



REPORT

Hydrogeological Assessment

Whitehorse Lagoon, Whitehorse, YT

Submitted to:

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Submitted by:

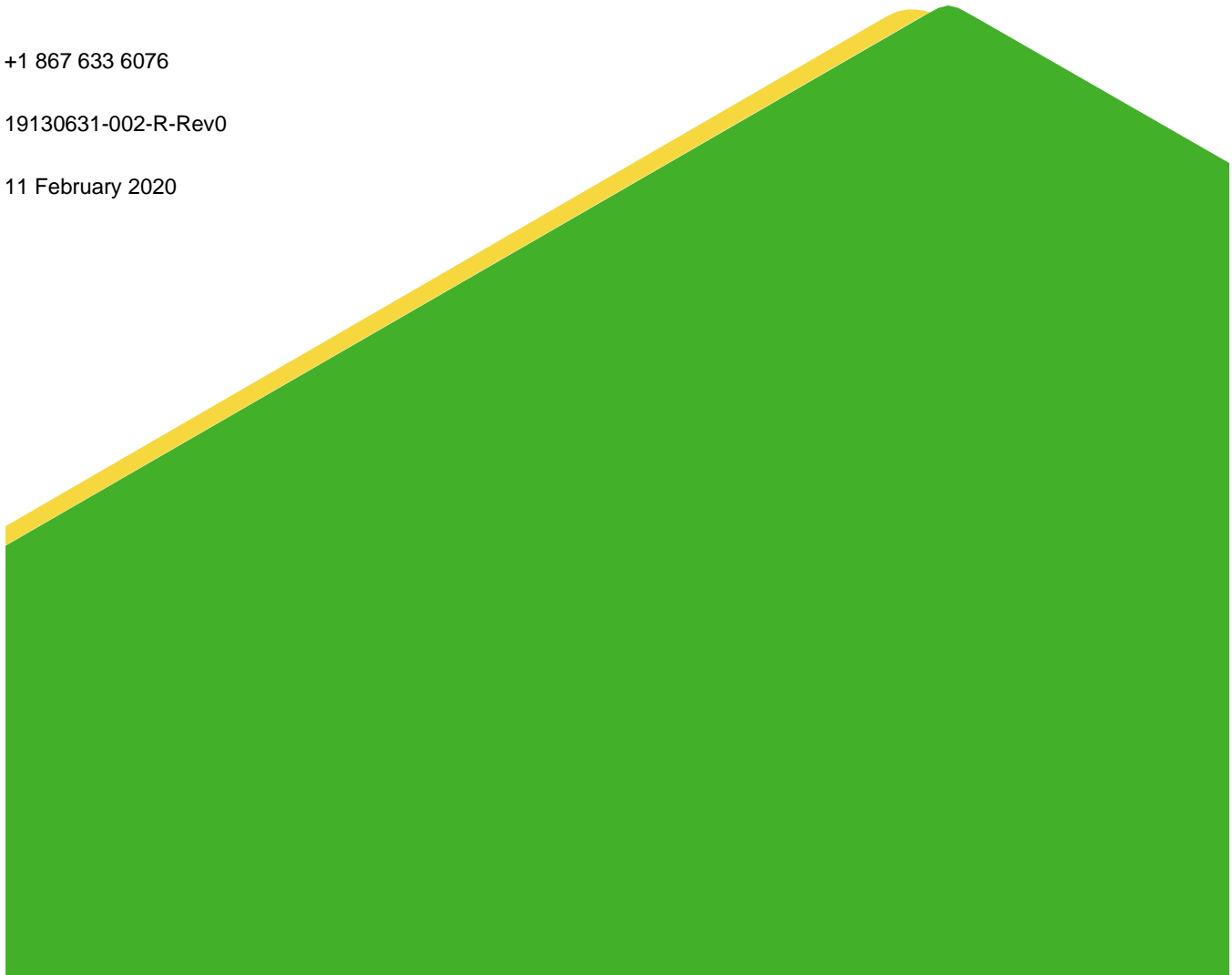
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19130631-002-R-Rev0

11 February 2020



Distribution List

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Executive Summary

Golder Associates Ltd. (Golder) was retained by the City of Whitehorse (the City) on 15 November 2019 to update the hydrogeological assessment at the Whitehorse Lagoon (the Site), as outlined by the City of Whitehorse's current short-term Water Use Licence (WUL), MN18-059.

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 existing wells at the facility were sampled in accordance with Section 39 of the City's WUL MN18-059 (effective 19 March 2019, expires 1 May 2020), and relevant Environment Yukon Protocols.

Because intrusive investigations have not been undertaken at the Site since the work carried out by EBA (2009), the understanding of soil stratigraphy across the Site remains unchanged and consists of sand or silty sand overlying a silt/clay unit, with interbedded seams of sand (EBA, 2009).

Groundwater across the Site is suspected to present only seasonally in the upper sand and silty sand layer, where MW5-08S and MW6-08S were installed. Regional groundwater was believed to be flowing through interbedded seams within the lower silt/clay unit and is captured at a depth of approximately 45 m. Monitoring wells MW5-08D and MW6-08D were installed within these seams. Due to the limited groundwater elevation data for the Site, the groundwater flow direction and velocity could not be determined. Based on the Site's location relative to the Yukon River, groundwater flow is anticipated to be to the west towards the Yukon River.

Analytical parameters collected from MW5-08D at the Whitehorse Lagoon were less than the applicable Yukon CSR AW standards. The concentrations of all analytes were lower in 2019 than in the previous sampling event in 2008 (EBA, 2009). Additional sampling rounds would be required to confirm a decreasing trend and not just variability.

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

- 1) In order to determine seasonal trends, and understand whether there is a seasonal, shallow groundwater unit, groundwater monitoring should be conducted three times a year; during spring freshet, mid-season, and fall.
- 2) In order to determine the groundwater flow direction and velocity across the site additional monitoring wells would be required in the deeper groundwater unit.
- 3) An elevation survey of the existing monitoring wells should be conducted to determine accurate groundwater elevations.

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 Whitehorse 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 party 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.

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by the City of Whitehorse (the City) to update the hydrogeological assessment at the Whitehorse 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 15 November 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°45'60" North and longitude 135°03'44" West. The Site is located along the Livingstone Trail and 350 m east of the Yukon River, and is accessed by a gravel road from the Livingstone Trail. The legal description of the Whitehorse Lagoon is Lot 5 Quad 105D/14, 64533 CLSR, 55209 LTO. It is located in the traditional territory of the Ta'an Kwäch'än Council and Kwanlin Dün First Nation.

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 Section 39 of the City's 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.
- Collect water quality samples from the existing monitoring wells.
- Submit the samples for laboratory analysis and identify potential impacts.
- Prepare this Hydrogeological Assessment documenting the results of this investigation.

2.0 REGULATORY FRAMEWORK

In the Yukon Territory, environmental matters pertaining to contaminated sites generally fall under the jurisdiction of Environment Yukon, pursuant to the *Environment Act*.

In the Yukon Territory, the two key regulations under the *Environment Act* relating to the assessment and remediation of contaminated sites are the Contaminated Sites Regulation (CSR) (Environment Yukon), and the Special Waste Regulations (SWR) (Environment Yukon, updated April 1, 2009).

The CSR provides Generic Numerical Water Standards (Schedule 3) for use in the assessment of groundwater quality at sites subject to investigation. The groundwater samples collected as part of the City's Water License (MW18-059) were compared to the Yukon CSR Schedule 3 standards for the Protection of Freshwater Aquatic Life (AW) 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	Not 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 Whitehorse Lagoon.

Aquatic Life

A review of the Yukon Lands Viewer and Google Earth Images by Golder in 2020, showed the nearest down-gradient body of water is the Yukon River, located approximately 350 m west of the site. It was therefore determined that CSR standards for freshwater aquatic life (AW) were **applicable** to the Whitehorse 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 2020, showed 3 geotechnical boreholes and no water wells located within a 1.5 km radius of the site. It was therefore determined that CSR standards for drinking water (DW) were **not applicable** to the Whitehorse Lagoon.

Irrigation and Livestock

A review of the Groundwater Information Network (GIN) website and the Yukon Water Data Catalogue and reviewed by Golder in 2020, showed no irrigation wells or wells for livestock on record for the Whitehorse 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 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 Whitehorse Lagoon.

3.0 METHODS

3.1 Monitoring Well Network

In August 2008, EBA installed four monitoring wells, shown on Figure 2 at the Whitehorse Lagoon as part of a 2009 Hydrogeological Assessment of the Whitehorse Lagoon (EBA, 2009). MW5-08 (D&S) and MW6-08 (D&S) 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 Whitehorse Lagoon.

Table 2: Monitoring Well Details

Monitoring Well ID	UTM Coordinates (Zone 8V)	Completion Date	Hydraulic Location of Well Relative to Whitehorse Lagoon	Water-Bearing Unit	Drilled depth (m bgs)	Screen Interval (m bgs)	Filter Pack Interval (m bgs)
MW5-08D	6736629 m N, 496802 m E	18-Aug-08	Up-gradient	Silt and Fine Sand	50.2	41.0-47.1	40.2-47.6
MW5-08S	6736629 m N, 496802 m E	18-Aug-08	Up-gradient	Sand	50.2	3.0-4.5	2.5-5.0
MW6-08D	6736803 m N, 496416 m E	19-Aug-08	Down-gradient	Sand	56.4	44.0-47.2	43.4-47.5
MW6-08D	6736803 m N, 496416 m E	19-Aug-08	Down-gradient	Sand	56.4	6.0-7.9	5.3-7.9

Notes: Data for monitoring wells installed by EBA in 2008 was collected from the borehole logs provided in the 2009 Hydrogeological Assessment.

3.2 Groundwater Sampling

A groundwater sample was collected from monitoring well MW5-08D at the Whitehorse Lagoon 25 November 2019. Monitoring wells MW5-08S and MW6-08 (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.

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 $\pm 0.2^{\circ}\text{C}$)
- ± 0.1 for pH
- ± 3 percent for conductivity
- ± 10 mv for redox potential
- ± 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 dedicated high-density polyethylene Waterra™ tubing and foot valve using a Hydrolift and generator. Sample containers and appropriate preservatives were obtained from Caro Analytical Services (CARO) in Richmond, BC.

The sample was submitted for analysis of the parameters outlined in Section 3.2.1. The sample was kept in a cooler with ice packs prior to the 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.

Groundwater purging, and sampling sheets are provided in Appendix A and the laboratory analytical results and chain of custody forms are provided in Appendix B.

3.2.1 Groundwater and Surface Water Analytical Parameters

In accordance with the Change Order dated 8 November 2019, groundwater wells were sampled and analyzed for the following parameters:

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

The parameter list complies with the City's Water Use 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).

3.3 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: 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
 - Two site-specific laboratory splits

4.0 RESULTS

4.1 Soil Stratigraphy

Because intrusive investigations have not been undertaken at the Site since the work completed by EBA (2009), the understanding of soil stratigraphy across the Site remains unchanged and consists of the following stratigraphic units:

- Variable amounts of sand or silty sand overlying a silt/clay unit overlying
- Interbedded fine and coarse-grained sand seams were observed throughout the silt/clay layer

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. 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 25 November 2019

Well ID	Top of PVC Casing Surveyed Elevation (masl)	Stick up height (m)	Ground Elevation Estimate* (masl)	Standing Water Level (mbtoc)	Groundwater Elevation (masl)
MW5-08D	-	0.80	661.000	39.781	622.019
MW5-08S	-	0.77	661.000	5.461**	656.309**
MW6-08D	-	0.92	523.797	Dry	Dry
MW6-08S	-	0.89	523.797	Dry	Dry

Notes:

masl = metres above sea level

*Ground elevation estimates collected from the contour map on Geomatics Yukon (Government of Yukon, 2011).

** indicates monitoring well contained an insufficient volume of water to sample

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

As discussed in EBA's report (2009), groundwater across the Site is inferred to be present only seasonally in the upper sand and silty sand layer, where MW5-08S and MW6-08S were installed. Regional groundwater was believed to be flowing through interbedded seams within the lower silt/clay unit and was encountered at a depth of approximately 45 m. Monitoring wells MW5-08D and MW6-08D were installed within these seams. The water level in MW5-08S is considered suspect due to the water column height of only 6 cm which may represent water trapped in the well cap at the bottom of the screen.

Due to the lack of available groundwater elevation data for the Site, the groundwater flow direction and velocity could not be determined at this time. Based on the site's location relative to the Yukon River, the groundwater flow is anticipated to be to the west towards the Yukon River.

4.3 Groundwater Chemistry

Groundwater monitoring was conducted at the Whitehorse Lagoon on 25 November 2019. Groundwater analytical results are provided in the attached Tables 4 and 5. The analyzed analytical parameters were less than the applicable Yukon CSR AW standards. The concentrations of analytes in 2019 were lower than the previous sampling event in 2008 (EBA, 2009). With only two sampling rounds having been conducted from the one monitoring well with water (MW5-08D) since the monitoring wells were installed, it is unknown if the concentration decreases represent seasonal changes, natural variability or an overall decrease in concentrations over time. Chain of custody forms for the groundwater samples collected in November 2019, along with the laboratory analytical results are provided in Appendix B.

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 B). 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.
- The sample dilution set-up for BOD analysis contained 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, including the geology, hydrogeology and topography, and assess the potential impacts that the lagoon may have on local groundwater. To meet this objective, the existing 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.

Soil stratigraphy across the Site consists of sand or silty sand overlying a silt/clay unit, with interbedded seams of sand (EBA, 2009).

Groundwater across the Site is suspected to present only seasonally in the upper sand and silty sand layer, where MW5-08S and MW6-08S were installed. Regional groundwater was believed to be flowing through interbedded seams within the lower silt/clay unit and is captured at a depth of approximately 45 m. Monitoring wells MW5-08D and MW6-08D were installed within these seams. Due to the limited groundwater elevation data for the Site, the groundwater flow direction and velocity could not be determined. Based on the Site's location relative to the Yukon River, groundwater flow is anticipated to be to the west towards the Yukon River.

Analytical parameters collected from MW5-08D at the Whitehorse Lagoon were less than the applicable Yukon CSR AW standards. The concentrations of all analytes were lower in 2019 than in the previous sampling event in 2008 (EBA, 2009). Additional sampling rounds would be required to confirm a decreasing trend and not just variability.

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

- In order to determine seasonal trends, and understand whether there is a seasonal, shallow groundwater unit, groundwater monitoring should be conducted three times a year; during spring freshet, mid-season, and fall.
- In order to determine the groundwater flow direction and velocity across the site additional monitoring wells would be required in the deeper groundwater unit.
- An elevation survey of the existing monitoring wells should be conducted to determine accurate groundwater elevations.

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.



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Environmental Scientist



Tamra Reynolds, MSc, PGeo
Associate, Senior Hydrogeologist

KB/TR/lih

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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. Dated February 2009.

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,
Whitehorse Lagoon, Whitehorse, Yukon**

19130631/3000

Field Parameters	Sample Name	MW5-08D	MW5-08S	MW6-08D	MW6-08S
	Sample Date	2019-11-25	2019-11-25	2019-11-25	2019-11-25
	Units				
DTB	m btoc	48.40	5.47	48.08	8.552
DTW	m btoc	39.781	5.461*	Dry	Dry
Temperature	°C	5.4	-	-	-
pH	pH units	8.00	-	-	-
Specific Conductivity	µS/cm	627.9	-	-	-
Oxidation Reduction Potential	mV	-51.8	-	-	-
Dissolved Oxygen	mg/L	2.82	-	-	-

Notes:

* indicates insufficient volume to sample

- indicates results not collected

**Table 5: Analytical Results of October 2008 and November 2019
Groundwater Sampling at MW5-08D, Whitehorse Lagoon, Whitehorse, Yukon**

19130631/3000

Parameters	Laboratory ID	648080-3	9110874-01	Yukon CSR
	Sample Name	MW5-08D	MW5-08D	
	Sample Date	2008-10-08	2019-11-25	AW
	Units			
Chloride	mg/L	3.91	0.77	-
Nitrate+Nitrite (as N)	mg/L	-	<0.0200	400
Nitrite (as N)	mg/L	0.5	<0.010	0.2-2.0*
Nitrate (as N)	mg/L	0.97	0.012	400
Temperature, at pH	°C	-	7.6	-
Ammonia, Total (as N)	mg/L	1.47	0.078	1.31-18.5**
BOD, 5-day	mg/L	10	<2.2	-
Oxygen, Dissolved	mg/L	26.1	8.5	-
pH	pH units	8.05	7.89	-
Conductivity (EC)	uS/cm	448	663	-

Notes:

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

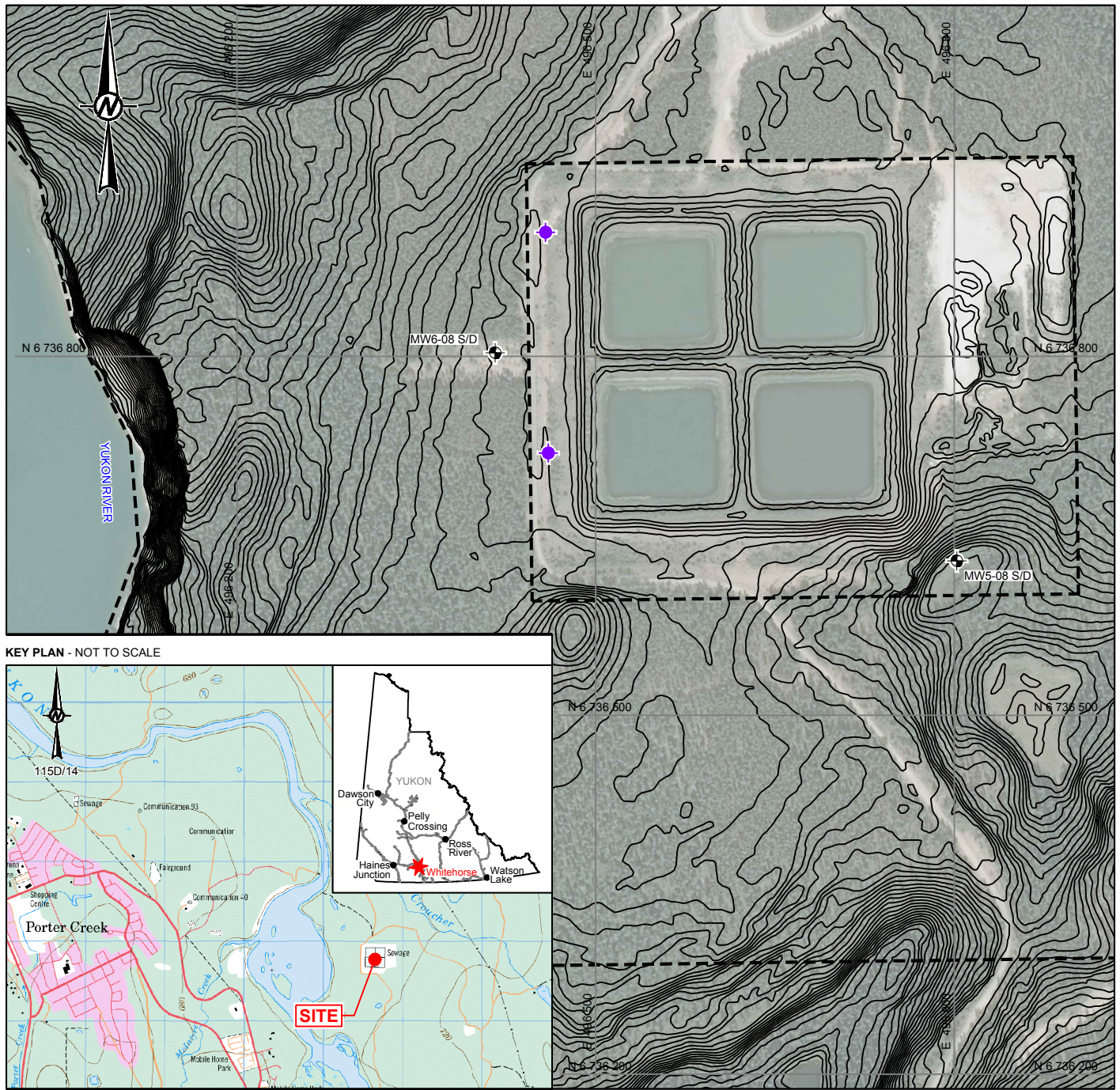
*Standard is dependent on chloride concentrations.

**Standard is dependant on pH.

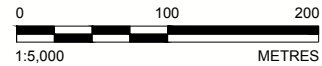
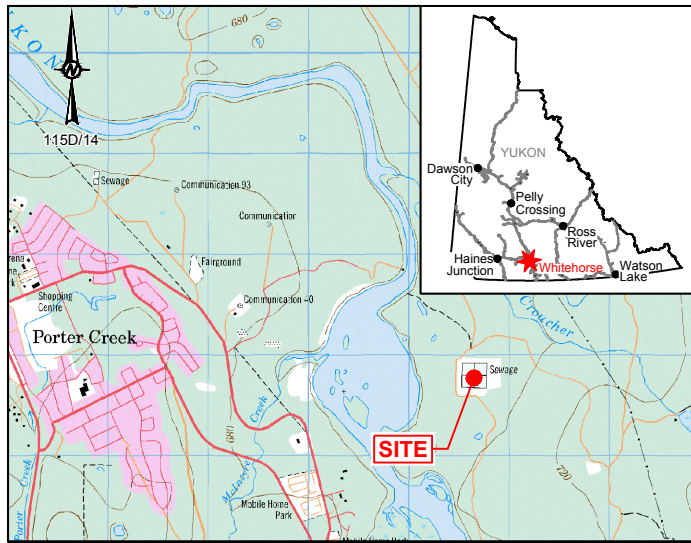
Data from 2008 was collected by EBA (2009).

Highlighted results exceed the Yukon CSR AW standard

0.12



KEY PLAN - NOT TO SCALE



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 : 2020-01-22
IMAGE GEOREFERENCED BY GOLDER AND INTENDED FOR INDICATIVE PURPOSES ONLY
LOT BOUNDARIES & CONTOURS WERE PROVIDED BY THE CITY OF WHITEHORSE ON 2020-01-22
KEY PLAN FROM CANMATRIX 1: 50000 NTS - 105D/14

DATUM: NAD83, PROJECTION: UTM ZONE 8

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CLIENT
CITY OF WHITEHORSE

PROJECT
WHITEHORSE LAGOON HYDROGEOLOGICAL ASSESSMENT

TITLE
SITE PLAN

CONSULTANT

YYYY-MM-DD 2019-02-10

DESIGNED KB

PREPARED RTJ

REVIEWED KB

APPROVED TR



PROJECT NO.
19130631

PHASE
3000

REV.
0

FIGURE
1



LEGEND

- LOT BOUNDARY
- CONTOUR (1 m INTERVAL)
- INFERRED GROUNDWATER FLOW DIRECTION
- 365.15 GROUNDWATER ELEVATION (masl), NOVEMBER 2019
- ⊕ MONITORING WELL LOCATION

REFERENCES

* INDICATES MONITORING WELL CONTAINED AN INSUFFICIENT VOLUME OF WATER TO SAMPLE

REFERENCES

BACKGROUND IMAGE SUPPLIED BY AND SOURCED UNDER LICENSE FROM BING IMAGES FOR ARCMAP ON : 2020-01-22
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CLIENT
CITY OF WHITEHORSE

PROJECT
WHITEHORSE LAGOON HYDROGEOLOGICAL ASSESSMENT

TITLE
GROUNDWATER ELEVATIONS AND FLOW DIRECTION

CONSULTANT

YYYY-MM-DD 2019-02-10

DESIGNED KB

PREPARED RTJ

REVIEWED KB

APPROVED TR



GOLDER

PROJECT NO.
19130631

PHASE
3000


REV.
0


FIGURE
2

APPENDIX A

**Field Forms and Calibration
Records**

Reviewed by:

 Development

 Purge/Sample

PROJECT NO.: 119130631

FIELD PERSONNEL: 1 KB

DATE: 25 Nov 2019

TIME: 13:01

Easting: 496429 Northing: 6736805

Well headspace: ppm

Completion: ☐ Flushmount ☒ Stickup monument

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

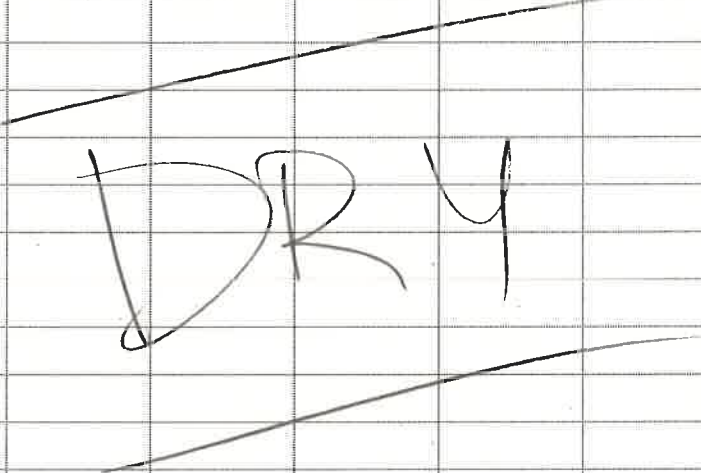
Purge Volumes

Casing In. Diam.	1/2"	1"	1 1/4"	1 1/2"	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	

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
								

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)

well labelled as MW6-08 DdS

SCN: - @

Bottle count:

Reviewed by:



Groundwater Development, Purging and Sampling Sheet

☐ Development
☒ Purge/Sample

WELL ID:

MWS-08D

PROJECT NO.:

19130631

SITE:

WH Lagoon

FIELD PERSONNEL:

KB

WEATHER:

Overcast/Snow

DATE:

25 Nov 2019.

TEMPERATURE:

-8

TIME:

13:30

Depth to Bottom of Well Below Top of Casing (A): 48.40 (meters)
 Depth to Water Below Top of Casing (B): 39.781 (meters)
 Water Column: 8.619 (meters)
 Stick-up: 0.80 (meters)

Easting: 496750 Northing: 6736629
 Well headspace: ppm
 Completion: ☐ Flushmount ☐ Stickup monument
 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.	1/2"	1"	1 1/4"	1 1/2"	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): 17.2 * 3 = 51.7 litres

Purge start time: 13:40

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
14:08	10	41.69	5.2	7.94	624.0	-85.0	4.32	turbid, spilling
14:13	20	—	5.0	7.88	628.6	-72.7	4.14	Same
14:22	30	41.30	5.4	7.86	623.6	-61.3	3.10	Same
14:28	40	—	5.3	7.97	624.0	-55.0	2.98	Same
14:36	52	—	5.4	8.00	627.9	-51.8	2.82	Same

SAMPLING Water Odour: ☐ No ☒ Yes (describe): Sulphur 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: - @ MWS-08D @ 14:40

Bottle count:

Reviewed by:

Reviewed by:

APPENDIX B

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

PO NUMBER

PROJECT 19126478/1000

PROJECT INFO Whitehorse - Water Monitoring Program

WORK ORDER 9110874

RECEIVED / TEMP 2019-11-26 13:30 / 8°C

REPORTED 2019-12-03 18:24

COC NUMBER B94747

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

1-888-311-8846 | www.caro.ca

#110 4011 Viking Way Richmond, BC V6V 2K9 | #102 3677 Highway 97N Kelowna, BC V1X 5C3 | 17225 109 Avenue Edmonton, AB T5S 1H7

TEST RESULTS

REPORTED TO PROJECT Golder Associates Ltd. (Whitehorse)
19126478/1000

WORK ORDER REPORTED 9110874
2019-12-03 18:24

Analyte	Result	RL	Units	Analyzed	Qualifier
MW5-08D (9110874-01) Matrix: Water Sampled: 2019-11-25 14:40					
Anions					
Chloride	0.77	0.10	mg/L	2019-11-28	
Nitrate (as N)	0.012	0.010	mg/L	2019-11-28	
Nitrite (as N)	< 0.010	0.010	mg/L	2019-11-28	
Calculated Parameters					
Nitrate+Nitrite (as N)	< 0.0200	0.0200	mg/L	N/A	
General Parameters					
Ammonia, Total (as N)	0.078	0.020	mg/L	2019-11-27	
BOD, 5-day	< 2.2	2.0	mg/L	2019-12-03	BOD2
Conductivity (EC)	663	2.0	µS/cm	2019-11-29	
Oxygen, Dissolved	8.5	1.0	mg/L	2019-11-27	HT2
pH	7.89	0.10	pH units	2019-12-02	HT2
Temperature, at pH	7.6		°C	2019-12-03	HT2

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.

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

APPENDIX 1: SUPPORTING INFORMATION

REPORTED TO PROJECT Golder Associates Ltd. (Whitehorse)
19126478/1000

WORK ORDER REPORTED 9110874
2019-12-03 18:24

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
Conductivity in Water	SM 2510 B (2017)	Conductivity Meter	Richmond
Dissolved Oxygen in Water	SM 4500-O G (2017)	Membrane Electrode	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
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)
PROJECT 19126478/1000

WORK ORDER 9110874
REPORTED 2019-12-03 18:24

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
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Anions, Batch B9K2756

Blank (B9K2756-BLK1)			Prepared: 2019-11-28, Analyzed: 2019-11-28						
Chloride	< 0.10	0.10 mg/L							
Nitrate (as N)	< 0.010	0.010 mg/L							
Nitrite (as N)	< 0.010	0.010 mg/L							
Blank (B9K2756-BLK2)			Prepared: 2019-11-28, Analyzed: 2019-11-28						
Chloride	< 0.10	0.10 mg/L							
Nitrate (as N)	< 0.010	0.010 mg/L							
Nitrite (as N)	< 0.010	0.010 mg/L							
LCS (B9K2756-BS1)			Prepared: 2019-11-28, Analyzed: 2019-11-28						
Chloride	16.0	0.10 mg/L	16.0		100	90-110			
Nitrate (as N)	4.07	0.010 mg/L	4.00		102	90-110			
Nitrite (as N)	1.92	0.010 mg/L	2.00		96	85-115			
LCS (B9K2756-BS2)			Prepared: 2019-11-28, Analyzed: 2019-11-28						
Chloride	15.7	0.10 mg/L	16.0		98	90-110			
Nitrate (as N)	4.24	0.010 mg/L	4.00		106	90-110			
Nitrite (as N)	2.06	0.010 mg/L	2.00		103	85-115			

General Parameters, Batch B9K2710

Blank (B9K2710-BLK1)			Prepared: 2019-11-27, Analyzed: 2019-11-27						
Ammonia, Total (as N)	< 0.020	0.020 mg/L							
Blank (B9K2710-BLK2)			Prepared: 2019-11-27, Analyzed: 2019-11-27						
Ammonia, Total (as N)	< 0.020	0.020 mg/L							
LCS (B9K2710-BS1)			Prepared: 2019-11-27, Analyzed: 2019-11-27						
Ammonia, Total (as N)	0.989	0.020 mg/L	1.00		99	90-115			
LCS (B9K2710-BS2)			Prepared: 2019-11-27, Analyzed: 2019-11-27						
Ammonia, Total (as N)	0.995	0.020 mg/L	1.00		100	90-115			

General Parameters, Batch B9K2804

APPENDIX 2: QUALITY CONTROL RESULTS

REPORTED TO PROJECT Golder Associates Ltd. (Whitehorse)
19126478/1000

WORK ORDER REPORTED 9110874
2019-12-03 18:24

Analyte	Result	RL Units	Spike Level	Source Result	% REC	REC Limit	% RPD	RPD Limit	Qualifier
General Parameters, Batch B9K2804, Continued									
Blank (B9K2804-BLK1)				Prepared: 2019-11-27, Analyzed: 2019-11-27					
Oxygen, Dissolved	9.4	1.0 mg/L							
General Parameters, Batch B9K2835									
Blank (B9K2835-BLK1)				Prepared: 2019-11-28, Analyzed: 2019-12-03					
BOD, 5-day	< 2.0	2.0 mg/L							
LCS (B9K2835-BS1)				Prepared: 2019-11-28, Analyzed: 2019-12-03					
BOD, 5-day	167	56.1 mg/L	180		93	85-115			
General Parameters, Batch B9K2967									
Blank (B9K2967-BLK1)				Prepared: 2019-11-29, Analyzed: 2019-11-29					
Conductivity (EC)	< 2.0	2.0 µS/cm							
LCS (B9K2967-BS1)				Prepared: 2019-11-29, Analyzed: 2019-11-29					
Conductivity (EC)	149	2.0 µS/cm	147		101	90-110			
Reference (B9K2967-SRM1)				Prepared: 2019-11-29, Analyzed: 2019-11-29					
Conductivity (EC)	1020	2.0 µS/cm	1000		102	95-105			
General Parameters, Batch B9L0055									
Reference (B9L0055-SRM1)				Prepared: 2019-12-02, Analyzed: 2019-12-02					
pH	7.56	0.10 pH units	7.30		104	94.5-105.5			

#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

CHAIN OF CUSTODY RECORD

COC# **B94747**

PAGE 1 OF 6

REPORT TO:
COMPANY: Golder Associates Ltd
ADDRESS: 13-151 Industrial Rd., Whse, Y1, Y1A 2V3
CONTACT: Kurkee Bendera
TEL/FAX: 867 334 6422

INVOICE TO: SAME AS REPORT TO ☒
COMPANY:
ADDRESS:
CONTACT:
TEL/FAX:



* 9 1 1 0 8 7 4 *

DELIVERY METHOD: EMAIL ☐ ONLINE ☐ OTHER* ☐
DATA FORMAT: EXCEL ☒ WATERTRAX ☐ ESdat ☐
EQUS ☒ BC EMS ☐ OTHER* ☐
EMAIL 1: kbendera@golder.com
EMAIL 2: abruemmer@golder.com
EMAIL 3: mmckay@golder.com

DELIVERY METHOD: EMAIL ☒ ONLINE ☐ OTHER* ☐
EMAIL 1:
EMAIL 2:
EMAIL 3:
PO #:

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

SAMPLED BY: KB

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)

CLIENT SAMPLE ID:

MW5-08D

☒

2019-11-25

1440

☒

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

Nitrates + Nitrites

Chloride

Dissolved Oxygen

Temperature

HOLD

POSSIBLE SAMPLE HAZARD CODE(S)

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

SAMPLE RETENTION:

30 Days (default) ☐

60 Days ☐ 90 Days ☐

Other (surcharges will apply):

*** OTHER INSTRUCTIONS:**

Freezer

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

SAMPLE RECEIPT CONDITION:

COOLER 1 (°C): 7.9 ICE: Y ☒ N ☐

COOLER 2 (°C): ICE: Y ☐ N ☐

COOLER 3 (°C): ICE: Y ☐ N ☐

CUSTODY SEALS INTACT: NA ☐ Y ☐ N ☐



golder.com