequent hydrogeology analysis was to expand the groundwater and surface water level dataset and provide recommendations based on the updated data. Associated completed the following scope of work in January and February 2021:

- Updated the most recent (January 2020) dataset and completed preliminary quality assurance/quality control of the dataset;
- Interpreted the data, reviewed the recommendations made in the 2018 reports, and made new recommendations, as needed, based on the expanded dataset; and
- Prepared this addendum memo to the 2018 report validating the 2018 recommendations (this document). These recommendations could be used to:
  - help the City and the Council determine next steps to address surface ponding;
  - aid in master planning for Polson Park; and
  - provide further technical investigation recommendations to potentially support grant applications that could supplement City funding (such as the Okanagan Basin Water Board Water Conservation and Quality Improvement Grant program, submission due February 26, 2021).

2 2018 RESULTS SUMMARY

Associated recommended four options/future studies to support mitigation of flooding issues (see Appendix A for further details):

1. Empty or lower the surface water elevation in the lower duck pond more often and for longer periods of time in the spring and summer to lower groundwater levels across the aquifer.
2. Remove the channelized portion of Vernon Creek and widen the Creek. A more detailed investigation into the construction of the wall and interactions with surface and groundwater levels (including interactions with the walls around the lower duck pond) would be warranted prior to implementation.
3. Dewatering wells strategically placed in the Park could help to reduce the groundwater level over a large area.
4. Continue to monitor water levels in the monitoring wells and Vernon Creek over time, which would provide valuable data to further assess the seasonal variability in groundwater-surface water interactions and could be used to aid in designing new infrastructure and park planning (COMPLETED).

3 WATER LEVEL DATA

Since 2018, Associated has periodically recorded manual water levels from the three monitoring wells (18MW01, 18MW02, and 18MW03), as well as the hydrometric station on Vernon Creek, and downloaded data from the transducers. Table 3-1 presents a summary of the manual water level data from 2018 to 2021.

Table 3-1
Manual Water Level Data (2018-2021)

Date	18MW01		18MW02		18MW03		Vernon Creek
	Depth to Water (mbtoc)	Elevation (relative to BM#1)[1]	Depth to Water (mbtoc)	Elevation (relative to BM#1)[1]	Depth to Water (mbtoc)	Elevation (relative to BM#1)[1]	Elevation (relative to BM#1)[1]
09-Feb-18	ND	ND	ND	ND	ND	ND	3.876
16-Feb-18	1.094	4.890	0.994	4.771	1.343	5.383	ND
28-Feb-18	1.103	4.881	1.004	4.761	1.358	5.368	ND
01-Mar-18	1.122	4.862	1.044	4.721	1.361	5.365	3.880
16-Mar-18	1.045	4.939	0.957	4.808	1.315	5.411	3.901
08-Jun-18	0.977	5.007	0.887	4.878	1.165	5.561	ND
13-Jun-18	ND	ND	ND	ND	ND	ND	4.217
21-Jan-19	1.180	4.804	1.098	4.667	1.415	5.311	3.910
04-Feb-19	ND	ND	ND	ND	1.430	5.296	3.884
26-Jun-19	1.290	4.694	1.164	4.601	1.582	5.144	3.678
11-Jul-19	ND	ND	ND	ND	ND	ND	3.677
06-Jan-20	1.150	4.834	1.165	4.600	1.470	5.256	3.759
24-Jul-20	0.754	5.230	0.885	4.880	0.665 [(2)]	6.061 [(2)]	4.232
27-Jul-20	0.746	5.238	0.642	5.123	0.865	5.861	4.213
09-Nov-20	1.020	4.964	0.900	4.865	1.170	5.556	3.868
18-Jan-21	1.140	4.844	1.040	4.725	1.315	5.411	3.801

Notes:
mbtoc = metres below top of casing
ND = No Data collected
[1] BM#1 refers to Bench Mark 1, set at an arbitrary height of 5 metes.
[2] Data point (18MW03 on July 24, 2020) believed to be inaccurate. Not used in data correction.

Water levels were converted to relative elevations using the survey data and used to calibrate the transducer data at each location. Associated used Aquarius (a third-party data processing software) to correct for any drift in the data and complete QA/QC on the dataset. One datapoint (18MW03 on July 24, 2020) was questionable and was removed from the data corrections. The data from the loggers were plotted along with the manual readings for the time period of February 2018 to January 2021 (Figure 3-1).

Figure 3-1
Groundwater and Surface Water Levels (February 2018 - January 2021)

4 DISCUSSION

The water level data for the period of record shows similar trends to those observed in 2018. Associated makes the following observations for the current dataset:

- The groundwater levels in the monitoring wells continue to closely mirror the water levels in Vernon Creek. Small spikes observed in the Creek are observed almost immediately within all groundwater wells. However, during freshet periods (typically between May and August), the Creek reaches a peak before the groundwater, indicating a delay of approximately one month.
- There was no observable freshet period in the record between May and August of 2019. This may be a result of the controlled flow within Vernon Creek[1]. During this period in 2019, groundwater levels also did not increase as a result of localized infiltration from precipitation/snowmelt within the Park – indicating groundwater levels are closely linked to Creek levels.
- Groundwater levels recorded in 18MW02 between October 2019 and July 2020 were quite variable and may be the result of an improperly functioning datalogger. This logger was adjusted on July 27, 2020 and groundwater level data thereafter appeared to improve.
- During freshet in 2018, the Creek levels reached a maximum of approximately 4.27 m, 18MW03 (for example) reached a maximum of approximately 5.62 m (difference of 1.35 m). In 2020, Creek levels peaked at similar levels (around 4.35 m), and maximum groundwater levels at 18MW03 reached a high of 5.86 m (difference of 1.51 m). The reason for this increase is not clear, but may be due to additional recharge sources contributing to the groundwater levels in the aquifer.
- In the study area, the groundwater levels in the aquifer are higher than the Creek level. This suggests a constant local groundwater flow direction towards the Creek. Monitoring well 18MW03 is closest to the Creek measurement station and groundwater levels are typically 1.5 m higher than the Creek.
- The steep hydraulic gradient between the monitoring wells and the Creek suggests that the concrete walls used to channelize the Creek may be acting as a barrier for the groundwater to flow into the Creek.
- The ponding water observed at the Park may be exacerbated by clay in the soil. Clay layer(s) were observed during drilling of 18MW02 and 18MW01, and this clay may reduce the local infiltration capacity of the ground, causing precipitation and snowmelt to pond in certain areas.
- The water levels in the monitoring wells are closely linked, which suggests that they are within the same aquifer and are being recharged by the same source, possibly from local recharge in the Park where the soil allows (i.e., where clay is not present) and/or from recharge of the hill northeast of the Park.
- At 8:30 on August 18, 2020 groundwater levels at 18MW01 and 18MW02 started to drop. By the same time next day, the levels had dropped by approximately 0.15 m. Groundwater levels at 18MW03 also lowered, but the drop was on the order of 0.10 m. During the same time period, the Creek level remained constant at approximately 4.08 m. The reason for this drop is unclear, although we understand that the City has been working on improving the drainage throughout the Park, which may explain this sudden drop in groundwater levels.
- We understand that the City has worked to lower the water levels in the duck pond multiple times over the past two summers and has observed little to no change in the surface ponding around the playground. However, based on observations made in the 2018 report, we know that the groundwater levels in the aquifer are

[1] Vernon Creek flow at Polson Park is largely controlled at the outlet of Kalamalka Lake.

connected to water levels in the pond. This suggests that the surface water flooding at the playground may not be connected to the underlying aquifer and that the clay layer (observed at 18MW01 and 18MW02) may be widespread and inhibiting the infiltration of surface water.

5 CONCLUSION

Based on the updated water level dataset, a preliminary review of work completed by the City operators, and the continued observations of ponding throughout the Park, Associated maintains that the mitigation options recommended in 2018 to lower groundwater levels throughout the aquifer are still valid and do not require updating.

Groundwater levels are closely linked to surface water levels, although some changes observed in the aquifer (e.g. August 18, 2020) are not influenced by the Creek. Recharge to the local aquifer within the Park is also not clear; there appears to be evidence for local recharge in the aquifer (i.e., some infiltration of precipitation/rain), but the potentially extensive clay layer observed at 18MW01 and 18MW02 likely reduces the potential for infiltration, at least in some areas. Due to the complex nature of the lithology and the largely unknown history of the Park, it is difficult to properly define the exact nature of the hydraulic connection between the aquifer and the Creek.

Based on our conversation with the City, we understand that the City is interested in pursuing the viability of option 2 (remove the Creek retaining walls) as it would result in:

- a more naturalized stream that would increase fish habitat and wildlife value,
- improved aesthetics of the Park, and
- reduce safety concerns as the wall is aging and the vertical walls may pose safety hazards for the public during high flow events.

Given the complexity of the lithology within the Park and the variability of the groundwater/surface water interaction, further investigations are warranted to determine potential impacts to the surface water ponding in the Park following the naturalization of the stream channel. As indicated above, the surface water ponding observed within the playground may be the result of a less permeable clay layer in the soil, inhibiting the infiltration of rain and snowmelt, rather than the result of increased groundwater levels.

To further investigate the feasibility of Option 2, we recommend the following investigations to have a deeper understanding of water level connections and assess the effectiveness/potential impacts of removing retaining walls (along the Creek and potentially duck pond) within the Park:

- Request a full record of and compare City Operation 2020 ponding mitigation actions (draining the duck pond, installing French drains, pumping out irrigation valve boxes, etc.) to water level data from 2020 to assess the effectiveness of these actions. Formulate short-term ponding mitigation recommendations based on the results of this comparison, if possible.
- Now that nearly three years of data have been recorded, the datalogging interval should be changed from 15 minutes to every 6 hours.

- Develop a work plan to assess the feasibility of removing the walls. This work plan may include:
  - installing additional monitoring wells in the Park near to areas of high concern.
  - installing additional hydrometric stations on Vernon Creek (at least 1 upstream of the current location) to better understand the hydraulic gradient within the creek.
  - collecting additional groundwater and surface water samples for comparison of water type.
  - conducting infiltration tests of the soil within the Park.
  - reviewing precipitation events and how they correspond to changes in groundwater and surface water levels.
- Review the results and recommendations from the City's Flood Mitigation Study that will be completed in April 2021.
- Review past stormwater management planning and future planning for Polson Park and area with City Engineers.
- Review available City documentation around the original channel construction of Vernon Creek and investigate the history of the construction and alignment of the original creek.

6 CLOSING

We trust the information provided herein is satisfactory and meets the objective of the hydrogeology analysis. If you have any questions or comments, please contact the undersigned at nadeauc@ae.ca.

Prepared by:

Mike Weldon P.Geo
Hydrogeologist

Reviewed by:

Carrie Nadeau, R.P.Bio.
Project Manager
Senior Ecologist

Attachment A:
Ponding water study at Polson Park, City of Vernon. August 1, 2018.

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August 1, 2018
File: 2018-8012

Kendra Kryszak
Parks Planner, Long Range Planning & Sustainability
City of Vernon
Community Services Building
3001 32 Ave
Vernon, BC V1T 2L8

Re: PONDING WATER STUDY AT POLSON PARK, CITY OF VERNON

Dear Ms. Kryszak:

Associated Environmental Consultants Inc. (Associated) was retained by the City of Vernon (the City) to complete a groundwater investigation (the study) into seepage and ponding of water at Polson Park (the park). This letter is the final document for the current scope of work with the City and expands upon the preliminary report provided on April 6, 2018 (Appendix A).[1]

1 BACKGROUND, OBJECTIVES AND SCOPE OF WORK

Vernon Creek (the creek) bisects the park located south of Vernon's downtown centre. The park includes several manmade water features including two ponds (upper and lower duck ponds) which are directly connected to the creek, and a Japanese garden with pond that is not directly connected to the creek. Ponding water has been observed near the washrooms, tennis courts, Japanese pagoda, and other small areas along the northern bank of the creek towards Highway 97. In 2012, the City carried out a preliminary investigation to determine the cause of the ponding and installed a series of French drains (i.e., passive water drainage systems comprised of drain rock and piping) to collect surface water and direct it to the upper duck pond. Water is no longer ponding near the washrooms, but ponding still occurs in some areas serviced by, and surrounding, the French drains.

The City retained Associated to complete a groundwater investigation to determine the origin of the ponding water and propose mitigation measures to reduce or eliminate the ponding.

The objectives of the investigation are to:

1. Understand the subsurface lithology at the park and associated aquifers.
2. Record groundwater and surface water levels before and during freshet.
3. Assess and compare groundwater and surface water chemistry.

[1] Associated Environmental Consultants Inc. 2018. Preliminary Assessment – Ponding Water Study at Polson Park, City of Vernon. Prepared for The City of Vernon. April 5, 2018.

4. Determine the hydraulic connection between groundwater and surface water.

Previously, Associated had completed the following tasks:

1. Attended a site visit and start-up meeting with the City.
2. Installed a hydrometric station with a pressure-transducer data logger on Vernon Creek.
3. Supervised the drilling and installation of three monitoring wells that included pressure-transducer data loggers.
4. Surveyed the hydrometric station and groundwater monitoring wells to a local elevation control point.
5. Collected surface water and groundwater samples pre-freshet for chemistry analysis.
6. Prepared a preliminary letter summarizing pre-freshet results (attached in Appendix A).

Following the preliminary report, Associated completed the following tasks:

7. Collected surface water and groundwater samples during peak creek flows for chemical analyses.
8. Retrieved and processed surface water and groundwater data from the dataloggers.
9. Prepared a final letter summarizing the freshet and post-freshet results (this letter).

2 SITE PHYSIOGRAPHY AND METHODOLOGY

The preliminary report discusses site physiography. For this letter, Associated collected additional water quality samples from Vernon Creek at the bridge that crosses the creek and from the three groundwater wells during peak flows in Vernon Creek. We also retrieved data from the dataloggers. Methods for these tasks is described in detail in the preliminary report (Appendix A).

3 RESULTS

3.1 WATER LEVEL MONITORING

On June 8, the data loggers from the three monitoring wells (18MW01, 18MW02, and 18MW03) were downloaded. On June 13, the data logger from Vernon Creek at Bridge hydrometric station were downloaded and the surface water level at the station was measured against the benchmark.

Water levels were converted to relative elevations using the survey data collected pre-freshet. Figure 3-1 shows groundwater elevations between February 16 and June 8, 2018 and surface water levels in Vernon Creek between February 10 and June 13, 2018. Figure 3-2 shows water elevation contours on June 8, during peak flows in Vernon Creek.

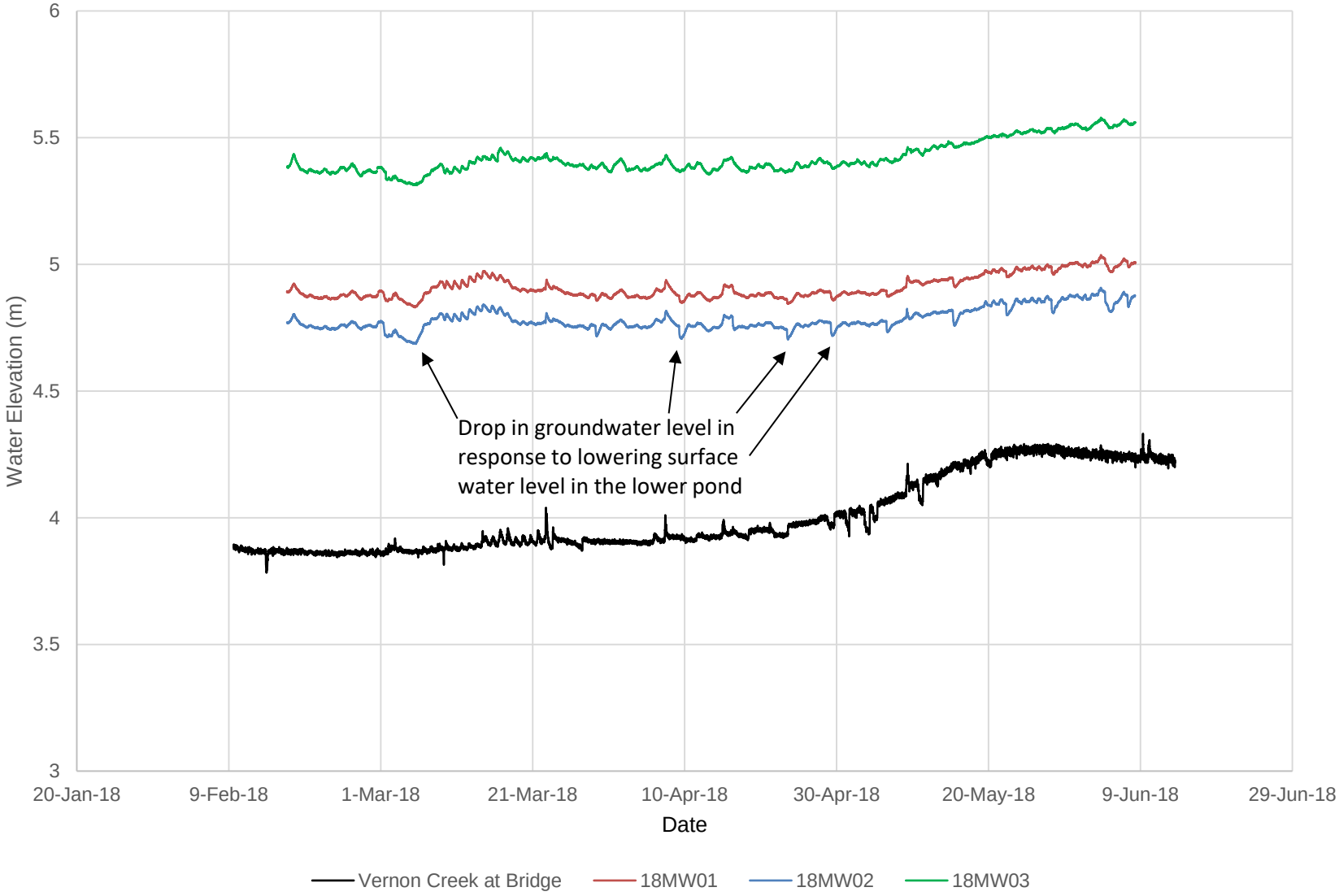

Figure 3-1
Groundwater and Surface Water Elevations (February 10 to June 13, 2018)

Figure June contours.mxd / 7/31/2018 / 9:53:42 AM

Associated Environmental

PROJECT NO.:	2018-8012.000.000
DATE:	August 2018
DRAWN BY:	DA

3-2 WATER LEVEL CONTOURS (JUNE 8, 2018)

City of Vernon

Polson Park Groundwater Study

The trend of groundwater levels and surface water levels pre-, during, and post-freshet (i.e., spring run-off) are very similar. For the period of record for this study, the creek level is always lower than the groundwater surface, suggesting that groundwater is recharging the creek. In most cases where surface and groundwater interact, during freshet, the creek level will be higher than the surrounding groundwater levels, causing the creek to contribute to groundwater. However, that is not the case here.

Every Monday throughout this period of record, the City would clean the duck pond. This involved lowering the water level in the lower pond. When this occurs, there is a short time-lag before the groundwater level in 18MW02 starts to drop in response. This is less pronounced in wells further away from the radius of influence, notably 18MW01 and 18MW03.

Toward the end of this period of record, the creek level started to decline, but the groundwater levels continue to rise, further increasing the gradient between the creek and the groundwater. This is to be expected as groundwater usually has a lag time before it will start to decline. Section 5 provides recommendations to continue monitoring of dataloggers to determine how the groundwater and surface water interact throughout the year.

3.2 WATER CHEMISTRY

The water chemistry laboratory report is attached in Appendix B. In both pre-freshet and freshet samples, the Piper Diagrams (Figures 3-4 and 3-5) indicate that the water from all four locations is generally a Calcium-Bicarbonate Type; however, wells 18MW01 and 18MW02 have a higher percentage sulphate and are borderline Calcium-Sulphate type. Between pre-freshet and freshet, the composition of 18MW01 and 18MW02 do not change substantially; however, the composition of 18MW03 and the creek do change. The sulphate in 18MW03 increases during freshet. Chloride reduces in the creek, while calcium increases during freshet. This suggests road salts used during winter are being diluted in surface water during freshet with higher flow volumes. The increased sulphate in the groundwater could be attributed to fertilizers, as sulphate is quite common in most fertilizers. However, looking at the overall composition, the surface water has a different signature from groundwater and changes in surface water chemistry are more pronounced than in the groundwater samples.

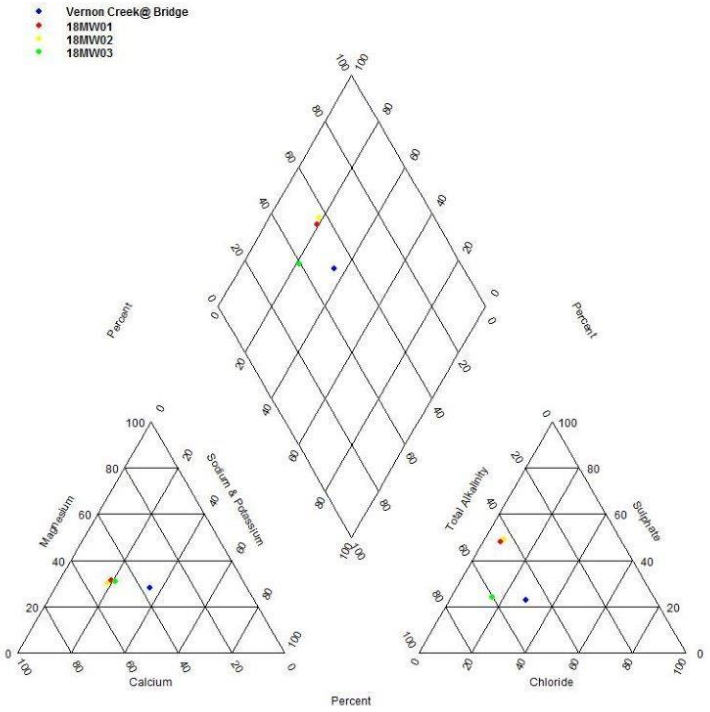

Figure 3-4
Piper Diagram showing composition of samples pre-freshet (Feb 28, 2018)

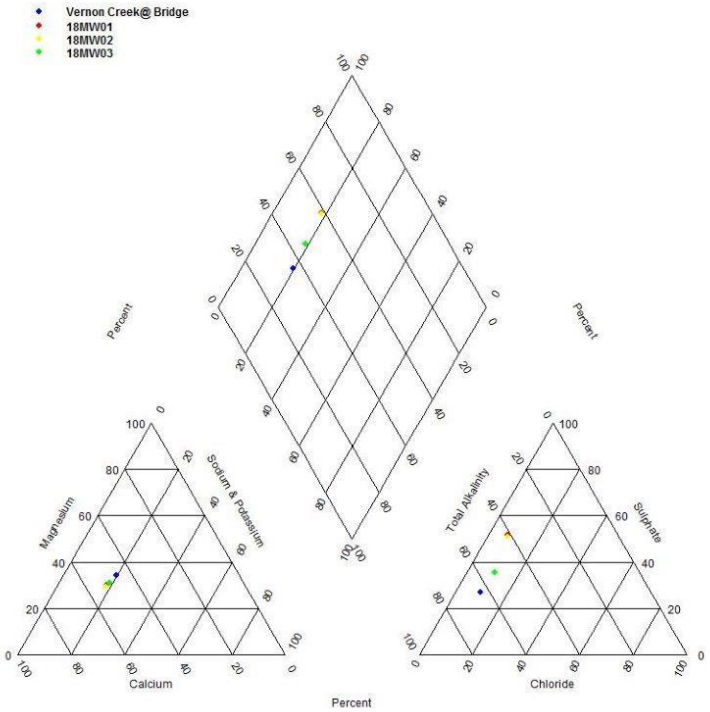

Figure 3-5
Piper Diagram showing composition of samples during freshet (June 8, 2018)

4 DISCUSSION

The water level data up to June 8, 2018 indicate groundwater elevations are always higher than Vernon Creek. The groundwater flow direction is from the northeast towards the creek. The hydraulic gradient becomes less steep during freshet when creek levels rise more quickly than groundwater levels, but the gradient between 18MW03 and the creek is an order of magnitude higher than the gradient around 18MW01 and 18MW02.

When the water level in the duck pond is lowered every Monday, the groundwater level in 18MW02 (the well closest to the pond) drops the most in response, while groundwater levels in 18MW01 and 18MW03 drop to a lesser extent.

Groundwater quality does not change significantly between pre-freshet and freshet, aside from a slight increase in sulphates in 18MW03 (the well nearest to the creek). The chemical signature of the creek changes the most significantly, largely due to higher volumes of water and therefore more dilution.

These data suggest that groundwater constantly contributes to flow in the creek; at no time during the period of record does the creek contribute to the aquifer. The monitoring wells are within the same aquifer and are recharged from local recharge in the park (snow-melt, precipitation, and irrigation) and from infiltration from the hill northeast of the park.

The ponding water observed at the park has likely been exacerbated by greater precipitation events and more snow-melt in recent years. Additionally, the clay layer(s) present in 18MW02 and 18MW01 reduce the local infiltration capacity of the ground, causing precipitation and snow-melt to pond in certain areas. Section 5 provides recommendations to continue to monitor groundwater levels.

5 RECOMMENDATIONS

Following a review of the hydraulic regime pre- and during freshet, we propose the following mitigation options.

1. Empty or lower the surface water elevation in the lower duck pond more often and for longer periods of time in the spring and summer to lower groundwater levels across the aquifer. This option will passively lower the groundwater level in the park and allow ponding water to more easily infiltrate the pond. If the City does not want to have an empty pond, the bottom of the pond could be excavated to allow for a deeper pond, and a lowered surface water elevation. An additional pond(s) to increase groundwater dewatering capacity is also an option. This option would be aesthetically pleasing to the park and a system can be put in place whereby ponds are dewatered in rotation, so at least one pond will have water during the summer months.

2. The hydraulic gradient between 18MW03 and the creek is quite high, suggesting that the retaining wall may be acting as a barrier to groundwater flow into the creek. Removing the channelized portion of the creek and widening the creek may help to lower creek levels and groundwater levels. The expectation is that groundwater will more freely flow into the creek, so groundwater elevations will drop to more closely mimic the creek elevation. However, without a more detailed understanding of the construction of the wall (i.e. depth of wall and potential seepage rates of groundwater through the wall) it is not clear what the extent of the impact of removing it will have on groundwater levels.
3. Since the aquifer is highly transmissive (i.e., groundwater moves through the soil easily), dewatering wells strategically placed in the park will help to reduce the groundwater level over a large area. Dewatering wells may have lower initial costs compared to Options 1 and 2 but will require annual operating and maintenance costs for the life of the well (~25 years).

We also recommend that the City purchase dataloggers to continually monitor groundwater levels in the three monitoring wells and creek levels at the bridge. Continually monitoring water levels will:

1. Provide valuable data to further assess the seasonal variability in groundwater-surface water interactions and fluctuations in water levels.
2. Monitor changes in groundwater levels once one or more mitigation option is implemented.
3. Provide the City with the variation in groundwater levels in the aquifer which can aid in designing new infrastructure and park planning.

Yours truly,

Mike Weldon, GIT
Hyrogeologist

Jacques Groenewald, M.Sc., P.Geo
Senior Hydrogeologist

Attachments:
Appendix A: Preliminary Report
Appendix B: Laboratory Report

Appendix A: Preliminary Report

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April 5, 2018
File: 2018-8012.000.000

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Community Services Building
3001 32 Ave
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Re: PRELIMINARY ASSESSMENT - PONDING WATER STUDY AT POLSON PARK, CITY OF VERNON

Dear Ms. Kryszak:

Associated Environmental Consultants Inc. (Associated) was retained by the City of Vernon (the City) to complete a groundwater investigation (the study) into seepage and ponding of water at Polson park (the park). This letter summarizes Associated's interim findings as part of the ongoing investigation.

1 BACKGROUND, OBJECTIVES, AND SCOPE OF WORK

Vernon Creek (the creek) bisects the park located south of Vernon's downtown centre. The park includes several manmade water features including two ponds (upper and lower duck ponds) which are directly connected to the creek, and a Japanese garden with pond that is not directly connected to the creek. Ponding water has been observed near the washrooms, tennis courts, Japanese pagoda, and other small areas along the northern bank of the creek towards Highway 97. In 2012, the City carried out a preliminary investigation to determine the cause of the ponding and installed a series of French drains (i.e., passive water drainage systems comprised of drain rock and piping) to collect surface water and direct it to the upper duck pond. Water is no longer ponding near the washrooms, but ponding still occurs in some areas serviced by, and surrounding, the French drains.

The City retained Associated to complete a groundwater investigation to determine the origin of the ponding water, and propose mitigation measures to reduce or eliminate the ponding.

The objectives of the investigation are to:

1. Understand the subsurface lithology at the park and associated aquifers.
2. Record groundwater and surface water levels before and during freshet.
3. Assess and compare groundwater and surface water chemistry.
4. Determine the hydraulic connection between groundwater and surface water.

To date, Associated has completed the following tasks:

1. **January 25, 2018 -** Attended a site visit and start-up meeting with the City.
2. **February 9, 2018** - Installed a hydrometric station with a pressure-transducer data logger on Vernon Creek.
3. **February 14-15, 2018** - Supervised the drilling and installation of three monitoring wells that included pressure-transducer data loggers.
4. **March 1, 2018** - Surveyed the hydrometric station and groundwater monitoring wells to a local datum.
5. **February 28, 2018** - Collected surface water and groundwater samples for chemistry analysis.
6. **April 5, 2018 -** Prepared a preliminary letter summarizing pre-freshet results (this letter).

Following freshet, Associated will complete a second round of sampling and water level analysis and provide the City with an updated report (sometime in June).

2 SITE PHYSIOGRAPHY

The park is at a low point in the valley and is relatively flat, with an approximate elevation of 376 metres above mean sea level (mamsl) (Figure 2-1). The park is bisected by Vernon Creek which originates at a controlled gate structure at Kalamalka Lake (hydrometric station number 08NM065), approximately 3 km upstream of the park and enters Okanagan Lake 5.8 km's downstream after leaving the park.

Vernon Creek flows from south to north through the entire length of the park and is channelized by concrete retaining walls for approximately 300 m at the southern extent of the park. In its channelized portion, the creek is approximately 3 m wide. Downstream of the retaining walls, stream banks are lined with small riprap and the channel width varies between 4.5 and 5.0 m. The streambed appears to be natural throughout the park, but this could not be confirmed during field investigations by Associated.

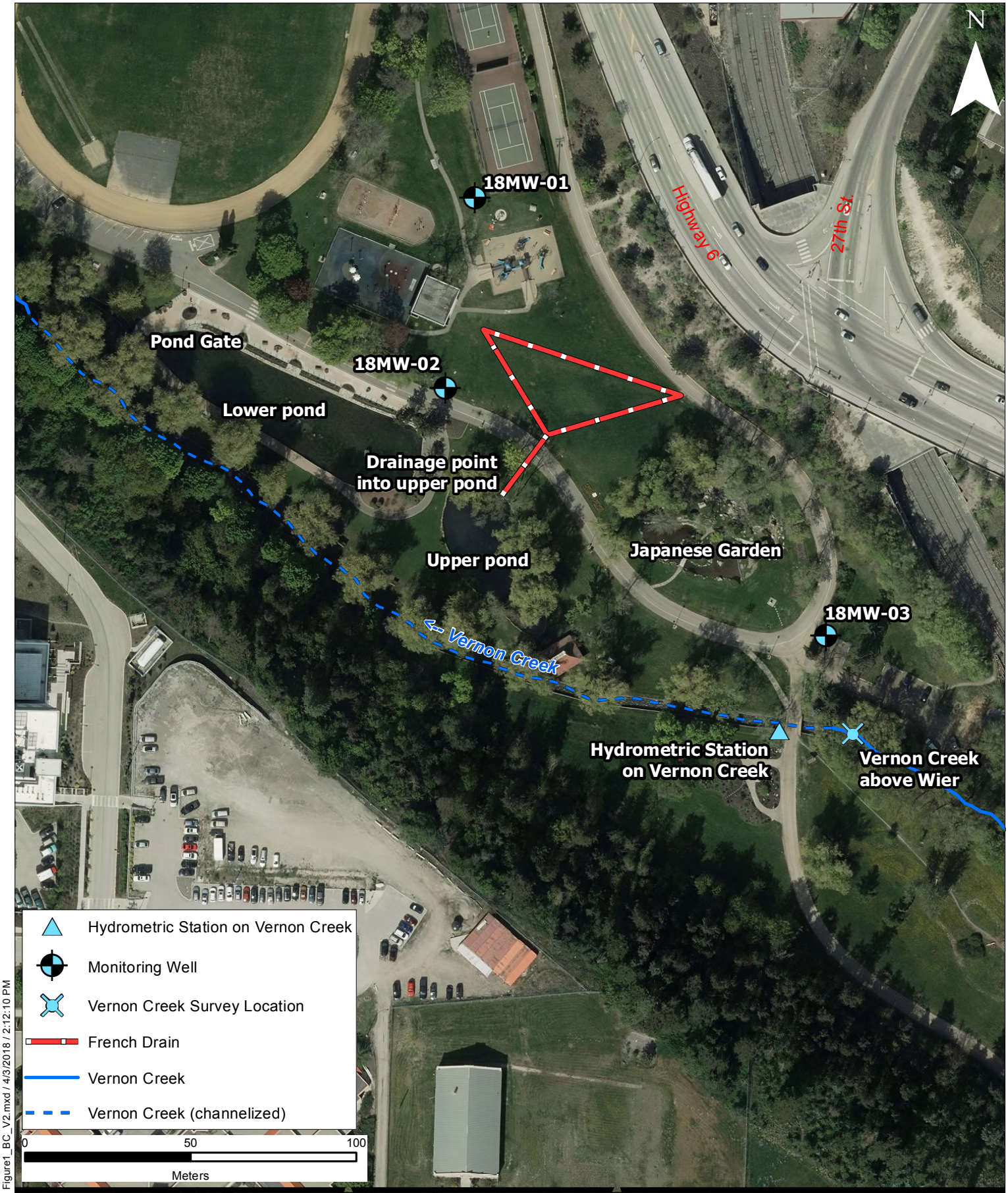
The upper duck pond has an intake from Vernon Creek located upstream of its channelized section. This intake has been nearly closed by the shut-off valve (approximately 95% closed) for the past several years.[1] The upper pond primarily receives water from the French drain system and from numerous other undocumented drainage pipes that may be connected to other French drains. Water from the upper pond flows freely into the lower pond via two 200 mm (approx.) diameter culverts. The lower duckpond is constructed with concrete walls, and the pond bed material is unknown due to significant sedimentation. The outlet of the lower pond is controlled by a gate that the City can manually open or close. Outflow from the lower pond joins Vernon Creek at the downstream extent of its channelized portion (Figure 2-1).

[1] Cyr, A. 2018. Personal communication (start-up meeting). City of Vernon. Vernon, BC.

A review of the BC Water Resources Atlas indicates there was a 152 mm diameter water supply well drilled in 1962 approximately 300 m northwest of the park, in what is now a parking lot. The borehole log from this well (Well Tag Number 17350) indicates surficial sediments comprising gravel, sand, and clay from 79.6 to 99.7 m; weathered bedrock to 105.8 m; and bedrock below 105.8 m.[2] Lithology information is missing from 0 to 79.6 m, but based on the depositional environment, material is presumed to be alluvial/fluvial in origin, comprising sand and gravel. Due to the proximity of the well to the park and Vernon Creek, the lithology and depth to bedrock is assumed to be similar.

Climate normals data are available for 1981-2010 from the Vernon Bella Vista climate station (Climate ID 1128553), located approximately 3.5 km west of the park at an elevation of 427 mamsl.[3] Daily average temperatures range from -2.1°C in January to 20.5°C in July, with an average annual temperature of 8.9°C. The average total precipitation is 428.1 mm/year with the majority occurring as snowfall between December and February (31.3 to 11.9 cm, respectively) and rainfall during May and June (41.7 and 47.4 mm, respectively).

[2] British Columbia Ministry of Environment. 2018. Groundwater Wells and Aquifers. WTN 17350. https://apps.nrs.gov.bc.ca/gwells/well/17350 accessed 26 March 2018.
[3] Environment Canada. 2018. Canadian Climate Normals 1981-2010 Station Data. Vernon Bella Vista. Climate ID 1128553.



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PROJECT NO.: 2018-8012.000.000
DATE: April 2018
DRAWN BY: DA

FIGURE 2-1: SITE PLAN

City of Vernon

Polson Park Groundwater Study

3 METHODS

3.1 HYDROMETRIC STATION INSTALLATION

On February 9, 2018, Associated's Field Hydrologist (Lawrence Bird, M.Sc.) and Field Hydrogeologist (Mike Weldon, GIT) installed a hydrometric station on Vernon Creek. The hydrometric station installation included the following:

- a stilling well and water level sensor (i.e., ONSET Hobo U20 pressure transducer);
- atmospheric pressure transducer (i.e., ONSET Hobo U20 pressure transducer); and
- two benchmarks and a complete site survey of each benchmark and water level.

The purpose of the hydrometric station was to continuously (at 15-minute intervals) record water levels in Vernon Creek. Changes in water levels would then be compared to relative changes in groundwater levels recorded in three groundwater monitoring wells installed within the park (Section 3.2).

The hydrometric station was installed under the most upstream pedestrian bridge in the southeast corner of the park, within the channelized section of Vernon creek (Figure 2-1). Approximately 10 m upstream from the hydrometric station, a control weir structure exists at the upstream extent of the channelized stream section.

3.2 MONITORING WELL INSTALLATION

Associated retained Kel Environmental Drilling Ltd. (Kel Drilling) to drill and install three groundwater monitoring wells at locations determined through discussion with the City. The locations were visited by the Field Hydrogeologist and City staff (K. Kryszak, A. Cyr, and G. Olson) to ensure the locations were clear of underground utilities. Between February 14 and 15, 2018, three groundwater monitoring wells were drilled and installed in the park (Figure 2-1).

During drilling, Associated's Field Hydrogeologist was on site to record lithology and design construction. Boreholes were advanced using hollow-stem augers, while split-spoon samples were continuously collected in 0.76 m lengths. Boreholes were drilled to approximately 9 m, at which point monitoring wells were installed. Monitoring wells comprised schedule 40 PVC with 3.05 m length 10-slot screen and 10/20 sand artificial filter packs. Above the artificial filter pack, the borehole annulus was filled with bentonite. The wells were completed with stick-ups approximately 0.75 m above grade, and finished with lockable steel protectors cemented into place.

On February 16, 2018 ONSET Hobo U20 pressure transducer dataloggers were suspended from steel cables approximately 30 cm from the bottom of each well to record groundwater levels every 15 minutes (i.e., the same schedule as the dataloggers at the hydrometric station).

On February 28, 2018, the Field Hydrogeologist developed the newly drilled monitoring wells by pumping and discharging water and fine sediment from the wells for at least 30 minutes. A combination of inertial pump (foot valve and Waterra™) and submersible pumps were used to clean the wells out and improve turbidity to below 10 NTU.

The three monitoring wells were given the identifiers 18MW01, 18MW02, and 18MW03; based on the order they were drilled in.

3.3 LOCAL ELEVATION SURVEY

To ensure that water levels recorded at the hydrometric station and at each of the groundwater monitoring wells are relative to the same benchmark, Associated completed a local elevation survey on March 1, 2018. The local survey determined the elevation of the two benchmarks at the hydrometric station, water level at the hydrometric station, and the three groundwater monitoring wells. All of the benchmark points were referenced to an assumed elevation datum (5.000 m) assigned to the benchmark at the southern bridge abutment of the pedestrian bridge near the hydrometric station.

3.4 WATER QUALITY SAMPLING (PRE-FRESHET)

Towards the end of well development (Section 3.2) and while using the submersible pump, the Field Hydrogeologist measured field parameters (pH, conductivity, redox potential, dissolved oxygen, temperature, and turbidity) of the discharge water. When field parameters were stable and approximately 30 well-volumes had been removed, water samples were collected in laboratory-supplied containers and sent via chain of custody protocol to CARO Analytics in Kelowna, BC for analysis of the following constituents:

- Chloride
- Fluoride
- Nitrate (as N)
- Nitrite (as N)
- Sulfate
- Alkalinity
- Ammonia, Total (as N)
- Total Dissolved Solids
- Hardness
- Dissolved Metals

Grab samples were collected from Vernon Creek approximately 1 m upstream of the weir and submitted to CARO for the same set of constituents as listed above. Field parameters were measured in the creek using a YSI 556 multi-parameter sensor.

Tri-linear diagrams (i.e., Piper, Extended Durov, and Stiff diagrams) were generated using the water quality data from Vernon Creek and monitoring wells 18MW01, 18MW02, and 18MW03. These diagrams provide

six major ions or combinations of ions plotted onto one diagram[4], and are used to assess the different types of water present at the park. Groundwater types are influenced by residence time (i.e., freshly recharged vs. longer residence time and higher mineralization).

3.5 AQUIFER TESTING

Between development and sampling at 18MW02, the submersible pump was used to perform a 60-minute constant-rate discharge test. The pump intake was installed approximately 0.3 m above the bottom of the well and discharged at a rate of 0.21 L/s for 60 minutes. During this time, the flow rate was measured with a bucket and stop watch, while groundwater levels were measured with an electric water level tape. After 60-minutes, the pump was shut off, allowing water levels to recover.

The data was analyzed with Aquifer Test Pro using Theis, Cooper & Jacob, and Theis Recovery solutions to determine the hydraulic conductivity of the aquifer.

[4] Hounslow, A.W. 1995. Water Quality Data, Analysis and Interpretation. CRC Press LLC. ISBN 0-87371-676-0.

4 RESULTS

4.1 MONITORING WELL CONSTRUCTION

Table 4-1 summarizes the construction of the monitoring wells. Well logs are provided in Appendix A.

Table 4-1 Monitoring Well Construction Details

Monitoring Well-ID		18MW01	18MW02	18MW03
Monitoring Well Location	Easting (m) (11 U)	338245	338236	338351
	Northing (m) (11 U)	5569828	5569770	5569696
	Ground elevation (m)[1]	5.231	5.013	5.984
	Top of casing elevation (m)[1]	5.984	5.765	6.726
Monitoring Well Construction	Date drilling completed	2/14/2018	2/14/2018	2/15/2018
	Borehole depth (m bg)[2]	8.84	8.84	8.99
	10-slot screened interval (m bg)	5.79-8.84	4.88-7.92	5.79-8.84
Groundwater Elevation (m)[1]	2/16/2018	4.889	4.771	5.383
	3/16/2018	4.939	4.808	5.411

1. Elevation is relative to benchmark at hydrometric station.
2. m bg = metres below ground.

A sand and gravel aquifer was intersected at all three wells. In 18MW01 it was intersected at 5.18 m bg and the material above the aquifer included dry silts and clays with some till-like material, suggesting the aquifer was locally confined. In 18MW02, the aquifer was intersected at 2.13 m bg and was overlain by firm white clay and sand and gravel. In 18MW03, the aquifer was intersected below the topsoil, 0.15 m bg. The upper lithology in the park is quite variable, but based on its composition; the sand and gravel aquifer is believed the be laterally extensive. The clay layer observed in 18MW01 and 18MW02 was not observed in 18MW03, so this confining unit is not laterally extensive.

4.2 WATER LEVEL MONITORING AND AQUIFER TEST RESULTS

On March 16, 2018 the data loggers from the Vernon Creek hydrometric station and the three wells were downloaded. The surface water level at the Vernon Creek hydrometric station was measured against the benchmark and another location on the creek approximately 10 m upstream of the weir (Figure 2-1). On

March 16, 2018 at 11:17, the water level approximately 10 m upstream from the weir was measured to be 0.384 m higher than at the hydrometric station.

Figure 4-1 shows water levels over time in the three monitoring wells and at the hydrometric station. Hourly temperature data from February 9 to March 17, 2018 recorded at Vernon Auto (Climate ID 1128582) is also included.

The water levels recorded on March 16, 2018 were converted to elevations relative to the benchmark at the hydrometric station and input to Surfer 12, a gridding and contouring software, to generate water elevation contours (Figure 4-2).

The results of the aquifer test on 18MW02 are provided in Appendix B. The hydraulic conductivity for the aquifer material is approximately 3.86×10^{2} m/day. This is a relatively high value and indicates that groundwater flows at higher rates through the porous medium. This value is typical of sand and gravel aquifers.[5]

[5] Freeze, R. A., and Cherry, J. A. 1979. Groundwater. Prentice-Hall, Inc., Englewood Cliffs, N.J.

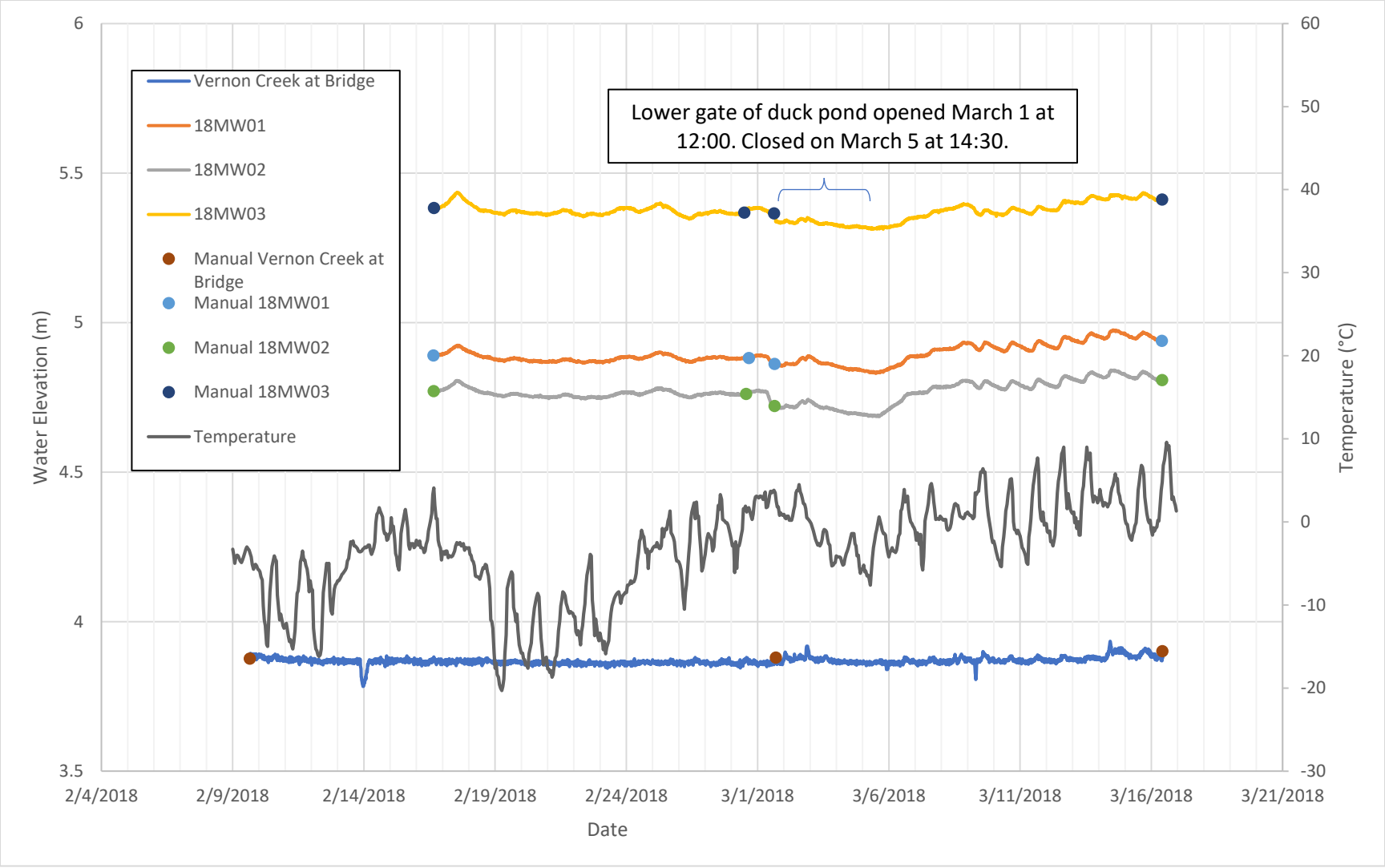
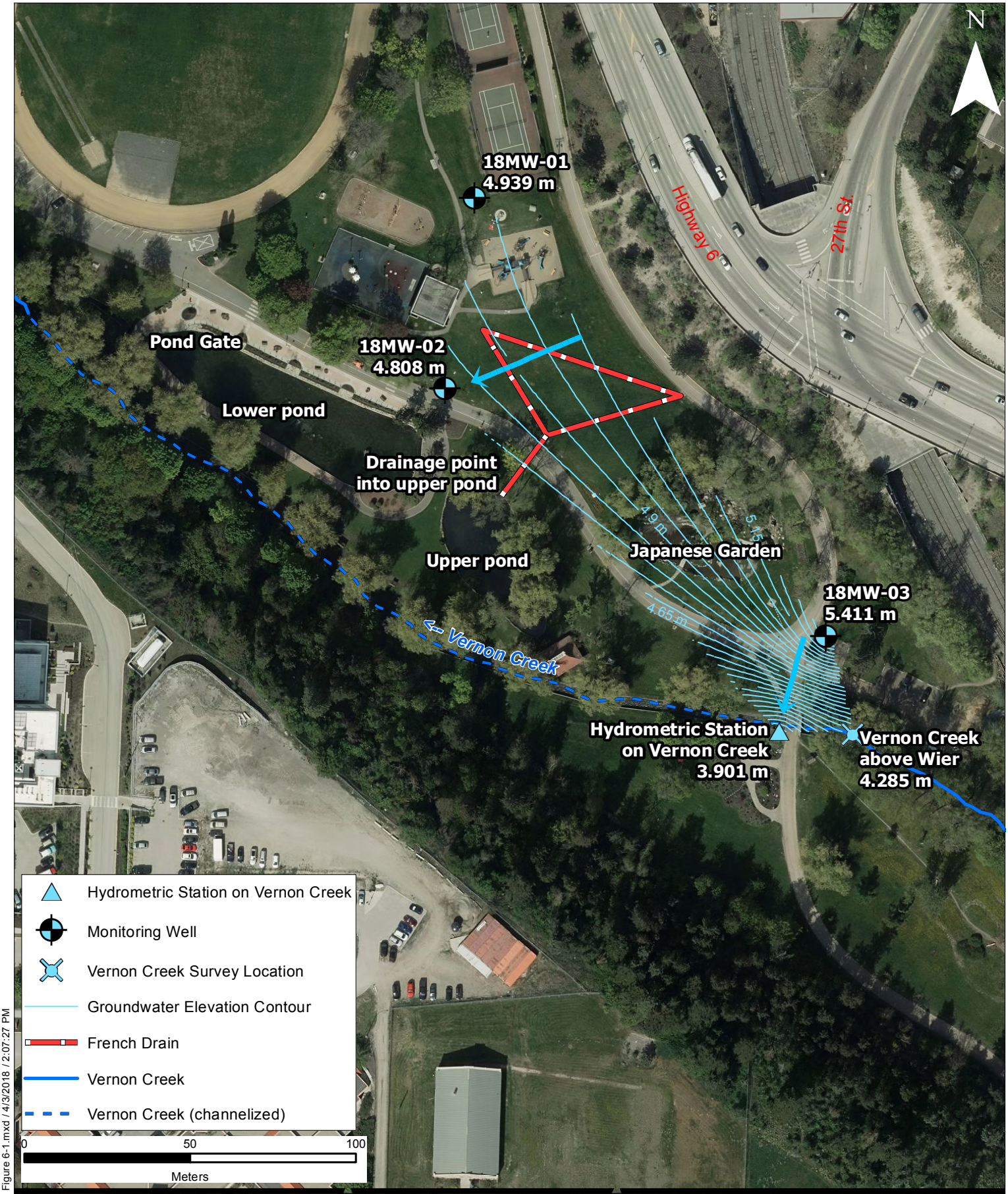


Figure 4-1

Water levels in Vernon Creek and monitoring wells. Hourly temperature data from February 9 to March 17 recorded at Vernon Auto.



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PROJECT NO.: 2018-8012.000.000
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FIGURE 4-2: WATER LEVEL CONTOURS (MARCH 16, 2018)

City of Vernon

Polson Park Groundwater Study

The changes in groundwater levels in all three wells closely match one another, suggesting that monitoring wells are all installed in the same aquifer. On March 1, the lower duck pond was emptied, which resulted in an almost immediate drop in water level in all three wells. The drop was most pronounced in 18MW02 (the well closest to the pond) and least pronounced in 18MW03 (the well furthest from and upgradient from the pond). The pond was refilled on March 5, causing the groundwater levels in the monitoring wells to rise again. After March 6, 2018, temperatures in Vernon start to rise above 0 °C during the day, and groundwater and surface water levels begin to experience diurnal fluctuations in response. In comparing the lag between the peak water levels at each point, there does not seem to be a pattern. For the most part, the creek levels rise first and are followed shortly after by the groundwater levels, but on some days (e.g., March 15, 2018) the groundwater levels rise before the creek levels.

The contour data indicate groundwater flow direction is from the northeast hill towards the creek. This is typical during times of low creek flow (i.e., pre-freshet) when groundwater is contributing to the base-flow of the creek. The hydraulic gradient is high between 18MW03 and Vernon Creek (0.05 m/m), compared to the hydraulic gradient near 18MW01 and 18MW02, which is approximately 0.005 m/m. Also of note is that the groundwater levels at this time of the year are much higher than the creek levels. Based on the hydraulic gradient recorded, it is not possible for the creek to recharge the aquifer. This is in line with normal groundwater discharge to creeks during low baseflow conditions. Water levels in the creek and wells will continue to be recorded, as this may be reversed during higher creek flow events (i.e., during freshet).

4.3 WATER CHEMISTRY

The water chemistry laboratory report is attached in Appendix C. The Piper and Expanded Durov Diagrams (Figures 4-3 and 4-4) indicate that the water from all four locations is generally a Calcium-Bicarbonate Type; however, wells 18MW01 an 18MW02 have a higher percentage sulphate and are borderline Calcium-Sulphate type. Well 18MW03 is more freshly recharged and similar to Vernon Creek, likely reflecting mixing with the creek. Wells 18MW01 and 18MW02 have higher Total Dissolved Solids (TDS), indicating a longer groundwater residence time than 18MW03, but they are still generally freshly recharged.

The Stiff Diagrams (Figure 4-5) are a way of plotting the major-ion composition of water to produce a symbol whose shape indicates the relative proportions of the different ions and whose size indicates total concentrations. It is particularly useful to show similarities and differences among different groundwater types[6] at a glance.[7] These diagrams confirm what is shown in the Piper and Expanded Durov Diagrams: 18MW01 and 18MW02 have a similar signature (although sulphate is higher in 18MW02), and 18MW03 and Vernon Creek have a similar signature (although sodium and chloride is higher in Vernon Creek).

The TDS component in Vernon Creek is relatively high for surface water, which suggests the groundwater inflow component to surface water during this time of year (i.e., baseflow period) may be quite significant. This should be the case with normal groundwater flow characteristics during the time of year when creek levels are low, and groundwater discharges into the creek. During freshet or higher creek flow events this could change substantially to be mostly dominant surface water (with less groundwater influence). Additionally, the observed chemistry could reflect the many potential external influences to this creek (i.e. anthropogenic influences).

[6] Groundwater type refers to the major ionic composition of water found in a specific aquifer hosted by a specific geological formation and yields some information on residence time and water-rock (material) interaction.
[7] Drever, James, I. 1997. The geochemistry of natural waters: surface and groundwater environments. 3rd edition. Prentice-Hall, Inc. ISBN 0-13-272790-0.

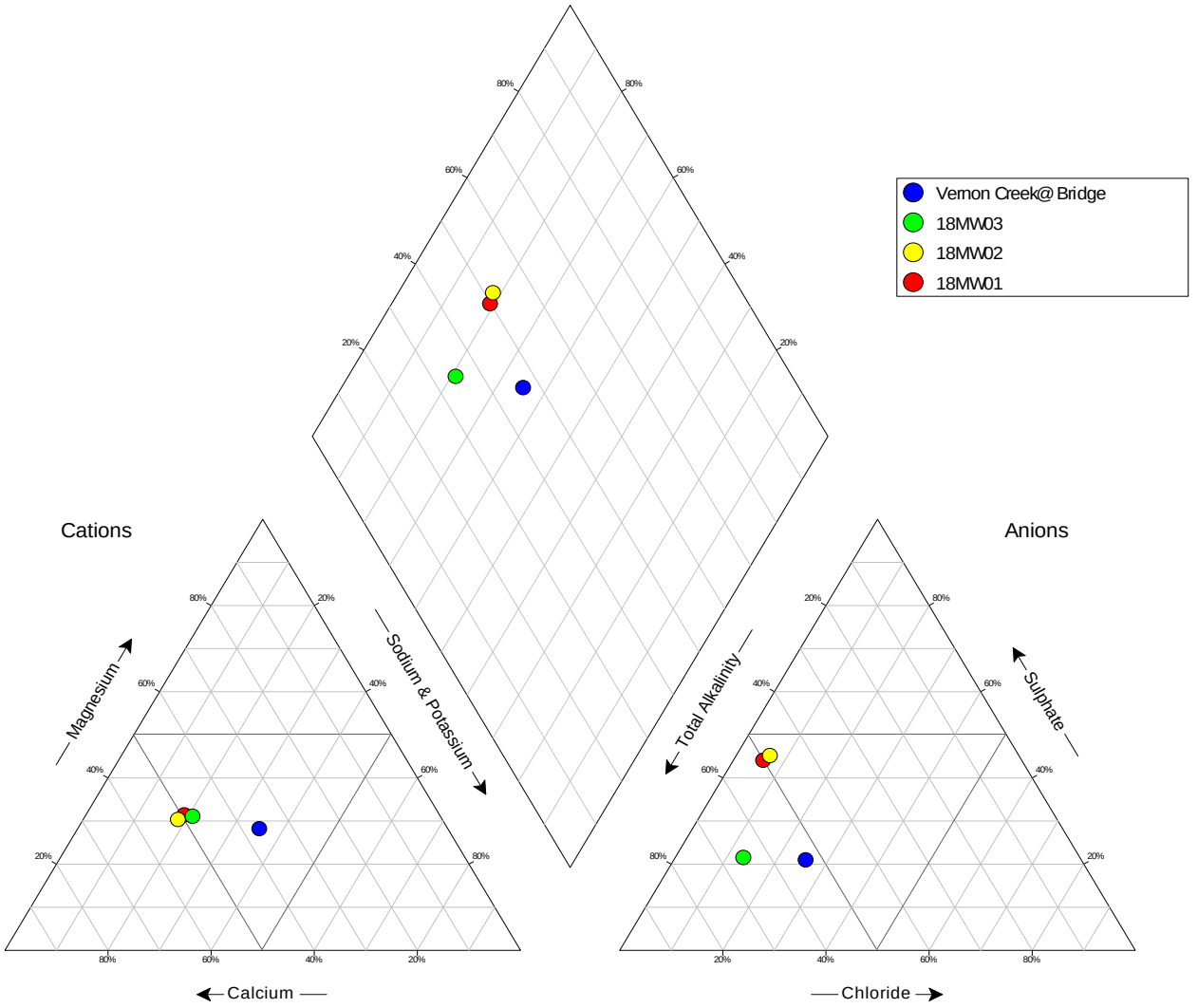


Figure 4-3: Piper Diagram

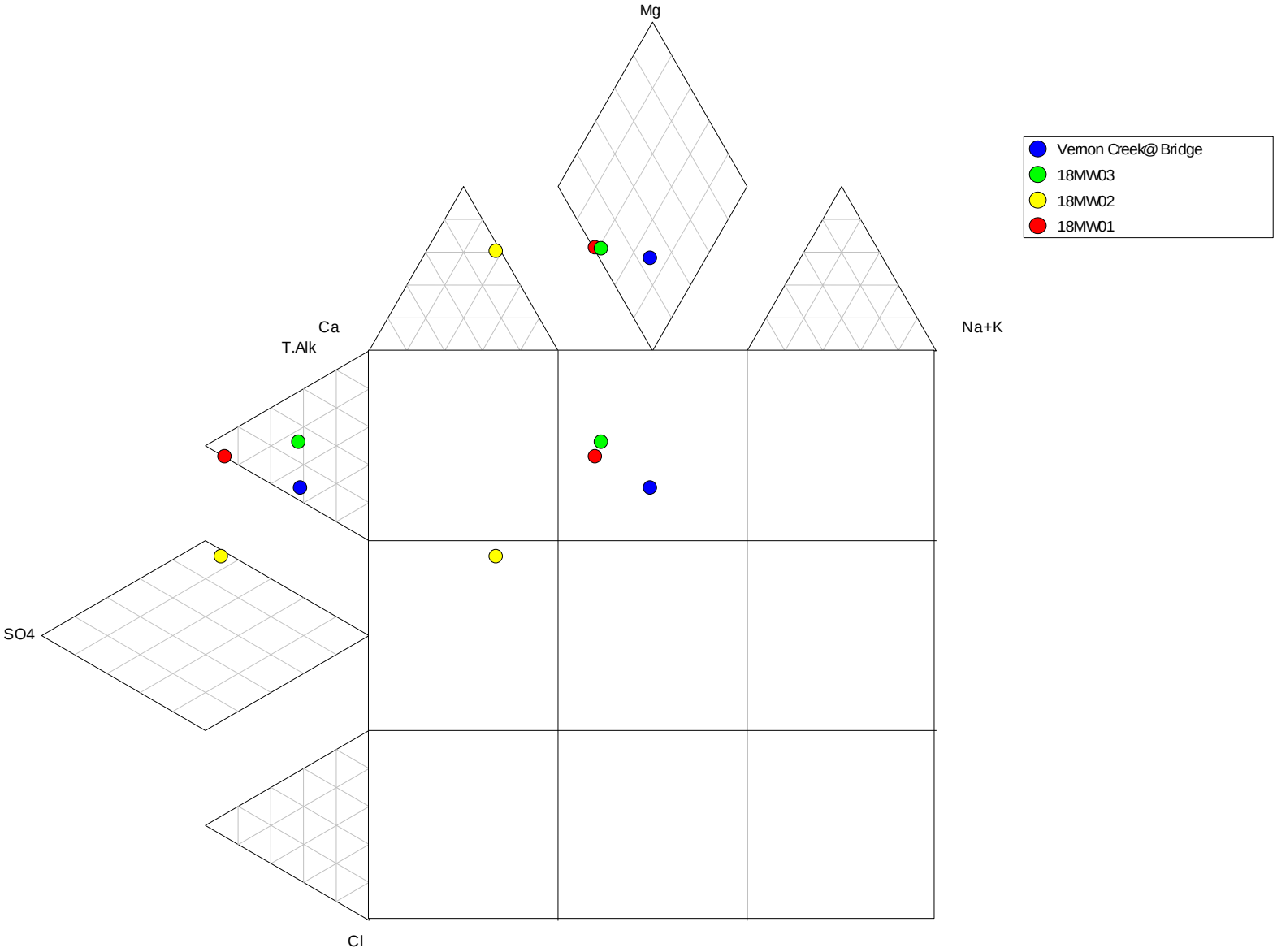


Figure 4-4: Expanded Durov Diagra

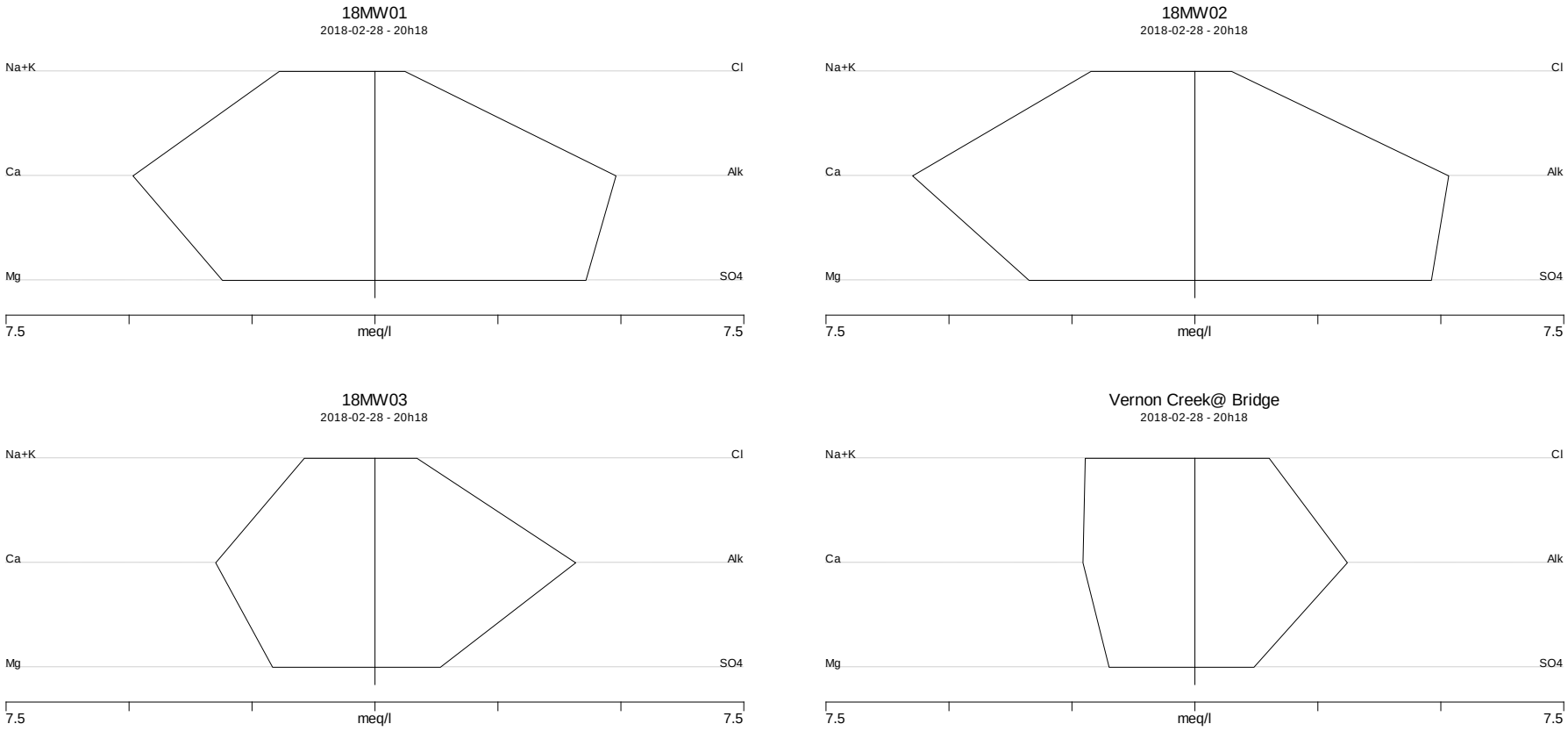


Figure 4-5: Stiff Diagrams

5 DISCUSSION

The aquifer at the park is a sand and gravel aquifer that extends to an unknown depth, but extends to at least 9 m in the eastern portion of the park. It is primarily unconfined, with some local confining layers near wells 18MW01 and 18MW02.

The water level data (Figures 4-1 and 4-2) indicates that groundwater elevations are higher than surface water levels in Vernon Creek up to and including March 16, 2018. Throughout the park, the groundwater flow direction is from the northeast towards the creek. Near 18MW01 and 18MW02, the hydraulic gradient is 0.005 m/m, while it is 0.05 m/m between 18MW03 and Vernon Creek.

When the lower duck pond was emptied, groundwater levels lowered. This indicates that the lower duck pond was receiving groundwater from the aquifer due to an increased water level difference between the aquifer and the lower duck pond. Groundwater levels continued to drop until the outflow of the lower duck pond was closed, which caused groundwater levels to rise again.

The groundwater is Calcium Bicarbonate Type with 18MW02 being borderline Calcium Sulphate Type. Based on both Piper and Expanded Durov, Vernon Creek and 18MW03 are freshly recharged water. Since 18MW03 is closest to the creek, there may be some mixing between the aquifer and creek in this area. The other two wells have higher TDS, which means they likely have a longer residence time but are still freshly recharged.

These data suggest that groundwater is currently contributing to baseflow in the creek. All of the monitoring wells are within the same aquifer, and are likely currently being recharged from local recharge in the park (snow-melt) and from infiltration from the hill northeast of the park. At this time of year, the creek does not appear to be contributing water to the aquifer.

The ponding water observed at the park has likely been exacerbated by greater precipitation events and more snow-melt in recent years. Additionally, the clay layer(s) present in 18MW02 and 18MW01 reduce the local infiltration capacity of the ground, causing precipitation and snow-melt to pond in certain areas.

6 RECOMMENDATIONS

Based on these findings we recommend proceeding with the following work (as per the scope of work):

1. Continue monitoring water levels in Vernon Creek and the monitoring wells during freshet.
2. Complete one more round of water sampling during peak flows and analyze for the same constituents.
3. Prepare an addendum to this report with any additional findings (to be completed after freshet 2018, sometime in June).

Based on this preliminary review of the data, Associated proposes the following potential mitigation options:

1. Empty the lower duck pond more often and for longer periods of time in the spring and summer to lower groundwater levels across the aquifer. This option will passively lower the groundwater level in the park and allow ponding water to more easily infiltrate into the ground.
2. Explore options to drill dewatering wells at strategic locations within the park to actively lower the groundwater level in the future.
3. Remove the retaining wall and naturalize the Vernon Creek stream channel to more easily allow the flow of groundwater into the creek.

As we are still in the data acquisition phase we do not anticipate the application of any of the above three options until sufficient freshet data is available for interpretation. As part of our ongoing investigation, we may need to empty the lower duck pond to further assess its interaction with groundwater. Associated will liaise with the City when this is to occur.

7 CLOSURE

The services provided by Associated in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions. No other warranty expressed or implied is made.

We trust this completes our assessment to your satisfaction. Please contact the undersigned if you have any questions or would like to discuss any aspect of this report.

Yours truly,

Mike Weldon, GIT
Hydrogeologist

Jacques Groenewald, M.Sc. P.Geo.
Senior Hydrogeologist

Attachments:
Appendix A – Well Logs
Appendix B – Aquifer Test Results
Appendix C – Laboratory Reports

Appendix A: Well Logs

Project Details		18MW01	Location	
Project Number:	2018-8012		Northing (m):	5569828
Client:	City of Vernon		Easting (m):	338245
Location:	City of Vernon		Elevation (m):	5.231

Subsurface Profile

Well Completion

Depth (m)	Graphic Log	Description	Well Construction	Details	Depth (m)

Ground Level (m): 5.231

0 — Sandy clay with organics (0-0.15 m)

Sub-angular medium sand. Light grey. Moist. (0.15-0.76 m)

1 — White. Dry. Blocky. (0.76-1.22 m)

Fine sand and clay. Brown. (1.22-1.83 m)

2 — Grey. (1.83-2.13 m)

Fine. Grey. Wet (2.13-2.44 m)

Silty. Brown. Wet. (2.44-2.90 m)

3 — Medium sand. Some wood at 2.90 m. (2.90-3.51 m)

Sandy. Brown. Seam of fine sand from 3.66-3.75 m (3.51-3.75 m)

4 — Firm clay with cobbles and gravel. (Till). (3.75-4.72)

5

6

Some coarse gravel. Brown. Water Bearing (4.72-8.84 m)

7

8

1.045 m btoc

Stick-Up Protector

Sched 40 PVC (50 mm) with 10-slot screen

10-20 Sand

-0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5

Associated Environmental

Lithology Legend

Clay | Sand | Sand and Gravel | Topsoil

Construction Legend

Screen | Bentonite | Sand | Casing | Well Cap

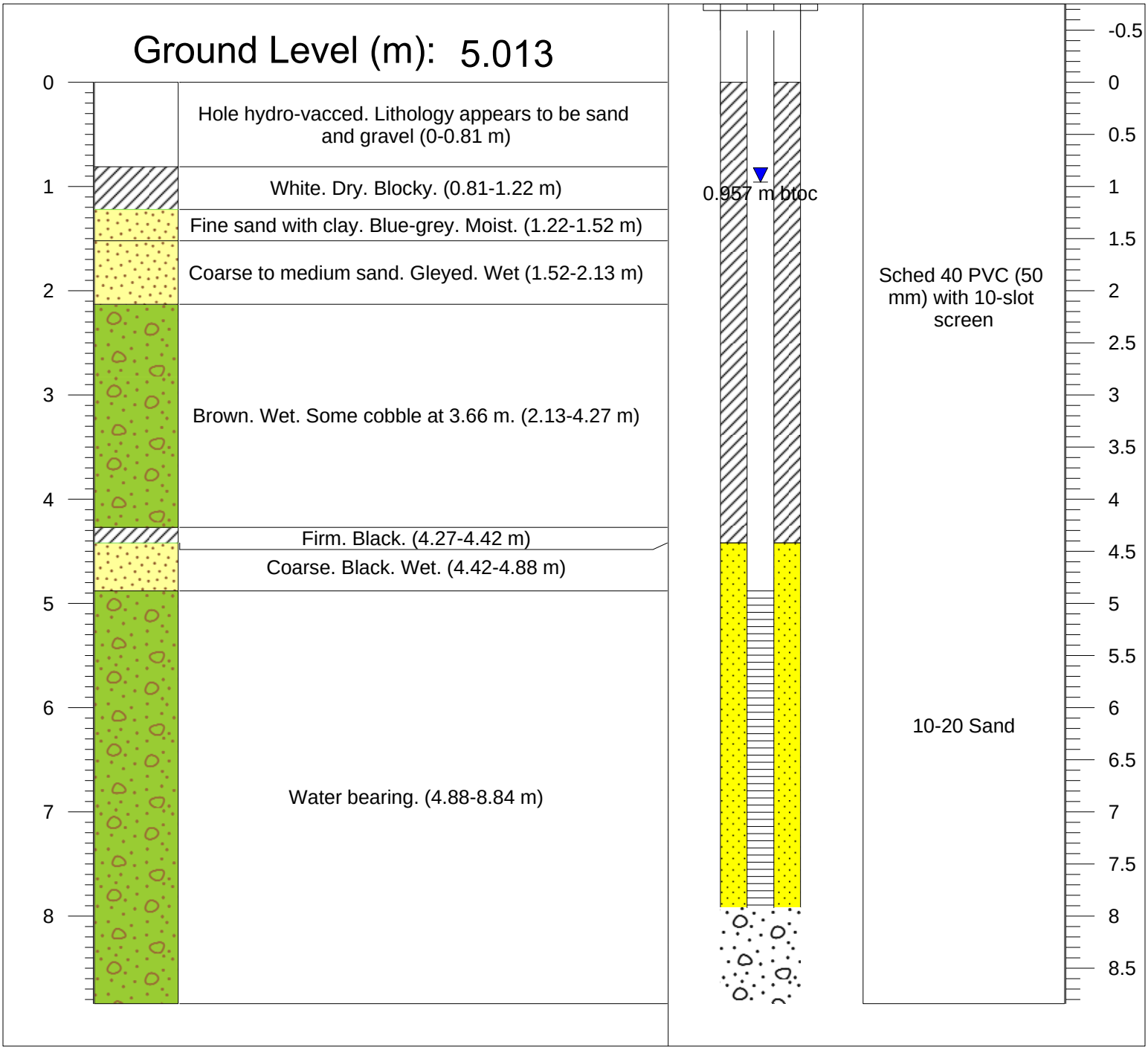
Contractor:	Kel Drilling
Operator:	Kelvin Marte
Date of Construction:	14 / Feb / 2018
Drawn by:	M. Weldon

Project Details		18MW02	Location	
Project Number:	2018-8012		Northing (m):	5569770
Client:	City of Vernon		Easting (m):	338236
Location:	City of Vernon		Elevation (m):	5.013

Subsurface Profile

Well Completion

Depth (m)	Graphic Log	Description	Well Construction	Details	Depth (m)



Associated Environmental

Lithology Legend

Clay | Sand | Sand and Gravel

Construction Legend

Screen | Bentonite | Well Cap

Casing | Native Material | Sand

Contractor:	Kel Drilling
Operator:	Kelvin Marte
Date of Construction:	14 / Feb / 2018

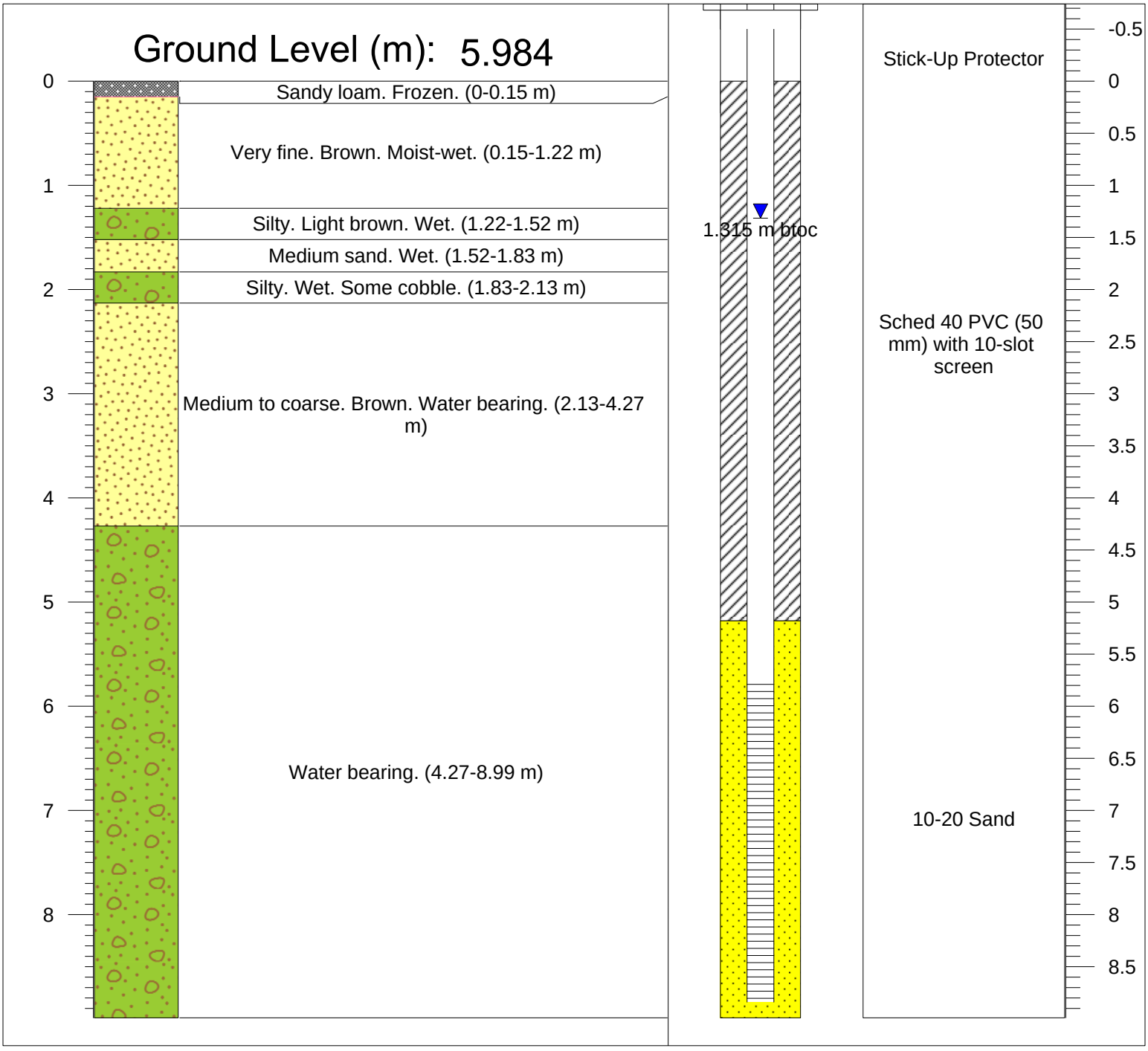
Drawn by: M. Weldon

Project Details		18MW03	Location	
Project Number:	2018-8012		Northing (m):	5569696
Client:	City of Vernon		Easting (m):	338351
Location:	City of Vernon		Elevation (m):	5.984

Subsurface Profile

Well Completion

Depth (m)	Graphic Log	Description	Well Construction	Details	Depth (m)



Associated Environmental

Lithology Legend

Topsoil | Sand | Sand and Gravel

Construction Legend

Screen | Bentonite | Sand | Casing | Well Cap

Contractor:	Kel Drilling
Operator:	Kelvin Marte
Date of Construction:	15 / Feb / 2018

Drawn by: M. Weldon

Appendix B: Aquifer Test Results

Associated Environmental

Pumping Test - Water Level Data

Project: Polson Park GW Study

Number: 2018-8012.000.000

Client: City of Vernon

Location: Polson Park	Pumping Test: Constant Discharge Test	Pumping Well: 18MW02
Test Conducted by: M. Weldon	Test Date: 2/28/2018	Discharge: variable, average rate 0.214 [l/s]
Observation Well: 18MW02	Static Water Level [m]: 1.00	Radial Distance to PW [m]: -

	Time [s]	Water Level [m]	Drawdown [m]
1	30	1.039	0.039
2	60	1.039	0.039
3	90	1.042	0.042
4	120	1.042	0.042
5	180	1.042	0.042
6	240	1.043	0.043
7	300	1.042	0.042
8	360	1.042	0.042
9	420	1.042	0.042
10	480	1.043	0.043
11	540	1.042	0.042
12	600	1.043	0.043
13	720	1.045	0.045
14	840	1.043	0.043
15	960	1.043	0.043
16	1200	1.043	0.043
17	1500	1.043	0.043
18	1800	1.043	0.043
19	2100	1.043	0.043
20	2400	1.043	0.043
21	2700	1.043	0.043
22	3000	1.043	0.043
23	3600	1.043	0.043
24	3630	1.004	0.004
25	3690	1.002	0.002
26	3720	1.002	0.002
27	3750	1.001	0.001
28	3780	1.00	0.00

Associated Environmental

Pumping Test - Discharge Data

Project: Polson Park GW Study

Number: 2018-8012.000.000

Client: City of Vernon

Location: Polson Park	Pumping Test: Constant Discharge Test	Pumping Well: 18MW02
Test Conducted by: M. Weldon	Test Date: 2/28/2018	Discharge: variable, average rate 0.214 [l/s]
Observation Well: 18MW02		Radial Distance to PW [m]: -

	Time [s]	Discharge [l/s]
1	3600	0.214
2	3601	0.00

Associated Environmental

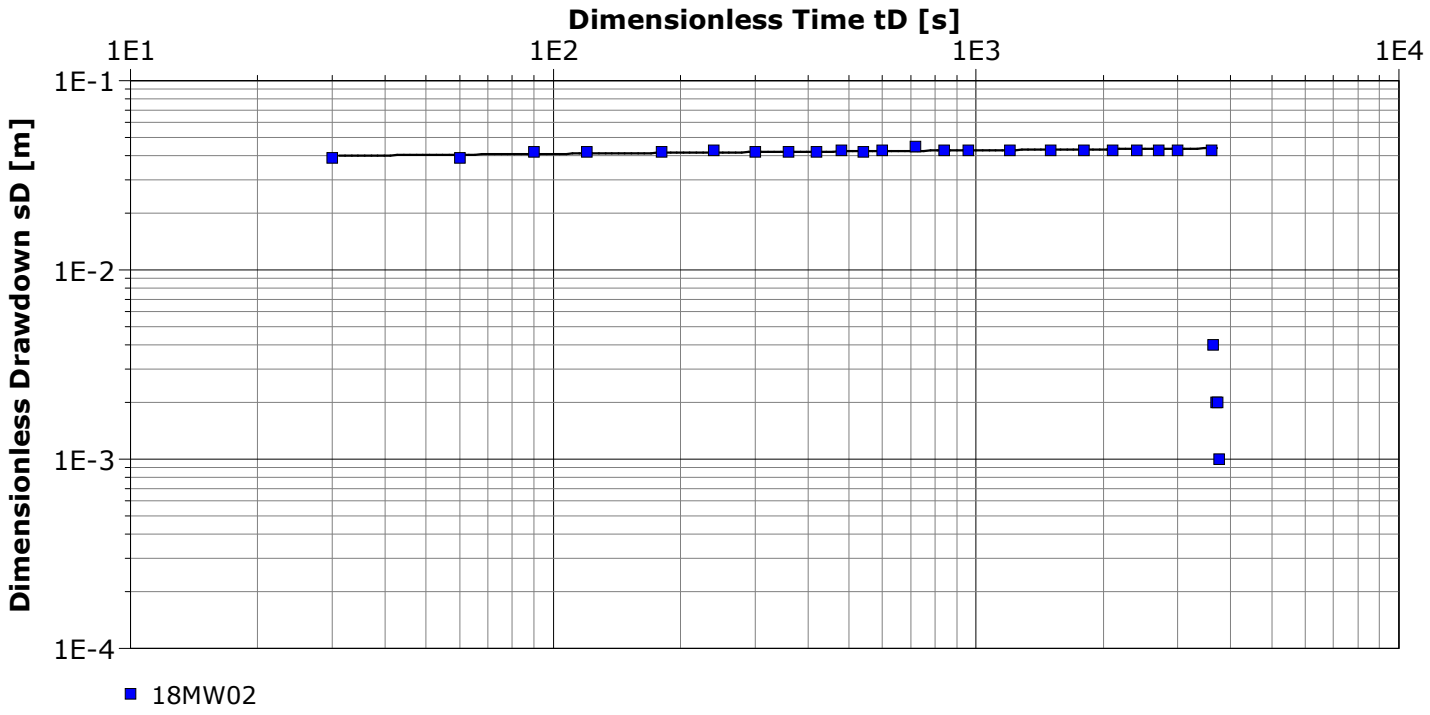
Pumping Test Analysis Report

Project: Polson Park GW Study

Number: 2018-8012.000.000

Client: City of Vernon

Location: Polson Park	Pumping Test: Constant Discharge Test	Pumping Well: 18MW02
Test Conducted by: M. Weldon		Test Date: 2/28/2018
Analysis Performed by: M. Weldon	Theis	Analysis Date: 3/2/2018
Aquifer Thickness: 4.11 m	Discharge: variable, average rate 0.214 [l/s]	



Calculation using Theis

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
18MW02	1.86×10^{3}	4.52×10^{2}	2.03×10^{-19}	0.03	

Associated Environmental

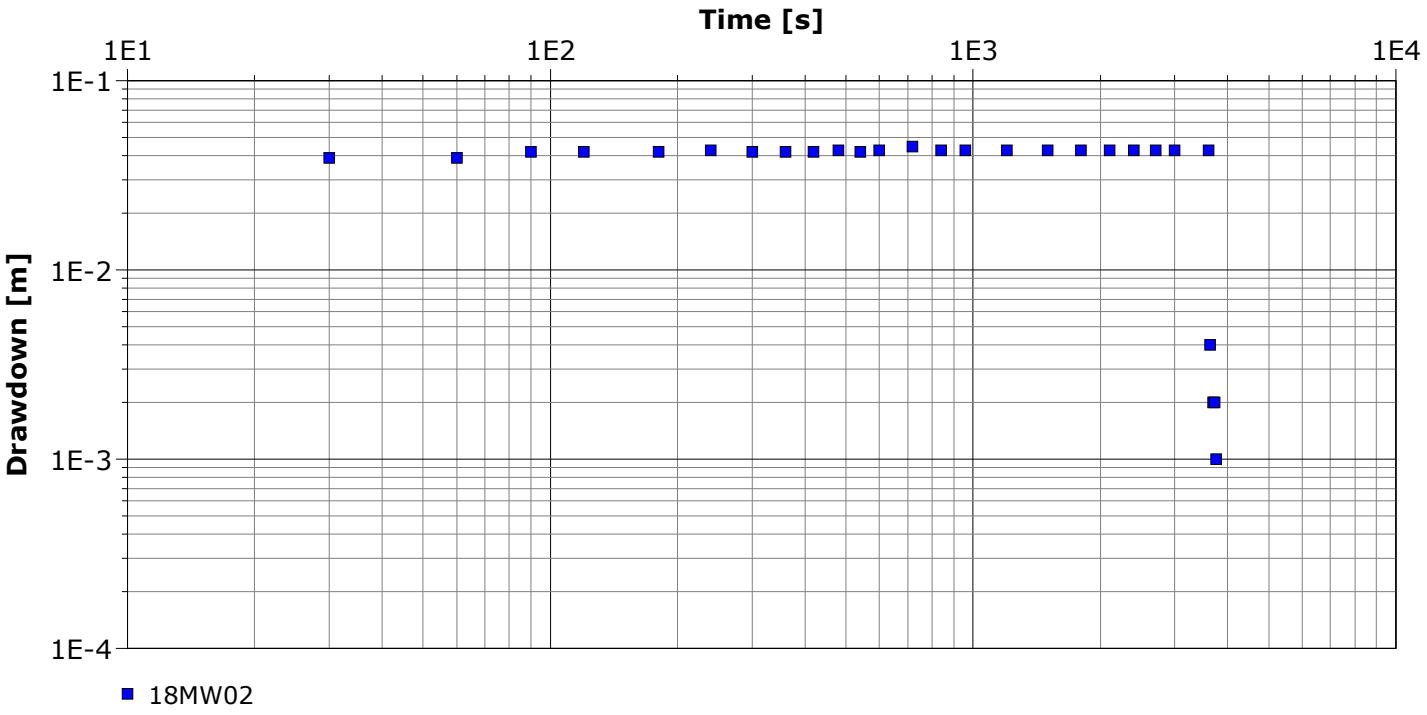
Pumping Test Analysis Report

Project: Polson Park GW Study

Number: 2018-8012.000.000

Client: City of Vernon

Location: Polson Park	Pumping Test: Constant Discharge Test	Pumping Well: 18MW02
Test Conducted by: M. Weldon		Test Date: 2/28/2018
Analysis Performed by: M. Weldon	Cooper Jacob	Analysis Date: 3/2/2018
Aquifer Thickness: 4.11 m	Discharge: variable, average rate 0.214 [l/s]	

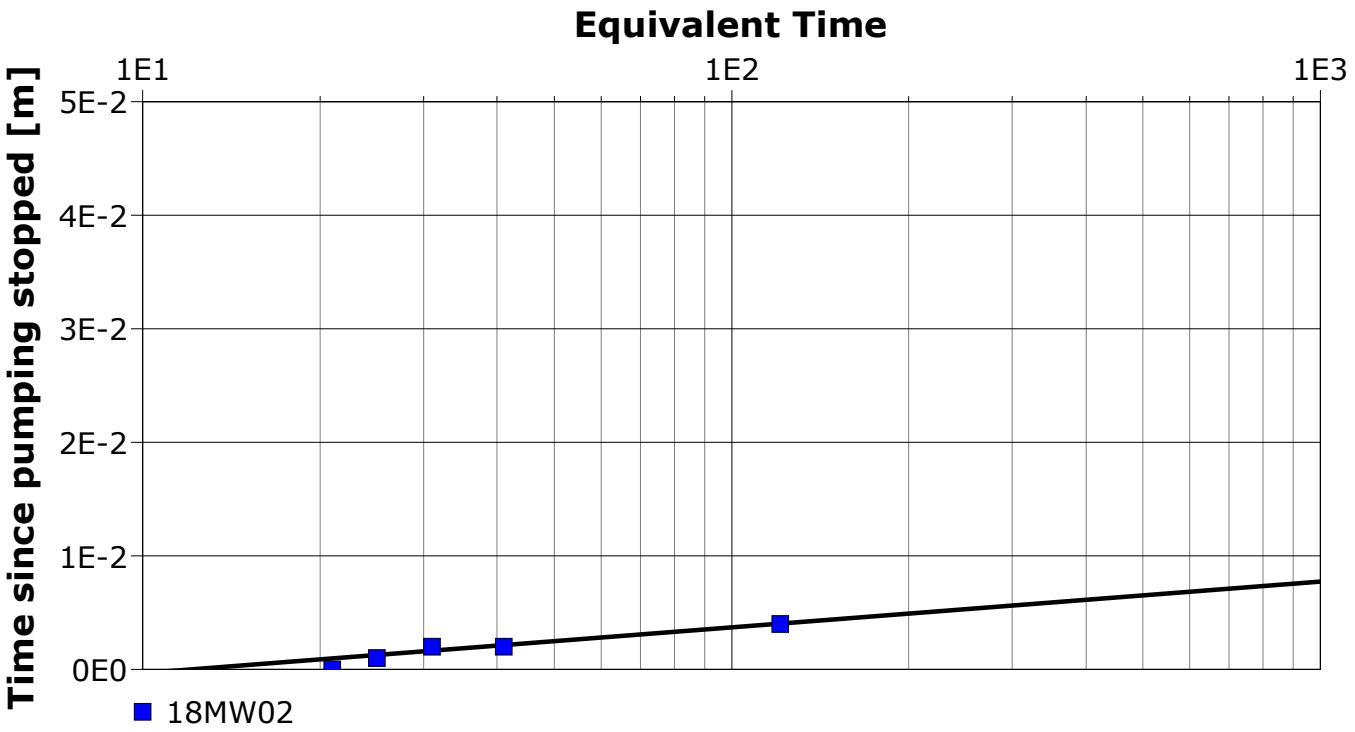


Calculation using COOPER & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Storage coefficient	Radial Distance to PW [m]	
18MW02	2.07×10^{3}	5.02×10^{2}	5.73×10^{-22}	0.03	

Associated Environmental	**Pumping Test Analysis Report**
	Project: Polson Park GW Study
	Number: 2018-8012.000.000
	Client: City of Vernon

Location: Polson Park	Pumping Test: Constant Discharge Test	Pumping Well: 18MW02
Test Conducted by: M. Weldon		Test Date: 2/28/2018
Analysis Performed by: M. Weldon	Theis Recovery	Analysis Date: 3/2/2018
Aquifer Thickness: 4.11 m	Discharge: variable, average rate 0.214 [l/s]	



Calculation using THEIS & JACOB

Observation Well	Transmissivity [m²/d]	Hydraulic Conductivity [m/d]	Radial Distance to PW [m]	
18MW02	8.37×10^{2}	2.03×10^{2}	0.03	

Associated Environmental

Pumping Test Analysis Report

Project: Polson Park GW Study

Number: 2018-8012.000.000

Client: City of Vernon

Location: Polson Park	Pumping Test: Constant Discharge Test	Pumping Well: 18MW02
Test Conducted by: M. Weldon		Test Date: 2/28/2018
Aquifer Thickness: 4.11 m	Discharge: variable, average rate 0.214 [l/s]	

	Analysis Name	Analysis Performed by	Analysis Date	Method name	Well	T [m²/d]	K [m/d]	S
1	Theis	M. Weldon	3/2/2018	Theis	18MW02	1.86×10^{3}	4.52×10^{2}	2.03×10^{-19}
2	Cooper Jacob	M. Weldon	3/2/2018	Cooper & Jacob I	18MW02	2.07×10^{3}	5.02×10^{2}	5.73×10^{-22}
3	Theis Recovery	M. Weldon	3/2/2018	Theis Recovery	18MW02	8.37×10^{2}	2.03×10^{2}	
					Average	1.59×10^{3}	3.86×10^{2}	1.02×10^{-19}

Appendix C: Laboratory Reports

CERTIFICATE OF ANALYSIS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon) #200 - 2800 29th Street Vernon, BC V1T 9P9		
ATTENTION	Mike Weldon	**WORK ORDER**	8030144
PO NUMBER	2018-8012	**RECEIVED / TEMP**	2018-03-01 14:00 / 1°C
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20
PROJECT INFO		**COC NUMBER**	57220

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO 17025:2005 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at kmckeown@caro.ca

Authorized By:

Kristin McKeown
Account Manager

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Analyzed	Qualifier
Vernon Creek@ Bridge (8030144-01) | Matrix: Water | Sampled: 2018-02-28 12:40					
Anions					
Chloride	**53.6**	0.10	mg/L	2018-03-05	
Fluoride	**0.34**	0.10	mg/L	2018-03-03	
Nitrate (as N)	**0.187**	0.010	mg/L	2018-03-03	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-03-03	
Sulfate	**57.7**	1.0	mg/L	2018-03-03	
General Parameters					
Alkalinity, Total (as CaCO3)	**155**	1.0	mg/L	2018-03-04	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Bicarbonate (as CaCO3)	**155**	1.0	mg/L	2018-03-04	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Ammonia, Total (as N)	**0.051**	0.020	mg/L	2018-03-05	
Conductivity (EC)	**566**	2.0	µS/cm	2018-03-04	
pH	**8.07**	0.10	pH units	2018-03-04	HT2
Solids, Total Dissolved	**330**	15	mg/L	2018-03-07	
Calculated Parameters					
Hardness, Total (as CaCO3)	**201**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2018-03-06	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Arsenic, dissolved	**0.00097**	0.00050	mg/L	2018-03-06	
Barium, dissolved	**0.0336**	0.0050	mg/L	2018-03-06	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Boron, dissolved	**0.0177**	0.0050	mg/L	2018-03-06	
Cadmium, dissolved	< 0.000010	0.000010	mg/L	2018-03-06	
Calcium, dissolved	**45.6**	0.20	mg/L	2018-03-06	
Chromium, dissolved	< 0.00050	0.00050	mg/L	2018-03-06	
Cobalt, dissolved	**0.00014**	0.00010	mg/L	2018-03-06	
Copper, dissolved	**0.00108**	0.00040	mg/L	2018-03-06	
Iron, dissolved	< 0.010	0.010	mg/L	2018-03-06	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Lithium, dissolved	**0.00773**	0.00010	mg/L	2018-03-06	
Magnesium, dissolved	**21.2**	0.010	mg/L	2018-03-06	
Manganese, dissolved	**0.0127**	0.00020	mg/L	2018-03-06	
Molybdenum, dissolved	**0.00522**	0.00010	mg/L	2018-03-06	
Nickel, dissolved	**0.00056**	0.00040	mg/L	2018-03-06	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-03-06	
Potassium, dissolved	**5.86**	0.10	mg/L	2018-03-06	
Selenium, dissolved	**0.00106**	0.00050	mg/L	2018-03-06	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Analyzed	Qualifier
Vernon Creek@ Bridge (8030144-01) | Matrix: Water | Sampled: 2018-02-28 12:40, Continued					
Dissolved Metals, Continued					
Silicon, dissolved	**2.6**	1.0	mg/L	2018-03-06	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-03-06	
Sodium, dissolved	**47.8**	0.10	mg/L	2018-03-06	
Strontium, dissolved	**0.555**	0.0010	mg/L	2018-03-06	
Sulfur, dissolved	**20.2**	3.0	mg/L	2018-03-06	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-03-06	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-03-06	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Tin, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-03-06	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Uranium, dissolved	**0.00374**	0.000020	mg/L	2018-03-06	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Zinc, dissolved	< 0.0040	0.0040	mg/L	2018-03-06	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
18MW01 (8030144-02) | Matrix: Water | Sampled: 2018-02-28 16:40					
Anions					
Chloride	**21.6**	0.10	mg/L	2018-03-03	
Fluoride	**0.20**	0.10	mg/L	2018-03-03	
Nitrate (as N)	**1.10**	0.010	mg/L	2018-03-03	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-03-03	
Sulfate	**206**	1.0	mg/L	2018-03-05	
General Parameters					
Alkalinity, Total (as CaCO3)	**245**	1.0	mg/L	2018-03-04	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Bicarbonate (as CaCO3)	**245**	1.0	mg/L	2018-03-04	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Ammonia, Total (as N)	< 0.020	0.020	mg/L	2018-03-05	
Conductivity (EC)	**859**	2.0	µS/cm	2018-03-04	
pH	**7.78**	0.10	pH units	2018-03-04	HT2
Solids, Total Dissolved	**618**	15	mg/L	2018-03-07	
Calculated Parameters					
Hardness, Total (as CaCO3)	**402**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	**0.0063**	0.0050	mg/L	2018-03-06	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Arsenic, dissolved	**0.00062**	0.00050	mg/L	2018-03-06	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW01 (8030144-02) | Matrix: Water | Sampled: 2018-02-28 16:40, Continued					
Dissolved Metals, Continued					
Barium, dissolved	**0.0666**	0.0050	mg/L	2018-03-06	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Boron, dissolved	**0.0158**	0.0050	mg/L	2018-03-06	
Cadmium, dissolved	**0.000022**	0.000010	mg/L	2018-03-06	
Calcium, dissolved	**98.6**	0.20	mg/L	2018-03-06	
Chromium, dissolved	**0.00083**	0.00050	mg/L	2018-03-06	
Cobalt, dissolved	**0.00019**	0.00010	mg/L	2018-03-06	
Copper, dissolved	< 0.00040	0.00040	mg/L	2018-03-06	
Iron, dissolved	< 0.010	0.010	mg/L	2018-03-06	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Lithium, dissolved	**0.00755**	0.00010	mg/L	2018-03-06	
Magnesium, dissolved	**37.7**	0.010	mg/L	2018-03-06	
Manganese, dissolved	**0.0631**	0.00020	mg/L	2018-03-06	
Molybdenum, dissolved	**0.00301**	0.00010	mg/L	2018-03-06	
Nickel, dissolved	**0.00061**	0.00040	mg/L	2018-03-06	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-03-06	
Potassium, dissolved	**6.33**	0.10	mg/L	2018-03-06	
Selenium, dissolved	**0.00345**	0.00050	mg/L	2018-03-06	
Silicon, dissolved	**9.3**	1.0	mg/L	2018-03-06	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-03-06	
Sodium, dissolved	**41.0**	0.10	mg/L	2018-03-06	
Strontium, dissolved	**0.899**	0.0010	mg/L	2018-03-06	
Sulfur, dissolved	**77.9**	3.0	mg/L	2018-03-06	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-03-06	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-03-06	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Tin, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-03-06	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Uranium, dissolved	**0.00629**	0.000020	mg/L	2018-03-06	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Zinc, dissolved	**0.0097**	0.0040	mg/L	2018-03-06	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
18MW02 (8030144-03) | Matrix: Water | Sampled: 2018-02-28 14:55					
Anions					
Chloride	**26.5**	0.10	mg/L	2018-03-03	
Fluoride	**0.18**	0.10	mg/L	2018-03-03	
Nitrate (as N)	**1.19**	0.010	mg/L	2018-03-03	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-03-03	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW02 (8030144-03) | Matrix: Water | Sampled: 2018-02-28 14:55, Continued					
Anions, Continued					
Sulfate	**231**	1.0	mg/L	2018-03-05	
General Parameters					
Alkalinity, Total (as CaCO3)	**258**	1.0	mg/L	2018-03-04	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Bicarbonate (as CaCO3)	**258**	1.0	mg/L	2018-03-04	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Ammonia, Total (as N)	< 0.020	0.020	mg/L	2018-03-05	
Conductivity (EC)	**948**	2.0	µS/cm	2018-03-04	
pH	**7.78**	0.10	pH units	2018-03-04	HT2
Solids, Total Dissolved	**654**	15	mg/L	2018-03-07	
Calculated Parameters					
Hardness, Total (as CaCO3)	**456**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2018-03-06	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Arsenic, dissolved	< 0.00050	0.00050	mg/L	2018-03-06	
Barium, dissolved	**0.0888**	0.0050	mg/L	2018-03-06	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Boron, dissolved	**0.0168**	0.0050	mg/L	2018-03-06	
Cadmium, dissolved	**0.000022**	0.000010	mg/L	2018-03-06	
Calcium, dissolved	**115**	0.20	mg/L	2018-03-06	
Chromium, dissolved	**0.00059**	0.00050	mg/L	2018-03-06	
Cobalt, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Copper, dissolved	< 0.00040	0.00040	mg/L	2018-03-06	
Iron, dissolved	< 0.010	0.010	mg/L	2018-03-06	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Lithium, dissolved	**0.00761**	0.00010	mg/L	2018-03-06	
Magnesium, dissolved	**41.0**	0.010	mg/L	2018-03-06	
Manganese, dissolved	**0.0841**	0.00020	mg/L	2018-03-06	
Molybdenum, dissolved	**0.00225**	0.00010	mg/L	2018-03-06	
Nickel, dissolved	**0.00058**	0.00040	mg/L	2018-03-06	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-03-06	
Potassium, dissolved	**6.60**	0.10	mg/L	2018-03-06	
Selenium, dissolved	**0.00499**	0.00050	mg/L	2018-03-06	
Silicon, dissolved	**9.3**	1.0	mg/L	2018-03-06	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-03-06	
Sodium, dissolved	**44.7**	0.10	mg/L	2018-03-06	
Strontium, dissolved	**1.01**	0.0010	mg/L	2018-03-06	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW02 (8030144-03) | Matrix: Water | Sampled: 2018-02-28 14:55, Continued					
Dissolved Metals, Continued					
Sulfur, dissolved	**87.7**	3.0	mg/L	2018-03-06	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-03-06	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-03-06	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Tin, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-03-06	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Uranium, dissolved	**0.00644**	0.000020	mg/L	2018-03-06	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Zinc, dissolved	< 0.0040	0.0040	mg/L	2018-03-06	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
18MW03 (8030144-04) | Matrix: Water | Sampled: 2018-02-28 12:50					
Anions					
Chloride	**30.3**	0.10	mg/L	2018-03-03	
Fluoride	**1.61**	0.10	mg/L	2018-03-03	
Nitrate (as N)	**0.768**	0.010	mg/L	2018-03-03	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-03-03	
Sulfate	**63.9**	1.0	mg/L	2018-03-03	
General Parameters					
Alkalinity, Total (as CaCO3)	**204**	1.0	mg/L	2018-03-04	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Bicarbonate (as CaCO3)	**204**	1.0	mg/L	2018-03-04	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-03-04	
Ammonia, Total (as N)	< 0.020	0.020	mg/L	2018-03-05	
Conductivity (EC)	**589**	2.0	µS/cm	2018-03-04	
pH	**7.73**	0.10	pH units	2018-03-04	HT2
Solids, Total Dissolved	**370**	15	mg/L	2018-03-07	
Calculated Parameters					
Hardness, Total (as CaCO3)	**266**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2018-03-06	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Arsenic, dissolved	< 0.00050	0.00050	mg/L	2018-03-06	
Barium, dissolved	**0.0466**	0.0050	mg/L	2018-03-06	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Boron, dissolved	**0.0179**	0.0050	mg/L	2018-03-06	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW03 (8030144-04) | Matrix: Water | Sampled: 2018-02-28 12:50, Continued					
Dissolved Metals, Continued					
Cadmium, dissolved	**0.000033**	0.000010	mg/L	2018-03-06	
Calcium, dissolved	**64.9**	0.20	mg/L	2018-03-06	
Chromium, dissolved	**0.00059**	0.00050	mg/L	2018-03-06	
Cobalt, dissolved	**0.00013**	0.00010	mg/L	2018-03-06	
Copper, dissolved	**0.00065**	0.00040	mg/L	2018-03-06	
Iron, dissolved	< 0.010	0.010	mg/L	2018-03-06	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Lithium, dissolved	**0.00686**	0.00010	mg/L	2018-03-06	
Magnesium, dissolved	**25.3**	0.010	mg/L	2018-03-06	
Manganese, dissolved	**0.0694**	0.00020	mg/L	2018-03-06	
Molybdenum, dissolved	**0.00368**	0.00010	mg/L	2018-03-06	
Nickel, dissolved	**0.00110**	0.00040	mg/L	2018-03-06	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-03-06	
Potassium, dissolved	**5.36**	0.10	mg/L	2018-03-06	
Selenium, dissolved	**0.00155**	0.00050	mg/L	2018-03-06	
Silicon, dissolved	**7.4**	1.0	mg/L	2018-03-06	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-03-06	
Sodium, dissolved	**29.9**	0.10	mg/L	2018-03-06	
Strontium, dissolved	**0.565**	0.0010	mg/L	2018-03-06	
Sulfur, dissolved	**32.9**	3.0	mg/L	2018-03-06	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-03-06	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-03-06	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	
Tin, dissolved	< 0.00020	0.00020	mg/L	2018-03-06	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-03-06	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Uranium, dissolved	**0.00452**	0.000020	mg/L	2018-03-06	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-03-06	
Zinc, dissolved	**0.0059**	0.0040	mg/L	2018-03-06	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-03-06	

Sample Qualifiers:

HT2 The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analysis Description	Method Ref.	Technique	Location
Alkalinity in Water	SM 2320 B* (2011)	Titration with H2SO4	Kelowna
Ammonia, Total in Water	SM 4500-NH3 G* (2011)	Automated Colorimetry (Phenate)	Kelowna
Anions in Water	SM 4110 B (2011)	Ion Chromatography	Kelowna
Conductivity in Water	SM 2510 B (2011)	Conductivity Meter	Kelowna
Dissolved Metals in Water	EPA 200.8 / EPA 6020B	0.45 µm Filtration / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	Richmond
Hardness in Water	SM 2340 B (2011)	Calculation: 2.497 [diss Ca] + 4.118 [diss Mg]	N/A
pH in Water	SM 4500-H+ B (2011)	Electrometry	Kelowna
Solids, Total Dissolved in Water	SM 2540 C* (2011)	Gravimetry (Dried at 103-105C)	Kelowna

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
mg/L	Milligrams per litre
pH units	pH < 7 = acidic, ph > 7 = basic
µS/cm	Microsiemens per centimetre
EPA	United States Environmental Protection Agency Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued unless otherwise agreed to in writing.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Anions, Batch B8C0152										
Blank (B8C0152-BLK2)				Prepared: 2018-03-03, Analyzed: 2018-03-03						
Chloride	< 0.10	0.10	mg/L							
Fluoride	< 0.10	0.10	mg/L							
Nitrate (as N)	< 0.010	0.010	mg/L							
Nitrite (as N)	< 0.010	0.010	mg/L							
Sulfate	< 1.0	1.0	mg/L							
LCS (B8C0152-BS1)				Prepared: 2018-03-03, Analyzed: 2018-03-03						
Chloride	16.1	0.10	mg/L	16.0		101	90-110			
Fluoride	4.00	0.10	mg/L	4.00		100	88-108			
Nitrate (as N)	4.00	0.010	mg/L	4.00		100	93-108			
Nitrite (as N)	2.02	0.010	mg/L	2.00		101	85-114			
Sulfate	16.2	1.0	mg/L	16.0		101	91-109			
LCS (B8C0152-BS2)				Prepared: 2018-03-03, Analyzed: 2018-03-03						
Chloride	16.1	0.10	mg/L	16.0		100	90-110			
Fluoride	3.88	0.10	mg/L	4.00		97	88-108			
Nitrate (as N)	4.09	0.010	mg/L	4.00		102	93-108			
Nitrite (as N)	2.02	0.010	mg/L	2.00		101	85-114			
Sulfate	16.4	1.0	mg/L	16.0		102	91-109			
Duplicate (B8C0152-DUP1)		**Source: 8030144-01**		Prepared: 2018-03-03, Analyzed: 2018-03-03						
Chloride	54.9	0.10	mg/L		53.6			2	10	
Fluoride	0.31	0.10	mg/L		0.34				10	
Nitrate (as N)	0.176	0.010	mg/L		0.187			6	10	
Nitrite (as N)	< 0.010	0.010	mg/L		< 0.010				6	
Sulfate	57.4	1.0	mg/L		57.7			< 1	6	
Matrix Spike (B8C0152-MS1)		**Source: 8030144-01**		Prepared: 2018-03-03, Analyzed: 2018-03-03						
Chloride	73.2	0.10	mg/L	16.0	53.6	123	75-125			
Fluoride	4.07	0.10	mg/L	4.00	0.34	93	75-125			
Nitrate (as N)	4.38	0.010	mg/L	4.00	0.187	105	75-125			
Nitrite (as N)	1.99	0.010	mg/L	2.00	< 0.010	99	80-120			
Sulfate	70.7	1.0	mg/L	16.0	57.7	81	75-125			
Dissolved Metals, Batch B8C0334										

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B8C0334, Continued										
Blank (B8C0334-BLK1)				Prepared: 2018-03-06, Analyzed: 2018-03-06						
Aluminum, dissolved	< 0.0050	0.0050	mg/L							
Antimony, dissolved	< 0.00020	0.00020	mg/L							
Arsenic, dissolved	< 0.00050	0.00050	mg/L							
Barium, dissolved	< 0.0050	0.0050	mg/L							
Beryllium, dissolved	< 0.00010	0.00010	mg/L							
Bismuth, dissolved	< 0.00010	0.00010	mg/L							
Boron, dissolved	< 0.0050	0.0050	mg/L							
Cadmium, dissolved	< 0.000010	0.000010	mg/L							
Calcium, dissolved	< 0.20	0.20	mg/L							
Chromium, dissolved	< 0.00050	0.00050	mg/L							
Cobalt, dissolved	< 0.00010	0.00010	mg/L							
Copper, dissolved	< 0.00040	0.00040	mg/L							
Iron, dissolved	< 0.010	0.010	mg/L							
Lead, dissolved	< 0.00020	0.00020	mg/L							
Lithium, dissolved	< 0.00010	0.00010	mg/L							
Magnesium, dissolved	< 0.010	0.010	mg/L							
Manganese, dissolved	< 0.00020	0.00020	mg/L							
Molybdenum, dissolved	< 0.00010	0.00010	mg/L							
Nickel, dissolved	< 0.00040	0.00040	mg/L							
Phosphorus, dissolved	< 0.050	0.050	mg/L							
Potassium, dissolved	< 0.10	0.10	mg/L							
Selenium, dissolved	< 0.00050	0.00050	mg/L							
Silicon, dissolved	< 1.0	1.0	mg/L							
Silver, dissolved	< 0.000050	0.000050	mg/L							
Sodium, dissolved	< 0.10	0.10	mg/L							
Strontium, dissolved	< 0.0010	0.0010	mg/L							
Sulfur, dissolved	< 3.0	3.0	mg/L							
Tellurium, dissolved	< 0.00050	0.00050	mg/L							
Thallium, dissolved	< 0.000020	0.000020	mg/L							
Thorium, dissolved	< 0.00010	0.00010	mg/L							
Tin, dissolved	< 0.00020	0.00020	mg/L							
Titanium, dissolved	< 0.0050	0.0050	mg/L							
Tungsten, dissolved	< 0.0010	0.0010	mg/L							
Uranium, dissolved	< 0.000020	0.000020	mg/L							
Vanadium, dissolved	< 0.0010	0.0010	mg/L							
Zinc, dissolved	< 0.0040	0.0040	mg/L							
Zirconium, dissolved	< 0.00010	0.00010	mg/L							
LCS (B8C0334-BS1)				Prepared: 2018-03-06, Analyzed: 2018-03-06						
Aluminum, dissolved	0.0226	0.0050	mg/L	0.0200		113	80-120			
Antimony, dissolved	0.0196	0.00020	mg/L	0.0200		98	80-120			
Arsenic, dissolved	0.0193	0.00050	mg/L	0.0200		96	80-120			
Barium, dissolved	0.0199	0.0050	mg/L	0.0200		100	80-120			
Beryllium, dissolved	0.0208	0.00010	mg/L	0.0200		104	80-120			
Bismuth, dissolved	0.0187	0.00010	mg/L	0.0200		93	80-120			
Boron, dissolved	0.0211	0.0050	mg/L	0.0200		106	80-120			
Cadmium, dissolved	0.0197	0.000010	mg/L	0.0200		98	80-120			
Calcium, dissolved	1.98	0.20	mg/L	2.00		99	80-120			
Chromium, dissolved	0.0194	0.00050	mg/L	0.0200		97	80-120			
Cobalt, dissolved	0.0194	0.00010	mg/L	0.0200		97	80-120			
Copper, dissolved	0.0208	0.00040	mg/L	0.0200		104	80-120			
Iron, dissolved	2.00	0.010	mg/L	2.00		100	80-120			
Lead, dissolved	0.0201	0.00020	mg/L	0.0200		101	80-120			
Lithium, dissolved	0.0194	0.00010	mg/L	0.0200		97	80-120			
Magnesium, dissolved	2.04	0.010	mg/L	2.00		102	80-120			
Manganese, dissolved	0.0200	0.00020	mg/L	0.0200		100	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B8C0334, Continued										
LCS (B8C0334-BS1), Continued				Prepared: 2018-03-06, Analyzed: 2018-03-06						
Molybdenum, dissolved	0.0193	0.00010	mg/L	0.0200		96	80-120			
Nickel, dissolved	0.0201	0.00040	mg/L	0.0200		101	80-120			
Phosphorus, dissolved	1.87	0.050	mg/L	2.00		94	80-120			
Potassium, dissolved	1.99	0.10	mg/L	2.00		99	80-120			
Selenium, dissolved	0.0196	0.00050	mg/L	0.0200		98	80-120			
Silicon, dissolved	2.1	1.0	mg/L	2.00		104	80-120			
Silver, dissolved	0.0200	0.000050	mg/L	0.0200		100	80-120			
Sodium, dissolved	2.05	0.10	mg/L	2.00		103	80-120			
Strontium, dissolved	0.0191	0.0010	mg/L	0.0200		96	80-120			
Sulfur, dissolved	4.1	3.0	mg/L	5.00		82	80-120			
Tellurium, dissolved	0.0193	0.00050	mg/L	0.0200		97	80-120			
Thallium, dissolved	0.0198	0.000020	mg/L	0.0200		99	80-120			
Thorium, dissolved	0.0161	0.00010	mg/L	0.0200		80	80-120			
Tin, dissolved	0.0195	0.00020	mg/L	0.0200		97	80-120			
Titanium, dissolved	0.0209	0.0050	mg/L	0.0200		105	80-120			
Tungsten, dissolved	0.0213	0.0010	mg/L	0.0200		107	80-120			
Uranium, dissolved	0.0218	0.000020	mg/L	0.0200		109	80-120			
Vanadium, dissolved	0.0187	0.0010	mg/L	0.0200		94	80-120			
Zinc, dissolved	0.0206	0.0040	mg/L	0.0200		103	80-120			
Zirconium, dissolved	0.0192	0.00010	mg/L	0.0200		96	80-120			
Reference (B8C0334-SRM1)				Prepared: 2018-03-06, Analyzed: 2018-03-06						
Aluminum, dissolved	0.238	0.0050	mg/L	0.233		102	79-114			
Antimony, dissolved	0.0472	0.00020	mg/L	0.0430		110	89-123			
Arsenic, dissolved	0.440	0.00050	mg/L	0.438		100	87-113			
Barium, dissolved	3.39	0.0050	mg/L	3.35		101	85-114			
Beryllium, dissolved	0.227	0.00010	mg/L	0.213		106	79-122			
Boron, dissolved	1.74	0.0050	mg/L	1.74		100	79-117			
Cadmium, dissolved	0.224	0.000010	mg/L	0.224		100	89-112			
Calcium, dissolved	8.12	0.20	mg/L	7.69		106	85-120			
Chromium, dissolved	0.432	0.00050	mg/L	0.437		99	87-113			
Cobalt, dissolved	0.129	0.00010	mg/L	0.128		101	90-117			
Copper, dissolved	0.870	0.00040	mg/L	0.844		103	90-115			
Iron, dissolved	1.29	0.010	mg/L	1.29		100	86-112			
Lead, dissolved	0.114	0.00020	mg/L	0.112		102	90-113			
Lithium, dissolved	0.102	0.00010	mg/L	0.104		98	77-127			
Magnesium, dissolved	6.98	0.010	mg/L	6.92		101	84-116			
Manganese, dissolved	0.347	0.00020	mg/L	0.345		100	85-113			
Molybdenum, dissolved	0.429	0.00010	mg/L	0.426		101	87-112			
Nickel, dissolved	0.859	0.00040	mg/L	0.840		102	90-114			
Phosphorus, dissolved	0.511	0.050	mg/L	0.495		103	74-119			
Potassium, dissolved	3.18	0.10	mg/L	3.19		100	78-119			
Selenium, dissolved	0.0334	0.00050	mg/L	0.0331		101	89-123			
Sodium, dissolved	19.2	0.10	mg/L	19.1		100	81-117			
Strontium, dissolved	0.902	0.0010	mg/L	0.916		98	82-111			
Thallium, dissolved	0.0392	0.000020	mg/L	0.0393		100	90-113			
Uranium, dissolved	0.273	0.000020	mg/L	0.266		102	87-113			
Vanadium, dissolved	0.848	0.0010	mg/L	0.869		98	85-110			
Zinc, dissolved	0.877	0.0040	mg/L	0.881		100	88-114			
General Parameters, Batch B8C0118										
Blank (B8C0118-BLK1)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8C0118, Continued										
Blank (B8C0118-BLK2)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8C0118-BLK3)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
LCS (B8C0118-BS1)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Ammonia, Total (as N)	1.02	0.020	mg/L	1.00		102	90-115			
LCS (B8C0118-BS2)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Ammonia, Total (as N)	1.01	0.020	mg/L	1.00		101	90-115			
LCS (B8C0118-BS3)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Ammonia, Total (as N)	1.03	0.020	mg/L	1.00		103	90-115			
General Parameters, Batch B8C0240										
Blank (B8C0240-BLK1)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Conductivity (EC)	1.4	1.0	µS/cm							BLK
Blank (B8C0240-BLK2)				Prepared: 2018-03-04, Analyzed: 2018-03-04						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Blank (B8C0240-BLK3)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
LCS (B8C0240-BS1)				Prepared: 2018-03-04, Analyzed: 2018-03-04						
Alkalinity, Total (as CaCO3)	101	1.0	mg/L	100		101	92-106			
LCS (B8C0240-BS2)				Prepared: 2018-03-04, Analyzed: 2018-03-04						
Conductivity (EC)	1380	1.0	µS/cm	1410		98	95-104			
LCS (B8C0240-BS3)				Prepared: 2018-03-04, Analyzed: 2018-03-04						
Alkalinity, Total (as CaCO3)	101	1.0	mg/L	100		101	92-106			
LCS (B8C0240-BS4)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Conductivity (EC)	1380	1.0	µS/cm	1410		98	95-104			
LCS (B8C0240-BS5)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Alkalinity, Total (as CaCO3)	9.7	1.0	mg/L	10.0		97	92-106			
LCS (B8C0240-BS7)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
Alkalinity, Total (as CaCO3)	9.7	1.0	mg/L	10.0		97	92-106			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8030144
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-03-08 09:20

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8C0240, Continued										
Reference (B8C0240-SRM1)				Prepared: 2018-03-04, Analyzed: 2018-03-04						
pH	6.99	0.10	pH units	7.01		100	98-102			
Reference (B8C0240-SRM2)				Prepared: 2018-03-04, Analyzed: 2018-03-04						
pH	6.99	0.10	pH units	7.01		100	98-102			
Reference (B8C0240-SRM3)				Prepared: 2018-03-05, Analyzed: 2018-03-05						
pH	6.99	0.10	pH units	7.01		100	98-102			
General Parameters, Batch B8C0315										
Blank (B8C0315-BLK1)				Prepared: 2018-03-07, Analyzed: 2018-03-07						
Solids, Total Dissolved	< 15	15	mg/L							
LCS (B8C0315-BS1)				Prepared: 2018-03-07, Analyzed: 2018-03-07						
Solids, Total Dissolved	236	15	mg/L	240		98	85-115			

QC Qualifiers:

BLK Analyte concentration in the Method Blank is above the Reporting Limit (RL).

Appendix B: Laboratory Report

CERTIFICATE OF ANALYSIS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon) #200 - 2800 29th Street Vernon, BC V1T 9P9		
ATTENTION	Mike Weldon	**WORK ORDER**	8060849
PO NUMBER		**RECEIVED / TEMP**	2018-06-08 14:30 / 11°C
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17
PROJECT INFO		**COC NUMBER**	B52227

Introduction:

CARO Analytical Services is a testing laboratory full of smart, engaged scientists driven to make the world a safer and healthier place. Through our clients' projects we become an essential element for a better world. We employ methods conducted in accordance with recognized professional standards using accepted testing methodologies and quality control efforts. CARO is accredited by the Canadian Association for Laboratories Accreditation (CALA) to ISO 17025:2005 for specific tests listed in the scope of accreditation approved by CALA.

Big Picture Sidekicks

You know that the sample you collected after snowshoeing to site, digging 5 meters, and racing to get it on a plane so you can submit it to the lab for time sensitive results needed to make important and expensive decisions (whew) is VERY important. We know that too.

We've Got Chemistry

It's simple. We figure the more you enjoy working with our fun and engaged team members; the more likely you are to give us continued opportunities to support you.

Ahead of the Curve

Through research, regulation knowledge, and instrumentation, we are your analytical centre for the technical knowledge you need, BEFORE you need it, so you can stay up to date and in the know.

If you have any questions or concerns, please contact me at estclair@caro.ca

Authorized By:

Eilish St.Clair, B.Sc., C.I.T.
Client Service Representative

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Analyzed	Qualifier
Vernon Creek@ Bridge (8060849-01) | Matrix: Water | Sampled: 2018-06-08 09:10					
Anions					
Chloride	**13.3**	0.10	mg/L	2018-06-10	
Fluoride	**0.49**	0.10	mg/L	2018-06-10	
Nitrate (as N)	**0.062**	0.010	mg/L	2018-06-10	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-06-10	
Sulfate	**50.0**	1.0	mg/L	2018-06-10	
General Parameters					
Alkalinity, Total (as CaCO3)	**151**	1.0	mg/L	2018-06-12	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Bicarbonate (as CaCO3)	**151**	1.0	mg/L	2018-06-12	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Ammonia, Total (as N)	**0.029**	0.020	mg/L	2018-06-10	
Conductivity (EC)	**404**	2.0	µS/cm	2018-06-12	
pH	**7.80**	0.10	pH units	2018-06-12	HT2
Solids, Total Dissolved	**241**	15	mg/L	2018-06-13	
Calculated Parameters					
Hardness, Total (as CaCO3)	**177**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2018-06-14	
Antimony, dissolved	**0.00043**	0.00020	mg/L	2018-06-14	
Arsenic, dissolved	**0.00097**	0.00050	mg/L	2018-06-14	
Barium, dissolved	**0.0293**	0.0050	mg/L	2018-06-14	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Boron, dissolved	**0.0138**	0.0050	mg/L	2018-06-14	
Cadmium, dissolved	< 0.000010	0.000010	mg/L	2018-06-14	
Calcium, dissolved	**40.9**	0.20	mg/L	2018-06-14	
Chromium, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Cobalt, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Copper, dissolved	**0.00063**	0.00040	mg/L	2018-06-14	
Iron, dissolved	< 0.010	0.010	mg/L	2018-06-14	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Lithium, dissolved	**0.00663**	0.00010	mg/L	2018-06-14	
Magnesium, dissolved	**18.2**	0.010	mg/L	2018-06-14	
Manganese, dissolved	**0.00446**	0.00020	mg/L	2018-06-14	
Molybdenum, dissolved	**0.00484**	0.00010	mg/L	2018-06-14	
Nickel, dissolved	**0.00045**	0.00040	mg/L	2018-06-14	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-06-14	
Potassium, dissolved	**4.94**	0.10	mg/L	2018-06-14	
Selenium, dissolved	**0.00088**	0.00050	mg/L	2018-06-14	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Analyzed	Qualifier
Vernon Creek@ Bridge (8060849-01) | Matrix: Water | Sampled: 2018-06-08 09:10, Continued					
Dissolved Metals, Continued					
Silicon, dissolved	**2.0**	1.0	mg/L	2018-06-14	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-06-14	
Sodium, dissolved	**17.1**	0.10	mg/L	2018-06-14	
Strontium, dissolved	**0.450**	0.0010	mg/L	2018-06-14	
Sulfur, dissolved	**17.7**	3.0	mg/L	2018-06-14	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-06-14	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Tin, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-06-14	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Uranium, dissolved	**0.00327**	0.000020	mg/L	2018-06-14	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Zinc, dissolved	< 0.0040	0.0040	mg/L	2018-06-14	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
18MW01 (8060849-02) | Matrix: Water | Sampled: 2018-06-08 10:00					
Anions					
Chloride	**24.8**	0.10	mg/L	2018-06-10	
Fluoride	**0.21**	0.10	mg/L	2018-06-10	
Nitrate (as N)	**1.40**	0.010	mg/L	2018-06-10	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-06-10	
Sulfate	**239**	1.0	mg/L	2018-06-10	
General Parameters					
Alkalinity, Total (as CaCO3)	**242**	1.0	mg/L	2018-06-12	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Bicarbonate (as CaCO3)	**242**	1.0	mg/L	2018-06-12	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Ammonia, Total (as N)	< 0.020	0.020	mg/L	2018-06-10	
Conductivity (EC)	**931**	2.0	µS/cm	2018-06-12	
pH	**7.51**	0.10	pH units	2018-06-12	HT2
Solids, Total Dissolved	**635**	15	mg/L	2018-06-13	
Calculated Parameters					
Hardness, Total (as CaCO3)	**425**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2018-06-14	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Arsenic, dissolved	**0.00060**	0.00050	mg/L	2018-06-14	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW01 (8060849-02) | Matrix: Water | Sampled: 2018-06-08 10:00, Continued					
Dissolved Metals, Continued					
Barium, dissolved	**0.0746**	0.0050	mg/L	2018-06-14	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Boron, dissolved	**0.0134**	0.0050	mg/L	2018-06-14	
Cadmium, dissolved	**0.000031**	0.000010	mg/L	2018-06-14	
Calcium, dissolved	**107**	0.20	mg/L	2018-06-14	
Chromium, dissolved	**0.00097**	0.00050	mg/L	2018-06-14	
Cobalt, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Copper, dissolved	< 0.00040	0.00040	mg/L	2018-06-14	
Iron, dissolved	< 0.010	0.010	mg/L	2018-06-14	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Lithium, dissolved	**0.00792**	0.00010	mg/L	2018-06-14	
Magnesium, dissolved	**37.9**	0.010	mg/L	2018-06-14	
Manganese, dissolved	**0.00669**	0.00020	mg/L	2018-06-14	
Molybdenum, dissolved	**0.00265**	0.00010	mg/L	2018-06-14	
Nickel, dissolved	**0.00040**	0.00040	mg/L	2018-06-14	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-06-14	
Potassium, dissolved	**6.38**	0.10	mg/L	2018-06-14	
Selenium, dissolved	**0.00386**	0.00050	mg/L	2018-06-14	
Silicon, dissolved	**8.9**	1.0	mg/L	2018-06-14	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-06-14	
Sodium, dissolved	**39.7**	0.10	mg/L	2018-06-14	
Strontium, dissolved	**1.01**	0.0010	mg/L	2018-06-14	
Sulfur, dissolved	**78.2**	3.0	mg/L	2018-06-14	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-06-14	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Tin, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-06-14	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Uranium, dissolved	**0.00708**	0.000020	mg/L	2018-06-14	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Zinc, dissolved	< 0.0040	0.0040	mg/L	2018-06-14	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
18MW02 (8060849-03) | Matrix: Water | Sampled: 2018-06-08 08:35					
Anions					
Chloride	**27.4**	0.10	mg/L	2018-06-10	
Fluoride	**0.20**	0.10	mg/L	2018-06-10	
Nitrate (as N)	**1.14**	0.010	mg/L	2018-06-10	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-06-10	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW02 (8060849-03) | Matrix: Water | Sampled: 2018-06-08 08:35, Continued					
Anions, Continued					
Sulfate	**245**	1.0	mg/L	2018-06-10	
General Parameters					
Alkalinity, Total (as CaCO3)	**252**	1.0	mg/L	2018-06-12	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Bicarbonate (as CaCO3)	**252**	1.0	mg/L	2018-06-12	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Ammonia, Total (as N)	**0.121**	0.020	mg/L	2018-06-10	
Conductivity (EC)	**971**	2.0	µS/cm	2018-06-12	
pH	**7.66**	0.10	pH units	2018-06-12	HT2
Solids, Total Dissolved	**657**	15	mg/L	2018-06-13	
Calculated Parameters					
Hardness, Total (as CaCO3)	**444**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	< 0.0050	0.0050	mg/L	2018-06-14	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Arsenic, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Barium, dissolved	**0.0948**	0.0050	mg/L	2018-06-14	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Boron, dissolved	**0.0147**	0.0050	mg/L	2018-06-14	
Cadmium, dissolved	**0.000034**	0.000010	mg/L	2018-06-14	
Calcium, dissolved	**114**	0.20	mg/L	2018-06-14	
Chromium, dissolved	**0.00066**	0.00050	mg/L	2018-06-14	
Cobalt, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Copper, dissolved	< 0.00040	0.00040	mg/L	2018-06-14	
Iron, dissolved	< 0.010	0.010	mg/L	2018-06-14	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Lithium, dissolved	**0.00780**	0.00010	mg/L	2018-06-14	
Magnesium, dissolved	**38.7**	0.010	mg/L	2018-06-14	
Manganese, dissolved	**0.0171**	0.00020	mg/L	2018-06-14	
Molybdenum, dissolved	**0.00191**	0.00010	mg/L	2018-06-14	
Nickel, dissolved	**0.00043**	0.00040	mg/L	2018-06-14	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-06-14	
Potassium, dissolved	**6.68**	0.10	mg/L	2018-06-14	
Selenium, dissolved	**0.00460**	0.00050	mg/L	2018-06-14	
Silicon, dissolved	**9.5**	1.0	mg/L	2018-06-14	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-06-14	
Sodium, dissolved	**42.3**	0.10	mg/L	2018-06-14	
Strontium, dissolved	**1.06**	0.0010	mg/L	2018-06-14	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW02 (8060849-03) | Matrix: Water | Sampled: 2018-06-08 08:35, Continued					
Dissolved Metals, Continued					
Sulfur, dissolved	**85.3**	3.0	mg/L	2018-06-14	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-06-14	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Tin, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-06-14	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Uranium, dissolved	**0.00624**	0.000020	mg/L	2018-06-14	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Zinc, dissolved	**0.0119**	0.0040	mg/L	2018-06-14	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
18MW03 (8060849-04) | Matrix: Water | Sampled: 2018-06-08 09:30					
Anions					
Chloride	**24.3**	0.10	mg/L	2018-06-10	
Fluoride	**0.25**	0.10	mg/L	2018-06-10	
Nitrate (as N)	**1.59**	0.010	mg/L	2018-06-10	
Nitrite (as N)	< 0.010	0.010	mg/L	2018-06-10	
Sulfate	**112**	1.0	mg/L	2018-06-11	
General Parameters					
Alkalinity, Total (as CaCO3)	**216**	1.0	mg/L	2018-06-12	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Bicarbonate (as CaCO3)	**216**	1.0	mg/L	2018-06-12	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L	2018-06-12	
Ammonia, Total (as N)	< 0.020	0.020	mg/L	2018-06-10	
Conductivity (EC)	**688**	2.0	µS/cm	2018-06-12	
pH	**7.67**	0.10	pH units	2018-06-12	HT2
Solids, Total Dissolved	**417**	15	mg/L	2018-06-13	
Calculated Parameters					
Hardness, Total (as CaCO3)	**298**	0.500	mg/L	N/A	
Dissolved Metals					
Aluminum, dissolved	**0.0607**	0.0050	mg/L	2018-06-14	
Antimony, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Arsenic, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Barium, dissolved	**0.0542**	0.0050	mg/L	2018-06-14	
Beryllium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Bismuth, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Boron, dissolved	**0.0153**	0.0050	mg/L	2018-06-14	

TEST RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Analyzed	Qualifier
18MW03 (8060849-04) | Matrix: Water | Sampled: 2018-06-08 09:30, Continued					
Dissolved Metals, Continued					
Cadmium, dissolved	**0.000025**	0.000010	mg/L	2018-06-14	
Calcium, dissolved	**73.9**	0.20	mg/L	2018-06-14	
Chromium, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Cobalt, dissolved	**0.00011**	0.00010	mg/L	2018-06-14	
Copper, dissolved	**0.00059**	0.00040	mg/L	2018-06-14	
Iron, dissolved	< 0.010	0.010	mg/L	2018-06-14	
Lead, dissolved	< 0.00020	0.00020	mg/L	2018-06-14	
Lithium, dissolved	**0.00743**	0.00010	mg/L	2018-06-14	
Magnesium, dissolved	**27.6**	0.010	mg/L	2018-06-14	
Manganese, dissolved	**0.00427**	0.00020	mg/L	2018-06-14	
Molybdenum, dissolved	**0.00362**	0.00010	mg/L	2018-06-14	
Nickel, dissolved	**0.00194**	0.00040	mg/L	2018-06-14	
Phosphorus, dissolved	< 0.050	0.050	mg/L	2018-06-14	
Potassium, dissolved	**5.59**	0.10	mg/L	2018-06-14	
Selenium, dissolved	**0.00251**	0.00050	mg/L	2018-06-14	
Silicon, dissolved	**6.3**	1.0	mg/L	2018-06-14	
Silver, dissolved	< 0.000050	0.000050	mg/L	2018-06-14	
Sodium, dissolved	**28.8**	0.10	mg/L	2018-06-14	
Strontium, dissolved	**0.631**	0.0010	mg/L	2018-06-14	
Sulfur, dissolved	**39.5**	3.0	mg/L	2018-06-14	
Tellurium, dissolved	< 0.00050	0.00050	mg/L	2018-06-14	
Thallium, dissolved	< 0.000020	0.000020	mg/L	2018-06-14	
Thorium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	
Tin, dissolved	**0.00023**	0.00020	mg/L	2018-06-14	
Titanium, dissolved	< 0.0050	0.0050	mg/L	2018-06-14	
Tungsten, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Uranium, dissolved	**0.00540**	0.000020	mg/L	2018-06-14	
Vanadium, dissolved	< 0.0010	0.0010	mg/L	2018-06-14	
Zinc, dissolved	< 0.0040	0.0040	mg/L	2018-06-14	
Zirconium, dissolved	< 0.00010	0.00010	mg/L	2018-06-14	

Sample Qualifiers:

HT2 The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analysis Description	Method Ref.	Technique	Location
Alkalinity in Water	SM 2320 B* (2011)	Titration with H2SO4	Kelowna
Ammonia, Total in Water	SM 4500-NH3 G* (2011)	Automated Colorimetry (Phenate)	Kelowna
Anions in Water	SM 4110 B (2011)	Ion Chromatography	Kelowna
Conductivity in Water	SM 2510 B (2011)	Conductivity Meter	Kelowna
Dissolved Metals in Water	EPA 200.8 / EPA 6020B	0.45 µm Filtration / Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS)	Richmond
Hardness in Water	SM 2340 B (2011)	Calculation: 2.497 [diss Ca] + 4.118 [diss Mg]	N/A
pH in Water	SM 4500-H+ B (2011)	Electrometry	Kelowna
Solids, Total Dissolved in Water	SM 2540 C* (2011)	Gravimetry (Dried at 103-105C)	Kelowna

Note: An asterisk in the Method Reference indicates that the CARO method has been modified from the reference method

Glossary of Terms:

RL	Reporting Limit (default)
<	Less than the specified Reporting Limit (RL) - the actual RL may be higher than the default RL due to various factors
mg/L	Milligrams per litre
pH units	pH < 7 = acidic, ph > 7 = basic
µS/cm	Microsiemens per centimetre
EPA	United States Environmental Protection Agency Test Methods
SM	Standard Methods for the Examination of Water and Wastewater, American Public Health Association

General Comments:

The results in this report apply to the samples analyzed in accordance with the Chain of Custody document. This analytical report must be reproduced in its entirety. CARO is not responsible for any loss or damage resulting directly or indirectly from error or omission in the conduct of testing. Liability is limited to the cost of analysis. Samples will be disposed of 30 days after the test report has been issued unless otherwise agreed to in writing.

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

The following section displays the quality control (QC) data that is associated with your sample data. Groups of samples are prepared in "batches" and analyzed in conjunction with QC samples that ensure your data is of the highest quality. Common QC types include:

- **Method Blank (Blk)**: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.
- **Duplicate (Dup)**: An additional or second portion of a randomly selected sample in the analytical run carried through the entire analytical process. Duplicates provide a measure of the analytical method's precision (reproducibility).
- **Blank Spike (BS)**: A sample of known concentration which undergoes processing identical to that carried out for test samples, also referred to as a laboratory control sample (LCS). Blank spikes provide a measure of the analytical method's accuracy.
- **Matrix Spike (MS)**: A second aliquot of sample is fortified with with a known concentration of target analytes and carried through the entire analytical process. Matrix spikes evaluate potential matrix effects that may affect the analyte recovery.
- **Reference Material (SRM)**: A homogenous material of similar matrix to the samples, certified for the parameter(s) listed. Reference Materials ensure that the analytical process is adequate to achieve acceptable recoveries of the parameter(s) tested.

Each QC type is analyzed at a 5-10% frequency, i.e. one blank/duplicate/spike for every 10-20 samples. For all types of QC, the specified recovery (% Rec) and relative percent difference (RPD) limits are derived from long-term method performance averages and/or prescribed by the reference method.

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Anions, Batch B8F0748										
Blank (B8F0748-BLK1)				Prepared: 2018-06-09, Analyzed: 2018-06-09						
Chloride	< 0.10	0.10	mg/L							
Fluoride	< 0.10	0.10	mg/L							
Nitrate (as N)	< 0.010	0.010	mg/L							
Nitrite (as N)	< 0.010	0.010	mg/L							
Sulfate	< 1.0	1.0	mg/L							
Blank (B8F0748-BLK2)				Prepared: 2018-06-10, Analyzed: 2018-06-10						
Chloride	< 0.10	0.10	mg/L							
Fluoride	< 0.10	0.10	mg/L							
Nitrate (as N)	< 0.010	0.010	mg/L							
Nitrite (as N)	< 0.010	0.010	mg/L							
Sulfate	< 1.0	1.0	mg/L							
LCS (B8F0748-BS1)				Prepared: 2018-06-09, Analyzed: 2018-06-09						
Chloride	16.1	0.10	mg/L	16.0		100	90-110			
Fluoride	3.85	0.10	mg/L	4.00		96	88-108			
Nitrate (as N)	3.93	0.010	mg/L	4.00		98	93-108			
Nitrite (as N)	2.10	0.010	mg/L	2.00		105	85-114			
Sulfate	15.6	1.0	mg/L	16.0		98	91-109			
LCS (B8F0748-BS2)				Prepared: 2018-06-10, Analyzed: 2018-06-10						
Chloride	16.0	0.10	mg/L	16.0		100	90-110			
Fluoride	3.87	0.10	mg/L	4.00		97	88-108			
Nitrate (as N)	3.97	0.010	mg/L	4.00		99	93-108			
Nitrite (as N)	2.10	0.010	mg/L	2.00		105	85-114			
Sulfate	15.6	1.0	mg/L	16.0		97	91-109			
Duplicate (B8F0748-DUP2)		**Source: 8060849-04**		Prepared: 2018-06-10, Analyzed: 2018-06-10						
Chloride	24.2	0.10	mg/L		24.3			< 1	10	
Fluoride	0.25	0.10	mg/L		0.25				10	
Nitrate (as N)	1.56	0.010	mg/L		1.59			2	10	
Nitrite (as N)	< 0.010	0.010	mg/L		< 0.010				6	
Sulfate	109	1.0	mg/L		112			2	6	
Matrix Spike (B8F0748-MS2)		**Source: 8060849-04**		Prepared: 2018-06-10, Analyzed: 2018-06-10						
Chloride	40.2	0.10	mg/L	16.0	24.3	99	75-125			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Anions, Batch B8F0748, Continued										
Matrix Spike (B8F0748-MS2), Continued	**Source: 8060849-04**			Prepared: 2018-06-10, Analyzed: 2018-06-10						
Fluoride	4.08	0.10	mg/L	4.00	0.25	96	75-125			
Nitrate (as N)	5.45	0.010	mg/L	4.00	1.59	96	75-125			
Nitrite (as N)	2.17	0.010	mg/L	2.00	< 0.010	109	80-120			
Sulfate	131	1.0	mg/L	16.0	112	117	75-125			
Dissolved Metals, Batch B8F1042										
Blank (B8F1042-BLK1)				Prepared: 2018-06-14, Analyzed: 2018-06-14						
Aluminum, dissolved	< 0.0050	0.0050	mg/L							
Antimony, dissolved	< 0.00020	0.00020	mg/L							
Arsenic, dissolved	< 0.00050	0.00050	mg/L							
Barium, dissolved	< 0.0050	0.0050	mg/L							
Beryllium, dissolved	< 0.00010	0.00010	mg/L							
Bismuth, dissolved	< 0.00010	0.00010	mg/L							
Boron, dissolved	< 0.0050	0.0050	mg/L							
Cadmium, dissolved	< 0.000010	0.000010	mg/L							
Calcium, dissolved	< 0.20	0.20	mg/L							
Chromium, dissolved	< 0.00050	0.00050	mg/L							
Cobalt, dissolved	< 0.00010	0.00010	mg/L							
Copper, dissolved	< 0.00040	0.00040	mg/L							
Iron, dissolved	< 0.010	0.010	mg/L							
Lead, dissolved	< 0.00020	0.00020	mg/L							
Lithium, dissolved	< 0.00010	0.00010	mg/L							
Magnesium, dissolved	< 0.010	0.010	mg/L							
Manganese, dissolved	< 0.00020	0.00020	mg/L							
Molybdenum, dissolved	< 0.00010	0.00010	mg/L							
Nickel, dissolved	< 0.00040	0.00040	mg/L							
Phosphorus, dissolved	< 0.050	0.050	mg/L							
Potassium, dissolved	< 0.10	0.10	mg/L							
Selenium, dissolved	< 0.00050	0.00050	mg/L							
Silicon, dissolved	< 1.0	1.0	mg/L							
Silver, dissolved	< 0.000050	0.000050	mg/L							
Sodium, dissolved	< 0.10	0.10	mg/L							
Strontium, dissolved	< 0.0010	0.0010	mg/L							
Sulfur, dissolved	< 3.0	3.0	mg/L							
Tellurium, dissolved	< 0.00050	0.00050	mg/L							
Thallium, dissolved	< 0.000020	0.000020	mg/L							
Thorium, dissolved	< 0.00010	0.00010	mg/L							
Tin, dissolved	< 0.00020	0.00020	mg/L							
Titanium, dissolved	< 0.0050	0.0050	mg/L							
Tungsten, dissolved	< 0.0010	0.0010	mg/L							
Uranium, dissolved	< 0.000020	0.000020	mg/L							
Vanadium, dissolved	< 0.0010	0.0010	mg/L							
Zinc, dissolved	< 0.0040	0.0040	mg/L							
Zirconium, dissolved	< 0.00010	0.00010	mg/L							
LCS (B8F1042-BS1)				Prepared: 2018-06-14, Analyzed: 2018-06-14						
Aluminum, dissolved	0.0205	0.0050	mg/L	0.0200		103	80-120			
Antimony, dissolved	0.0213	0.00020	mg/L	0.0200		107	80-120			
Arsenic, dissolved	0.0194	0.00050	mg/L	0.0200		97	80-120			
Barium, dissolved	0.0196	0.0050	mg/L	0.0200		98	80-120			
Beryllium, dissolved	0.0191	0.00010	mg/L	0.0200		95	80-120			
Bismuth, dissolved	0.0199	0.00010	mg/L	0.0200		100	80-120			
Boron, dissolved	0.0181	0.0050	mg/L	0.0200		91	80-120			
Cadmium, dissolved	0.0187	0.000010	mg/L	0.0200		94	80-120			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B8F1042, Continued										
LCS (B8F1042-BS1), Continued					Prepared: 2018-06-14, Analyzed: 2018-06-14					
Calcium, dissolved	2.16	0.20	mg/L	2.00		108	80-120			
Chromium, dissolved	0.0182	0.00050	mg/L	0.0200		91	80-120			
Cobalt, dissolved	0.0183	0.00010	mg/L	0.0200		92	80-120			
Copper, dissolved	0.0192	0.00040	mg/L	0.0200		96	80-120			
Iron, dissolved	1.84	0.010	mg/L	2.00		92	80-120			
Lead, dissolved	0.0199	0.00020	mg/L	0.0200		99	80-120			
Lithium, dissolved	0.0198	0.00010	mg/L	0.0200		99	80-120			
Magnesium, dissolved	1.91	0.010	mg/L	2.00		96	80-120			
Manganese, dissolved	0.0190	0.00020	mg/L	0.0200		95	80-120			
Molybdenum, dissolved	0.0186	0.00010	mg/L	0.0200		93	80-120			
Nickel, dissolved	0.0181	0.00040	mg/L	0.0200		90	80-120			
Phosphorus, dissolved	1.89	0.050	mg/L	2.00		95	80-120			
Potassium, dissolved	2.03	0.10	mg/L	2.00		102	80-120			
Selenium, dissolved	0.0176	0.00050	mg/L	0.0200		88	80-120			
Silicon, dissolved	1.7	1.0	mg/L	2.00		83	80-120			
Silver, dissolved	0.0188	0.000050	mg/L	0.0200		94	80-120			
Sodium, dissolved	1.92	0.10	mg/L	2.00		96	80-120			
Strontium, dissolved	0.0193	0.0010	mg/L	0.0200		96	80-120			
Sulfur, dissolved	4.2	3.0	mg/L	5.00		85	80-120			
Tellurium, dissolved	0.0211	0.00050	mg/L	0.0200		106	80-120			
Thallium, dissolved	0.0200	0.000020	mg/L	0.0200		100	80-120			
Thorium, dissolved	0.0193	0.00010	mg/L	0.0200		96	80-120			
Tin, dissolved	0.0202	0.00020	mg/L	0.0200		101	80-120			
Titanium, dissolved	0.0200	0.0050	mg/L	0.0200		100	80-120			
Tungsten, dissolved	0.0185	0.0010	mg/L	0.0200		92	80-120			
Uranium, dissolved	0.0233	0.000020	mg/L	0.0200		117	80-120			
Vanadium, dissolved	0.0181	0.0010	mg/L	0.0200		91	80-120			
Zinc, dissolved	0.0204	0.0040	mg/L	0.0200		102	80-120			
Zirconium, dissolved	0.0205	0.00010	mg/L	0.0200		102	80-120			
Reference (B8F1042-SRM1)					Prepared: 2018-06-14, Analyzed: 2018-06-14					
Aluminum, dissolved	0.259	0.0050	mg/L	0.233		111	79-114			
Antimony, dissolved	0.0497	0.00020	mg/L	0.0430		116	89-123			
Arsenic, dissolved	0.468	0.00050	mg/L	0.438		107	87-113			
Barium, dissolved	3.52	0.0050	mg/L	3.35		105	85-114			
Beryllium, dissolved	0.214	0.00010	mg/L	0.213		101	79-122			
Boron, dissolved	1.57	0.0050	mg/L	1.74		90	79-117			
Cadmium, dissolved	0.222	0.000010	mg/L	0.224		99	89-112			
Calcium, dissolved	8.09	0.20	mg/L	7.69		105	85-120			
Chromium, dissolved	0.439	0.00050	mg/L	0.437		100	87-113			
Cobalt, dissolved	0.128	0.00010	mg/L	0.128		100	90-117			
Copper, dissolved	0.854	0.00040	mg/L	0.844		101	90-115			
Iron, dissolved	1.28	0.010	mg/L	1.29		99	86-112			
Lead, dissolved	0.114	0.00020	mg/L	0.112		102	90-113			
Lithium, dissolved	0.107	0.00010	mg/L	0.104		103	77-127			
Magnesium, dissolved	6.76	0.010	mg/L	6.92		98	84-116			
Manganese, dissolved	0.354	0.00020	mg/L	0.345		102	85-113			
Molybdenum, dissolved	0.435	0.00010	mg/L	0.426		102	87-112			
Nickel, dissolved	0.831	0.00040	mg/L	0.840		99	90-114			
Phosphorus, dissolved	0.475	0.050	mg/L	0.495		96	74-119			
Potassium, dissolved	3.27	0.10	mg/L	3.19		103	78-119			
Selenium, dissolved	0.0312	0.00050	mg/L	0.0331		94	89-123			
Sodium, dissolved	18.2	0.10	mg/L	19.1		95	81-117			
Strontium, dissolved	0.956	0.0010	mg/L	0.916		104	82-111			
Thallium, dissolved	0.0396	0.000020	mg/L	0.0393		101	90-113			
Uranium, dissolved	0.265	0.000020	mg/L	0.266		100	87-113			

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Dissolved Metals, Batch B8F1042, Continued										
Reference (B8F1042-SRM1), Continued				Prepared: 2018-06-14, Analyzed: 2018-06-14						
Vanadium, dissolved	0.865	0.0010	mg/L	0.869		99	85-110			
Zinc, dissolved	0.896	0.0040	mg/L	0.881		102	88-114			
General Parameters, Batch B8F0772										
Blank (B8F0772-BLK1)				Prepared: 2018-06-10, Analyzed: 2018-06-10						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B8F0772-BLK2)				Prepared: 2018-06-10, Analyzed: 2018-06-10						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
LCS (B8F0772-BS1)				Prepared: 2018-06-10, Analyzed: 2018-06-10						
Ammonia, Total (as N)	1.03	0.020	mg/L	1.00		103	90-115			
LCS (B8F0772-BS2)				Prepared: 2018-06-10, Analyzed: 2018-06-10						
Ammonia, Total (as N)	1.03	0.020	mg/L	1.00		103	90-115			
General Parameters, Batch B8F0907										
Blank (B8F0907-BLK1)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Conductivity (EC)	< 2.0	2.0	µS/cm							
Blank (B8F0907-BLK2)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
Alkalinity, Total (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Bicarbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L							
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L							
Conductivity (EC)	< 2.0	2.0	µS/cm							
LCS (B8F0907-BS1)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
Alkalinity, Total (as CaCO3)	99.2	1.0	mg/L	100		99	92-106			
LCS (B8F0907-BS2)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
Alkalinity, Total (as CaCO3)	100	1.0	mg/L	100		100	92-106			
LCS (B8F0907-BS3)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
Conductivity (EC)	1420	2.0	µS/cm	1410		100	95-104			
LCS (B8F0907-BS4)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
Conductivity (EC)	1420	2.0	µS/cm	1410		101	95-104			
Duplicate (B8F0907-DUP1)		**Source: 8060849-01**		Prepared: 2018-06-12, Analyzed: 2018-06-12						
Alkalinity, Total (as CaCO3)	152	1.0	mg/L		151			< 1	10	
Alkalinity, Phenolphthalein (as CaCO3)	< 1.0	1.0	mg/L		< 1.0				10	
Alkalinity, Bicarbonate (as CaCO3)	152	1.0	mg/L		151			< 1	10	
Alkalinity, Carbonate (as CaCO3)	< 1.0	1.0	mg/L		< 1.0				10	
Alkalinity, Hydroxide (as CaCO3)	< 1.0	1.0	mg/L		< 1.0				10	
Conductivity (EC)	405	2.0	µS/cm		404			< 1	5	
pH	8.04	0.10	pH units		7.80			3	4	HT2

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Associated Environmental Consultants Inc. (Vernon)	**WORK ORDER**	8060849
PROJECT	2018-8012 Polson Park GW	**REPORTED**	2018-06-15 14:17

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B8F0907, Continued										
Reference (B8F0907-SRM1)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
pH	7.01	0.10	pH units	7.01		100	98-102			
Reference (B8F0907-SRM2)				Prepared: 2018-06-12, Analyzed: 2018-06-12						
pH	7.01	0.10	pH units	7.01		100	98-102			
General Parameters, Batch B8F0915										
Blank (B8F0915-BLK1)				Prepared: 2018-06-14, Analyzed: 2018-06-14						
Solids, Total Dissolved	< 15	15	mg/L							
LCS (B8F0915-BS1)				Prepared: 2018-06-13, Analyzed: 2018-06-13						
Solids, Total Dissolved	233	15	mg/L	240		97	85-115			

QC Qualifiers:

HT2 The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.