REPORT

Hydrogeological Assessment

Crestview Lagoon, Whitehorse, YT

Submitted to:

Michael Abbott, PEng
City of Whitehorse
4210 4th Ave.
Whitehorse, YT Y1A 1K1

Submitted by:

Golder Associates Ltd.
#13 - 151 Industrial Road Calcite Business Centre, Whitehorse, Yukon Territory, Y1A 2V3, Canada

+1 867 633 6076

19130631-001-R-Rev2

27 February 2020

Distribution List

e-copy: City of Whitehorse

Executive Summary

Golder Associates Ltd. (Golder) was retained by the City of Whitehorse on 18 October 2019 to complete an update to the current hydrogeological assessment at the Crestview Lagoon, as outlined on the City of Whitehorse's current short-term Water Use Licence (WUL), MN18-059. The WUL outlines the installation of new monitoring wells around the Crestview lagoons to monitor groundwater quality and update the findings of the previously conducted *Hydrogeological Investigations at the Crestview and Whitehorse Sewage Lagoons Whitehorse, Yukon* completed in 2009 EBA Engineering Consultants Ltd (EBA)

This work included the installation of two monitoring wells and a reassessment of the impact the lagoon may have on the groundwater, based on historical and current groundwater quality information. The rationale for the location of the two monitoring wells are described below:

- The monitoring well MW1-19 was installed as a replacement to the on-site well MW2-08. The existing well, MW2-08, initially contained water after installation and later has become consistently dry or contained insufficient amounts of water, preventing the collection of samples since it was completed. A new deeper well was recommended to be installed in the vicinity of the existing monitoring well as a substitute.
- The monitoring well MW2-19 location was selected based on the recommendation made by EBA (2009) and as requested in the City of Whitehorse Water License MN18-059, which was to install a bedrock well between the Crestview Lagoon and the neighbouring property, Yukon Springs. The anticipated depth to groundwater for this well was estimated to be approximately 25 to 30 m.

The objective of this assessment was to update the Site's conceptual hydrogeological model, including the geology, hydrogeology and topography, and assess the potential impacts that the lagoon may have on local groundwater. To meet this objective, two new monitoring wells were installed, all of the wells at the facility were sampled in accordance with the WUL MN18-059 (effective 19 March 2019, expires 1 May 2020), and relevant Environment Yukon Protocols.

The soil encountered during the drilling investigation was generally consistent with what was previously identified by EBA in 2009, and included the following distinct stratigraphic units: sand ranging in thickness from approximately 1.8 m to 3.0, underlain by silt or sandy silt ranging in thickness from approximately 14.4 m to 37 m, followed by bedrock which was encountered at depths ranging from 16.2 m to 40.2 m.

Groundwater was encountered in two different stratigraphic units including perched groundwater at the base of the silt/sandy silt unit and above the bedrock, and a fractured bedrock aquifer. MW1-19 was screened within the silt/clay layer above bedrock in order to intersect the perched groundwater table located above bedrock, similar to MW1-08 and MW4-08. MW2-19 was installed approximately 12.3 m below the top of bedrock to intersect groundwater flowing through fractured bedrock. MW2-19 is the first well on the Crestview Lagoon screened within the bedrock. Additionally, as discussed by EBA (2009) groundwater may have been encountered at MW3-08. MW3-08 is screened in the upper sand unit and was suspected to intersect seepage and near surface groundwater discharge.

The depth to groundwater in the monitoring wells screened above bedrock ranges from 630.24 to 658.424 masl. The groundwater which is considered perched flows in an easterly direction towards the Yukon River. The groundwater contours and flow direction of this perched groundwater are shown on Figure 2. Based on a calculated horizontal gradient of 0.15 m/m, a hydraulic conductivity of 1 x 10^{-6} m/s based on published values (Freeze and Cherry, 1979)[1], and an assumed porosity for silt of 0.4, the estimated groundwater velocity was calculated using Darcy's Law to be 3.7 x 10^{-7} m/s for an approximate travel time of 11.8 m/yr.

The second aquifer in fractured bedrock was intersected by MW2-19. The interconnectivity of the fractures is not known; however, flow is expected to be to the east towards the Yukon River. As there is only one well (MW2-19) intersecting the fractured bedrock, the groundwater flow direction and velocity could not be determined.

Based on the groundwater flow direction in the upper perched groundwater, the Yukon Springs facility is considered up-gradient of the Crestview lagoon. In the EBA report (2009), the source of the Yukon Springs water was believed to have been from the deeper bedrock aquifer. Following a review of Yukon Springs' water license, it appears that the water intake is from approximately 8' depth and likely from the perched groundwater. Based on this information, the Crestview Lagoon would not be a potential source of contamination to the water well located at Yukon Springs.

Based on a review of analytical data from groundwater samples collected from the Crestview lagoon from 2008 to 2019, the concentrations of the various parameters appear to be stable with some variability.

Analytical parameters collected from MW1-19, MW2-19, MW3-08, and MW4-08 at the Crestview Lagoon met the applicable Yukon CSR AW and DW standards.

The following recommendations are made based on the groundwater monitoring results presented in this report:

- As required by the City's WUL requirements, groundwater monitoring should be conducted three times a year; during spring freshet, mid-season, and fall, as conditions may change seasonally
- Conduct upstream and downstream surface water sampling from the Yukon River to confirm that there are no impacts from the Crestview Lagoon.
- Based on the groundwater flow direction in the upper perched aquifer, the Crestview Lagoon does not have a reliable up-gradient monitoring well (as MW1-08 has been routinely dry or with insufficient water to sample). Installation of an up-gradient monitoring well is recommended to determine the background concentrations of leachate indicator parameters in groundwater in order to evaluate whether concentrations increase across the Site.
- Install an additional down-gradient monitoring well on the north side of the Crestview Lagoon in order to assess the groundwater quality and flow direction on the north side of the lagoon.
- An elevation survey of all wells on site should be conducted to increase the accuracy of the groundwater flow direction.

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

Study Limitations

This report was prepared for the use of the City of Whitehorse and is intended to provide an assessment of hydrogeological investigation work associated with the property located at the Crestview Lagoon, Whitehorse, Yukon. The inferences concerning the site conditions contained in this report are based on information obtained during the investigations conducted by Golder personnel, as outlined in this report, and are based solely on the condition of the property at the time of the site investigation, supplemented by historical information obtained by Golder, as described in this report. The data presented in this report represent hydrogeological conditions encountered at the sampling locations tested during this time period. Hydrogeological conditions may vary with location, depth, time, sampling methodology, analytical techniques and other factors. Golder makes no warranty, expressed or implied, and assumes no liability with respect to the use of the information contained in this report at the subject site, or any other site, for other than its intended purpose.

This report was prepared, based in part, on information obtained from historic information sources. In evaluating the site, Golder has relied in good faith on information provided. We accept no responsibility for any deficiency or inaccuracy contained in this report as a result of our reliance on the aforementioned information.

The findings and conclusions documented in this report have been prepared for the specific application to this project, and have been developed in a manner consistent with that level of care normally exercised by environmental professionals currently practising under similar conditions in the jurisdiction. Golder makes no other warranty, expressed or implied.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third part as a result of decisions made or action based on this report. Golder disclaims responsibility of consequential financial effects on transactions or property values, or requirements for follow-up action and costs, which result from reporting the factual information contained herein.

Golder makes no other representation whatsoever, including those concerning the legal significance of its findings, or as to other legal matters touched on in this report, including, but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation. These interpretations may change over time.

If new information is discovered during future work, including excavations, soil boring, or other investigations, Golder should be requested to re-evaluate the conclusions of this report and to provide amendments, as required, prior to any reliance upon the information presented herein.

Table of Contents

TABLES

TABLES (ATTACHED)

FIGURES

APPENDICES

APPENDIX C
Field Forms and Calibration Records
forms

APPENDIX D
Laboratory Reports and Chain-of-Custody

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by the City of Whitehorse (the City) to update the hydrogeological assessment at the Crestview Lagoon (the Site), as outlined by the City of Whitehorse's current short-term Water Use Licence (WUL), MN18-059.

Authorization to proceed with the work was provided by the City on 2 October 2019.

1.1 Background

The Site is located within the City of Whitehorse, Yukon. It lies within the Southern Lakes Ecological Region at latitude 60°47'40" North and longitude 135°09'20" West. The Site is located across the Alaska Highway from the Crestview subdivision and 150 m southwest of the Yukon River, and is accessed by a gravel road from the east side of the highway. The legal description of the Crestview Lagoon is Lot 1410, 87561 CLSR, 2003-0084 LTO. It is located in the traditional territory of the Ta'an Kwäch'än Council and Kwanlin Dün First Nation.

The WUL outlines the requirement for installation of new monitoring wells around the Crestview lagoons to monitor groundwater quality and update the findings of the previously conducted *Hydrogeological Investigations at the Crestview and Whitehorse Sewage Lagoons Whitehorse, Yukon* completed in 2009 by EBA Engineering Consultants Ltd (EBA).

1.2 Objectives and Scope of Work

The objective of this assessment was to update the Site's conceptual hydrogeological model, including the geology, hydrogeology and topography, and assess the potential impacts that the lagoon may have on local groundwater. To meet this objective, the following scope of work was conducted, in accordance with the WUL MN18-059 (effective 19 March 2019, expires 1 May 2020), and relevant Environment Yukon Protocols:

- Review previous reports, the applicable WUL and other relevant documents;
- Drill and install two additional monitoring wells on the Site to replace monitoring well MW2-08 and to install a deeper well in the area of MW1-08;
- Develop and collect water quality samples from the newly installed monitoring wells and the existing monitoring wells;
- Submit the samples for laboratory analysis and identify potential impacts; and
- Prepare this Hydrogeological Assessment documenting the results of this investigation.

2.0 REGULATORY FRAMEWORK

The groundwater samples were analyzed for parameters as outlined in the City's Water License (MW18-059) with results compared to the Yukon Contaminated Sites Regulation (CSR) Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW) in accordance with Yukon CSR Protocol 6 (Environment Yukon, 2012). The four types of water uses outlined in the CSR, the relevant water quality standards, and their applicability to this assessment are presented in Table 1.

Table 1: Applicable Water Quality Standards

Water Use	Applicable Water Quality Standard	Applicable Radius (km)	Applicability to Assessment
Aquatic Life	Schedule 3 – Contaminated Sites Regulation (O.I.C. 2002/171)	1	Applicable
Drinking Water	Schedule 3 – Contaminated Sites Regulation (O.I.C. 2002/171)	1.5	Applicable
Irrigation	Schedule 3 – Contaminated Sites Regulation (O.I.C. 2002/171)	1.5	Not Applicable
Livestock	Schedule 3 – Contaminated Sites Regulation (O.I.C. 2002/171)	1.5	Not Applicable

The following discusses the applicability of each water quality standard to the Crestview Lagoon.

Aquatic Life

A review of the Yukon Lands Viewer and Google Earth Images by Golder in 2019, showed the nearest downgradient body of water is the Yukon River, located approximately 150 m northeast of the site. It was therefore determined that CSR standards for freshwater aquatic life (AW) were **applicable** to the Crestview Lagoon.

Drinking Water

A search of drinking water wells on the Groundwater Information Network (GIN) website and the Yukon Water Data Catalogue by Golder in 2019, showed 17 water wells located within a 1.5 km radius of the site, use of wells include; domestic, commercial and unknown. Included in these 17 wells is a water bottling facility, Yukon Springs Inc. (Yukon Springs), which was known to Golder to be located approximately 150 m south of the site. It was therefore determined that CSR standards for drinking water (DW) were **applicable** to the Crestview Lagoon.

A review of the Yukon Springs Inc. water license (current water license IN19-038, previous water license IN94-001) and Yukon Environmental and Socio-economic Assessment Act application (project number 2019-0074) noted that the source of the water used for water bottling purposes was from a natural flowing underground spring. Golder's interpretation of the hand-written water license application was that the water intake for the Yukon Springs water was located within an on-site borehole at a maximum depth of 8 ft below ground surface; however, the screened section of the well cannot be confirmed as construction details for the well were not available for review.

Irrigation and Livestock

A review of the Groundwater Information Network (GIN) website and the Yukon Water Data Catalogue and reviewed by Golder in 2019, showed no irrigation wells or wells for livestock on record for the Crestview Lagoon. It should be noted that this is not a complete record of all wells in the Yukon, and it is possible that there are irrigation wells or wells for livestock in the area. A review of the Yukon Lands Viewer images and information on agricultural tenure in the Crestview area shows there are no agricultural properties within a 1.5 km radius of the Site. It was therefore considered that CSR water quality standards for irrigation and livestock are **not applicable** to the Crestview Lagoon.

3.0 METHODS

3.1 Site Selection

Monitoring well locations were determined based on the recommendations made by EBA (2009) and during consultation with the City. The rationale for the location of the two monitoring wells is described below:

- The monitoring well MW1-19 was installed as a replacement to the on-site well MW2-08. The existing well, MW2-08, initially contained water after installation and later has become consistently dry or contained insufficient amounts of water, preventing the collection of samples since it was completed. A new deeper well was recommended to be installed in the vicinity of the existing monitoring well as a substitute.
- The monitoring well MW2-19 location was selected based on the recommendation made by EBA (2009) and as requested in the City of Whitehorse Water License MN18-059, which was to install a monitoring well to capture deeper groundwater flow path through bedrock between the Crestview Lagoon and the neighbouring property, Yukon Springs. The anticipated depth to groundwater for this well was estimated to be approximately 25 to 30 m.

The locations of the new and existing monitoring wells present on-Site are shown in Figure 1.

3.2 Borehole Drilling and Monitoring Well Installation

The drilling and monitoring well installation were completed by Impact Well Drilling of Whitehorse, Yukon under the supervision of Golder field staff on 22 October 2019, using an air rotary drill rig. Drilling was extended at each location until groundwater and/or wet subsurface soil conditions were encountered. The geology encountered at each location was logged during the drilling based on the cuttings retrieved.

The monitoring wells were constructed in accordance with Yukon CSR Protocol No. 7: Groundwater Monitoring Well Installation and Sampling (Environment Yukon, 2017) using a machine-slotted well screen with 0.010 inch openings and schedule 40 PVC polyvinyl chloride (PVC) riser pipes with threaded joints and end capped with a sand point. The screen was placed to intersect the water table. A filter pack of clean silica sand surrounded the well screen to approximately 0.5 m above the top of screen. Monitoring wells were sealed above the filter pack to near ground surface with bentonite chips and completed above ground surface with a protective lockable steel casing. Monitoring well details are summarized below in Table 2, with the 2019 borehole logs provided in Appendix A and photographs collected during installation are provided in Appendix B.

3.3 Monitoring Well Network

In August 2008, EBA installed four monitoring wells, shown on Figure 2 at the Crestview Lagoon as part of a hydrogeological assessment of the Crestview Lagoon. MW1-08, MW2-08 (D&S), MW3-08, and MW4-08 were installed to provide up-gradient and down-gradient water quality monitoring points.

Table 2 below presents the monitoring well construction details, including their location relative to the Crestview Lagoon.

Table 2: Monitoring Well Details

Monitoring Well ID	UTM Coordinates (Zone 8V)	Completion Date	Location of Well Relative to Crestview Lagoon in terms of Groundwater Flow	Water-Bearing Unit	Drilled depth (m bgs)	Screen Interval (m bgs)	Filter Pack Interval (m bgs)
MW1-08	6739565 m N, 491689 m E	16 August 2008	Cross-gradient	Silt	7.0	4.1-7.0	3.5-7.0
MW2-08D	6739661 m N, 491803 m E	16 August 2008	Down-gradient	Silt/Clay	19.8	16.8-19.8	16.3-19.8
MW2-08S	6739661 m N, 491803 m E	16 August 2008	Down-gradient	Silt/Clay	19.8	4.5-7.6	4.1-8.3
MW3-08	6740319 m N, 491330 m E	16 August 2008	Cross-gradient	Sand	4.6	0.6-1.6	0.2-2.1
MW4-08	6740033 m N, 491583 m E	17 August 2008	Downgradient	Silt and Gravel	18.2	14.0-16.8	13.5-17.4
MW1-19	6739645.230 m N, 491822.540 m E	22 October 2019	Downgradient	Silt	41.2	39.0-41.1	36.9-41.2
MW2-19	6739511.794 m N, 491724.702 m E	22 October 2019	Cross-gradient/Bedrock Well	Bedrock	36.3	28.5-34.6	27.3-36.3

Notes:

Data for monitoring wells installed by EBA in 2008 was collected from the borehole logs provided in the 2009 Hydrogeological Assessment, except for MW4-08 as the UTM coordinates were incorrect. Coordinates for MW4-08 was collected in the field using a GPS (± 5m accuracy)

In November 2019, Underhill Geomatics completed a level survey to determine the horizontal positions and vertical elevation to the top of the PVC wellhead (measuring point) for the two newly installed wells. The UTM coordinates for the two wells are provided in Table 2. The top of PVC pipe at MW1-19 and MW2-19, which was obtained using a GPS instrument with a horizontal and vertical accuracy of ± 0.3 cm represents the initial absolute elevation. Vertical elevations are provided in Table 3, below.

3.4 Monitoring Well Development and Groundwater Sampling

Once the monitoring wells had been installed, the monitoring wells were developed to remove water or sediments that may have been introduced during drilling and to remove fines from around the well screen. Monitoring wells MW1-19 and MW2-19 were developed on 6 November 2019 by removing a minimum of five well volumes using dedicated Waterra™ tubing and a Hydrolift™ pump. Field parameters measured during development included temperature, pH, specific conductivity, dissolved oxygen, and oxidation reduction potential (ORP). Development logs are provided in Appendix C.

The monitoring wells were then allowed to stabilize for a minimum of 48 hours before being purged. The following procedures were followed when purging monitoring wells:

- remove at least three well casing volumes; or
- monitor water quality parameters until a minimum of three (minimum of four, if using temperature as an indicator) parameters listed below stabilize; or
- for low yield wells, until the well casing is evacuated.

During purging, physiochemical parameters (pH, temperature, conductivity, dissolved oxygen and oxidation reduction potential) were monitored at regular intervals using an YSI multi-meter. Purging continued until a minimum of three well volumes were removed. Water quality parameters are considered stable when three successive readings, collected three to five minutes apart, are within:

- ± 3 percent for temperature (minimum of ± 0.2°C);
- ± 0.1 for pH;
- ± 3 percent for conductivity;
- ± 10 mv for redox potential; and
- ± 10 percent for dissolved oxygen.

A water level was measured at each well prior to purging using a Heron 75 m water level meter. Groundwater purging and sampling were conducted using a GeoPump™ peristaltic pump and dedicated high density polyethylene and silicone tubing or dedicated high density polyethylene Waterra™ tubing and foot valve either by manual purging or using a Hydrolift and generator. Sample containers and appropriate preservatives were obtained from Caro Analytical Services (CARO) in Richmond, BC.

The groundwater samples were collected from monitoring wells at Crestview (MW1-19, MW2-19, MW3-08, and MW4-08) on 8 November 2019. Monitoring wells MW1-08 and MW2-08 (D&S) were not sampled due to insufficient water or dry well conditions. Groundwater sampling followed the procedures outlined in the Yukon Contaminated Sites Regulation (CSR) (Environment Act, 2002) Protocol No. 7 (Environment Yukon, 2017). Groundwater samples were collected directly from the dedicated tubing installed in each well.

Samples were submitted for analysis of the parameters outlined in Section 2.3.1. Samples were kept in coolers with ice packs prior to their delivery to the Air North in Whitehorse and shipped to CARO in Richmond, BC, within appropriate holding times. CARO's laboratory is certified by the Canadian Association for Laboratory Accreditation and is accredited as conforming to ISO/IEC 17025 for analysis.

The laboratory analytical results and chain of custody forms are provided in Appendix D, and groundwater purging, and sampling sheets provided in Appendix C.

3.4.1 Groundwater and Surface Water Analytical Parameters

In accordance with the City's Water License monitoring requirements, groundwater wells were sampled and analyzed for the following parameters:

- pH
- Temperature
- Conductivity
- Ammonia
- Biological Oxygen Demand (BOD)
- Dissolved Oxygen
- Fecal Coliforms
- Chloride
- Nitrates+Nitrites

The parameter list complies with the City's Water License (MW18-059). Results were compared to the Yukon Contaminated Sites Regulation Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW).

3.5 Quality Assurance/Quality Control

The quality assurance and quality control (QA/QC) conducted for this program was completed in conjunction with ongoing monitoring in support of the City's WUL completed by Golder. The following QA/QC procedures were followed:

- Sample Integrity: All samples were kept at the appropriate temperature and delivered to the laboratory within the appropriate holding times with the exception of pH, temperature and dissolved oxygen which exceeded the literature holding time. A field pH, temperature and dissolved oxygen were also measured.
- Field Procedures: Monitoring wells were purged and/or developed and sampled using dedicated tubing. Equipment used in sampling more than one well was decontaminated using soap (Liquinox™) and distilled water.

- Calibration of Field Equipment: Calibration of field equipment was undertaken daily, prior to developing, purging, and sampling wells.
- QA/QC samples: For the November City of Whitehorse WUL sampling program the following QA/QC samples were collected:
  - Two field duplicates;
  - Two field blanks; and
  - Two site-specific laboratory splits.

4.0 RESULTS

4.1 Soil Stratigraphy

The soil encountered during the borehole drilling investigation was generally consistent with what was previously identified by EBA in 2009, and included the following distinct stratigraphic units:

- Sand ranging in thickness between the two boreholes, from approximately 1.8 m at MW2-19 to 3.0 m at MW1-19.
- Silt or sandy silt ranging in thickness from approximately 14.4 m at MW2-19 to 37 m at MW1-19.
- Bedrock was encountered at both borehole locations and was noted at depths ranging from 16.2 m bgs at MW2-19 to 40.2 m bgs at MW1-19.

A detailed description of the soil stratigraphy encountered at the two boreholes is presented in the borehole logs in Appendix A and photographs collected during drilling are presented in Appendix B. Soil stratigraphy across the site is displayed on the cross-section (Figure 3), including information from EBA's (2009) borehole logs.

4.2 Hydrogeology

Previously installed monitoring wells had not been previously surveyed; therefore, Golder used the groundwater depth data, stick-up height and an estimated ground elevation collected in November 2019 to calculate the groundwater elevation at each monitoring well. This data was used to establish the general groundwater flow direction beneath the Crestview Lagoon. Table 3 below summarizes the well elevation survey data and water level measurements in metres above sea level (masl) and metres below top of well casing (mbtoc). Groundwater elevations are shown on Figure 2.

Table 3: Monitoring Well Locations and Groundwater Elevations from the Monitoring Event on 8 November 2019

Well ID	Top of PVC Casing Surveyed Elevation (masl)	Stick up height (m)	Ground Elevation Estimate* (masl)	Water Level (mbtoc)	Groundwater Elevation (masl)
MW1-08	-	0.91	660.662	7.55	654.022
MW2-08D	-	0.86	662.35	Dry	Dry
MW2-08S	-	0.86	662.35	Dry	Dry
MW3-08	-	1.37	658.948	1.894	658.424
MW4-08	-	0.74	661.494	16.64**	645.594
MW1-19	663.661	0.97	662.525	33.255	630.24
MW2-19	660.891	0.42	659.999	15.209	645.21

Notes:
masl = metres above sea level
*Ground elevation estimates collected from the contour map on Geomatics Yukon (Government of Yukon, 2011).
** Depth to water for MW4-08 was taken from the last measurement in August 2019. Due to blockage of tubing in monitoring well during November event, the water level tape was unable to go past the tubing, however the collection of a sample was possible. Field staff were not successful in being able to remove the tubing.

Figure 1 shows the location of the monitoring wells included as part of this 2019 Hydrogeological Assessment.

Groundwater was identified in the various stratigraphic units present at the Site including perched groundwater within the silt/clay unit, and a fractured bedrock aquifer. The monitoring wells were screened as follows:

- MW1-19 was screened within the silt/clay layer above bedrock in order to intersect the perched groundwater table located above bedrock, similar to MW1-08 and MW4-08.
- MW2-19 was installed approximately 12.3 m below the top of bedrock in order to capture the groundwater within fractured bedrock. MW2-19 is the first well on the Crestview Lagoon that is drilled into this aquifer.
- Additionally, as discussed by EBA (2009) a potential third groundwater unit may have been encountered at MW3-08. MW3-08 is screened in the upper sand unit and above the silt/clay layer. Water present in this monitoring well is suspected to be seepage and near surface groundwater discharge.

The depth to groundwater across the Crestview Lagoon ranges from 630.24 to 658.424 masl. The perched groundwater, above bedrock flows in an easterly direction towards the Yukon River. The groundwater contours and flow direction of the perched groundwater are shown on Figure 2. Based on a calculated gradient of 0.15 m/m, a hydraulic conductivity of 1 x 10^{-6} m/s based on published values (Freeze and Cherry, 1979), and an assumed porosity for silt of 0.4, the estimated horizontal groundwater velocity of the perched aquifer was calculated using Darcy's Law to be 3.7 x 10^{-7} m/s for an approximate travel time of 11.8 m/yr.

The second deeper aquifer in fractured bedrock was intersected by MW2-19. The interconnectivity of the fractures is not known; however, flow is anticipated to be to the east towards the Yukon River. As there is only one well (MW2-19) intersecting the fractured bedrock, the groundwater flow direction and velocity could not be determined.

4.3 Groundwater Chemistry

Groundwater monitoring was conducted at the Crestview Lagoon on 8 November 2019. Groundwater chemistry results from 2019 are presented in the attached Tables 4 and 5. Chain of custody forms for the groundwater samples collected in November 2019, along with the laboratory analytical results are provided in Appendix D. All analyzed analytical parameters met the applicable Yukon CSR AW and DW standards.

Data plots over time were generated using the historical data that was provided by the City of Whitehorse and the data collected by Golder in 2019 for monitoring wells MW1-08, MW2-08S, MW3-08, and MW4-08. The historical data quality was not able to be verified as original laboratory reports were not available. Gaps in the data likely indicate dry or insufficient water in the monitoring well in question. A statistical trend analysis was not completed due to several factors:

- Significant data gaps were present forMW1-08 and MW2-08.
- The concentrations of several parameters were less than the laboratory method detection limit. For the purpose of plotting the data points, non-detect values were entered as half of the detection limit.
- Due to the variability in the data, no obvious trends were identified

The concentrations of key wastewater indicator parameters have been plotted over the sampling period duration and a commentary on trends provided.

4.3.1 Chloride

Chloride concentrations at the Crestview Lagoon have been less than the CSR DW standard in samples collected from all four monitoring wells. The concentrations in groundwater from MW3-08 (likely cross-gradient) and MW4-08 (down-gradient), ranged from 17.8 to 30.8 mg/L, with the exception a concentration decrease in 2009 in the two wells (1.52 to 3.04 mg/L). This decrease was also measured in groundwater from MW2-08S. A plot of the concentrations of chloride since monitoring began is shown in Figure 1. There is no noticeable increase in concentrations since 2009.

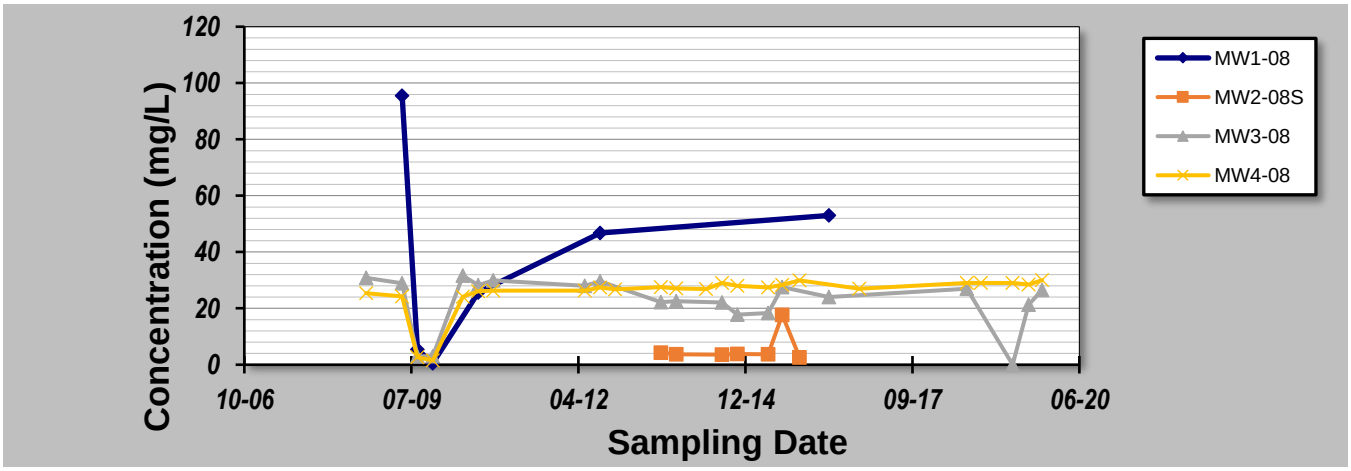


Figure 1: Chloride concentrations at Crestview Lagoon, 2008 - 2019.

4.3.2 Ammonia

Ammonia concentrations at the Crestview Lagoon have historically been less than the CSR AW standard with a few exceedances of the CSR DW standard measured in MW1-08 in November 2009 and August 2012, and a single exceedance in MW3-08 in August 2009. The concentrations have ranged from less than the method detection limit (0.01 mg/L) to 0.15 mg/L in MW3-08 (likely cross-gradient) and MW4-08 (down-gradient). A plot of the concentrations of ammonia over the sampling period is shown in Figure 2. There is some variability in the data; however, there is no noticeable increase in concentrations across the Site.

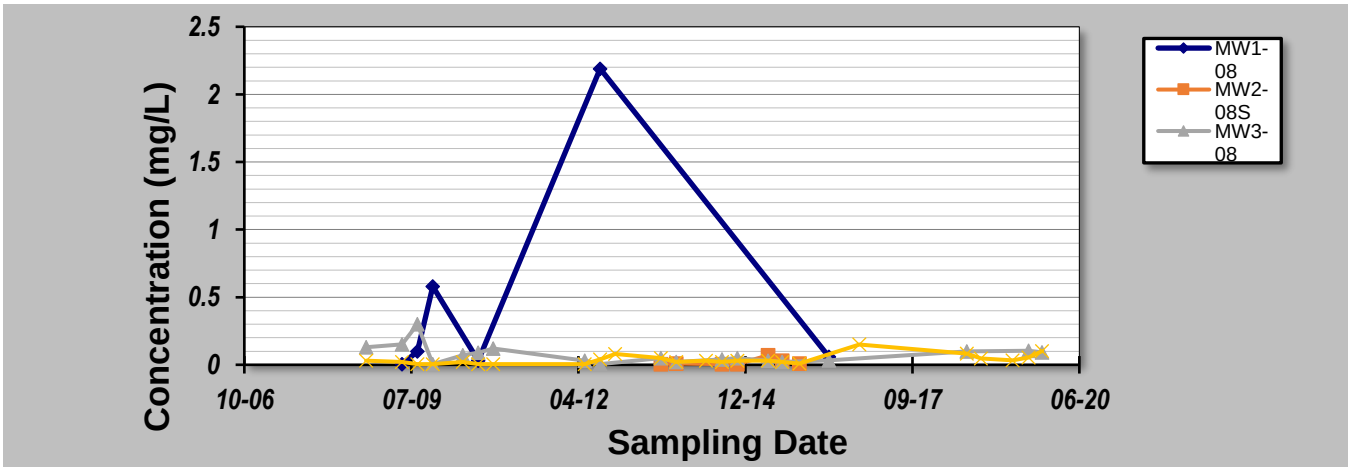


Figure 2: Ammonia concentrations at Crestview Lagoon, 2008 - 2019.

4.3.3 Biological Oxygen Demand

The concentrations of BOD at the Crestview Lagoon have been mostly below the laboratory detection limit in most wells. The concentrations often observed within monitoring wells, MW3-08 (likely cross-gradient) and MW4-08 (down-gradient), ranged from below laboratory detection limit (2.3 to 6 mg/L) to 12 mg/L. A data plot of the concentrations of BOD over time is shown in Figure 3. There is some variability in the data; however there is no noticeable increase in concentrations across the Site.

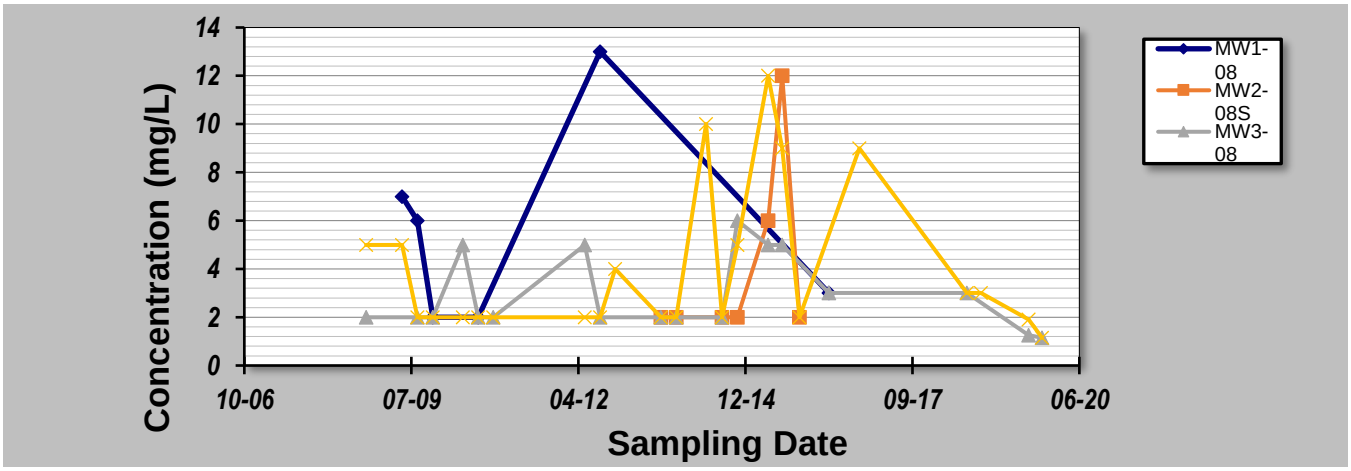


Figure 3: Biological Oxygen Demand concentrations at Crestview Lagoon, 2008 - 2019.

4.3.4 Dissolved Oxygen

The concentrations of Dissolved Oxygen (DO) ranged from 1.4 mg/L to 30.2 mg/L in groundwater from monitoring wells, MW3-08 (likely cross-gradient) and MW4-08 (down-gradient). A plot of the DO over time is shown in Figure 4. There is some variability in the data; however there is no noticeable increase in concentrations across the Site.

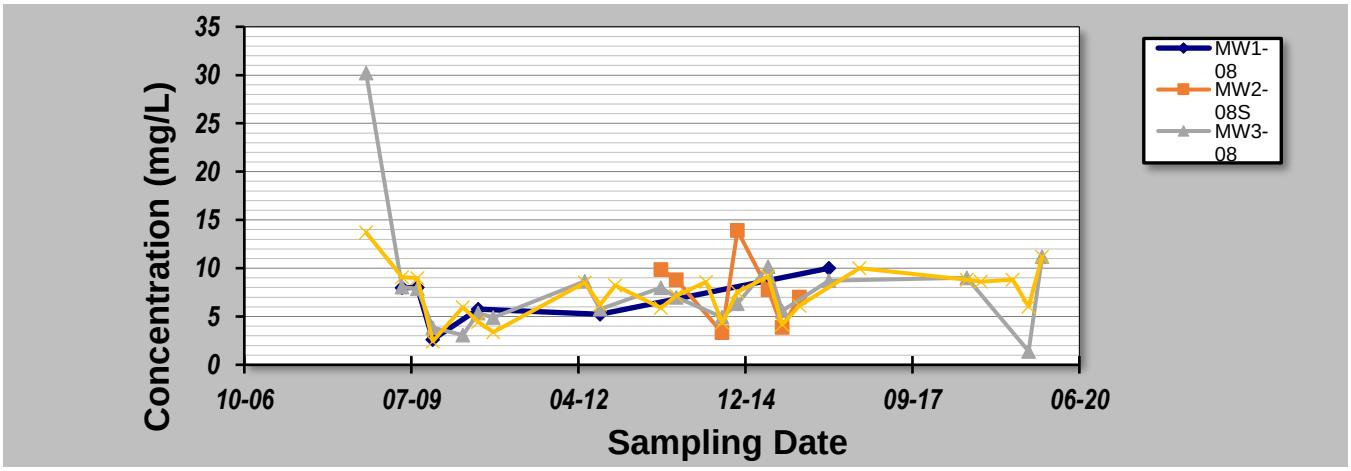


Figure 4: Dissolved Oxygen concentrations at the Crestview Lagoon, 2008 - 2019.

4.3.5 Nitrate plus Nitrite

Nitrate plus nitrite concentrations at the Crestview Lagoon have been historically less than the CSR AW and DW standard with the exception of an exceedance of the CSR DW standard measured in groundwater from MW1-08 in May 2016. The concentrations have ranged from less than the laboratory method detection limit (0.01 mg/L) to 2.41 mg/L in groundwater from monitoring wells, MW3-08 and MW4-08,. A plot of the concentrations of nitrate plus nitrite over time is shown in Figure 5. There is some variability in the data; however, concentrations appear to be stable across the Site.

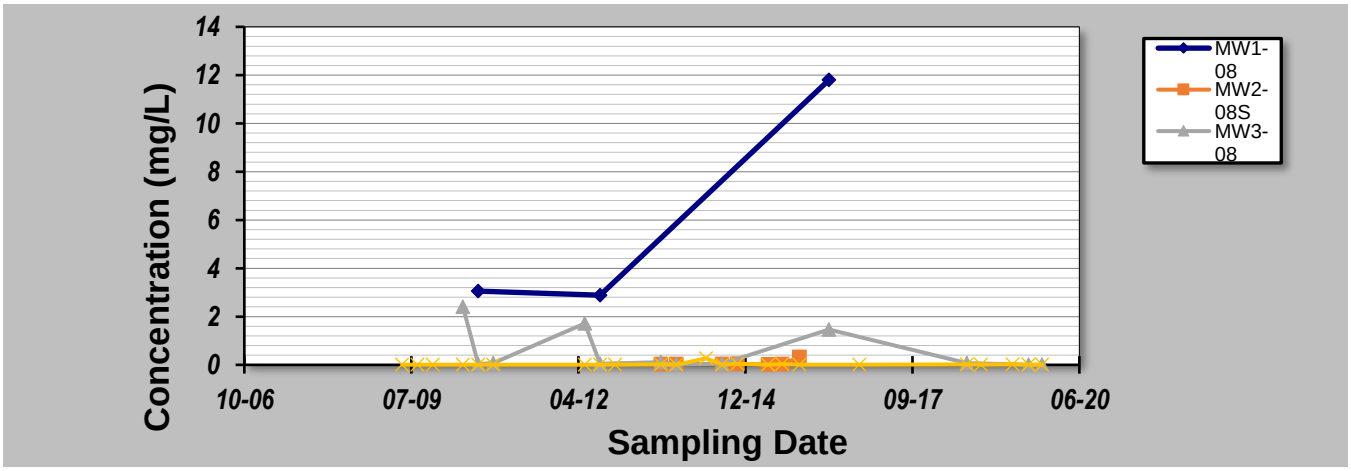


Figure 5: Nitrate plus Nitrite concentrations at the Crestview Lagoon, 2008 - 2019.

4.3.6 Conductivity

The concentrations of conductivity have ranged between 792 µS/cm to 1,327 µS/cm in groundwater from monitoring wells, MW3-08 and MW4-08. A plot of the concentrations of conductivity over time is shown in Figure 6. There has been no noticeable increase in concentrations since 2008.

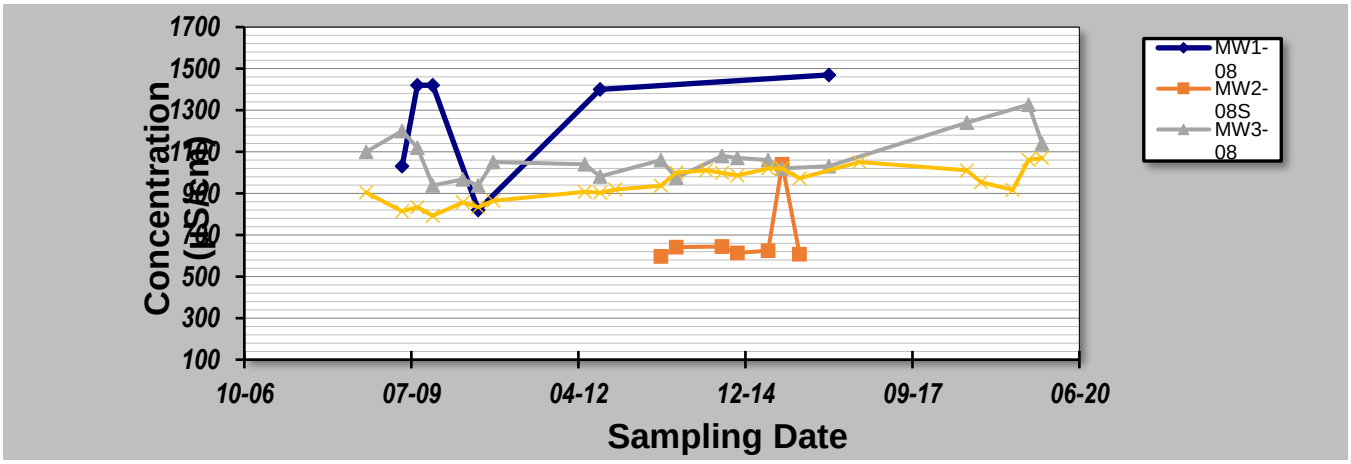


Figure 6: Conductivity concentrations at the Crestview Lagoon, 2008 - 2019.

4.3.7 pH

The pH has ranged between 6.69 and 8.02 in groundwater from monitoring wells, MW3-08 and MW4-08. A plot of the pH over time is shown in Figure 7. There has been no noticeable change in pH since 2008.

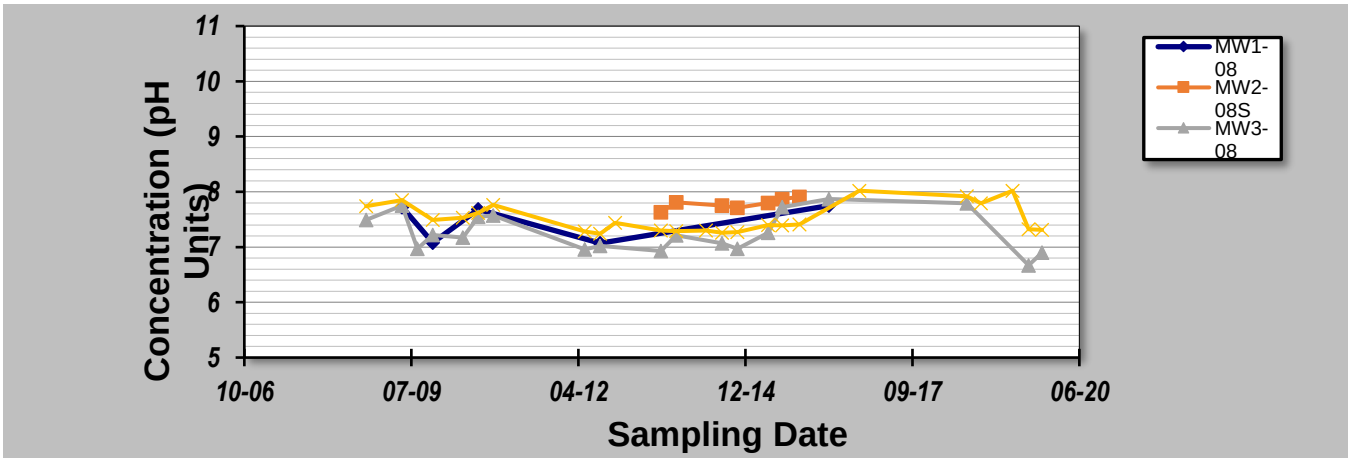


Figure 7: pH at the Crestview Lagoon, 2008 - 2019.

4.3.8 Fecal Coliform

The concentrations of Fecal Coliforms have ranged between less than the laboratory method detection limit (2 – 100 CFU/100mL) to 132 CFU/100mL in monitoring wells MW3-08 and MW4-08. A single incidence of 2,400 CFU/100mL was measured in MW3-08 in August 2019. A plot of fecal coliform over time is shown in Figure 8. There is some variability in the data; however, concentrations do not seem to have increased over time.

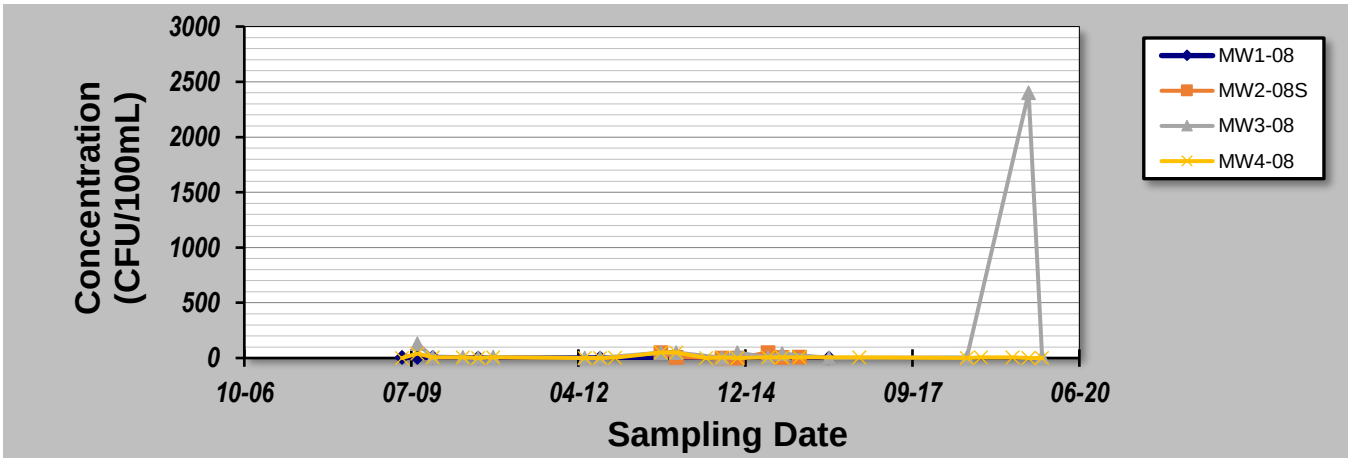


Figure 8: Fecal coliform concentrations at the Crestview Lagoon, 2008 - 2019.

4.4 Results of QA/QC Analyses

The results of the QA/QC data for the month of November was completed in conjunction with on-going monitoring in support of the City's WUL. The laboratory QA/QC is detailed in the primary laboratory report (Appendix D). Data quality objective issues identified in the laboratory report include:

- Samples were delivered to the laboratory within the appropriate holding times with the exception of pH, temperature and dissolved oxygen which exceeded the literature holding time. Field parameters were collected for these parameters knowing that the hold times would be exceeded.
- Samples collected on 8 November were received by the laboratory on the 9 November; however, analysis for Nitrite, Nitrate, and Nitrate+Nitrite, were analyzed outside of the three-day holding time criteria. Caro provided guidance to the rationale behind the three-day hold time. The three-day holding times for nitrate and nitrite analysis are set out by the BC Ministry of Environment and Climate Change. The method document provided by Caro stated that the hold time for Nitrate and Nitrite was determined "because of the utilization of nitrate, nitrite, and phosphate as nutrients by some species of bacteria, store samples at 4 degrees and analyze within 48 hours", which was based on an unpreserved sample. As nitrate+nitrite (as N) was analyzed on preserved sample, the concentration of nitrate+nitrite (as N) should remain intact regardless of the nitrite (as N) analysis qualifier noted in the laboratory report in Appendix D and considered representative for the purpose of this study.
- Samples collected on 8 November 2019 were received by the laboratory on 9 November 2019, however, analysis for BOD was analyzed outside of the three-day holding time criteria. Although there may be some uncertainty associated with the results for BOD, the November 2019 results were within the same magnitude of concentrations previously reported at the site and therefore, considered representative for the purpose of this study.
- The laboratory blank for BOD displayed a dissolved oxygen depletion that exceeded the lab data quality objective (DQO) of 0.2 mg/L. Detection limits were adjusted accordingly.

Overall, the lab report showed acceptable testing frequency and acceptable results for the method blanks, laboratory duplicates and matrix spikes.

5.0 CONCLUSIONS AND RECOMMENDATIONS

The objective of this assessment was to update the Site's conceptual hydrogeological model and assess the potential impacts that the lagoon may have on local groundwater. To meet this objective, two new monitoring wells were installed. All of the wells at the facility were sampled in accordance with the WUL MN18-059 (effective 19 March 2019, expires 1 May 2020), and relevant Environment Yukon Protocols.

The soil encountered during the drilling investigation was generally consistent with what was previously identified by EBA in 2009, and included the following distinct stratigraphic units: sand ranging in thickness from approximately 1.8 m to 3.0, underlain by silt or sandy silt ranging in thickness from approximately 14.4 m to 37 m, followed by bedrock which was encountered at depths ranging from 16.2 m to 40.2 m.

Groundwater was encountered in two different stratigraphic units including perched groundwater at the base of the silt/sandy silt unit and above the bedrock, and a fractured bedrock aquifer. MW1-19 was screened within the silt/clay layer above bedrock in order to intersect the perched groundwater table located above bedrock, similar to MW1-08 and MW4-08. MW2-19 was installed approximately 12.3 m below the top of bedrock to intersect groundwater flowing through fractured bedrock. MW2-19 is the first well on the Crestview Lagoon screened within the bedrock. Additionally, as discussed by EBA (2009) groundwater may have been encountered at MW3-08. MW3-08 is screened in the upper sand unit and was suspected to intersect seepage and near surface groundwater discharge.

The depth to groundwater in the monitoring wells screened above bedrock ranges from 630.24 to 658.424 masl. The groundwater which is considered perched flows in an easterly direction towards the Yukon River. The groundwater contours and flow direction of this perched groundwater are shown on Figure 2. Based on a calculated horizontal gradient of 0.15 m/m, a hydraulic conductivity of 1×10^{-6} m/s based on published values (Freeze and Cherry, 1979)[2], and an assumed porosity for silt of 0.4, the estimated horizontal groundwater velocity was calculated using Darcy's Law to be 3.7×10^{-7} m/s for an approximate travel time of 11.8 m/yr.

The second aquifer in fractured bedrock was intersected by MW2-19. The interconnectivity of the fractures is not known; however, flow is expected to be to the east towards the Yukon River. As there is only one well (MW2-19) intersecting the fractured bedrock, the groundwater flow direction and velocity could not be determined.

Based on the groundwater flow direction in the upper perched groundwater, the Yukon Springs facility is considered up-gradient of the Crestview lagoon. In the EBA report (2009), the source of the Yukon Springs water was believed to have been from the deeper bedrock aquifer. Following a review of Yukon Springs' water license, it appears that the water intake is from approximately 8' depth and likely from the perched groundwater. Based on this information, the Crestview Lagoon would not be a potential source of contamination to the water well located at Yukon Springs.

Based on a review of analytical data from groundwater samples collected from the Crestview lagoon from 2008 to 2019, the concentrations of the various parameters appear to be stable with some variability.

Analytical parameters collected from MW1-19, MW2-19, MW3-08, and MW4-08 at the Crestview Lagoon met the applicable Yukon CSR AW and DW standards.

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

The following recommendations are made based on the groundwater monitoring results presented in this report:

- As required by the City's WUL requirements, groundwater monitoring should be conducted three times a year; during spring freshet, mid-season, and fall, as conditions may change seasonally
- Conduct upstream and downstream surface water sampling from the Yukon River to confirm that there are no impacts from the Crestview Lagoon.
- Based on the groundwater flow direction in the upper perched aquifer, the Crestview Lagoon does not have a reliable up-gradient monitoring well (as MW1-08 has been routinely dry or with insufficient water to sample). Installation of an up-gradient monitoring well is recommended to determine the background concentrations of leachate indicator parameters in groundwater in order to evaluate whether concentrations increase across the Site.
- Install an additional down-gradient monitoring well on the north side (in the area of MW3-08) of the Crestview Lagoon in order to assess the groundwater quality and flow direction on the north side of the lagoon.
- An elevation survey of all wells on site should be conducted to increase the accuracy of the groundwater flow direction.

6.0 CLOSURE

We trust that this report is adequate for your current needs. Should you have any questions or require any additional information, please contact the undersigned at your convenience.

Golder Associates Ltd.

Karlee Bendera, BSc, AIT
Environmental Scientist

Tamra Reynolds, MSc, PGeo
Associate, Senior Hydrogeologist

KB/TR/lih

Golder and the G logo are trademarks of Golder Associates Corporation

https://golderassociates.sharepoint.com/sites/115625/project files/6 deliverables/issued to client_for wp/19130631-001-r-rev2/19130631-001-r-rev2-1000-hydrogeoassessment 27feb_20.docx

7.0 REFERENCES

EBA Engineering Consultants Ltd (EBA). 2009. Hydrogeological Investigations at the Crestview and Whitehorse Sewage Lagoons Whitehorse, Yukon. Prepared for the City of Whitehorse.

Environment Act (2002). Contaminated Sites Regulation (O.I.C. 2002/171). Dated September 30, 2002.

Environment Yukon. 2012. Protocol No. 6: Application of Water Quality Standards. Dated August 2012.

Environment Yukon. 2017. Protocol No. 7: Groundwater Monitoring Well Installation and Sampling. Dated December 2017.

Government of Yukon. 2011. Geomatics Yukon database. Available at http://www.geomaticsyukon.ca/

Table 4: Field Results of November 2019 Groundwater Sampling, Crestview Lagoon, Whitehorse, Yukon

Field Parameters	Sample Name	MW1-19	MW2-19	MW1-08	MW2-08S	MW2-08D	MW3-08	MW4-08
	Sample Date	2019-11-08	2019-11-08	2019-11-06	2019-11-08	2019-11-08	2019-11-08	2019-11-08
	Units							
DTB	m btoc	41.76	36.35	7.82	8.71	20.80	2.70	18.047*
DTW	m btoc	33.255	15.209	7.550	Dry	Dry	1.894	16.64*
Temperature	°C	3.7	2.3	-	-	-	1.3	3.3
pH	pH units	7.39	7.32	-	-	-	6.77	7.26
Specific Conductivity	µS/cm	772.1	606.0	-	-	-	1105	1017
Oxidation Reduction Potential	mV	-7.4	-30.9	-	-	-	-38.6	-8.5
Dissolved Oxygen	mg/L	2.46	7.50	-	-	-	2.00	5.96

Notes:
* indicates results collected in August 2019
- indicates results not collected

Table 5: Analytical Results of November 2019 Groundwater Sampling, Crestview Lagoon, Whitehorse, Yukon

Parameters			Laboratory ID	N001394-01	N001394-02	N001394-03	N001394-04	Yukon CSR	
			Sample Name	MW1-19	MW2-19	MW3-08	MW4-08		
			Sample Date	2019-11-08	2019-11-08	2019-11-08	2019-11-08	AW	DW
	Units	RL							
Chloride	mg/L	0.1		26.2	12.2	26.5	30	-	250
Nitrate+Nitrite (as N)	mg/L	0.005		0.0188	0.364	<0.0050	<0.0050	400	10
Nitrite (as N)	mg/L	0.005		<0.0050	0.0168	<0.0050	<0.0050	0.2-2.0*	3.2
Nitrate (as N)	mg/L	0.01		0.0188	0.347	<0.0100	<0.0100	400	10
Temperature, at pH	°C			18.4	12.1	9.8	7.7	-	-
Ammonia, Total (as N)	mg/L	0.02		0.137	0.088	0.091	0.102	1.31-18.5**	0.2
BOD, 5-day	mg/L	2.3		<2.4	<2.3	<2.3	<2.3	-	-
Oxygen, Dissolved	mg/L	1		11	11.3	11.2	11.2	-	-
pH	pH units	0.1		7.42	7.39	6.9	7.31	-	-
Conductivity (EC)	uS/cm	2		809	602	1140	1070	-	-
Coliforms, Fecal	MPN/100 mL	2		<2	<2	13	<2	-	-

Notes:

Yukon Contaminated Sites Regulation - Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW).

*Standard is dependent on chloride concentrations.

**Standard is dependant on pH.

Table 6: Summary of MW1-08 Groundwater Quality Data,
Crestview Lagoon, Whitehorse, Yukon

CITY OF WHITEHORSE
Crestview Lagoon, MW1-08
Sampled 3 times: Breakup, mid-season, and September

		Yukon CSR											
Parameters	Units	AW	DW	12-May-09	12-Aug-09	11-Nov-09	10-May-10	10-Aug-10	10-Nov-10	07-May-12	09-Aug-12	08-Nov-12	07-May-13
BOD5	mg/L	-	-	7	6	<4	-	<4	-	-	13	-	-
Dissolved Oxygen (O2)	mg/L	-	-	7.98	8.01	2.62	-	5.77	-	-	5.22	-	-
Dissolved Chloride (Cl)	mg/L	-	250	95.5	5.41	0.55	-	25.6	-	-	46.8	-	-
Total Ammonia (N)	mg/L	11.3-18.5**	0.2	<0.01	0.1	0.58	-	0.03	-	-	2.19	-	-
Nitrate plus Nitrite (N)	mg/L	400	10	-	-	-	-	3.05	-	-	2.89	-	-
Conductivity	µS/cm	-	-	1030	1420	1420	-	820	-	-	1400	-	-
pH	pH	-	-	7.72	-	7.08	-	7.68	-	-	7.07	-	-
Fecal Coliforms	CFU/100mL	-	-	<10	<10	<10	-	<2	-	-	<2	-	-
Depth of well	m	-	-	-	-	-	-	-	-	7.80	7.80	7.80	7.80
Depth of standing water	m	-	-	-	-	-	Dry	-	Dry	Dry	7.17	7.78	Dry

Notes:
Indicates a parameter was found above the CSR DW standards 0.12
Indicates a parameter was found above the CSR AW standards 1.5
Yukon Contaminated Sites Regulation - Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW).
*Standard is dependent on chloride concentrations.
**Standard is dependant on pH.
Historical data was provided by the City of Whitehorse; data from August 2019 and November 2019 was collected by Golder Associates Ltd.

Table 6: Summary of MW1-08 Groundwater Quality Data,
Crestview Lagoon, Whitehorse, Yukon

CITY OF WHITEHORSE
Crestview Lagoon, MW1-08
Sampled 3 times: Breakup, mid-season, and September

		Yukon CSR																
Parameters	Units	AW	DW	09-Aug-13	09-Nov-13	06-May-14	09-Aug-14	09-Nov-14	12-May-15	05-Aug-15	17-Nov-15	10-May-16	22-May-18	13-Aug-18	06-Nov-18	16-May-2019	20-Aug-2019	06-Nov-19
BOD5	mg/L	-	-	-	-	-	-	-	-	-	-	<6.0	-	-	-	-	-	-
Dissolved Oxygen (O2)	mg/L	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
Dissolved Chloride (Cl)	mg/L	-	250	-	-	-	-	-	-	-	-	53	-	-	-	-	-	-
Total Ammonia (N)	mg/L	11.3-18.5**	0.2	-	-	-	-	-	-	-	-	0.058	-	-	-	-	-	-
Nitrate plus Nitrite (N)	mg/L	400	10	-	-	-	-	-	-	-	-	11.8	-	-	-	-	-	-
Conductivity	µS/cm	-	-	-	-	-	-	-	-	-	-	1470	-	-	-	-	-	-
pH	pH	-	-	-	-	-	-	-	-	-	-	7.75	-	-	-	-	-	-
Fecal Coliforms	CFU/100mL	-	-	-	-	-	-	-	-	-	-	<2	-	-	-	-	-	-
Depth of well	m	-	-	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	-	-	7.87	7.8	7.826	-	-
Depth of standing water	m	-	-	7.67	7.66	Dry	7.63	7.69	Dry	7.67	7.69	-	Frozen	7.72	7.72	7.631	dry	dry

Notes:
Indicates a parameter was found above the CSR DW standards 0.12
Indicates a parameter was found above the CSR AW standards 1.5
Yukon Contaminated Sites Regulation - Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW).
*Standard is dependent on chloride concentrations.
**Standard is dependant on pH.
Historical data was provided by the City of Whitehorse; data from August 2019 and November 2019 was collected by Golder Associates Ltd.

Table 7: Summary of MW2-08S and MW2-08D Groundwater Quality Data,
Crestview Lagoon, Whitehorse, Yukon

CITY OF WHITEHORSE
Crestview Lagoon, MW2-08
Sampled 3 times: Breakup, mid-season, and September

		Yukon CSR																				
Parameters	Units	AW	DW	11-May-09	12-Aug-09	11-Nov-09	11-May-10	7-May-13	9-Aug-13	9-Nov-13	6-May-14	9-Aug-14	9-Nov-14	12-May-15	5-Aug-15	17-Nov-15	22-May-18	13-Aug-18	6-Nov-18	16-May-19	20-Aug-19	8-Nov-19
		-	-	-	-	-	-	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow
BOD5	mg/L	-	-	-	-	-	-	-	<4	<4	-	<4	<4	6	12	<4	-	-	-	-	-	-
Dissolved Oxygen (O2)	mg/L	-	-	-	-	-	-	-	9.88	8.8	-	3.34	13.9	7.79	3.87	7.03	-	-	-	-	-	-
Dissolved Chloride (Cl)	mg/L	-	250	-	-	-	-	-	4.27	3.71	-	3.63	3.82	3.69	17.7	2.60	-	-	-	-	-	-
Total Ammonia (N)	mg/L	11.3-18.5**	0.2	-	-	-	-	-	<0.01	0.01	-	<0.01	<0.01	0.07	0.03	0.01	-	-	-	-	-	-
Nitrate plus Nitrite (N)	mg/L	400	10	-	-	-	-	-	0.03	0.03	-	0.03	<0.1	0.02	0.03	0.32	-	-	-	-	-	-
Conductivity	µS/cm	-	-	-	-	-	-	-	597	641	-	644	613	624	1040	608	-	-	-	-	-	-
pH	pH	-	-	-	-	-	-	-	7.63	7.81	-	7.75	7.71	7.8	7.87	7.91	-	-	-	-	-	-
Fecal Coliforms	CFU/100mL	-	-	-	-	-	-	-	<100	<10	-	<2	<2	<100	<10	10	-	-	-	-	-	-
Depth of well	m	-	-	-	-	-	-	8.90	8.90	8.90	21.00	8.90	8.90	8.90	8.90	8.90	dry	8.66	8.72	-	-	8.71
Depth of standing water	m	-	-	Dry	Dry	Dry	Dry	Dry	6.74	7.30	Dry	7.39	6.84	7.69	8.2	7.72	dry	dry	dry	dry	dry	Dry

Parameters	Units	7-May-13	9-Aug-13	9-Nov-13	6-May-14	9-Aug-14	9-Nov-14	12-May-15	5-Aug-15	17-Nov-15	22-May-18	13-Aug-18	6-Nov-18	16-May-19	20-Aug-19	8-Nov-19
		Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep	Deep
BOD5	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Oxygen (O2)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Chloride (Cl)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Ammonia (N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate plus Nitrite (N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Conductivity	µS/cm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH	pH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fecal Coliforms	CFU/100mL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Depth of well	m	21.00	21.00	21.00	8.90	21.00	21.00	21.00	21.00	21.00	dry	20.7	20.70	-	-	20.80
Depth of standing water	m	Dry	Dry	20.63	Dry	Dry	20.78	Dry	20.69	20.69	dry	dry	dry	dry	dry	Dry

Notes:
Indicates a parameter was found above the CSR DW standards 0.12
Indicates a parameter was found above the CSR AW standards 1.5
Yukon Contaminated Sites Regulation - Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW).
*Standard is dependent on chloride concentrations.
**Standard is dependant on pH range
Historical data was provided by the City of Whitehorse; data from August 2019 and November 2019 was collected by Golder Associates Ltd.

Table 8: Summary of MW3-08 Groundwater Quality Data,
Crestview Lagoon, Whitehorse, Yukon

CITY OF WHITEHORSE
Crestview Lagoon, MW3-08
Sampled 3 times: Breakup, mid-season, and September

		Yukon CSR																										
Parameters	Units	AW	DW	08-Oct-08	12-May-09	12-Aug-09	11-Nov-09	11-May-10	10-Aug-10	9-Nov-10	10-May-12	9-Aug-12	8-Nov-12	7-May-13	9-Aug-13	9-Nov-13	6-May-14	9-Aug-14	9-Nov-14	12-May-15	5-Aug-15	17-Nov-15	10-May-16	22-May-18	13-Aug-18	6-Nov-18	16-May-19	20-Aug-19	8-Nov-19
BOD5	mg/L	-	-	<4	-	<4	<4	5	<4	<4	5	<4	-	-	<4	<4	-	<4	6	5	5	-	<6.0	-	<6.0	-	-	< 2.5	<2.3
Dissolved Oxygen (O2)	mg/L	-	-	30.2	8.06	7.87	3.84	3.09	5.37	4.89	8.63	5.77	-	-	7.97	6.98	-	4.93	6.31	10.17	5.58	-	8.7	-	9	-	-	1.4	11.2
Dissolved Chloride (Cl)	mg/L	-	250	30.8	28.9	3.03	3.04	31.6	28.2	29.9	28	29.6	-	-	22.2	22.5	-	22.1	17.8	18.4	27.6	-	24	-	27	-	-	21.3	26.5
Total Ammonia (N)	mg/L	11.3-18.5**	0.2	0.13	0.15	0.3	<0.01	0.07	0.09	0.12	0.03	<0.01	-	-	0.05	0.02	-	0.04	0.05	0.03	0.02	-	0.032	-	0.1	-	-	0.104	0.091
Nitrate plus Nitrite (N)	mg/L	400	10	-	-	-	-	2.41	0.037	0.076	1.716	0.041	-	-	0.11	0.02	-	0.05				-	1.47	-	0.068	-	-	<0.02	<0.005
Conductivity	µS/cm	-	-	1100	1200	1120	938	967	938	1050	1040	982	-	-	1060	976	-	1080	1070	1060	1020	-	1030	-	1240	-	-	1327	1140
pH	pH	-	-	7.49	7.75	6.97	7.22	7.17	7.55	7.57	6.96	7.02	-	-	6.93	7.21	-	7.07	6.97	7.26	7.72	-	7.87	-	7.79	-	-	6.67	6.9
Fecal Coliforms	CFU/100mL	-	-	-	-	132	<10	<10	<2	10	<2	<2	-	-	<100	<100	-	2	<100	<10	40	-	<2	-	<10	-	-	2400	13
Depth of well	m	-	-	1.8	-	-	-	-	-	-	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	-	dry	2.7	2.71	-	-	2.70
Depth of standing water	m	-	-	1.18	-	-	-	-	-	-	1.74	1.89	2.42	Frozen	1.89	2.30	Frozen	1.89	1.89	1.94	2.39	Frozen	-	dry	2.2	2.2	2.693	1.875	1.894

Notes:
Indicates a parameter was found above the CSR DW standards (0.12)
Indicates a parameter was found above the CSR AW standards (1.5)
Yukon Contaminated Sites Regulation - Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW).
*Standard is dependent on chloride concentrations.
**Standard is dependant on pH range
Historical data was provided by the City of Whitehorse; data from August 2019 and November 2019 was collected by Golder Associates Ltd.

Table 9: Summary of MW4-08 Groundwater Quality Data,
Crestview Lagoon, Whitehorse, Yukon

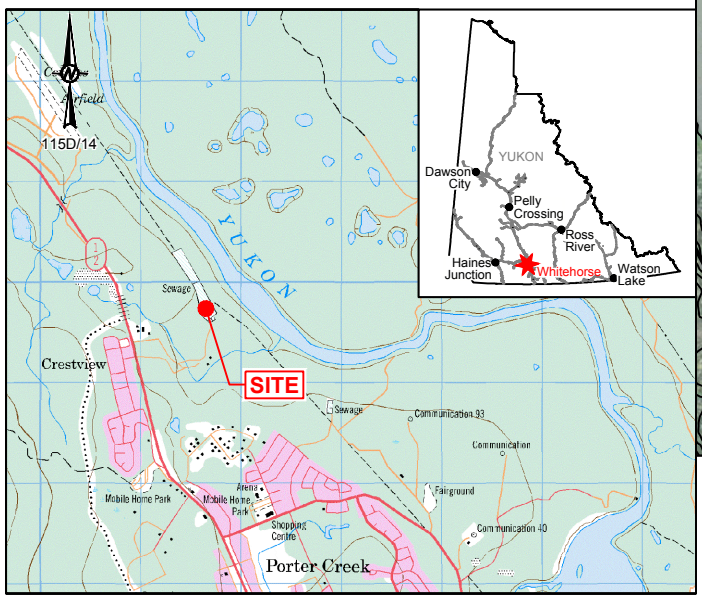
CITY OF WHITEHORSE
Crestview Lagoon, MW4-08
Sampled 3 times: Breakup, mid-season, and September

		Yukon CSR																										
Parameters	Units	AW	DW	08-Oct-08	12-May-09	12-Aug-09	11-Nov-09	10-May-10	10-Aug-10	9-Nov-10	10-May-12	9-Aug-12	8-Nov-12	7-May-13	9-Aug-13	9-Nov-13	6-May-14	9-Aug-14	9-Nov-14	12-May-15	5-Aug-15	17-Nov-15	9-Nov-16	22-May-18	13-Aug-18	6-Nov-18	17-May-19	20-Aug-19	8-Nov-19
BOD5	mg/L	-	-	5	5	<4	<4	<4	<4	<4	<4	<4	4	-	<4	<4	10	<4	5	12	9	<4	9	-	<6.0	<6.0	-	< 3.8	<2.3
Dissolved Oxygen (O2)	mg/L	-	-	13.7	9.08	8.99	2.43	5.97	4.42	3.39	8.51	6.21	8.22	-	5.89	7.16	8.58	4.38	7.56	9.14	4.17	6.13	10	-	8.8	8.6	8.8	6.01	11.2
Dissolved Chloride (Cl)	mg/L	-	250	25.4	24.3	2.64	1.52	24.1	26.1	26.3	26.3	27.4	26.8	-	27.6	27.1	26.9	29	28	27.4	28.3	29.9	27	-	29.0	29.0	29	28.5	30
Total Ammonia (N)	mg/L	11.3-18.5**	0.2	0.03	0.02	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.04	0.08	-	0.05	0.02	0.03	0.02	0.03	0.03	0.02	0.01	0.15	-	0.082	0.046	0.032	0.055	0.102
Nitrate plus Nitrite (N)	mg/L	400	10	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	0.02	<0.01	0.27	<0.01	<0.1	<0.01	0.03	<0.01	<0.02	-	0.025	<0.02	0.025	<0.02	<0.005
Conductivity	µS/cm	-	-	904	813	834	792	857	834	865	907	903	919	-	937	1000	1010	999	986	1020	1020	972	1050	-	1010	953	917	1062	1070
pH	pH	-	-	7.74	7.85	-	7.49	7.53	7.62	7.76	7.28	7.24	7.44	-	7.3	7.29	7.3	7.26	7.27	7.4	7.39	7.41	8.02	-	7.92	7.79	8.02	7.32	7.31
Fecal Coliforms	CFU/100mL	-	-	-	<2	41	<10	<10	<1	<10	<2	<2	2	-	<100	<100	<2	<10	<1	<10	<10	<10	<10	-	<1	<10	<10	<2	<2
Depth of well	m	-	-	17.0	-	-	-	-	-	-	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	-	-	18.32	18.20	-	18.047	18.047
Depth of standing water	m	-	-	15.88	-	-	-	-	-	-	17.33	16.92	17.07	Dry	16.92	17.04	17.24	16.93	16.98	17.14	17.12	17.15	-	Insufficient	17.87	16.98	17.421	16.64	16.64

Notes:
Indicates a parameter was found above the CSR DW standards (0.12)
Indicates a parameter was found above the CSR AW standards (1.5)

Yukon Contaminated Sites Regulation - Schedule 3 Generic Numerical Water Standards for the Protection of Freshwater Aquatic Life (AW) and Drinking Water (DW).
*Standard is dependent on chloride concentrations.
**Standard is dependant on pH range
Historical data was provided by the City of Whitehorse; data from August 2019 and November 2019 was collected by Golder Associates Ltd.

KEY PLAN - NOT TO SCALE



0 100 200
1:5,000 METRES

LEGEND

- LOT BOUNDARY
- CONTOUR (1 m INTERVAL)
- MONITORING WELL LOCATION
- PROPOSED MONITORING WELL LOCATION

REFERENCES

BACKGROUND IMAGE SUPPLIED BY AND SOURCED UNDER LICENSE FROM BING IMAGES FOR ARCMAP ON : 2019-11-29
IMAGE GEOREFERENCED BY GOLDER AND INTENDED FOR INDICATIVE PURPOSES ONLY

LOT BOUNDARIES AND CONTOURS (1 m) WERE PROVIDED BY GEOYUKON ON 2019-11-28

KEY PLAN FROM CANMATRIX 1: 50000 NTS - 105D/14

DATUM: NAD83, PROJECTION: UTM ZONE 8

THIS DRAWING IS INTENDED FOR CLIENT'S ONE TIME USE ONLY AND IT IS NOT INTENDED OR REPRESENTED BY GOLDER TO BE SUITABLE FOR REUSE BY ANY PARTY, INCLUDING, BUT NOT LIMITED TO, THE CLIENT, ITS EMPLOYEES, AGENTS, SUBCONTRACTORS OR SUBSEQUENT OWNERS ON ANY EXTENSION OF A SPECIFIC PROJECT OR FUTURE PROJECTS, WHETHER CLIENT'S OR OTHERWISE, WITHOUT GOLDER'S PRIOR WRITTEN PERMISSION. ANY MANIPULATION, ADAPTATION, MODIFICATION, ALTERATION, MISUSE OR REUSE UNAUTHORIZED BY GOLDER WILL BE AT CLIENT'S SOLE RISK. GOLDER EXPRESSLY DISCLAIMS ALL LIABILITY AGAINST ALL THIRD PARTIES RELYING, USING OR MAKING DECISIONS ON THIS DRAWING. THIRD PARTIES DO SO AT THEIR OWN RISK. EXCEPT WHERE WRITTEN AGREEMENT STATES OTHERWISE, THIS DRAWING IS THE PROPERTY OF GOLDER ASSOCIATES LTD.

CLIENT
CITY OF WHITEHORSE

PROJECT
CRESTVIEW LAGOON HYDROGEOLOGICAL ASSESSMENT

TITLE
SITE PLAN

CONSULTANT
GOLDER

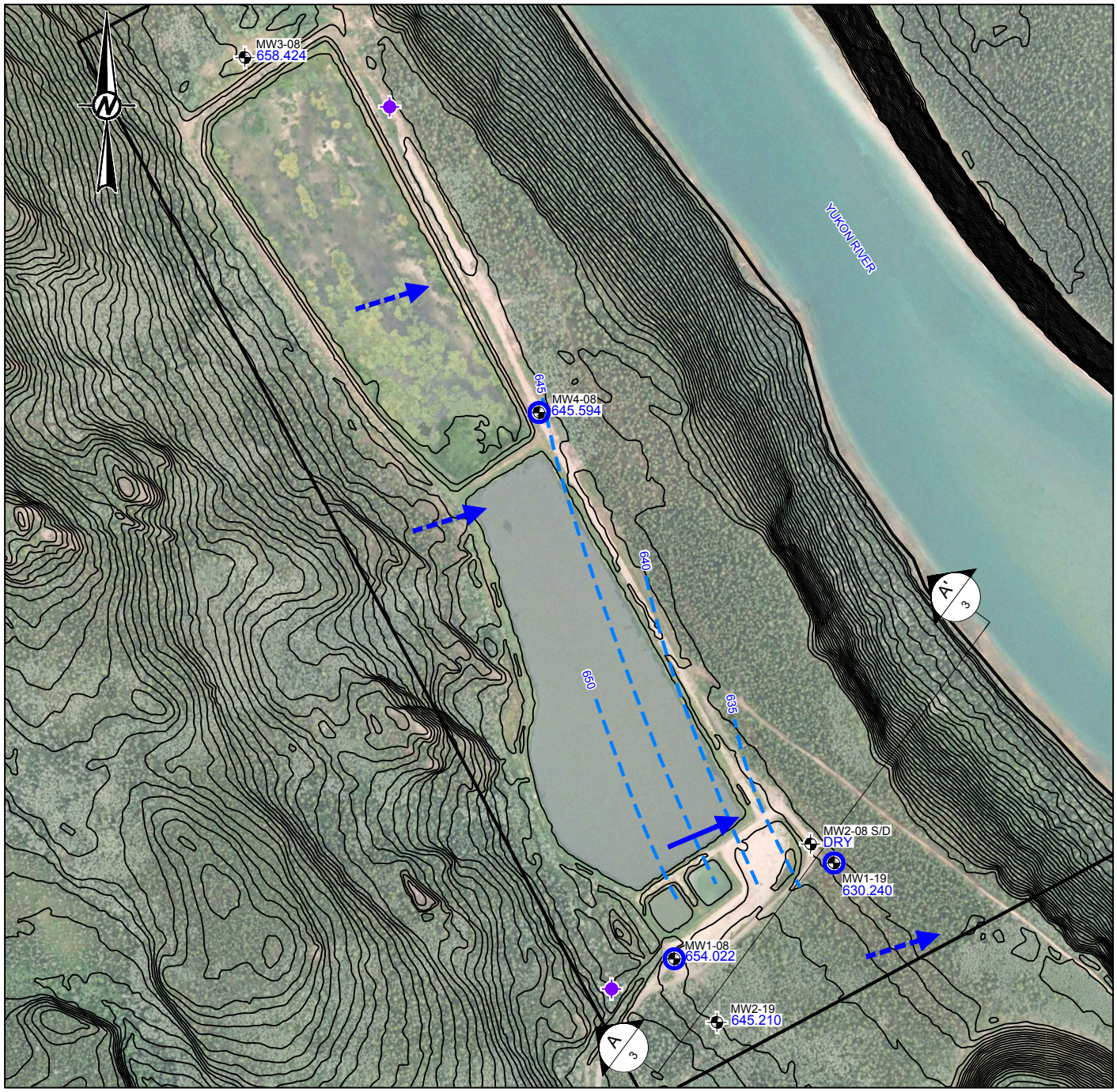
YYYY-MM-DD	2020-02-24
DESIGNED	KB
PREPARED	RTJ
REVIEWED	AB
APPROVED	TR

PROJECT NO.	PHASE	REV.	FIGURE
19130631	1000	1	1

Last Edited By: rylames Date: 2020-01-23 Time:12:29:42 PM | Printed By: RYJames Date: 2020-02-24 Time:10:42:33 AM | File Name: 19130631_1000 - SITE.dwg
Path: \\golder.gds\gal\Kelowna\CAD-GIS\Client\CITY OF WHITEHORSE\Crestview Lagoon\9g_PROJECTS\19130631_Enviro\1000\No Task\19130631_1000\002_PRODUCTION\DWG\

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

0 25 mm



LEGEND

- LOT BOUNDARY
- CONTOUR (1 m INTERVAL)
- INFERRED GROUNDWATER CONTOUR (5 m CONTOUR INTERVAL)
- GROUNDWATER FLOW DIRECTION
- INFERRED GROUNDWATER FLOW DIRECTION
- 365.15 — GROUNDWATER ELEVATION (masl), NOVEMBER 2019
- MONITORING WELL LOCATION
- MONITORING WELL LOCATION LOCATION SCREENED IN PERCHED BEDROCK AQUIFER AND USED TO CALCULATE GROUNDWATER FLOW DIRECTION
- PROPOSED MONITORING WELL LOCATION

REFERENCES

BACKGROUND IMAGE SUPPLIED BY AND SOURCED UNDER LICENSE FROM BING IMAGES FOR ARCMAP ON : 2019-11-29
IMAGE GEOREFERENCED BY GOLDER AND INTENDED FOR INDICATIVE PURPOSES ONLY
LOT BOUNDARIES AND CONTOURS (1 m) WERE PROVIDED BY GEOYUKON ON 2019-11-28
DATUM: NAD83, PROJECTION: UTM ZONE 8

THIS DRAWING IS INTENDED FOR CLIENT'S ONE TIME USE ONLY AND IT IS NOT INTENDED OR REPRESENTED BY GOLDER TO BE SUITABLE FOR REUSE BY ANY PARTY, INCLUDING, BUT NOT LIMITED TO, THE CLIENT, ITS EMPLOYEES, AGENTS, SUBCONTRACTORS OR SUBSEQUENT OWNERS ON ANY EXTENSION OF A SPECIFIC PROJECT OR FUTURE PROJECTS, WHETHER CLIENT'S OR OTHERWISE, WITHOUT GOLDER'S PRIOR WRITTEN PERMISSION. ANY MANIPULATION, ADAPTATION, MODIFICATION, ALTERATION, MISUSE OR REUSE UNAUTHORIZED BY GOLDER WILL BE AT CLIENT'S SOLE RISK. GOLDER EXPRESSLY DISCLAIMS ALL LIABILITY AGAINST ALL THIRD PARTIES RELYING, USING OR MAKING DECISIONS ON THIS DRAWING. THIRD PARTIES DO SO AT THEIR OWN RISK. EXCEPT WHERE WRITTEN AGREEMENT STATES OTHERWISE, THIS DRAWING IS THE PROPERTY OF GOLDER ASSOCIATES LTD.

0 100 200
1:5,000 METRES

CLIENT
CITY OF WHITEHORSE

PROJECT
CRESTVIEW LAGOON HYDROGEOLOGICAL ASSESSMENT

TITLE
GROUNDWATER CONTOURS AND FLOW DIRECTION OF THE PERCHED BEDROCK AQUIFER, NOVEMBER 2019

CONSULTANT
GOLDER

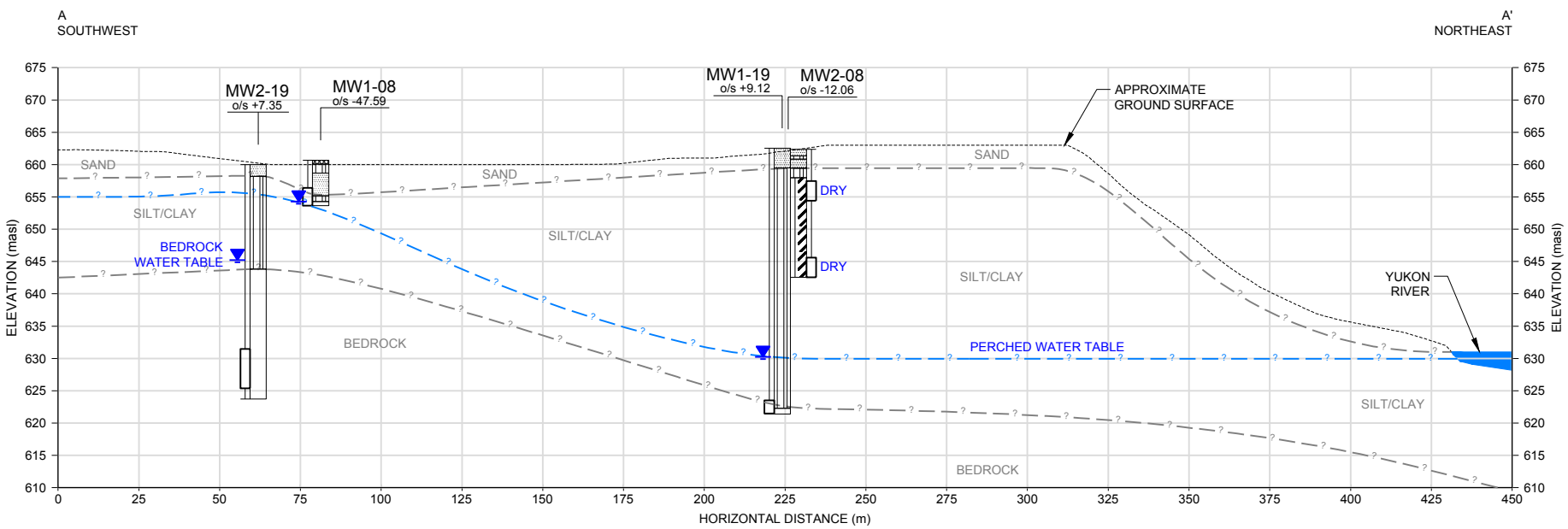
YYYY-MM-DD	2020-02-24
DESIGNED	KB
PREPARED	RTJ
REVIEWED	AB
APPROVED	TR

PROJECT NO.	PHASE	REV.	FIGURE
19130631	1000	1	2

Last Edited By: rylames Date: 2020-01-23 Time:12:29:42 PM | Printed By: RYJames Date: 2020-02-24 Time:10:43:33 AM
Path: \\golder.gds\gal\Kelowna\CAD-GIS\Client\CITY OF WHITEHORSE\Crestview Lagoon\99_PROJECTS\19130631_Enviro\1000\No Task\19130631_1000\02_PRODUCTION\DWG\ | File Name: 19130631_1000 - SITE.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
0 25 mm

Last Edited By: ryjames Date: 2019-12-06 Time:2:57:42 PM | Printed By: RYJames Date: 2020-01-23 Time:12:27:29 PM
Path: \\golder.gds\gal\Kelowna\CAD-GIS\Client\CITY OF WHITEHORSE\Crestview Lagoon\99_PROJECTS\19130631_Enviro\1000\No Task\19130631_1000\02_PRODUCTION\DWG\ | File Name: 19130631_1000 - SECTIONS.dwg



HORZ SCALE 1:2000
VERT SCALE 1:1000

A
2

CROSS-SECTION A-A'

0 25 50
1:1,000 (VERTICAL) METRES

0 50 100
1:2,000 (HORIZONTAL) METRES

LEGEND

- APPROXIMATE GROUND SURFACE
- INFERRED STRATIGRAPHIC BOUNDARY
- INFERRED WATER TABLE (NOVEMBER, 2019)

LOCATION
OFFSET (o/s)

- SOIL STRATIGRAPHY
- WELL SCREEN INTERVAL
- MEASURED WATER LEVEL (NOVEMBER, 2019)

TEST HOLE GRAPHICS

BEDROCK, SAND, CLAY, FILL, SILT

VARIOUS COMBINATIONS OF THE ABOVE SYMBOLS HAVE BEEN USED TO REPRESENT MIXTURES OF THE ABOVE MATERIALS.

NOTES

1. GROUND SURFACE IS APPROXIMATE (BASED ON CITY OF WHITEHORSE 1 m CONTOURS)
2. FOR DETAILED SOIL STRATIGRAPHY REFER TO MONITORING WELL LOGS
3. STRATIGRAPHY FOR MW1-08 AND MW2-08 ARE BASED OFF OF OBSERVATIONS MADE BY EBA
4. STRATIGRAPHY FOR MW1-19 AND MW2-19 ARE BASED OFF OF OBSERVATIONS MADE BY GOLDER

THIS DRAWING IS INTENDED FOR CLIENT'S ONE TIME USE ONLY AND IT IS NOT INTENDED OR REPRESENTED BY GOLDER TO BE SUITABLE FOR REUSE BY ANY PARTY, INCLUDING, BUT NOT LIMITED TO, THE CLIENT, ITS EMPLOYEES, AGENTS, SUBCONTRACTORS OR SUBSEQUENT OWNERS ON ANY EXTENSION OF A SPECIFIC PROJECT OR FUTURE PROJECTS, WHETHER CLIENT'S OR OTHERWISE, WITHOUT GOLDER'S PRIOR WRITTEN PERMISSION. ANY MANIPULATION, ADAPTATION, MODIFICATION, ALTERATION, MISUSE OR REUSE UNAUTHORIZED BY GOLDER WILL BE AT CLIENT'S SOLE RISK. GOLDER EXPRESSLY DISCLAIMS ALL LIABILITY AGAINST ALL THIRD PARTIES RELYING, USING OR MAKING DECISIONS ON THIS DRAWING. THIRD PARTIES DO SO AT THEIR OWN RISK. EXCEPT WHERE WRITTEN AGREEMENT STATES OTHERWISE, THIS DRAWING IS THE PROPERTY OF GOLDER ASSOCIATES LTD.

CLIENT
CITY OF WHITEHORSE

PROJECT
CRESTVIEW LAGOON HYDROGEOLOGICAL ASSESSMENT

TITLE
CROSS-SECTION A-A'

CONSULTANT
GOLDER

YYYY-MM-DD	2020-01-23
DESIGNED	KB
PREPARED	RTJ
REVIEWED	AB
APPROVED	TR

PROJECT NO.	PHASE	REV.	FIGURE
19130631	1000	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
0 25 mm

APPENDIX A

Borehole Logs

PROJECT No.: 19130631 / 1000

CLIENT: City of Whitehorse
PROJECT: Crestview Sewage Lagoon Monitoring
LOCATION: Whitehorse, YT
N: 6739647.00 E: 491819.00

RECORD OF MONITORING WELL: MW1-19

DRILLING DATE: October 22 2019
DRILLING CONTRACTOR: Impact Well Drilling

DATUM: Ground Surface

DEPTH SCALE METRES	DRILLING RIG / DRILLING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		662.53					SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ○; Pocket Pen - ■ (20 40 60 80)	WATER CONTENT PERCENT: Wp — W — Wl; NP - Non-Plastic (10 20 30 40)		Stick-up 0.97 m
0	Air Rotary / Reverse Circulation (Casing:152 mm;)	**(SW)** SAND, medium to fine, trace silt; brown; dry, compact - inferred.		0.00								
				659.48								
		(ML) SILT, trace medium sand; brown; w~PL, soft to firm.		3.05								
2												
4												
6												
8												
10												
12												Bentonite Chips
14												
16												
18												
20												
22												
24		*CONTINUED NEXT PAGE*										

DEPTH SCALE
1 : 125

GOLDER

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: HD
CHECKED: TR

National IM Server:GINT_GAL_NATIONALIM Unique Project ID: Output Form:BC_BOREHOLE (AUTO) 20/8 rvjames 6/12/19

PROJECT No.: 19130631 / 1000

CLIENT: City of Whitehorse
PROJECT: Crestview Sewage Lagoon Monitoring
LOCATION: Whitehorse, YT
N: 6739647.00 E: 491819.00

RECORD OF MONITORING WELL: MW1-19

SHEET 2 OF 2
DATUM: Ground Surface

DRILLING DATE: October 22 2019
DRILLING CONTRACTOR: Impact Well Drilling

DEPTH SCALE METRES	DRILLING RIG / DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
									SHEAR STRENGTH Cu, kPa (20 40 60 80); nat V. + Q - ●; rem V. ⊕ U - ○; Pocket Pen - ■	WATER CONTENT PERCENT: Wp — W — Wl; NP - Non-Plastic (10 20 30 40)		
26	Air Rotary / Reverse Circulation (Casing:152 mm.)	**(ML)** SILT, trace medium sand; brown; w~PL, soft to firm. *(continued)*										
28												
30												Bentonite Chips
32												33.15 mbtoc (10/23/2019) ▽
34												
36												
38												Silica Sand
40				622.29								Screen Length 1.5 m
		BEDROCK; black; water present.		40.23								
				621.38								
		End of Monitoring Well.		41.15								
42												
44												
46												
48												
50												

DEPTH SCALE
1 : 125

GOLDER

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: HD
CHECKED: TR

National IM Server:GINT_GAL_NATIONALIM Unique Project ID: Output Form:BC_BOREHOLE (AUTO) 2018 ryjames 6/12/19

PROJECT No.: 19130631 / 1000

CLIENT: City of Whitehorse
PROJECT: Crestview Sewage Lagoon Monitoring
LOCATION: Whitehorse, YT
N: 6739517.00 E: 491722.00

RECORD OF MONITORING WELL: MW2-19

DRILLING DATE: October 23 2019
DRILLING CONTRACTOR: Impact Well Drilling

DATUM: Ground Surface

DEPTH SCALE METRES	DRILLING RIG / DRILLING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER / TYPE / RECOVERY % / BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		660.00		SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ○; Pocket Pen - ■ (20 40 60 80)	WATER CONTENT PERCENT: Wp — W — Wl; NP - Non-Plastic (10 20 30 40)		Stick-up 0.42 m
0	Air Rotary (Casing:152 mm;) Reverse Circulation	**(SW)** SAND, mediume to fine, trace silt; brown; dry, compact to dense - inferred.		0.00					
				658.17					
2		**(ML)** sandy SILT, medium to fine sand; grey to brown; w=<PL, very stiff.		1.83					
4									
6									
8									
10									
12									Bentonite Chips
14									14.21 mbtoc (10/25/2019) ▽
16				643.84					
		BEDROCK; grey-green; hard - inferred. - moisture observed from 16.3 m to 16.7 m depth - BEDROCK became dry from 16.7 m to 28.5 m depth - moisture observed from28.5 m to 34.3 m depth, water present at 34.3 m.		16.15					
18									
20									
22									
24									
		CONTINUED NEXT PAGE							

DEPTH SCALE
1 : 125

GOLDER

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: HD
CHECKED: TR

National IM Server:GINT_GAL_NATIONALIM Unique Project ID: Output Form:BC_BOREHOLE (AUTO) 20/8 rvjames 6/12/19

PROJECT No.: 19130631 / 1000

CLIENT: City of Whitehorse
PROJECT: Crestview Sewage Lagoon Monitoring
LOCATION: Whitehorse, YT
N: 6739517.00 E: 491722.00

RECORD OF MONITORING WELL: MW2-19

DRILLING DATE: October 23 2019
DRILLING CONTRACTOR: Impact Well Drilling

DATUM: Ground Surface

DEPTH SCALE METRES	DRILLING RIG / DRILLING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	RECOVERY %	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
26	Air Rotary Reverse Circulation (Casing:152 mm;)	BEDROCK; grey-green; hard - inferred. - moisture observed from 16.3 m to 16.7 m depth - BEDROCK became dry from 16.7 m to 28.5 m depth - moisture observed from28.5 m to 34.3 m depth, water present at 34.3 m. *(continued)*							SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ○; Pocket Pen - ■ (20 40 60 80)	WATER CONTENT PERCENT: Wp ⊢ W ⊣ Wl; NP - Non-Plastic (10 20 30 40)		Bentonite Chips
28												
30												Silica Sand Screen Length 4.57 m
32												
34		- water present at 34.3 m depth										
36				623.73								
		End of Monitoring Well.		36.27								
38												
40												
42												
44												
46												
48												
50												

DEPTH SCALE
1 : 125

GOLDER

SOIL CLASSIFICATION SYSTEM: GACS
LOGGED: HD
CHECKED: TR

National IM Server:GINT_GAL_NATIONALIM Unique Project ID: Output Form:BC_BOREHOLE (AUTO) 20/8 rvjames 6/12/19

APPENDIX B

Site Photographs

Photo 2: Initial survey site selection, proposed MW2-19 looking north, MW2-08 in foreground. (21 October 2019)

Photo 1: Initial survey site selection, proposed MW2-19 looking south. (21 October 2019)

Photo 3: Air-rotary drill rig at MW1-19, Impact Well Drilling. (22 October 2019)

Photo 4: Monitoring well supplies, schedule 40 solid PVC and prepacked screened PVC. (22 October 2019)

Photo 5: Drill cuttings from BH2-19 at sandy-silt/bedrock contact at 16.15 mbgs. (24 October 2019)

Photo 6: Drill cuttings from BH2-19 in bedrock at approximately 16.7 mbgs. (24 October 2019)

Photo 7: Completed Monitoring Well MW1-19. (25 October 2019)

Photo 8: Completed Monitoring Well MW2-19. (25 October 2019)

APPENDIX C

Field Forms and Calibration Records

DEVELOPMENT

Groundwater Development, Purging and Sampling Sheet

GOLDER

☑ Development ☐ Purge/Sample

WELL ID: MW1-19 | PROJECT NO.: 19126478 / 1000

SITE: Crestview | FIELD PERSONNEL: MM

WEATHER: overcast | DATE: 06-Nov-19

TEMPERATURE: ~-7°C | TIME: 13:53

Depth to Bottom of Well Below Top of Casing **(A)**:	41.76	(meters)	Easting:	—	Northing: —
Depth to Water Below Top of Casing **(B)**:	33.264	(meters)	Well headspace:	—	ppm
Water Column:	08.496	(meters)	Completion:	☐ Flushmount	☒ Stickup monument
Stick-up :	—	(meters)	Well locked:	☒ Yes	☐ No

FIELD EQUIPMENT

Field Meters Calibrated: 451

Pump:	☐ none		☒ Waterra		☐ Submersible	☐ Peristaltic		☐ Bladder	
Bailer:	☒ none			☐ Stainless Steel		☐ Teflon		☐ PVC	
Filter:	☒ none			☒ In-line		☐ Vacuum		☐ Syringe	
Equipment left in well:	☐ none			☐ Bailer		☒ Tubing		☐ Datalogger	

WELL DEVELOPMENT / PURGING

One well volume **((A – B(* C)**: 17 * 6 = 102 litres

Purge Volumes

Purge start time: 14:00

Purge end time: _____

Pump inlet depth: _____ m bTOC

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"
Vol (L/m of casing)* **(C)**	0.1	0.5	0.8	1.1	2.0	8.1	18.2

*double for filter pack

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
14:10	15	-	2.7	7.20	762.0	155.4	5.32	light brown 4/10
14:17	30	-	3.2	7.36	786.4	133.0	3.47	cloudy light brown/grey 4/10
14:23	45	-	2.7	7.90	768.0	24.7	4.67	light grey cloudy 3/10
14:29	60	-	3.5	7.52	760.3	21.5	3.94	cloudy 3/10
14:33	75	-	3.6	7.46	762.5	17.8	4.20	〃 2/10
14:41	90	34.42	3.6	7.40	766.9	13.1	2.59	slightly cloudy 2/10
14:45	105	-	3.6	7.39	770.8	8.3	2.52	〃 2/10

SAMPLING Water Odour: ☒ No ☐ Yes (describe): _____ Sheen ☒ No ☐ Yes (describe): _____

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 2 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☒ No **QA/QC Type and ID :** None

NOTES (consumables, well condition, pictures, etc)

SCN: - @ Bottle count: 2

Reviewed by:

GOLDER

Groundwater Development, Purging and Sampling Sheet

☐ Development
☒ Purge/Sample

WELL ID: MW1-19
PROJECT NO.: 19126478 / 1000
SITE: Crestview
FIELD PERSONNEL: MM
WEATHER: Overcast
DATE: 08-Nov-19
TEMPERATURE: ~6°C
TIME: 11:35

Depth to Bottom of Well Below Top of Casing (A):	41.76 (meters)	Easting: —	Northing: —
Depth to Water Below Top of Casing (B):	33.255 (meters)	Well headspace: —	ppm
Water Column:	8.505 (meters)	Completion: ☐ Flushmount	☒ Stickup monument
Stick-up :	(meters)	Well locked: ☒ Yes	☐ No

FIELD EQUIPMENT

Field Meters Calibrated: _____

Pump:	☐ none	☒ Waterra	☐ Submersible	☐ Peristaltic	☐ Bladder
Bailer:	☒ none	☐ Stainless Steel	☐ Teflon	☐ PVC
Filter:	☒ none	☐ In-line	☐ Vacuum	☐ Syringe
Equipment left in well:	☐ none	☐ Bailer	☒ Tubing	☐ Datalogger

WELL DEVELOPMENT / PURGING

Purge Volumes

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"
Vol (L/m of casing)* (C)	0.1	0.5	0.8	1.1	2.0	8.1	18.2

*double for filter pack

One well volume ((A – B(* C): 18 x3 = 54 litres
Purge start time: 12:20
Purge end time: 12:36
Pump inlet depth: m bTOC

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
12:24	18	–	3.4	7.39	778.4	3.6	2.42	clear, no odour
12:27	2024	–	3.6	7.39	769.9	0.5	2.47	↓
12:30	~~30~~34	–	3.6	7.38	771.5	-2.6	2.41	
12:33	~~40~~44	–	3.6	7.40	770.4	-4.8	2.41	
12:36	54	–	3.7	7.39	772.1	-7.4	2.46	↓

SAMPLING Water Odour: ☒ No ☐ Yes (describe): _____ Sheen ☒ No ☐ Yes (describe): _____

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear (1) (2) 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☒ No **QA/QC Type and ID :** None

NOTES (consumables, well condition, pictures, etc)

Sample @ 12:40

SCN: - @ Bottle count: 4

Reviewed by:

DEVELOPMENT

GOLDER

Groundwater Development, Purging and Sampling Sheet

☒ Development ☐ Purge/Sample

WELL ID: MW2-19 | PROJECT NO.: 19126478 / 1000

SITE: Crestview Lagoon | FIELD PERSONNEL: MM

WEATHER: Overcast | DATE: 06-Nov-19

TEMPERATURE: ~7°C 36.25 | TIME: 12:40

Depth to Bottom of Well Below Top of Casing (A): ~~37.75~~	(meters)	Easting:	Northing:
Depth to Water Below Top of Casing (B): ~~15.175~~	(meters)	Well headspace: ~	ppm
Water Column: 36.35 15.125 ~~16.575~~ 21.225	(meters)	Completion: ☐ Flushmount	☒ Stickup monument
Stick-up :	(meters)	Well locked: ☒ Yes	☐ No

FIELD EQUIPMENT

Field Meters Calibrated: _____

Pump:	☐ none	☒ Waterra	☐ Submersible	☐ Peristaltic	☐ Bladder				
Bailer:	☒ none		☐ Stainless Steel	☐ Teflon	☐ PVC				
Filter:	☒ none		☐ In-line	☐ Vacuum	☐ Syringe				
Equipment left in well:	☐ none		☐ Bailer	☐ Tubing	☐ Datalogger				

WELL DEVELOPMENT / PURGING

Purge Volumes

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"
Vol (L/m of casing)* (C)	0.1	0.5	0.8	1.1	2.0	8.1	18.2

*double for filter pack

One well volume ((A – B(* C): ~~38.35~~ 42 x 6 = ~~192~~ 252 litres

Purge start time: 15:10

Purge end time: _____

Pump inlet depth: ~~29.30~~ m bTOC

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
13:25	45	–	2.5	6.19	652.1	171.5	14.96	~~Brown~~ Chocolate milk ~~colour~~ ~~3/10~~ 6/10
13:35	75	33.196	2.2	6.98	710.6	156.6	7.29	some ~~sediment~~ sediment 6/10
13:51	~~70~~ attempt to ~~top~~ develop more ~300 more							liters = 792 total

SAMPLING Water Odour: ☒ No ☐ Yes (describe): _____ Sheen ☒ No ☐ Yes (describe): _____

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 2 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☒ No **QA/QC Type and ID :** None

NOTES (consumables, well condition, pictures, etc)

SCN: NONE Bottle count: 10

Reviewed by:

GOLDER

Groundwater Development, Purging and Sampling Sheet

Development
Purge/Sample

WELL ID: MW2-19
PROJECT NO.: 19126478 / 1000
SITE: Crestview
FIELD PERSONNEL: MM
WEATHER: overcast
DATE: 08-Nov-19
TEMPERATURE: ~-6°C
TIME: 09:44

Depth to Bottom of Well Below Top of Casing (A):	36.35	(meters)	Easting:	—	Northing: —
Depth to Water Below Top of Casing (B):	15.209	(meters)	Well headspace:	—	ppm
Water Column:	21.141	(meters)	Completion:	☐ Flushmount	☑ Stickup monument
Stick-up :		(meters)	Well locked:	☒ Yes	☐ No

FIELD EQUIPMENT

Field Meters Calibrated: _____

Pump:	☐ none	☒ Waterra	☐ Submersible	☐ Peristaltic	☐ Bladder
Bailer:	☒ none		☐ Stainless Steel	☐ Teflon	☐ PVC
Filter:	☑ none		☐ In-line	☐ Vacuum	☐ Syringe
Equipment left in well:	☐ none		☐ Bailer	☒ Tubing	☐ Datalogger

WELL DEVELOPMENT / PURGING

One well volume ((A – B(* C): 42 * 3 = 126 litres
Purge start time: 09:54 *2 = 252 126 78 204
Purge end time: — 78
Pump inlet depth: — m bTOC 204

Purge Volumes

Casing In. Diam.	½"	1"	1¼	½	(2")	4"	6"	*double for filter pack
Vol (L/m of casing)* (C)	0.1	0.5	0.8	1.1	(2.0)	8.1	18.2	

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
10:02	15	—	3.0	8.47	698.4	-7.9	10.95	light brown 9/10
10:07	30	—	2.2	7.64	595.6	-35.4	6.81	same 8/10
10:11	45	—	2.3	7.41	593.0	-40.0	6.34	light brown 4/10
10:15	60	31.333	2.3	7.32	606.0	~~-50.9~~	7.50	same 4/10
(8.845)			78					
(5.410)			60					
			138 - total development					

SAMPLING Water Odour: ☑ No ☐ Yes (describe): _____ Sheen ☑ No ☐ Yes (describe): _____

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 2 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☒ No **QA/QC Type and ID :** None

NOTES (consumables, well condition, pictures, etc)

- ~~Development~~ purged 78L on 06-Nov-19 6x VV = 252

126
78
48

SCN: - @ Bottle count:

Reviewed by:

GOLDER

Groundwater Development, Purging and Sampling Sheet

☐ Development
☐ Purge/Sample

WELL ID:	MW1-08	PROJECT NO.:	19126478 / 1000
SITE:	Crestview	FIELD PERSONNEL:	MM
WEATHER:	Overcast	DATE :	06-Nov-14
TEMPERATURE:	~-6°C	TIME :	13:30

Depth to Bottom of Well Below Top of Casing **(A)**:	7.82 (meters)	Easting:	Northing:
Depth to Water Below Top of Casing **(B)**:	7.550 (meters)	Well headspace:	ppm
Water Column:	0.27 (meters)	Completion:	☐ Flushmount ☐ Stickup monument
Stick-up :	(meters)	Well locked:	☐ Yes ☐ No

FIELD EQUIPMENT

Field Meters Calibrated:

Pump:	☐ none	☐ Waterra	☐ Submersible	☐ Peristaltic	☐ Bladder
Bailer:	☐ none		☐ Stainless Steel	☐ Teflon	☐ PVC
Filter:	☐ none		☐ In-line	☐ Vacuum	☐ Syringe
Equipment left in well:	☐ none		☐ Bailer	☐ Tubing	☐ Datalogger

WELL DEVELOPMENT / PURGING

One well volume **((A – B(* C)**: litres

Purge Volumes

Purge start time:

Purge end time:

Pump inlet depth: m bTOC

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"
Vol (L/m of casing)* **(C)**	0.1	0.5	0.8	1.1	2.0	8.1	18.2

*double for filter pack

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
								INSUFFICIENT

SAMPLING Water Odour: ☐ No ☐ Yes (describe): Sheen ☐ No ☐ Yes (describe):

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 2 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☐ No **QA/QC Type and ID :**

NOTES (consumables, well condition, pictures, etc)

SCN: - @ Bottle count:

Reviewed by:

GOLDER

Groundwater Development, Purging and Sampling Sheet

☐ Development
☐ Purge/Sample

WELL ID: MW2-08D
SITE: Crestview
WEATHER: overcast
TEMPERATURE: ~ 6°C

PROJECT NO.: 19126478 / 1000
FIELD PERSONNEL: ~~10:50~~ MM
DATE: ~~10~~ 08-Nov-19
TIME: 10:50

Depth to Bottom of Well Below Top of Casing (A):	20.80	(meters)	Easting: _____ Northing: _____
Depth to Water Below Top of Casing (B):	DRY ~~20.80~~	(meters)	Well headspace: _____ ppm
Water Column:		(meters)	Completion: ☐ Flushmount ☒ Stickup monument
Stick-up :		(meters)	Well locked: ☒ Yes ☐ No

FIELD EQUIPMENT

Field Meters Calibrated: _____

Pump:	☐	none	☐	Waterra	☐	Submersible	☐	Peristaltic	☐ Bladder
Bailer:	☐	none			☐	Stainless Steel	☐	Teflon	☐ PVC
Filter:	☐	none			☐	In-line	☐	Vacuum	☐ Syringe
Equipment left in well:	☐	none			☐	Bailer	☐	Tubing	☐ Datalogger

WELL DEVELOPMENT / PURGING

One well volume ((A – B(* C): _____ litres

Purge Volumes

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"
Vol (L/m of casing)* (C)	0.1	0.5	0.8	1.1	2.0	8.1	18.2

*double for filter pack

Purge start time: _____
Purge end time: _____
Pump inlet depth: _____ m bTOC

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	~~+/- 3%~~	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable

DRY

SAMPLING Water Odour: ☐ No ☐ Yes (describe): _____ Sheen ☐ No ☐ Yes (describe): _____

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 2 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☐ No **QA/QC Type and ID :**

NOTES (consumables, well condition, pictures, etc)

SCN: - @ Bottle count:

Reviewed by:

GOLDER

Groundwater Development, Purging and Sampling Sheet

☐ Development
☐ Purge/Sample

WELL ID:	MW2-08S	PROJECT NO.:	19126478 / 1000
SITE:	Crestview	FIELD PERSONNEL:	MM
WEATHER:	overcast	DATE:	08-Nov-19
TEMPERATURE:	2-6°C	TIME:	11:00

Depth to Bottom of Well Below Top of Casing (A):	8.71 (meters)	Easting:	Northing:
Depth to Water Below Top of Casing (B):	Dry (meters)	Well headspace:	ppm
Water Column:	(meters)	Completion:	☐ Flushmount ☐ Stickup monument
Stick-up :	(meters)	Well locked:	☐ Yes ☐ No

FIELD EQUIPMENT

Field Meters Calibrated:

Pump:	☐ none	☐ Waterra	☐ Submersible	☐ Peristaltic	☐ Bladder
Bailer:	☐ none		☐ Stainless Steel	☐ Teflon	☐ PVC
Filter:	☐ none		☐ In-line	☐ Vacuum	☐ Syringe
Equipment left in well:	☐ none		☐ Bailer	☐ Tubing	☐ Datalogger

WELL DEVELOPMENT / PURGING

One well volume ((A – B(* C): litres

Purge Volumes

Purge start time:

Purge end time:

Pump inlet depth: m bTOC

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"	*double for filter pack
Vol (L/m of casing)* (C)	0.1	0.5	0.8	1.1	2.0	8.1	18.2	

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
			DRY					

SAMPLING Water Odour: ☐ No ☐ Yes (describe): Sheen ☐ No ☐ Yes (describe):

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 2 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☐ No **QA/QC Type and ID :**

NOTES (consumables, well condition, pictures, etc)

SCN: - @ Bottle count:

Reviewed by:

GOLDER

Groundwater Development, Purging and Sampling Sheet

☐ Development
☒ Purge/Sample

WELL ID: MW3-08
PROJECT NO.: 19126478 / 1000
SITE: Crestview
FIELD PERSONNEL: MM
WEATHER: overcast
DATE: 08-May-19
TEMPERATURE: ~ -6°C
TIME: 12:05

Depth to Bottom of Well Below Top of Casing **(A)**:	2.70	(meters)	Easting:	—	Northing: —
Depth to Water Below Top of Casing **(B)**:	1.894	(meters)	Well headspace:	—	ppm
Water Column:	0.806	(meters)	Completion:	☐ Flushmount	☒ Stickup monument
Stick-up :	—	(meters)	Well locked:	☒ Yes	☐ No

FIELD EQUIPMENT

Field Meters Calibrated: _____

Pump:	☐	none	☐	Waterra	☐	Submersible	☒	Peristaltic	☐ Bladder
Bailer:	☒	none			☐	Stainless Steel	☐	Teflon	☐ PVC
Filter:	☒	none			☐	In-line	☐	Vacuum	☐ Syringe
Equipment left in well:	☐	none			☐	Bailer	☒	Tubing	☐ Datalogger

WELL DEVELOPMENT / PURGING

Purge Volumes

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"
Vol (L/m of casing)* **(C)**	0.1	0.5	0.8	1.1	2.0	8.1	18.2

*double for filter pack

One well volume ((A – B(* C): 1.6 x 3 = 4.2 litres
Purge start time: 12:10
Purge end time: 12:24
Pump inlet depth: ~ 2.5 m bTOC

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
12:12	1	2.185	1.4	6.97	1152	-22.9	3.41	slightly cloudy, no odour
12:15	2	2.115	1.1	6.68	1106	-28.6	2.45	same
12:20	3	2.124	~~1.3~~ 1.2	6.77	1102	-34.9	2.15	"
12:24	4	~~2.176~~	1.3	6.77	1105	-38.6	2.00	"

SAMPLING Water Odour: ☒ No ☐ Yes (describe): _____ Sheen ☒ No ☐ Yes (describe): _____

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 2 (3) 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☒ No **QA/QC Type and ID :** None

NOTES (consumables, well condition, pictures, etc)

Sample @ 12:05

SCN: - @ Bottle count: 4

Reviewed by:

GOLDER

Groundwater Development, Purging and Sampling Sheet

☐ Development
☑ Purge/Sample

WELL ID: MW4-08 | PROJECT NO.: 19126478 / 1000
SITE: Crestview | FIELD PERSONNEL: MM
WEATHER: overcast | DATE: 08-Nov-19
TEMPERATURE: ~ 6°C | TIME: 12:43

Depth to Bottom of Well Below Top of Casing **(A)**:	18.067* (meters)	Easting:	Northing:
Depth to Water Below Top of Casing **(B)**:	16.640* (meters)	Well headspace:	ppm
Water Column:	(meters)	Completion: ☐ Flushmount	☐ Stickup monument
Stick-up :	(meters)	Well locked: ☐ Yes	☐ No

FIELD EQUIPMENT

Field Meters Calibrated:

Pump:	☐ none	☒ Waterra	☐ Submersible	☐ Peristaltic	☐ Bladder
Bailer:	☐ none		☐ Stainless Steel	☐ Teflon	☐ PVC
Filter:	☐ none		☐ In-line	☐ Vacuum	☐ Syringe
Equipment left in well:	☐ none		☐ Bailer	☐ Tubing	☐ Datalogger

WELL DEVELOPMENT / PURGING

One well volume **((A – B(* C)**: _____ litres

Purge Volumes

Purge start time: 13:00
Purge end time:
Pump inlet depth: m bTOC

Casing In. Diam.	½"	1"	1¼	½	2"	4"	6"
Vol (L/m of casing)* **(C)**	0.1	0.5	0.8	1.1	2.0	8.1	18.2

*double for filter pack

TIME	VOL REMOVED	Water Level (m bTOC)	TEMP (°C)	pH (UNITS)	SP.COND. (uS/cm)	REDOX (mV)	DIS.O_2 (mg/L) or %	REMARKS (colour, odour, sheen, brittle film, silt content, etc.)
Stabilisation Criteria (ASTM D4448-01)			+/- 0.2	+/-0.1	+/- 3%	+/- 10	+/- 10%	Colour, turbidity, odour etc should be stable
13:14	3	–	2.8	7.56	934	-9.3	5.67	slightly turbid, no odour
16	6	–	3.6	7.29	1004	-9.0	4.30	
13:20	9	–	3.3	7.26	1017	-8.5	5.96	

SAMPLING Water Odour: ☒ No ☐ Yes (describe): _____ Sheen ☒ No ☐ Yes (describe): _____

Turbidity: _____ NTU or relative scale (circle as appropriate): Clear 1 (2) 3 4 5 6 7 8 9 10 Very Silty

QA/QC Sample/s : ☐ Yes ☒ No **QA/QC Type and ID :**

NOTES (consumables, well condition, pictures, etc)

depth to bottom and water used from August unable to measure dtw.

SCN: - @ Bottle count: 4

Reviewed by:

SUBJECT	Calibration Records	
Job No. 19126478/19130631	Made by MM Reviewed	Date Nov - 19 Sheet 1 of 1

Calibration Records - BUR 142285

05 - Nov - 19

	Soln val	Pre	Post	mV / Baro
DO	–	97.4	94.4	717.7 mm Hg
Cond.	1413	1435	1413	–
pH 4	~~3.~~	3.95	–	136.7
pH 7		7.06	–	-34.1
pH 10		10.08	10.05	-199.7

06 - Nov - 19

DO	–	95.4	98.3	709.5 mm Hg
cond	1413	1401	1413	–
pH 7	703	7.07	–	-34.7 mV
pH 4	4.00	3.99	–	136.3
pH 10	10.07	10.08	10.05	-201.4 mV
ORP	240.0	239.5	240.0	–

08 - Nov - 19

DO	–	94.6	92.8	
Cond	1413	1257	1413	
pH 7	7.02	7.05	–	-35.7
pH 4	4.00	4.06	–	136.3
pH 10	10.06	9.89	10.04	-199.6

15 - Nov - 19

DO	–	96.8	90.9	689.1 mm Hg
pH	7.03	7.06	–	-34.5
	4.00	3.94	–	137.7
	10.08	10.06	10.06	-200.3
Cond	1413	1471	1414	

APPENDIX D

Laboratory Reports and Chain-of-Custody forms

CERTIFICATE OF ANALYSIS

REPORTED TO	Golder Associates Ltd. (Whitehorse) 13-151 Industrial Rd Whitehorse, YT Y1A 2V3		
ATTENTION	Karlee Bendera	**WORK ORDER**	N001394
PO NUMBER		**RECEIVED / TEMP**	2019-11-09 11:37 / 2°C
PROJECT	19126478/1000	**REPORTED**	2019-11-26 15:49
PROJECT INFO	Whitehorse - Water Monitoring Program	**COC NUMBER**	B94731

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 acrump@caro.ca

Authorized By:

Alana Crump
Junior Account Manager

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Golder Associates Ltd. (Whitehorse)	**WORK ORDER**	N001394
PROJECT	19126478/1000	**REPORTED**	2019-11-26 15:49

Analyte	Result	RL	Units	Analyzed	Qualifier
MW19-1 (N001394-01) | Matrix: Water | Sampled: 2019-11-08 11:40					
Anions					
Chloride	**26.2**	0.10	mg/L	2019-11-14	
Nitrate+Nitrite (as N)	**0.0188**	0.0050	mg/L	2019-11-15	
Nitrite (as N)	< 0.0050	0.0050	mg/L	2019-11-13	HT1
Calculated Parameters					
Nitrate (as N)	**0.0188**	0.0100	mg/L	N/A	
General Parameters					
Ammonia, Total (as N)	**0.137**	0.020	mg/L	2019-11-14	
BOD, 5-day	< 2.4	2.0	mg/L	2019-11-18	BOD2, HT1
Conductivity (EC)	**809**	2.0	µS/cm	2019-11-15	
Oxygen, Dissolved	**11.0**	1.0	mg/L	2019-11-19	HT2
pH	**7.42**	0.10	pH units	2019-11-16	HT2
Temperature, at pH	**18.4**		°C	2019-11-13	HT2
Microbiological Parameters					
Coliforms, Fecal	< 2	2	MPN/100 mL	2019-11-08	
MW19-2 (N001394-02) | Matrix: Water | Sampled: 2019-11-08 13:40					
Anions					
Chloride	**12.2**	0.10	mg/L	2019-11-14	
Nitrate+Nitrite (as N)	**0.364**	0.0050	mg/L	2019-11-15	
Nitrite (as N)	**0.0168**	0.0050	mg/L	2019-11-13	HT1
Calculated Parameters					
Nitrate (as N)	**0.347**	0.0100	mg/L	N/A	
General Parameters					
Ammonia, Total (as N)	**0.088**	0.020	mg/L	2019-11-14	
BOD, 5-day	< 2.3	2.0	mg/L	2019-11-19	BOD2, HT1
Conductivity (EC)	**602**	2.0	µS/cm	2019-11-15	
Oxygen, Dissolved	**11.3**	1.0	mg/L	2019-11-19	HT2
pH	**7.39**	0.10	pH units	2019-11-16	HT2
Temperature, at pH	**12.1**		°C	2019-11-13	HT2
Microbiological Parameters					
Coliforms, Fecal	< 2	2	MPN/100 mL	2019-11-08	
MW3-08 (N001394-03) | Matrix: Water | Sampled: 2019-11-08 12:25					
Anions					
Chloride	**26.5**	0.10	mg/L	2019-11-14	
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L	2019-11-20	

CARO ANALYTICAL SERVICES

TEST RESULTS

REPORTED TO	Golder Associates Ltd. (Whitehorse)	**WORK ORDER**	N001394
PROJECT	19126478/1000	**REPORTED**	2019-11-26 15:49

Analyte	Result	RL	Units	Analyzed	Qualifier
MW3-08 (N001394-03) | Matrix: Water | Sampled: 2019-11-08 12:25, Continued					
Anions, Continued					
Nitrite (as N)	< 0.0050	0.0050	mg/L	2019-11-13	HT1
Calculated Parameters					
Nitrate (as N)	< 0.0100	0.0100	mg/L	N/A	
General Parameters					
Ammonia, Total (as N)	**0.091**	0.020	mg/L	2019-11-14	
BOD, 5-day	< 2.3	2.0	mg/L	2019-11-19	BOD2, HT1
Conductivity (EC)	**1140**	2.0	µS/cm	2019-11-15	
Oxygen, Dissolved	**11.2**	1.0	mg/L	2019-11-19	HT2
pH	**6.90**	0.10	pH units	2019-11-16	HT2
Temperature, at pH	**9.8**		°C	2019-11-13	HT2
Microbiological Parameters					
Coliforms, Fecal	**13**	2	MPN/100 mL	2019-11-08	
MW4-08 (N001394-04) | Matrix: Water | Sampled: 2019-11-08 13:25					
Anions					
Chloride	**30.0**	0.10	mg/L	2019-11-14	
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L	2019-11-20	
Nitrite (as N)	< 0.0050	0.0050	mg/L	2019-11-13	HT1
Calculated Parameters					
Nitrate (as N)	< 0.0100	0.0100	mg/L	N/A	
General Parameters					
Ammonia, Total (as N)	**0.102**	0.020	mg/L	2019-11-14	
BOD, 5-day	< 2.3	2.0	mg/L	2019-11-19	BOD2, HT1
Conductivity (EC)	**1070**	2.0	µS/cm	2019-11-15	
Oxygen, Dissolved	**11.2**	1.0	mg/L	2019-11-19	HT2
pH	**7.31**	0.10	pH units	2019-11-16	HT2
Temperature, at pH	**7.7**		°C	2019-11-13	HT2
Microbiological Parameters					
Coliforms, Fecal	< 2	2	MPN/100 mL	2019-11-08	

Sample Qualifiers:

BOD2	The sample dilutions set-up for the BOD analysis did not meet the oxygen depletion criterion of at least 2 mg/L.
HT1	The sample was prepared and/or analyzed past the recommended holding time.
HT2	The 15 minute recommended holding time (from sampling to analysis) has been exceeded - field analysis is recommended.

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO	Golder Associates Ltd. (Whitehorse)	**WORK ORDER**	N001394
PROJECT	19126478/1000	**REPORTED**	2019-11-26 15:49

Analysis Description	Method Ref.	Technique	Location
Ammonia, Total in Water	SM 4500-NH3 G* (2017)	Automated Colorimetry (Phenate)	Kelowna
Anions in Water	SM 4110 B (2017)	Ion Chromatography	Kelowna
Biochemical Oxygen Demand in Water	SM 5210 B (2017)	Dissolved Oxygen Meter	Richmond
Coliforms, Fecal in Water	SM 9221 (2017)	Multiple-Tube Fermentation	Sublet
Conductivity in Water	SM 2510 B (2017)	Conductivity Meter	Richmond
Dissolved Oxygen in Water	SM 4500-O G (2017)	Membrane Electrode	Richmond
Nitrate+Nitrite in Water	SM 4500-NO3- F (2017)	Automated Colorimetry (Cadmium Reduction)	Kelowna
Nitrite in Water	SM 4500-NO2 B (2017)	Colorimetry	Richmond
pH in Water	SM 4500-H+ B (2017)	Electrometry	Richmond

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
°C	Degrees Celcius
mg/L	Milligrams per litre
MPN/100 mL	Most Probable Number per 100 millilitres
pH units	pH < 7 = acidic, ph > 7 = basic
µS/cm	Microsiemens per centimetre
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.

Results in **Bold** indicate values that are above CARO's method reporting limits. Any results that are above regulatory limits are highlighted **red**. Please note that results will only be highlighted red if the regulatory limits are included on the CARO report. Any Bold and/or highlighted results do not take into account method uncertainty. If you would like method uncertainty or regulatory limits to be included on your report, please contact your Account Manager:acrump@caro.ca

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Golder Associates Ltd. (Whitehorse)	**WORK ORDER**	N001394
PROJECT	19126478/1000	**REPORTED**	2019-11-26 15:49

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 B9K1254										
Blank (B9K1254-BLK1)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Chloride	< 0.10	0.10	mg/L							
Blank (B9K1254-BLK2)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Chloride	< 0.10	0.10	mg/L							
LCS (B9K1254-BS1)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Chloride	15.9	0.10	mg/L	16.0		99	90-110			
LCS (B9K1254-BS2)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Chloride	16.0	0.10	mg/L	16.0		100	90-110			
Duplicate (B9K1254-DUP1)			**Source: N001394-01**	Prepared: 2019-11-14, Analyzed: 2019-11-14						
Chloride	25.8	0.10	mg/L		26.2			1	10	
Matrix Spike (B9K1254-MS1)			**Source: N001394-01**	Prepared: 2019-11-14, Analyzed: 2019-11-14						
Chloride	41.0	0.10	mg/L	16.0	26.2	92	75-125			
Anions, Batch B9K1271										
Blank (B9K1271-BLK1)				Prepared: 2019-11-13, Analyzed: 2019-11-13						
Nitrite (as N)	< 0.0050	0.0050	mg/L							
LCS (B9K1271-BS1)				Prepared: 2019-11-13, Analyzed: 2019-11-13						
Nitrite (as N)	0.0464	0.0050	mg/L	0.0500		93	90-110			
Duplicate (B9K1271-DUP1)			**Source: N001394-02**	Prepared: 2019-11-13, Analyzed: 2019-11-13						
Nitrite (as N)	0.0155	0.0050	mg/L		0.0168				10	
Anions, Batch B9K1377										
Blank (B9K1377-BLK2)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L							
Blank (B9K1377-BLK3)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Golder Associates Ltd. (Whitehorse)	**WORK ORDER**	N001394
PROJECT	19126478/1000	**REPORTED**	2019-11-26 15:49

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
Anions, Batch B9K1377, Continued										
Blank (B9K1377-BLK4)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L							
Blank (B9K1377-BLK5)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L							
Blank (B9K1377-BLK6)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L							
Blank (B9K1377-BLK7)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	< 0.0050	0.0050	mg/L							
LCS (B9K1377-BS2)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	0.494	0.0050	mg/L	0.500		99	91-108			
LCS (B9K1377-BS3)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	0.498	0.0050	mg/L	0.500		100	91-108			
LCS (B9K1377-BS4)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	0.491	0.0050	mg/L	0.500		98	91-108			
LCS (B9K1377-BS5)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	0.492	0.0050	mg/L	0.500		98	91-108			
LCS (B9K1377-BS6)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	0.480	0.0050	mg/L	0.500		96	91-108			
LCS (B9K1377-BS7)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Nitrate+Nitrite (as N)	0.510	0.0050	mg/L	0.500		102	91-108			
General Parameters, Batch B9K1226										
Blank (B9K1226-BLK1)				Prepared: 2019-11-13, Analyzed: 2019-11-18						
BOD, 5-day	< 2.0	2.0	mg/L							BOD6
LCS (B9K1226-BS1)				Prepared: 2019-11-13, Analyzed: 2019-11-18						
BOD, 5-day	173	60.3	mg/L	180		96	85-115			
General Parameters, Batch B9K1383										
Blank (B9K1383-BLK1)				Prepared: 2019-11-14, Analyzed: 2019-11-19						
BOD, 5-day	< 2.0	2.0	mg/L							BOD6
LCS (B9K1383-BS1)				Prepared: 2019-11-14, Analyzed: 2019-11-19						
BOD, 5-day	184	58.2	mg/L	180		102	85-115			
General Parameters, Batch B9K1385										
Blank (B9K1385-BLK1)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B9K1385-BLK2)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
Blank (B9K1385-BLK3)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO	Golder Associates Ltd. (Whitehorse)	**WORK ORDER**	N001394
PROJECT	19126478/1000	**REPORTED**	2019-11-26 15:49

Analyte	Result	RL	Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B9K1385, Continued										
Blank (B9K1385-BLK4)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	< 0.020	0.020	mg/L							
LCS (B9K1385-BS1)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	0.971	0.020	mg/L	1.00		97	90-115			
LCS (B9K1385-BS2)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	0.962	0.020	mg/L	1.00		96	90-115			
LCS (B9K1385-BS3)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	0.991	0.020	mg/L	1.00		99	90-115			
LCS (B9K1385-BS4)				Prepared: 2019-11-14, Analyzed: 2019-11-14						
Ammonia, Total (as N)	0.945	0.020	mg/L	1.00		94	90-115			
General Parameters, Batch B9K1537										
Blank (B9K1537-BLK1)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Conductivity (EC)	< 2.0	2.0	µS/cm							
LCS (B9K1537-BS1)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Conductivity (EC)	148	2.0	µS/cm	147		100	90-110			
Reference (B9K1537-SRM1)				Prepared: 2019-11-15, Analyzed: 2019-11-15						
Conductivity (EC)	1010	2.0	µS/cm	1000		101	95-105			
General Parameters, Batch B9K1538										
Reference (B9K1538-SRM1)				Prepared: 2019-11-16, Analyzed: 2019-11-16						
pH	7.31	0.10	pH units	7.30		100	94.5-105.5			
General Parameters, Batch B9K1912										
Blank (B9K1912-BLK1)				Prepared: 2019-11-19, Analyzed: 2019-11-19						
Oxygen, Dissolved	10.6	1.0	mg/L							
Duplicate (B9K1912-DUP1)		**Source: N001394-01**		Prepared: 2019-11-19, Analyzed: 2019-11-19						
Oxygen, Dissolved	11.0	1.0	mg/L		11.0			< 1	20	

QC Qualifiers:

BOD6 The BOD unseeded blank dissolved oxygen depletion exceeded 0.2 mg/L.

CARO ANALYTICAL SERVICES
Caring About Results, Obviously.

CARO.ca **1-888-311-8846**
#110-4011 Viking Way, Richmond, BC V6V 2K9
#102-3677 Highway 97N, Kelowna, BC V1X 5C3
17225 109 Avenue NW, Edmonton, AB T5S 1H7
#108-4475 Wayburne Drive, Burnaby, BC V5G 4X4

CARO BC COC, Rev 2019-01

CHAIN OF CUSTODY RECORD

COC# B94731 PAGE 1 OF 1

RELINQUISHED BY:	DATE: 08-Nov-19	RECEIVED BY:	DATE:
	TIME: 15:15		TIME:

TURNAROUND TIME REQUESTED:
Routine: (5-7 Days) ☒
Rush: 1 Day* ☐ 2 Day* ☐ 3 Day* ☐
Other* ____
*Contact Lab To Confirm. Surcharge May Apply

REGULATORY APPLICATION: Show on Report ☐
Canadian Drinking Water Quality ☐ BC WQG ☐ BC HWR ☐
BC CSR Soil: WL ☐ AL ☐ PL ☐ RL-LD ☐ RL-HD ☐ CL ☐ IL ☐
BC CSR Water: AW ☐ IW ☐ LW ☐ DW ☐
CCME: ____ Other: ____

REPORT TO:
COMPANY: Golder Associates
ADDRESS: 13-151 Industrial Rd Whse, YT Y1A 2V3
CONTACT: Karlee Bandera
TEL/FAX: 633-6076
DELIVERY METHOD: EMAIL ☐ ONLINE ☐ OTHER* ☐
DATA FORMAT: EXCEL ☐ WATERTRAX ☐ ESdat ☐ EQuIS ☐ BC EMS ☐ OTHER* ☐
EMAIL 1: kbandera@golder.com
EMAIL 2: abruemmer@golder.com
EMAIL 3: Mmckay@golder.com

INVOICE TO: SAME AS REPORT TO ☒
COMPANY:
ADDRESS:
CONTACT:
TEL/FAX:
DELIVERY METHOD: EMAIL ☐ ONLINE ☐ OTHER* ☐
EMAIL 1:
EMAIL 2:
EMAIL 3:
PO #:

PROJECT NUMBER / INFO: 19126478/1000

A: Biohazard B: Cyanide C: PCBs D: Asbestos E: Heavy Metals F: Flammable G: Strong Odour H: High Contamination I: Other (please specify*)

** If you would like to sign up for ClientConnect and/or EnviroChain, CARO's online service offerings, please check here: ☐

SAMPLED BY:

ANALYSES REQUESTED:

CLIENT SAMPLE ID:	MATRIX: DRINKING WATER	OTHER WATER	SOIL	OTHER	CONTAINER QTY	SAMPLING: DATE YYYY-MM-DD	TIME HH:MM	COMMENTS: CHLORINATED	FILTERED	PRESERVED	(e.g. flow/volume media ID/notes)	BTEX ☐ VPH ☐ PHC F1 ☐	VOC ☐ VPH ☐	EPH ☐ PHC F2-F4 ☐	PAH ☐ L/HEPH ☐	PHENOLS Chlorinated ☐ Non-Chlor. ☐	PCB ☐ GLYCOLS ☐ HAA ☐ THM ☐	PESTICIDES ☐ ACID HERBICIDES ☐	METALS - WATER TOTAL Hg ☐	METALS - WATER DISSOLVED Hg ☐	METALS - SOIL (SALM) ☐ Inc. pH ☐	pH ☒ EC ☒ ALK ☐ ANIONS ☐	TSS ☐ VSS ☐ TDS ☐	BOD ☒ COD ☐ TOG ☐ MOG ☐	TN ☐ NH3 ☒ TKN ☐	FECAL COLIFORMS ☒ HPC ☐	TOTAL COLIFORMS ☐ E.coli ☐	ESSENTIAL DRINKING WATER PACKAGE	ASBESTOS	Chloride	Nitrates + Nitrites	Temperature	Dissolved Oxygen	HOLD	POSSIBLE SAMPLE HAZARD CODE(S)
MW19-1		X				2019-11-08	11:40															X		X	X	X				X	X	X	X		
MW19-2		X				2019-11-08	13:40															X		X	X	X				X	X	X	X		
MW3-08		X				2019-11-08	13:25															X		X	X	X				X	X	X	X		
MW4-08		X				2019-11-08	13:25															X		X	X	X				X	X	X	X		

SHIPPING INSTRUCTIONS: Return Cooler(s) ☐
Supplies Needed:

SAMPLE RETENTION:
30 Days (default) ☐
60 Days ☐ 90 Days ☐
Other (surcharges will apply): ____

*** OTHER INSTRUCTIONS:**

If you would like to talk to a real live Scientist about your project requirements, please check here: ☐

SAMPLE RECEIPT CONDITION:
COOLER 1 (°C): ____ ICE: Y ☐ N ☐
COOLER 2 (°C): ____ ICE: Y ☐ N ☐
COOLER 3 (°C): ____ ICE: Y ☐ N ☐
CUSTODY SEALS INTACT: N/A ☐ Y ☐ N ☐

golder.com