**Mount Nansen September 2015**

**Groundwater Monitoring and Sampling**

Prepared for:

**Government of Yukon**

Assessment and Abandoned Mines Branch

P.O. Box 2703

Whitehorse, YT Y1A 2C6

Prepared by:

**Hemmera Envirochem Inc.**

230 – 2237 2nd Avenue

Whitehorse, YT Y1A 0K7

and

**Ecological Logistics & Research Ltd.**

204 – 105 Titanium Way

Whitehorse, YT Y1A 0E7

File: 1343-005.11

January 2016

**TABLE OF CONTENTS**

[1.0 Introduction 1](#_Toc441567314)

[1.1 Site Location 1](#_Toc441567315)

[1.2 Scope of Work 2](#_Toc441567316)

[1.3 Sample Sites 2](#_Toc441567317)

[2.0 Methodology 8](#_Toc441567318)

[2.1 Protocols 8](#_Toc441567319)

[2.2 Well Measurements and Purging 8](#_Toc441567320)

[2.3 Direct Sampling 9](#_Toc441567321)

[2.4 Field Parameters 10](#_Toc441567322)

[2.5 Groundwater Sampling 10](#_Toc441567323)

[2.6 Data Analysis 11](#_Toc441567324)

[2.7 Quality Assurance and Quality Control 11](#_Toc441567325)

[2.7.1 Field QA/QC 11](#_Toc441567326)

[2.7.2 Analytical QA/QC 11](#_Toc441567327)

[3.0 Results 13](#_Toc441567328)

[3.1 Groundwater Sampling Summary 13](#_Toc441567329)

[3.2 Analytical Results 18](#_Toc441567330)

[3.2.1 Dome Creek 18](#_Toc441567331)

[3.2.2 Mill Complex 20](#_Toc441567333)

[3.2.3 Brown McDade Pit 20](#_Toc441567334)

[3.2.4 Pony Creek 21](#_Toc441567335)

[3.2.5 Seepage Dam 21](#_Toc441567336)

[3.2.6 Tailings Facility 22](#_Toc441567337)

[3.3 Quality Assurance and Quality Control Results 22](#_Toc441567338)

[3.3.1 Field and Travel Blanks 23](#_Toc441567339)

[3.3.2 Field Duplicates 23](#_Toc441567340)

[3.3.2.1 GSI-DC-06B and MW15-500 23](#_Toc441567341)

[3.3.2.2 MW09-16 and MW15-100 23](#_Toc441567342)

[3.3.2.3 MP09-08 and MW15-400 23](#_Toc441567343)

[3.3.2.4 MP09-05 and MW15-200 24](#_Toc441567344)

[3.3.2.5 MW09-24 and MW15-300 24](#_Toc441567345)

[3.3.3 Quality Assurance and Quality Control Summary 24](#_Toc441567346)

[3.4 Analytical Test of Filtered Alkalinity 25](#_Toc441567347)

[4.0 Recommendations 27](#_Toc441567348)

[5.0 Closure 28](#_Toc441567349)

[6.0 References 29](#_Toc441567350)

**List of Tables *(within text)***

[Table 1-1 Summary of Groundwater Well Locations and Samples Collected 4](#_Toc441567351)

[Table 2-1 Groundwater Sampling – Field Parameter Purging Criteria 9](#_Toc441567352)

[Table 2-2 Groundwater Sampling Parameter Priority, Preservation, and Intended Analysis 10](#_Toc441567353)

[Table 3-1 Summary of Direct Samples Collected During September 2015 Sampling Program 14](#_Toc441567354)

[Table 3-2 Groundwater Field Parameters and Well Measurements for September 2015 Sampling Program 15](#_Toc441567355)

[Table 3-3 Summary of CCME FAL Guideline Exceedances for September 2015 Sampling Program 19](#_Toc441567356)

[Table 3-4 Comparison of Alkalinity and Filtered Alkalinity Results 25](#_Toc441567357)

**List of Figures *(within text)***

[Figure 1-1 Site Location – Mount Nansen Site 3](#_Toc441567358)

[Figure 1-2 Groundwater Sampling Locations – Dome Creek and Tailings Facility 6](#_Toc441567359)

[Figure 1-3 Groundwater Sampling Locations – Mill Complex and Brown McDade Pit 7](#_Toc441567360)

**List of Tables *(following text)***

Table A Groundwater Sampling Analytical Results and CCME Guideline Exceedances for 2015 September Sampling Program

Table B QA/QC Analytical Data

**List of Appendices**

Appendix A Site Photographs

Appendix B Field Forms

Appendix C Laboratory Reports

Appendix D Response to Comments Received on Draft Report

# Introduction

This Work was performed in accordance with Contract C00028455 between Hemmera Envirochem Inc. (“Hemmera”) and Government of Yukon (“Client”), dated May 11, 2015 (“Contract”). This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by Government of Yukon. In performing this Work, Hemmera has relied in good faith on information provided by others, and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

Hemmera Envirochem Inc. and Ecological Logistics & Research Ltd. (Hemmera/ELR) were retained by the Government of Yukon (GY), Assessment and Abandoned Mines (AAM) to conduct a groundwater monitoring and sampling program at the Mount Nansen site (the Site) in September, 2015. Hemmera/ELR’s scope of work included the monitoring of groundwater wells and collection of groundwater samples from a series of existing groundwater wells at the Site. This report summarizes the monitoring and sampling activities, a description of methodologies and field conditions encountered, a summary of field *in-situ* and laboratory analytical results including a comparison to applicable guidelines, a description of any observations and/or occurrences that may have influenced program results, and recommendations relating to sample procedures and monitoring well conditions. This report does not provide an interpretation of the results, nor does it provide recommendations relating to groundwater quality at the Site.

## Site Location

The Mount Nansen site is located approximately 45 kilometres (km) west of the Town of Carmacks (70 km by road). This Type II abandoned mine site consists of three (3) primary areas of existing infrastructure: the Brown McDade Pit, a Mill Complex, and a Tailings Facility (**Figure 1-1**). Groundwater monitoring wells exist throughout the Site, a subset of which were sampled during the September 2015 groundwater monitoring and sampling program. The groundwater monitoring locations included in this program are described in **Sections 1.2** and **1.3**.

## Scope of Work

The scope of work for this program included the coordination and execution of the September 2015 groundwater monitoring and sampling, analysis of samples, and the presentation of results in a report.

Groundwater sampling at the Site was conducted over a four (4) day period, between August 31 and September 3, 2015. Sampling was conducted by a team of four (4) qualified field staff from Hemmera/ELR (Justin Hains, Aaron Nicholson, Glenn Rudman, and Jeremy Chua). A total of 65 groundwater wells were included in the September 2015 sampling event (**Table 1-1**). It was not possible to sample four (4) of the groundwater wells listed in the scope of work as they had been destroyed; two (2) previously destroyed (MP09-01 and GSI-PC-01-B) and two (2) that appeared to have been destroyed during placer mining operations in the summer of 2015 (GSI-PC-02-B and MP09-02). One (1) of the remaining 61 groundwater wells assessed was known to be damaged (CH-P-13-02/10), but sampling and monitoring was attempted during the September 2015 program.

At each well (sampling station) headspace gas concentrations were measured, well and water level parameters were measured (depth to water, depth to bottom, well diameter, and well stick-up height), the well was purged, and then prescribed *in-situ* groundwater quality parameters were measured. Lastly, groundwater samples were collected for laboratory analysis. A detailed description of the sampling methods and measured groundwater quality parameters is provided in **Section 2**.

## Sample Sites

The groundwater wells included in the September 2015 monitoring and sampling event were grouped into six (6) main areas of the Mount Nansen Site (**Table 1-1**). The majority of groundwater wells were located around existing infrastructure including the tailings facility, and seepage dam (25 wells), the Brown McDade Pit (13 wells) and the Mill Complex (9 wells). Additional wells (primarily drive-point piezometer installations) were sampled in the vicinity of Dome Creek (9 wells) and Pony Creek (9 wells). **Table 1-1** provides the location, status, and sample recovery for groundwater wells included in the September 2015 sampling program. The well locations are also illustrated in **Figures 1-2** and **1-3**. Photographs of each sample site visited in September 2015 are included in **Appendix A**.

Figure 1-1 Site Location – Mount Nansen Site

Table 1-1 Summary of Groundwater Well Locations and Samples Collected

| **Area** | **Well Name** | **UTM (Zone 08N)** | **Status1,2** | **Sample Collected** | **QA/QC Sample Collected** |
| --- | --- | --- | --- | --- | --- |
| **Easting** | **Northing** |
| Dome Creek | GSI-DC-01B | 387675 | 6881124 | Direct Sampled1 | ✓ | - |
| GSI-DC-02B | 387879 | 6881129 | Direct Sampled1 | ✓ | - |
| GSI-DC-03B | 388107 | 6881079 | Direct Sampled1 | ✓ | - |
| GSI-DC-05B | 388725 | 6880836 | Direct Sampled1 | ✓ | - |
| GSI-DC-06B | 389788 | 6880567 | Good | ✓ | Duplicate |
| GSI-DC-07B | 390065 | 6880641 | Good | ✓ | - |
| GSI-DC-08-B | 390311 | 6880583 | Insufficient Volume | - | - |
| GSI-DC-09-B | 390614 | 6880494 | Good | ✓ | - |
| GSI-DC-10-B | 390859 | 6880447 | Good | ✓ | - |
| Mill Complex | GSI-HA-01A | 387842 | 6881132 | Direct Sampled1 | ✓ | - |
| GSI-HA-02A | 387861 | 6881135 | Good | ✓ | - |
| GSI-HA-03A | 387878 | 6881131 | Direct Sampled1 | ✓ | - |
| GSI-HA-04A | 387916 | 6881130 | Good | ✓ | - |
| GSI-HA-05A | 387898 | 6881125 | Good | ✓ | - |
| MW09-16 | 387992 | 6881094 | Good | ✓ | Duplicate, Field Blank |
| MW09-17 | 388075 | 6880970 | Good | ✓ | - |
| MW09-18 | 388054 | 6880986 | Good | ✓ | - |
| MW09-19 | 388051 | 6881016 | Good | ✓ | - |
| Brown McDade Pit | CH-P-13-01/10 | 388657 | 6881116 | Frozen | - | - |
| CH-P-13-03/10 | 389145 | 6881105 | Dry | - | - |
| CH-P-13-03/50 | 389143 | 6881110 | Insufficient Volume  | - | - |
| CH-P-13-04/10 | 389138 | 6881472 | Frozen | - | - |
| CH-P-13-04/35 | 389138 | 6881472 | Frozen | - | - |
| CH-P-13-05/50 | 388954 | 6881466 | Good | ✓ | - |
| GLL07-01 | 388851 | 6881783 | Frozen  | - | - |
| GLL07-02 | 389069 | 6881703 | Dry | - | - |
| GLL07-03 | 388959 | 6881477 | Good | ✓ | - |
| MW09-13 | 389006 | 6881664 | Frozen | - | - |
| MW09-14 | 389008 | 6881669 | Frozen | - | - |
| MW09-15 | 388920 | 6881727 | Frozen | - | - |
| CH-P-13-02/10 | 388924 | 6881014 | Damaged | - | - |
| Pony Creek | GSI-PC-01-B | N/A | N/A | Destroyed 2 | - | - |
| GSI-PC-02-B | 388907 | 6881786 | Destroyed | - | - |
| GSI-PC-03-B | 389256 | 6881706 | Direct Sampled 1 | ✓ | - |
| GSI-PC-04-B | 389586 | 6881656 | Direct Sampled 1 | ✓ | - |
| GSI-PC-05-B | 389713 | 6881661 | Good | ✓ | - |
| MP09-01 | N/A | N/A | Destroyed 2 | - | - |
| MP09-02 | 388867 | 6881816 | Destroyed | - | - |
| MP09-03 | 388956 | 6881739 | Direct Sampled 1 | ✓ | - |
| MP09-08 | 389160 | 6881718 | Good | ✓ | Duplicate, Field Blank |
| Seepage Dam | W14103083BH01 | 389522 | 6880669 | Frozen | - | - |
| W14103083BH02 | 389561 | 6880665 | Direct Sampled1 | ✓ | - |
| W14103083BH04 | 389544 | 6880666 | Direct Sampled1 | ✓ | - |
| Tailings Facility | MP09-04 | 389575 | 6880609 | Good | ✓ | - |
| MP09-05 | 389548 | 6880590 | Good | ✓ | Duplicate |
| MP09-09 | 389240 | 6880681 | Good | ✓ | - |
| MP09-10 | 389241 | 6880684 | Direct Sampled1 | ✓ | - |
| MP09-11 | 389220 | 6880619 | Good | ✓ | - |
| MP09-12 | 389220 | 6880619 | Direct Sampled1 | ✓ | - |
| MP09-14 | 389138 | 6880722 | Direct Sampled1 | ✓ | - |
| MW09-01 | 389396 | 6880563 | Direct Sampled1 | ✓ | - |
| MW09-02 | 389393 | 6880562 | Good | ✓ | - |
| MW09-03 | 389411 | 6880555 | Good | ✓ | - |
| MW09-04 | 389420 | 6880557 | Good | ✓ | - |
| MW09-05 | 389413 | 6880656 | Dry | - | - |
| MW09-06 | 389411 | 6880653 | Good | ✓ | - |
| MW09-07 | 389322 | 6880699 | Insufficient Volume  | - | - |
| MW09-08 | 389620 | 6880576 | Good | ✓ | Field Blank |
| MW09-11 | 389037 | 6880711 | Dry | - | - |
| MW09-20 | 389592 | 6880586 | Dry | - | - |
| MW09-21 | 389536 | 6880577 | Good | ✓ | - |
| MW09-22 | 389495 | 6880549 | Good | ✓ | - |
| MW09-23 | 389459 | 6880553 | Good | ✓ | - |
| MW09-24 | 389561 | 6880624 | Good | ✓ | Duplicate, Field Blank |
| W14103083BH03 | 389132 | 6880730 | Good | ✓ | - |

**Notes: 1** Direct sampling was completed at sample stations where insufficient volume had been encountered during the event, which limited standard purging and sampling methodologies.

**2** Destroyed wells are included in the scope of work and are therefore listed above in the summary table.

Figure 1-2 Groundwater Sampling Locations – Dome Creek and Tailings Facility

Figure 1-3 Groundwater Sampling Locations – Mill Complex and Brown McDade Pit

# Methodology

## Protocols

Groundwater purging, monitoring and sampling conducted by Hemmera/ELR were completed in accordance with the Groundwater Sampling Standard Operating Procedures included in the document *Scope of Work: Groundwater Sampling Program – Mount Nansen Site 2015*. These procedures were consistent with Environment Yukon’s *Protocol for the Contaminated Sites Regulation #7 - Sampling and Decommissioning* (Environment Yukon, 2011). Methods used were also consistent with the ASTM D4448-01 *Standard Guide for Sampling Groundwater Monitoring Wells* (ASTM, 2013), and the D6452-99 *Guide for Purging Methods for Wells used for Groundwater Quality Investigations* (ASTM, 2012).

## Well Measurements and Purging

Upon arriving at each sample station, headspace gases were measured prior to any other well measurements. Oxygen (%), carbon dioxide (ppm), and methane (%LEL) were measured using a MultiRAE Four-Gas Monitor System with photoionization detector (PID).

The well structure and casing were inspected for damage, closure, and general conditions. Depth to water (DTW; m), depth to bottom (DTB; m), well diameter (cm), and well stick-up height (m) were then recorded at each well.

DTB and DTW were measured using either a Solinst - Model 102 Water Level Meter (for 2.54 cm diameter wells) or a Solinst – Model 122 Interface Meter (for wells with diameter greater than 2.54 cm). DTB and DTW were measured from (in order of preference): 1) a black mark drawn on the top of the well; 2) the bottom of the most significant notch found on the top of the PVC if a mark was not present; or 3) a line that was drawn on the highest point of the well if no distinguishable point of measure was present. Stick-up height was measured from the lowest point on the bottom of the well casing to the highest point (or distinguishing mark) on the well. Water level meters were cleaned between each sample site using Alconox low-foaming phosphate-free detergent solution and deionized water.

Following initial inspection and measurements, groundwater wells were purged and sampled using dedicated equipment. Groundwater wells were purged and sampled using one of three (3) techniques: 1) Hydrolift electric pump using dedicated high density polyethelene (HDPE) Waterra tubing and footvalve, 2) manual purging using high density polyethylene (HDPE) Waterra tubing and a footvalve, or 3) GeoPump peristaltic pump with HDPE tubing. The purging technique chosen for each well was that which would produce the most representative groundwater sample.

Groundwater wells were determined to be sufficiently purged when either three successive field parameter measurements were recorded to be within an allowable tolerance level (as summarized in **Table 2-1**, below) or when a volume of water equivalent to three standing well volumes of water had been purged.

Groundwater turbidity measured in Nephelometric Turbidity Units (NTU) was also measured prior to sampling (described below in **Section 2.4**) and was used as an indication of sample quality. Where possible, samples were not collected until turbidity was less than 50 NTU. Purge volumes and purge rates were measured using a graduated container and stop watch. All well measurements, purging details, and additional field notes were recorded on customized field forms in order to minimize the potential for field errors; this information is presented in **Table 3-2**.

Table 2-1 Groundwater Sampling – Field Parameter Purging Criteria

|  |  |
| --- | --- |
| **Field Parameter** | **Allowable Variance** |
| Temperature (°C) | ± 3% |
| pH | ± 0.1 |
| Conductivity (µS/cm) | ± 3% |
| Specific Conductivity (µS/cm) | ± 3% |

## Direct Sampling

During previous events a select number of groundwater wells were found to have an insufficient volume of groundwater to sample using conventional methods, limiting the number of wells that were sampled during the event. An alternate sampling strategy was established by AAM’s consultant (AMEC) in order to obtain samples from low producing wells, which was followed during the September 2015 sampling event. At wells identified as having insufficient volume of water, Hemmera/ELR direct sampled (analytical samples collected prior to purging or collecting field parameter measurements), after which time field parameter measurements were collected if possible. Additionally, a priority ranking order for analytical sample collection previously established by AAM’s consultant (AMEC) was used when collected samples at directly sampled wells (as summarized in **Table 2-2**). This ranking system was used to ensure that samples for higher priority parameters were collected at each well if limited recharge or volume was encountered. Where sample collection was limited, Hemmera/ELR also re-visited wells, where feasible, in an attempt to collect a more thorough sample set.

In addition to the priority ranking order, Hemmera/ELR also considered the minimum sample volumes required for laboratory procedures (provided to Hemmera/ELR by ALS Laboratories). Where well volume was limited, minimum volumes were collected to maximize the number of program parameters collected.

## Field Parameters

Hemmera/ELR measured *in-situ* water quality parameters using YSI Professional Plus multi-parameter field meters, Lamotte 2020we turbidity meters, and Hach DR 890 Portable Colorimeters. Flow-through cells were used with the YSI meters to minimize field parameter variability; flow-through cells improve the precision of field measurements by limiting sample water contact with air, and by continuously moving sample water across the field meter sensors. The *in-situ* groundwater quality parameters recorded at each sample station included water temperature (oC), specific conductivity (μs/cm), conductivity (μs/cm), oxidation/reduction potential (ORP; mv), pH (pH units), sulphide (mg/l), dissolved oxygen (mg/l and percent saturation), and turbidity (NTU).

During purging, field parameters were monitored at 5 minute intervals, or at volume related intervals (e.g., every 500 mL) in the case of wells with slow recharge. The final set of in situ measurements were recorded at the conclusion of purging.

## Groundwater Sampling

Groundwater quality samples were collected and preserved in accordance with laboratory directions, and using techniques consistent with *Standard Methods for the Examination of Water and Wastewater* (Rice et al., 2012). ALS Global was the analytical laboratory chosen for this project, and a summary of the sample bottle set (including parameters analysed and preservation techniques) is provided in **Table 2-2**.

In addition to the analytical parameters provided to Hemmera/ELR in the SOW, a separate dissolved alkalinity sample was added to each bottle set during this event. Field filtering was used to remove any acid or alkaline-generating solids that are not representative of an equilibrium condition (and that could have affected alkalinity results). Field filtered and unfiltered alkalinity results were then compared to test whether unfiltered results were representative (equivalent to filtered results). For this, a threshold of 20% Relative Percent Difference (RPD) was used, as described in **Section 2.7.2** below.

Table 2-2 Groundwater Sampling Parameter Priority, Preservation, and Intended Analysis

| Priority | Bottle Type | Parameters Analyzed | Minimum Volume | Sample Treatment | Preservative Added |
| --- | --- | --- | --- | --- | --- |
| 1a | 120 ml (plastic) | Dissolved Metals | 100 ml | Field Filtered and Preserved | HNO3 |
| 1b | 40 ml (glass) | Dissolved Mercury | 15 mL | Field Filtered and Preserved | HCl |
| 2 | 1 L (plastic) | General Chemistry | 200 ml | - | - |
| 3 | 145 ml (plastic) | Cyanide (total, free, weak acid dissociable) | 120 ml | Preserved | NaOH |
| 4 | 250 ml (glass amber) | Ammonia (NH3) | 120 ml | Preserved | H2SO4 |
| 5 | 120 ml (plastic) | Thiocyanate (SCN) | 50 ml | Preserved | HNO3 |
| 6 | 120 ml (plastic) | Sulphide | 100 ml | Preserved | Zinc Acetate, and NaOH |
| 7 | 250 ml (glass amber) | Total Inorganic Carbon (TIC) | 100 ml | - | - |
| 8 | 120 ml (plastic) | Dissolved Alkalinity | 100 ml | Field Filtered | - |

## Data Analysis

Groundwater analytical field and laboratory results were tabulated and reviewed using Hemmera/ELR’s EQWin Data Manager water quality database. Data was tabulated for the report and compared to the Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Freshwater Aquatic Life (FAL; CCME, 2014) standards using the database application. All relevant CCME FAL guidelines are presented in **Table A**.

## Quality Assurance and Quality Control

### Field QA/QC

Several controls were used by Hemmera/ELR staff while in the field to ensure that sample integrity was maintained and that data were recorded completely and accurately. All equipment used during the sampling process was dedicated to individual wells, including HDPE tubing and Waterra footvalves, laboratory provided pre-cleaned sample bottles, disposable filters, and disposable syringes. Field staff used dedicated disposable nitrile gloves for all measurements, purging, and sampling. Water level meters were cleaned between well locations using Alconox low-foaming phosphate-free detergent and deionized water, and field instruments (YSI field meters, turbidity meters, and portable colorimeters) were checked and calibrated before the site visit to ensure the parameters recorded were as accurate as possible.

Project-specific field data sheets were created for the sampling event to help ensure that all required measurements were taken, and that information was recorded correctly. Field data sheets have been included as **Appendix B** of this report.

### Analytical QA/QC

Analytical QA/QC measures were included in the September 2015 sampling program as outlined in the scope of work and as per standard industry practice. This included the collection of field duplicates and field blanks, and the use of travel blanks. Duplicate samples were collected at a ratio of 10% of the regular samples (1 duplicate was collected for every 10 samples), and a field blank was prepared for each day field sampling was conducted (a total of 4 field blanks were prepared). Two travel blanks accompanied the analytical supplies and samples from the laboratory to the field, and back to the laboratory again (1 for each shipment).

The variation between sample and duplicate values was calculated as relative percent difference (RPD). RPD provides a measure of the relative difference between two values in comparison to their mean value, and is calculated as the difference between a sample and its field duplicate over the average of two values. RPD values greater than 20% indicate a greater than expected variation in data that could potentially have affected the precision of sampling or analysis. RPD was calculated according to the following formula:

$$\%RPD=\left(\frac{\left(\frac{x\_{1}-x\_{2}}{x\_{1}+x\_{2}}\right)}{2}\right) x 100$$

RPD is not calculated if either the sample or the field duplicate concentration is less than five times the detection limit.

The analytical results for field and travel blanks were reviewed to determine whether any of the parameters tested were detected (i.e., result exceeding the detection limit). In such cases, the parameter or element in question and its concentration were reviewed to determine potential sources of contamination or error.

# Results

A summary of laboratory analytical results is presented in **Table A** of this report, including a comparison of results to CCME FAL guidelines. A summary of the QA/QC sampling results is presented in **Table B**, including analytical data for duplicates, field blanks, and travel blanks. Laboratory analytical reports are appended to this report (**Appendix C**).

## Groundwater Sampling Summary

Groundwater sampling was completed between August 31 and September 3, 2015. Weather conditions varied throughout the time of sampling with ambient air temperature ranging from -5 to 12°C.

Of the sixty-five (65) wells specified for the September 2015 sampling event, sixty-one (61) were located and assessed during the program. Two (2) groundwater wells listed in the scope of work had previously been reported as destroyed and are not further discussed in this report (GSI-PC-01-B and MP09-01). Two (2) more groundwater wells were presumed to be destroyed during the September 2015 sampling program as placer mining earthworks were occurring at their location at the time of the site visit (GSI-PC-01-B and MP09-02); further details concerning these wells are provided in **Section 3.2**.

Of the sixty-one (61) wells located, forty-four (44) wells were sampled; twenty-nine (29) using purging and sample methods as per the program protocols, and fifteen (15) sampled directly without purging according to the sample priority ranking. In ten (10) of the fifteen (15) direct sampled wells, volumes were insufficient to collect a full sample set. **Table 3-1** provides a summary of limited sample set collection.

Of the remaining seventeen (17) of sixty-one (61) wells that were assessed but not sampled during the program, eight (8) wells were frozen, five (5) wells were dry, three (3) wells had insufficient volume for sampling, and one (1) well was damaged and could not be sampled. Despite not collecting water quality samples these wells were still assessed and water/ice depth, well depth, and headspace gas measurements were collected to the extent possible. Due to a technical issue with one of the gas meters (PIDs), carbon dioxide concentrations were not collected at five (5) of sample locations included in the scope of work (**Table 3-2**). All other headspace gas measurements were obtained prior to sample collection (**Table 3-2**). A summary of the overall condition (status) and sampling result for groundwater wells is provided in **Table 1-1**, and a summary of all well measurements, purge details, and *in-situ* parameter results is provided in **Table 3-2**.

Table 3-1 Summary of Direct Samples Collected During September 2015 Sampling Program

| Well Name | Dissolved Metals | Dissolved Mercury | Physical Parameters | Anions/ Nutrients | Cyanide | Ammonia | Thiocyanate | Sulphide | Total Inorganic Carbon | Dissolved Alkalinity |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Priority | 1a | 1b | 2 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| GSI-DC-01B 1 | - | ✓ | - | - | - | - | - | - | - | - |
| GSI-DC-02B | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSI-DC-03B | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| GSI-DC-05B | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSI-HA-01A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| GSI-HA-03A | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - |
| GSI-PC-03B 2 | ✓ | ✓ | - | - | ✓ | - | - | - | - | - |
| GSI-PC-04B | ✓ | ✓ | ✓ | - | - | - | - | - | - | - |
| MP09-03 | ✓ | ✓ | - | - | - | - | - | - | - | - |
| W14103083BH02 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| W14103083BH04 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - |
| MP09-10 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - |
| MP09-12 | ✓ | ✓ | - | - | - | - | - | - | - | - |
| MP09-14 1 | - | ✓ | - | - | - | - | - | - | - | - |
| MW09-01 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**Notes:** Refer to section 2.2 for details concerning direct sampling methodologies, including minimum volume collection. Samples were collected based on field priority ranking as specified in Table 2-2.

1  Insufficient volumes available to collect a full dissolved metals sample, only dissolved mercury samples were collected.

2 Insufficient volume available to collect general chemistry sample, remaining sample was used for cyanide analysis.

Table 3-2 Groundwater Field Parameters and Well Measurements for September 2015 Sampling Program

| **Area** | **Location ID** | **Sample Date** | **Stick up Height (m)** | **Depth To Water (m)** | **Depth to Bottom (m)** | **Standing Water Volume (L)** | **Volume Purged (L)** | **Purge Start Time** | **Purge End Time** | **Elapsed Purge Time** | **Purge Rate (l/min)** | **Criteria1 (3WV/PS/DS)** | **Draw Down (m)** | **pH** | **Temperature (ºC)** | **Conductivity (µS/cm)** | **Specific Conductivity (µS/cm)** | **ORP (mV)** | **Dissolved Oxygen (mg/L)** | **Field Sulphide (mg/L)** | **Methane (%LEL)** | **Oxygen (%)** | **Carbon Dioxide (ppm)** | **Field Turbidity (NTU)** | **Method Used** | **Well Diameter (cm)5** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Dome Creek | GSI-DC-01A | 31/08/2015 | 0.930 | 0.924 | 1.481 | 0.19 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.4 | 840 | - | - | 2.1 |
| GSI-DC-01B 2 | 31/08/2015 | 0.950 | 1.478 | 1.599 | 0.04 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.4 | 690 | - | peristaltic | 2.1 |
| GSI-DC-02A | 31/08/2015 | 0.992 | 1.493 | 2.016 | 0.18 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.5 | 830 | - | - | 2.1 |
| GSI-DC-02B 2 | 31/08/2015 | 0.923 | 1.848 | 3.867 | 0.70 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.4 | 870 | - | peristaltic | 2.1 |
| GSI-DC-03A 4 | 31/08/2015 | 0.958 | 1.179 | 1.979 | 0.28 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | - | - | - | 2.1 |
| GSI-DC-03B 2, 4 | 31/08/2015 | 0.962 | 1.327 | 3.837 | 0.87 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.9 | - | - | peristaltic | 2.1 |
| GSI-DC-05A | 01/09/2015 | 1.075 | 1.2 | 1.952 | 0.38 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 2.54 |
| GSI-DC-05B 2 | 01/09/2015 | 0.622 | 0.703 | 2.844 | 1.08 | - | - | - | - | - | DS | - | 7.37 | 1 | 620 | 1143 | -94.6 | 5.77 | - | 0 | 20.9 | 1200 | - | peristaltic | 2.54 |
| GSI-DC-06A | 03/09/2015 | 0.830 | 0.925 | 2.001 | 0.37 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 660 | - | - | 2.1 |
| GSI-DC-06B | 03/09/2015 | 0.480 | 0.059 | 2.913 | 0.99 | 1.3 | 13:32 | 13:47 | 0:15 | 0.09 | PS | 1.626 | 7.4 | 2.9 | 845 | 1457 | -127.4 | 0.16 | 0.03 | 0 | 20.9 | 610 | 18 | peristaltic | 2.1 |
| GSI-DC-07A | 03/09/2015 | 1.030 | 1.324 | 2.001 | 0.23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 20 | - | - | 2.1 |
| GSI-DC-07B | 03/09/2015 | 1.000 | 1.419 | 3.811 | 0.83 | 2.8 | 14:47 | 15:07 | 0:20 | 0.14 | PS | 0.001 | 6.84 | 2.4 | 782 | 1377 | -52 | 0.12 | 0.03 | 0 | 20.6 | 530 | 15.3 | peristaltic | 2.1 |
| GSI-DC-08A | 03/09/2015 | 0.95 | 1.256 | 1.855 | 0.30 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 2.54 |
| GSI-DC-08B | 04/09/2015 | 0.31 | 0.811 | 2.777 | 1.00 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 2.54 |
| GSI-DC-09A | 03/09/2015 | 0.885 | 1.152 | 1.853 | 0.36 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 300 | - | - | 2.54 |
| GSI-DC-09B | 03/09/2015 | 0.894 | 1.202 | 1.855 | 0.33 | 2 | 14:24 | 14:44 | 0:20 | 0.10 | 3WV | - | 6.89 | 3.5 | 332.1 | 564 | -70 | 0.24 | 0.05 | 0 | 20.7 | 200 | 1.29 | peristaltic | 2.54 |
| GSI-DC-10A | 03/09/2015 | 1.155 | 1.101 | 1.85 | 0.38 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 2.54 |
| GSI-DC-10B | 03/09/2015 | 1.135 | 1.025 | 3.698 | 1.35 | 2.2 | 13:06 | 13:21 | 0:15 | 0.15 | PS | - | 6.6 | 4.2 | 745 | 1238 | -54.2 | 6.27 | 0.04 | 0 | 20.9 | 600 | 58.6 | peristaltic | 2.54 |
| Mill Complex | GSI-HA-01A 2 | 31/08/2015 | 1.240 | 2.173 | 3.128 | 0.33 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.5 | 1150 | - | peristaltic | 2.1 |
| GSI-HA-02A | 31/08/2015 | 1.530 | 1.905 | 3.82 | 0.97 | 3.1 | 9:14 | 9:52 | 0:38 | 0.08 | PS | - | 6.88 | 3.7 | 547 | 921 | -80.8 | 10.83 | 0.07 | 0 | 20.7 | 300 | 0.9 | peristaltic | 2.54 |
| GSI-HA-03A 2 | 31/08/2015 | 0.985 | 1.099 | 2.192 | 0.38 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.6 | 610 | - | peristaltic | 2.1 |
| GSI-HA-04A | 31/08/2015 | 0.61 | 0.942 | 2.116 | 0.59 | 2.7 | 13:22 | 13:36 | 0:14 | 0.19 | PS | - | 6.78 | 2.8 | 187.1 | 325.1 | 3.1 | 6.33 | 0.1 | 0 | 20.9 | 4280 | 5.69 | peristaltic | 2.54 |
| GSI-HA-05A | 30/08/2015 | 1.058 | 1.268 | 2.192 | 0.47 | 2.05 | 11:21 | 11:37 | 0:16 | 0.13 | 3WV | - | 6.75 | 2.6 | 516 | 902 | -51.6 | 2.31 | 0.28 | 0 | 20.9 | 300 | 39.7 | peristaltic | 2.54 |
| MW09-16 | 31/08/2015 | 1.310 | 1.846 | 2.722 | 1.78 | 2.1 | 11:44 | 12:07 | 0:23 | 0.09 | PS | 0 | 6.54 | 4.5 | 977 | 1605 | 298.9 | 2.5 | 0 | 0 | 19.5 | 3420 | 1.79 | peristaltic | 5.08 |
| MW09-17 | 31/08/2015 | 0.965 | 5.303 | 5.707 | 0.82 | 6 | 15:01 | 15:22 | 0:21 | 0.29 | PS | 0.007 | 6.85 | 0.9 | 1230 | 2279 | 74 | 1.52 | 0.01 | 0 | 20.9 | 600 | 0.61 | peristaltic | 5.08 |
| MW09-18 | 31/08/2015 | 0.880 | 4.635 | 7.795 | 6.40 | 5 | 16:00 | 16:15 | 0:15 | 0.33 | PS | 0.005 | 6.89 | 0.5 | 1200 | 2256 | 73.2 | 0.41 | 0.05 | 0 | 20.9 | 300 | 17.1 | peristaltic | 5.08 |
| MW09-19 | 31/08/2015 | 0.990 | 2.58 | 5.891 | 6.71 | 8 | 17:03 | 17:39 | 0:36 | 0.22 | PS | 0.6 | 6.73 | 2.1 | 1044 | 1858 | -47.7 | 0.53 | 0.18 | 0 | 20.9 | 300 | 1.2 | peristaltic | 5.08 |
| Brown McDade Pit | CH-P-13-01/10 | 31/08/2015 | 0.52 | - | 6.542 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.5 | 950 | - | - | 3.81 |
| CH-P-13-03/10 4 | 31/08/2015 | 0.650 | - | 5.019 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | - | - | - | 3.81 |
| CH-P-13-03/50 4 | 31/08/2015 | 0.590 | 50.423 | 50.649 | 0.26 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | - | - | - | 3.81 |
| CH-P-13-04/10 | 02/09/2015 | 0.65 | - | 6.22 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 200 | - | - | 3.81 |
| CH-P-13-04/35 | 02/09/2015 | 0.70 | - | 6.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 200 | - | - | 3.81 |
| CH-P-13-05/50 | 01/09/2015 | 0.780 | 25.446 | 49.99 | 12.44 | 70 | 10:19 | 10:45 | 0:26 | 2.69 | PS | - | 5.89 | 0.8 | 1568 | 2915 | 164.5 | 4.8 | 0.4 | 0 | 20.9 | 520 | 1.82 | hydrolift | 2.54 |
| GLL07-01 | 02/09/2015 | 0.820 | - | 13.847 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 690 | - | - | 5.08 |
| GLL07-02 | 03/09/2015 | 1.366 | - | 7.161 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 1250 | - | - | 15.24 |
| GLL07-03 | 01/09/2015 | 1.10 | 3.8 | 11.69 | 15.97 | 50 | 9:22 | 9:49 | 0:27 | 1.85 | 3WV | 5.718 | 6.34 | 1.5 | 407.6 | 740 | 170.9 | 4.86 | 0.8 | 0 | 20.9 | 610 | >4000 | waterra | 5.08 |
| MW09-13 | 02/09/2015 | 0.76 | - | 8.96 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 400 | - | - | 5.08 |
| MW09-14 | 02/09/2015 | 0.74 | - | 6.52 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 400 | - | - | 5.08 |
| MW09-15 | 02/09/2015 | 0.9 | - | 14.087 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 19.5 | 2970 | - | - | 5.08 |
| CH-P-13-02/10 4 | 31/08/2015 | 0.640 | - | 8.12 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 16.5 | - | - | - | 3.81 |
| Pony Creek | GSI-PC-02A 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| GSI-PC-02B 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| GSI-PC-03A 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| GSI-PC-03B 2 | 03/09/2015 | 0.990 | 1.385 | 2.022 | 0.22 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.9 | 580 | - | peristaltic | 2.1 |
| GSI-PC-04A | 31/08/2015 | 0.903 | 0.917 | 0.93 | 0.01 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 2.54 |
| GSI-PC-04B 2 | 03/09/2015 | 0.985 | 1.355 | 1.589 | 0.12 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | peristaltic | 2.54 |
| GSI-PC-05A | 03/09/2015 | 0.910 | 1.251 | 1.85 | 0.30 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 400 | - | - | 2.54 |
| GSI-PC-05B | 03/09/2015 | 0.910 | 2.485 | 3.71 | 0.62 | 3.3 | 9:21 | 9:36 | 0:15 | 0.22 | PS | - | 6.79 | 2.5 | 133.7 | 234.3 | 213.1 | 0.57 | 0.12 | 0 | 20.9 | 400 | 29.7 | peristaltic | 2.54 |
| MP09-02 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MP09-03 2 | 03/09/2015 | 0.730 | 1.651 | 1.982 | 0.11 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.9 | 560 | - | peristaltic | 2.1 |
| MP09-08 | 03/09/2015 | 0.900 | 1.61 | 1.963 | 0.12 | 1.7 | 9:25 | 9:40 | 0:15 | 0.11 | PS | - | 7 | 1.1 | 418.3 | 771 | 20.8 | 2.76 | 0.19 | 0 | 20.7 | 640 | 2.38 | peristaltic | 2.1 |
| Seepage Dam | W14103083BH01 | 02/09/2015 | 0.600 | - | 6.535 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.7 | 3000 | - | - | 5.08 |
| W14103083BH02 2 | 02/09/2015 | 0.780 | 6.234 | 6.726 | 1.00 | - | - | - | - | - | DS | - | - | - | - | - | - | - | 0.02 | 0 | 20.6 | 750 | 7.14 | peristaltic | 5.08 |
| W14103083BH04 2 | 02/09/2015 | 0.750 | 6.254 | 6.68 | 0.86 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.6 | 640 | - | peristaltic | 5.08 |
| Tailings Facility | MP09-04 | 01/09/2015 | 1.245 | 2.071 | 3.082 | 1.15 | 4 | 15:35 | 15:59 | 0:24 | 0.17 | PS | 0.049 | 7.07 | 1.8 | 544 | 979 | 61.2 | 0.73 | 0 | 0 | 20.9 | 1200 | 0.57 | peristaltic | 3.81 |
| MP09-05 | 01/09/2015 | 1.090 | 1.367 | 1.832 | 0.53 | 3 | 12:36 | 12:53 | 0:17 | 0.18 | PS | 0.083 | 6.64 | 3.1 | 1038 | 1781 | 27.6 | 0.33 | 0.05 | 0 | 20.9 | 300 | 1.64 | peristaltic | 3.81 |
| MP09-09 | 02/09/2015 | 2.460 | 3.51 | 5.65 | 1.69 | 4 | 14:02 | 14:29 | 0:27 | 0.15 | PS | 0.935 | 9.57 | 4.5 | 396.6 | 652 | 77.5 | 6.16 | 0.12 | 0 | 20.9 | 300 | 41.3 | peristaltic | 3.175 |
| MP09-10 2 | 02/09/2015 | 2.200 | 3.265 | 4.32 | 0.84 | - | - | - | - | - | DS | - | - | - | - | - | - | - | >.8 | 0 | 20.9 | 300 | >4000 | peristaltic | 3.175 |
| MP09-11 | 02/09/2015 | 1.900 | 2.15 | 4.96 | 3.20 | 2.6 | 11:46 | 12:13 | 0:27 | 0.10 | PS | 0.71 | 7.33 | 4.8 | 694 | 1131 | -125.5 | 0.18 | 0.35 | 11 | 20.4 | 3100 | 2 | peristaltic | 3.81 |
| MP09-12 2,7 | 02/09/2015 | 1.850 | 2.184 | 4.209 | 2.31 | 1.4 | 12:34 | 12:48 | 0:14 | 0.10 | DS | 1.701 | 7.52 | 5.7 | 166.7 | 263.6 | -9.6 | 5.14 | - | 0 | 20.6 | 700 | - | peristaltic | 3.81 |
| MP09-14 2 | 02/09/2015 | 1.000 | 1.149 | 1.604 | 0.16 | - | - | - | - | - | DS | - | - | - | - | - | - | - | - | 0 | 20.6 | 720 | - | peristaltic | 2.1 |
| MW09-01 2,7 | 01/09/2015 | 0.790 | 6.685 | 9.215 | 2.88 | 0.5 | 16:30 | 16:36 | 0:06 | 0.08 | DS | 0.655 | 7 | 2.2 | 1668 | 2951 | 50.3 | 0.32 | - | 0 | 20.7 | 580 | - | peristaltic | 3.81 |
| MW09-02 6 | 01/09/2015 | 0.690 | 3.021 | 4.715 | 3.43 | 3.6 | 15:49 | 16:08 | 0:19 | 0.19 | PS | 0.899 | 7.16 | 3.1 | 1636 | 2808 | -71.6 | 0.12 | - | 0 | 20.5 | 1050 | 7.74 | peristaltic | 5.08 |
| MW09-03 | 01/09/2015 | 0.37 | 6.449 | 9.925 | 7.05 | 2.5 | 14:20 | 14:40 | 0:20 | 0.13 | PS | 0.262 | 8.11 | 2 | 1480 | 2644 | 163.4 | 0.14 | 0.01 | 0 | 20.7 | 630 | 1.27 | peristaltic | 5.08 |
| MW09-04 | 01/09/2015 | 0.35 | 4.261 | 7.666 | 6.80 | 2.4 | 15:00 | 15:17 | 0:17 | 0.14 | PS | 0.7 | 8.39 | 2.7 | 1578 | 2752 | 178.5 | 0.13 | 0.02 | 0 | 20.6 | 580 | 1.55 | peristaltic | 5.08 |
| MW09-05 | 02/09/2015 | 1.220 | - | 7.56 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 19.1 | 1500 | - | - | 5.08 |
| MW09-06 | 02/09/2015 | 2.085 | 3.84 | 5.99 | 4.36 | 2.1 | 10:45 | 11:12 | 0:27 | 0.08 | PS | 0.63 | 7.49 | 5.3 | 969 | 1552 | 42.9 | 2.22 | 0.02 | 0 | 20.4 | 800 | 6.63 | peristaltic | 5.08 |
| MW09-07 | 02/09/2015 | 1.340 | 3.372 | 3.405 | 0.07 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 300 | - | - | 5.08 |
| MW09-08 | 01/09/2015 | 1.130 | 1.12 | 3.927 | 5.69 | 5.5 | 16:41 | 16:59 | 0:18 | 0.31 | PS | 0.085 | 6.72 | 3.3 | 209.9 | 358.9 | -65.7 | 0.3 | 0.08 | 0 | 20.9 | 500 | 4.38 | peristaltic | 5.08 |
| MW09-11 | 02/09/2015 | 0.810 | - | 4.894 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.3 | 2030 | - | - | 5.08 |
| MW09-20 | 01/09/2015 | 0.950 | - | 3.605 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 20.9 | 1100 | - | - | 5.08 |
| MW09-21 | 01/09/2015 | 0.817 | 1.715 | 3.622 | 3.87 | 5 | 13:55 | 14:16 | 0:21 | 0.24 | PS | 0.165 | 6.82 | 2.9 | 1410 | 2440 | -66.7 | 0.29 | 0.01 | 0 | 20.9 | 300 | 9.06 | peristaltic | 5.08 |
| MW09-22 | 01/09/2015 | 0.860 | 4.158 | 5.277 | 2.27 | 4 | 10:58 | 11:22 | 0:24 | 0.17 | PS | 0.612 | 6.21 | 1.2 | 807 | 1479 | 12.2 | 0.78 | 0.08 | 0 | 20.9 | 300 | 13.6 | peristaltic | 5.08 |
| MW09-23 | 01/09/2015 | 0.019 | 12.692 | 15.822 | 6.34 | 21 | 12:00 | 12:20 | 0:20 | 1.05 | 3WV | 0.303 | 6.94 | 0.4 | 1051 | 1985 | 32.6 | 2.51 | 0.26 | 0 | 20.5 | 660 | 1.04 | hydrolift | 5.08 |
| MW09-24 | 02/09/2015 | 0.640 | 9.575 | 11.207 | 3.31 | 25 | 9:56 | 10:20 | 0:24 | 1.04 | PS | 0.075 | 7.19 | 0.5 | 543 | 1022 | 194.6 | 5.56 | 0.14 | 0 | 20.9 | 1480 | 64.2 | waterra | 5.08 |
| W14103083BH03 | 02/09/2015 | 0.760 | 1.755 | 4.534 | 5.63 | 4.3 | 14:16 | 14:44 | 0:28 | 0.15 | PS | 0.025 | 6.53 | 2.9 | 448 | 776 | -57.1 | 0.19 | 0.1 | 0 | 20.5 | 810 | 15.5 | peristaltic | 5.08 |

**Notes:**To maximize the sample return for analytical analysis, field parameters were not collected at all direct sampled wells.

1 3WV = Three well volumes purged prior to sample collection, PS = field parameters stabilized prior to sample collection, and DS = sample collected directly without purging.

2 Due to low well volumes (direct sampling), field parameters were not measured.

3 Well has either been destroyed by placer mining activity or conditions were unsafe to investigate due to ongoing mining operations.

4 Due to technical issues with gas monitoring equipment in-situ carbon dioxide measurements were not collected at this location.

5 Drawdown could not be recorded at drive-point piezometer locations or sites with 2.54 cm diameter wells (or less).

6 Field sulphide measurement was not collected at this location.

7  Field sulphide measurement was not collected at these locations due to a lack of sufficient volume (direct sampled wells).

\* Shaded rows indicate monitoring stations where analytical samples were collected.

## Analytical Results

Analytical results are provided below, including a brief summary of CCME FAL guideline exceedances and a description of factors that may have influenced data precision. Details regarding well status, including a description of damaged or underperforming wells, are also provided.

In several instances, laboratory reportable detection limits (RDL) for parameters exceeded applicable CCME FAL standards (lightly shaded values in**Table A**). In these cases, samples having elevated levels of certain parameters required laboratory dilution in order to perform the required analyses, thereby resulting in an elevated RDL. For the purpose of this report, samples where the reported RDL is greater than the applicable guideline have not been reported as CCME FAL exceedances.

### Dome Creek

Groundwater wells along Dome Creek were monitored between August 31 and September 3, 2015. Samples were obtained from eight (8) of the nine (9) drive-point piezometers located in this area. Groundwater well GSI-DC-08B was not sampled during the September 2015 field program due to insufficient volume and recharge. Four (4) of the drive-point piezometers located in this area were sampled directly without purging (GSI-DC-02B, GSI-DC-02B, GSI-DC-03B, GSI-DC-05B). All remaining wells were sampled according program protocols (GSI-DC-06B, GSI-DC-07B, GSI-DC-09B, and GSI-DC-10B). A summary of field measurements, including headspace gases, is provided in **Table 3-2**.

One or more CCME FAL guideline exceedances were observed at seven (7) sites in the Dome Creek area; including, exceedances of fluoride (two sites), dissolved arsenic (six sites), dissolved iron (seven sites) and dissolved zinc (one site). Field dissolved oxygen concentrations were below the CCME FAL guideline minimum at five (5) sites sampled in this area. Lab pH measurements were outside the CCME FAL guideline range at one (1) location. A summary of CCME FAL guidelines exceedances is provided in **Table 3-3**.

The measurement of in-situ headspace vapours was made difficult at the Dome Creek sample sites due to dedicated sampling tubing being present in these small diameter wells. There was no space in the well head to sample vapours until dedicated sampling equipment was removed, after which time well head gases may have dispersed. All drive-point piezometers located within this area are properly sealed with PVC caps.

Groundwater was turbid at sites GSI-DC-05B (183 NTU) and GSI-DC-10B (58.6 NTU) at the time of sampling. All other turbidity measurements within the Dome Creek area were less than 50 NTU at the time of sampling (**Table 3-2**).

Table 3-3 Summary of CCME FAL Guideline Exceedances for September 2015 Sampling Program

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Group | **Physical Tests** | **Anions and Nutrients** | **Cyanides** | **Dissolved Metals** |
|  | Parameter | Lab pH | Field pH | Field Dissolved Oxygen | Ammonia, Total (as N) | *Ammonia CCME-FAL2* | Fluoride (F) | Nitrite (as N) | Cyanide, Free | Arsenic (As) | Copper (Cu) | *Copper CCME-FAL 2* | Iron (Fe) | Lead (Pb) | *Lead CCME-FAL 2* | Mercury (Hg) | Selenium (Se) | Silver (Ag) | Zinc (Zn) |
|  | Units | pH units | pH units | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L |
|  | CCME-FAL1, | 6.5-9.0 5 | 6.5-9.0 5 | 9.5 6 | Varies 2 | 0.12 | 0.06 | 0.005 | 0.005 | Varies 2 | 0.3 | Varies 2 | 0.000026 | 0.001 | 0.0001 | 0.03 |
| **Dome Creek** | GSI-DC-02B 14 | - | - | - | - | - | - | - | - | 0.0122 | - | - | 7.57 | - | - | - | - | - | - |
| GSI-DC-03B | - | - | - | - | - | 0.141 | - | - | 0.00677 | - | - | 0.404 | - | - | - | - | - | 0.0589 |
| GSI-DC-05B | - | - | 5.77 | - | - | - | - | - | - | - | - | 0.903 | - | - | - | - | - | - |
| GSI-DC-06B | - | - | 0.16 | - | - | 0.254 | - | - | 0.492 | - | - | 27.4 | - | - | - | - | - | - |
| GSI-DC-07B | - | - | 0.12 | - | - | - | - | - | 0.188 | - | - | 41.7 | - | - | - | - | - | - |
| GSI-DC-09B | - | - | 0.24 | - | - | - | - | - | 0.0595 | - | - | 15.2 | - | - | - | - | - | - |
| GSI-DC-10B | 6.17 | - | 6.27 | - | - | - | - | - | 0.102 | - | - | 90.8 | - | - | - | - | - | - |
| **Mill Complex** | GSI-HA-01A 15 | - | - | - | - | - | 0.132 | - | - | - | 0.00574 | *0.004* | 0.510 | - | - | - | - | - | - |
| GSI-HA-02A | - | - | - | - | - | - | - | - | 0.0844 | - | - | 83.4 | - | - | - | - | - | - |
| GSI-HA-03A 16 | - | - | - | - | - | - | - | - | 0.0406 | - | - | 49.5 | - | - | - | - | - | - |
| GSI-HA-04A | - | - | 6.33 | - | - | - | - | - | 0.0328 | - | - | 4.28 | - | - | - | - | - | - |
| GSI-HA-05A | - | - | - | - | - | - | - | - | 0.103 | - | - | 29.1 | - | - | - | - | - | - |
| MW09-16 | - | - | 2.5 | - | - | 0.14 | - | - | 0.00802 | 0.00547 | *0.004* | - | - | - | - | - | - | 3.19 |
| MW09-17 | - | - | 1.52 | - | - | - | - | - | 0.0193 | - | - | - | - | - | - | - | - | - |
| MW09-18 | - | - | 0.41 | - | - | - | - | - | 0.0517 | - | - | - | - | - | - | - | - | - |
| MW09-19 | - | - | 0.53 | - | - | 0.14 | - | - | 0.121 | - | - | 17.6 | - | - | - | 0.00108 | - | - |
| **Bown McDade Pit** | CH-P-13-05/50 | 5.98 | 5.89 | 4.8 | - | - | 0.24 | - | - | - | 0.0993 | *0.004* | 14.7 | - | - | - | - | - | 31.1 |
| GLL07-03 | - | 6.34 | 4.86 | - | - | - | - | - | - | 0.00560 | *0.004* | 1.34 | - | - | - | - | - | 4.53 |
| **Pony Creek** | GSI-PC-03B | - | - | - | - | - | - | - | - | - | 0.0145 | *0.004* | - | - | - | - | - | - | - |
| GSI-PC-04B | - | - | - | - | - | - | - | - | 0.0107 | - | - | 9.79 | - | - | - | - | - | - |
| GSI-PC-05B | - | - | 0.57 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MP09-03 | - | - | - | - | - | - | - | - | 0.00631 | - | - | 1.48 | - | - | - | - | - | - |
| MP09-08 | - | - | 2.76 | - | - | - | - | - | 0.0328 | - | - | 0.519 | - | - | - | - | - | - |
| **Seepage Dam** | W14103083BH02 | - | - | - | - | - | 0.254 | - | - | - | - | - | - | - | - | - | - | - | - |
| W14103083BH04 | - | - | - | - | - | 0.193 | - | - | - | - | - | - | - | - | - | 0.00249 | - | - |
| **Tailings Facility** | MP09-04 | - | - | 0.73 | - | - | 0.38 | - | - | 3.38 | - | - | - | - | - | - | - | - | 0.471 |
| MP09-05 | - | - | 0.33 | - | - | - | - | - | 0.00861 | - | - | 3.03 | - | - | - | - | - | - |
| MP09-09 | - | 9.57 | 6.16 | 4.51 | *0.06177* | 1.70 | - | 1.05 | 14.2 | 0.327 | *0.004* | - | - | - | 0.0000697 | 0.00187 | 0.0110 | - |
| MP09-10 | - | - | - | - | - | 0.169 | 0.330 | 0.043 | 1.82 | 0.0507 | *0.02* | 0.328 | 0.0192 | *0.001* | 0.0000293 | - | 0.000491 | - |
| MP09-11 | - | - | 0.18 | 13.7 | *7.273* | 0.467 | - | - | 13.9 | - | - | 30.6 | 0.0379 | *0.007* | - | - | - | 0.0670 |
| MP09-12 | - | - | 5.14 | - | - | - | - | - | 6.62 | - | - | 4.19 | - | - | - | - | - | 0.0472 |
| MP09-14 | - | - | - | - | - | - | - | - | 3.94 | - | - | 4.12 | - | - | - | - | - | - |
| MW09-01 | - | - | 0.32 | - | - | 0.26 | - | - | 0.343 | 0.0041 | *0.004* | 1.99 | - | - | - | - | - | 2.67 |
| MW09-02 | 6.42 | - | 0.12 | - | - | 0.53 | - | - | 18.0 | - | - | 44.2 | - | - | - | - | - | 0.230 |
| MW09-03 | - | - | 0.14 | 3.46 | *1.534* | 0.34 | 0.089 | - | 2.11 | - | - | - | - | - | - | - | - | - |
| MW09-04 | - | - | 0.13 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| MW09-06 | - | - | 2.22 | - | - | 0.33 | - | - | 0.131 | 0.00689 | *0.004* | - | - | - | - | - | - | 0.110 |
| MW09-08 | - | - | 0.3 | - | - | - | - | - | 0.0869 | - | - | 47.5 | - | - | - | - | - | - |
| MW09-21 | - | - | 0.29 | - | - | - | - | - | 0.105 | - | - | 66.0 | - | - | - | - | - | - |
| MW09-22 | 6.26 | 6.21 | 0.78 | - | - | - | - | - | 0.00674 | - | - | 46.2 | - | - | - | - | - | - |
| MW09-23 | - | - | 2.51 | - | - | 0.16 | - | - | 0.0261 | - | - | 23.5 | - | - | - | - | - | 0.118 |
| MW09-24 | - | - | 5.56 | - | - | - | - | - | - | 0.00811 | *0.004* | - | - | - | - | - | - | - |
| W14103083BH03 | - | - | 0.19 | - | - | - | - | - | 0.0576 | - | - | 77.3 | - | - | - | - | - | - |

**Notes:**

1 CCME guideline exceedances shaded with dark grey.

2 Calculated CCME guidelines, refer to **Table A** for details.

“–“ indicates either no exceedance was observed or no analysis was conducted. Refer to Table A for full analytical report.

### Mill Complex

Groundwater in the Mill Complex Area was sampled on August 31, 2015. Samples were obtained from all of the nine (9) wells identified in this area. Drive-points GSI-HA-01A and GSI-HA-03A were sampled directly without purging, all other wells were sampled according program protocols. A summary of the samples collected is provided in **Table 3-1**.

One or more CCME FAL guideline exceedances were observed at all nine (9) sites in the Mill Complex area, including exceedances of fluoride (three sites), dissolved arsenic (eight sites), dissolved copper (two sites), dissolved iron (six sites), dissolved selenium (one site) and dissolved zinc (one site). Field dissolved oxygen concentrations were below the minimum CCME FAL guideline level at five (5) sites within this area. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Where measured, groundwater turbidity of all samples collected within this area was less than 50 NTU (**Table 3-2**).

### Brown McDade Pit

Groundwater wells in the Brown McDade Pit area were sampled between August 31 and September 1, 2015. Samples were obtained from two (2) of the thirteen (13) sample sites located within this area (CH-P-13-05/50 and GLL07-02). Seven (7) wells were frozen during the time of sampling (CH-P-13-01/10, CH-P-13-04/10, CH-P-13-04/35, GLL07-01, MW09-13, MW09-14, and MW09-15), two (2) wells were dry (CH-P-13-03/10 and GLL07-02), one was damaged (CH-P-13-02/10), and one had insufficient volume to collect a sample (CH-P-13-03/50). A summary of the samples collected is provided in **Table 3-1**.

CCME FAL guideline exceedances were observed at all two (2) sites sampled in the Brown McDade Pit area, including exceedances of fluoride (one site), dissolved copper (two sites), dissolved iron (two sites) and dissolved zinc (two sites). Field dissolved oxygen concentrations were below the minimum CCME FAL guideline level at both sites sampled in this area. Field pH measurements were observed to be outside the CCME FAL guideline range at both sampled wells, while laboratory pH was outside of the CCME FAL guideline range at one (1) location. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Groundwater at sample location GLL07-03 was extremely turbid (>4000 NTU) during the time of sampling. Groundwater turbidity at the other sampled location within the Brown McDade Pit area was less than 50 NTU at the time of sample (Table 3-2).

CH-P-13-02/10 was found damaged during the time of sampling. During previous sample events, bentonite was present at the bottom of the well and therefore the well status had been listed as dry/damaged. Camera footage obtained at this sample site in July 2015 (Hemmera, 2015a) confirmed the presence of bentonite and filter pack (filter sand) at the bottom of well. Bentonite was also observed seeping in the top portion of the well screen (Hemmera, 2015a). The camera footage from July 2015 suggested that the issue may be the result of improper well installation. Attempts made during the September 2015 event to remove the bentonite plug were unsuccessful. Waterra tubing was lowered into the well and forced into the bentonite plug to capture a portion of the bentonite, however the bentonite was frozen at the time of the September 2015 site visit, making it difficult to capture and remove the blockage.

### Pony Creek

Groundwater wells along Pony Creek were sampled on September 3, 2015. Samples were collected from five (5) of the seven (7) sample sites in this area during the sampling event. Two drive-point piezometers previously sampled within this area (GSI-PC-02B and MP09-02) were presumed to be destroyed as their location was undergoing placer mining earthworks (which also prevented the direct investigation of the wells). Of the five (5) wells located, three (3) were sampled directly without purging. All remaining wells were sampled according program protocols (GSI-PC-05B and MP09-08). A summary of the samples collected is provided in **Table 3-1**.

CCME FAL guideline exceedances were observed at all five (5) sites in the Pony Creek area, including exceedances of dissolved arsenic (three sites), dissolved copper (one site), and dissolved iron (three sites). Field dissolved oxygen concentrations were below the minimum CCME FAL guideline level at two (2) sites in this area. A summary of CCME FAL guidelines exceedances is provided in **Table 3-3**.

Where measured, groundwater turbidity of all samples collected within this area was less than 50 NTU (**Table 3-2**).

### Seepage Dam

Groundwater wells in the Seepage Dam area were monitored on September 2, 2015. Samples were obtained from two (2) of the three (3) sample sites in this area during the event. Sample site W14103083BH01 was frozen during the time of sampling. All samples collected in the Seepage Dam area were collected directly without purging. A summary of the samples collected is provided in **Table 3-1**.

CCME FAL guideline exceedances were observed at both of the two (2) sites sampled in the Seepage Dam area, including exceedances of fluoride (two sites) and dissolved selenium (one site). A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Where measured, groundwater turbidity of all samples collected within this area was less than 50 NTU (**Table 3-2**).

### Tailings Facility

Groundwater wells in the Tailings Facility area were sampled between September 1 and September 2, 2015. Samples were obtained from eighteen (18) of the twenty-two (22) sample sites located in this area. Three sample sites were dry during the time of sample (MW09-05, MW09-11, and MW09-20), and one well had insufficient volume to collect a sample (MW09-07). Of the eighteen (18) samples collected within this area, four (4) were collected directly without purging (MP09-10, MP09-12, MP09-14, and MW09-01). All remaining wells were sampled according program protocols. A summary of the samples collected is provided in **Table 3-1**.

CCME FAL guideline exceedances were observed at all eighteen (18) sites in the Tailings Facility area, including exceedances of fluoride (nine sites), total ammonia (three sites), nitrite (two sites), free cyanide (two sites), dissolved arsenic (sixteen sites), dissolved copper (five sites), dissolved iron (twelve sites), dissolved lead (two sites), dissolved mercury (two sites), dissolved selenium (one site), dissolved silver (two sites), and dissolved zinc (seven sites). Field dissolved oxygen concentrations were below the minimum CCME FAL guideline level at sixteen (16) sampled sites within this area. Field and laboratory pH measurements were each observed to be outside of the CCME FAL guideline range at two (2) sample locations. A summary of CCME FAL guideline exceedances is provided in **Table 3-3**.

Groundwater at sample location MP09-10 was extremely turbid (>4000 NTU) during sampling. Samples collected from location MW09-24 were moderately turbid (64.2 NTU). Where measured, groundwater turbidity at all other sample locations within the Tailings Facility area was less than 50 NTU at the time of sample (**Table 3-2**).

Although samples were obtained from well MW09-01 during the September 2015 sampling event, groundwater at this location is extremely turbid (by observation only, turbidity was not measured as this well was direct sampled). As documented in previous reports (Hemmera, 2015a), this well has a large gash/opening at the top of PVC. Tailings likely enter the well through this opening during periods of high water. Intended repairs on this well were not performed during September 2015 field event as it was discovered on site that the diameter of this well is slightly different than the standard 2 inch diameter, as previously believed, however the opening at the top of PVC was temporarily sealed during the September 2015 site visit using nitrile gloves and electrical tape.

## Quality Assurance and Quality Control Results

Five (5) duplicate groundwater samples were collected during the September 2015 sampling event. Two (2) travel blanks were provided by the laboratory and accompanied the samples throughout the sampling program. One (1) field blank was prepared on site for each day of sampling (4 field blanks in total). Detailed results of QA/QC sampling are provided in **Table B**, including RPD values for all duplicate and sample pairs.

### Field and Travel Blanks

All travel blank analytical results were reported as less than the RDL with the exception of ammonia which was recorded in both travel blanks (0.019 mg/L and 0.0107 mg/L; **Table B**). The program analytical laboratory (ALS Global) indicated that the detection of low levels of ammonia should not be considered an indication of contamination as low concentrations of ammonia are occasionally in travel blanks that are prepared too early in advance of the field program. All other parameters in both travel blanks were below RDL.

A detectable concentration of dissolved strontium (0.00041 mg/L) was recorded in field blank FB15-200, the source of which is not known but could be the result of dust during the field blank filling process or a laboratory process. All other field blank analytical results were reported as less than the RDL (**Table B**).

### Field Duplicates

#### GSI-DC-06B and MW15-500

Duplicate and duplicate pair analytical results show that RPD values for sulphate (53.98%) were reported above the acceptable range of variability. Field notes/measurements do not identify a potential source of contamination or suggest variability in groundwater quality during the purging process (**Table 3-2**).

All other duplicate and duplicate pair analytical results show that RPD values for samples GSI-DC-06B and MW15-500 were below the 20% RPD threshold limit (**Table B**).

#### MW09-16 and MW15-100

Duplicate and duplicate pair analytical results show that all RPD values for samples MW09-16 and MW15-100 were below the 20% RPD threshold limit, suggesting no contamination or bias in sampling (**Table B**).

#### MP09-08 and MW15-400

Duplicate and duplicate pair analytical results show that RPD values for dissolved antimony (22.05%) and arsenic (23.13%) were reported slightly above the acceptable range of variability. Field notes indicate that Pony Creek surface water (above where the drive points were located) was extremely turbid during the time of sampling. Increased turbidity is believed to have resulted from placer mining operations upstream of the sample site, and this could have potentially also influenced groundwater quality. Hemmera/ELR observed fluctuating turbidity during the sampling process at this site, which may have caused variability between duplicate and duplicate pair analytical results (**Table 3-2**).

All other duplicate and duplicate pair analytical results show that RPD values for samples MP09-08 and MW15-400 were below the 20% RPD threshold limit (**Table B**).

#### MP09-05 and MW15-200

Duplicate and duplicate pair analytical results show that RPD values for total Kjeldahl nitrogen (25.38%) and dissolved zinc (23.64%) were reported slightly above the acceptable range of variability. Field notes/measurements do not identify a potential source of contamination or suggest variability in groundwater quality during the purging process (**Table 3-2**).

All other duplicate and duplicate pair analytical results show that RPD values for samples MP09-05 and MW15-200 were below the 20% RPD threshold limit (**Table B**).

#### MW09-24 and MW15-300

Duplicate and duplicate pair analytical results show that all RPD values for samples MW09-24 and MW15-300 were below the 20% RPD threshold limit, suggesting no contamination or bias in sampling (**Table B**).

### Quality Assurance and Quality Control Summary

Results for the QA/QC analytical program show slight evidence of sampling variation during the field collection process. The minimal detections observed in the field blanks suggests that contamination during sampling was less likely the cause of variability, rather more likely the result of slight variations in groundwater quality. The results from the travel blanks did not suggest any type of contamination during transportation.

Overall, across four (4) field blanks, analytical results reported only one field blank (FB15-200) with a detectable concentration of dissolved strontium. All other field blank analytical results were reported as less than the RDL (**Table B**).

Dissolved strontium is reported in samples throughout the site, with concentrations ranging from 0.0242 mg/L and 1.39 mg/L. Low concentrations of dissolved strontium detected in field blank FB15-200 (0.00041 mg/L) may have been the result of environmental contamination. FB15-200 was prepared in the Tailings Facility area during the sampling process of site MW09-08. Field notes and conditions during the time of sample collection provide no indication for the probability of sample contamination.

Duplicate and duplicate pair analytical results show some variability in total Kjeldahl nitrogen, sulphate, as well as dissolved antimony, arsenic, and zinc. Overall, across five (5) duplicate samples, three (3) show variation with their duplicate pair. The majority of variation between duplicate and duplicate pairs was only slightly above the 20% RPD threshold, with spikes observed in no more than two parameters for each pair. The most notable variation observed was between GSI-DC-06B and MW15-500, with differences between sulphide concentrations resulting in a 53.98% RPD. All other parameters were below the 20% RPD threshold limit. Field notes/measurements do not identify a potential source of contamination or suggest variability in groundwater quality during the purging process (**Table 3-2**).

## Analytical Test of Filtered Alkalinity

Filtered alkalinity samples were collected in addition to non-filtered samples to test whether acid or alkaline-generating solids maybe affecting alkalinity results. Filtered and non-filtered alkalinity were both analyzed from thirty-seven (37) sample locations (**Table 3-3**) during the September 2015 program, and were also analyzed for all QA/QC samples (duplicates, field blanks, and travel blanks). The other seven (7) of forty-four (44) sample sites did not produce sufficient groundwater volume to collect filtered alkalinity (**Table 3-1**). A summary of filtered and unfiltered alkalinity results is provided in **Table 3-3**.

Table 3-4 Comparison of Alkalinity and Filtered Alkalinity Results

| Well Name | Non-Filtered Alkalinity | Filtered Alkalinity | RPD |
| --- | --- | --- | --- |
| mg/L | mg/L | % |
| GSI-DC-02B | 246 | 292 | 17.10 |
| GSI-DC-05B | 276 | 213 | ***25.77*** |
| MW15-500 | 850 | 766 | 10.40 |
| GSI-DC-06B | 868 | 768 | 12.22 |
| GSI-DC-07B | 169 | 176 | 4.06 |
| GSI-DC-09B | 98.3 | 103 | 4.67 |
| GSI-DC-10B | 96.7 | 91.0 | 6.07 |
| GSI-HA-01A | 192 | 197 | 2.57 |
| GSI-HA-02A | 155 | 165 | 6.25 |
| GSI-HA-04A | 74.3 | 77.1 | 3.70 |
| GSI-HA-05A | 194 | 206 | 6.00 |
| MW15-100 | 286 | 281 | 1.76 |
| MW09-16 | 284 | 284 | 0.00 |
| MW09-17 | 446 | 462 | 3.52 |
| MW09-18 | 458 | 459 | 0.22 |
| MW09-19 | 438 | 444 | 1.36 |
| CH-P-13-05/50 | 65.5 | 66.7 | 1.82 |
| GLL07-03 | 70.9 | 68.2 | 3.88 |
| MW15-400 | 246 | 248 | 0.81 |
| MP09-08 | 242 | 249 | 2.85 |
| W14103083BH02 | 216 | 221 | 2.29 |
| MP09-04 | 94.4 | 193 | ***68.62*** |
| MW15-200 | 290 | 278 | 4.23 |
| MP09-05 | 268 | 279 | 4.02 |
| MP09-11 | 564 | 580 | 2.80 |
| MW09-01 | 320 | 336 | 4.88 |
| MW09-02 | 35.7 | 29.6 | 18.68 |
| MW09-03 | 113 | 114 | 0.88 |
| MW09-04 | 181 | 96.2 | ***61.18*** |
| MW09-06 | 147 | 152 | 3.34 |
| MW09-08 | 119 | 123 | 3.31 |
| MW09-21 | 221 | 223 | 0.90 |
| MW09-22 | 131 | 141 | 7.35 |
| MW09-23 | 297 | 299 | 0.67 |
| MW15-300 | 353 | 376 | 6.31 |
| MW09-24 | 353 | 379 | 7.10 |
| W14103083BH03 | 193 | <1.0 | nc |

**Note:** nc = not calculated. RPD is not calculated if either the sample or the field duplicate concentration is less than five times the detection limit.

Of the thirty-seven (37) samples above RDL (including duplicate samples), only three (3) show variation between filtered alkalinity samples and unfiltered samples (GSI-DC-05B; 25.77% RPD, MP09-04; 68.62% RPD, MW09-04; 61.18% RPD). Similar to the results observed in previous sampling programs for filtered and non-filtered alkalinity, the data do not suggest a consistent and frequent difference between the two sampling methods. Accordingly, Hemmera/ELR suggest that the collection of filtered alkalinity samples is not a required procedure for the Mount Nansen site, and that the method be discontinued.

# Recommendations

Hemmera/ELR have prepared the following recommendations based on the observations and results of the September 2015 groundwater sampling program.

1. Damaged or degraded wells should be repaired, if possible.

Damaged or degraded wells noted during the September 2015 sampling event include the following, CH-P-13-02/10, CH-P-13-03/10, and MW09-01.

CH-P-13-02/10 was reported as damaged during the time of sampling. During previous sample events, bentonite was present at the bottom of the well and therefore the well status had been listed as dry/damaged. Camera footage obtained at this sample site in July 2015 (Hemmera, 2015a) confirmed the presence of bentonite and filter pack (filter sand) at the bottom of well. Bentonite was also observed seeping in the top portion of the well screen (Hemmera, 2015a). The camera footage from July 2015 suggested that the issue may be the result of improper well installation. Attempts made during the September 2015 event to remove the bentonite plug were unsuccessful. Waterra tubing was lowered into the well to attempt to force the bentonite into the tubing to remove it, however the bentonite was found frozen in the well. It is recommended that this method be re-attempted in the late spring or summer of 2016. It should be noted that if bentonite is seeping into the top portion of the well screen, removal of the blockage may only provide a temporary fix.

Sampling location CH-P-13-03/10 was found dry during the September 2015 sampling event. During a previous sampling program, the upper PVC stick-up of this well became detached from the well casing, allowing sand/filter pack material to drain into the well. Camera footage obtained in July 2015 from the sample site confirmed the presence of sand at the bottom of the well. Hemmera/ELR still recommends that the well be re-developed to remove the sand when conditions allow. The following methods should be considered: 1) Injecting water into the well and using air lift method to clear the well (using air compressor). Well logs should be reviewed prior to implementing this method to assess the hydraulic conductivity of the surrounding formation. A low hydraulic conductivity is required in order to saturate the sand and mobilize using an air compressor. This method may require a substantial volume of water. 2) Use a vacuum truck to remove sand. Vacuum head would need to be small enough to fit in the casing.

MW09-01 could not be sampled during previous events due to an excessive quantity of tailings present in the groundwater. Although samples were obtained from well MW09-01 during the September 2015 sampling event, groundwater at this location is extremely turbid. The well has a large gash/opening at the top of PVC. Tailings likely enter the well through this opening during periods of high water. The opening at the top of PVC was temporarily sealed during the September 2015 site visit using nitrile gloves and electrical tape. A more permanent fix should be established for this location (such as replacement of the top portion of the PVC well casing). This would require cutting the existing well and adding a coupler, PVC extension, and proper seal or j-plug. This well should also be re-developed to clear debris from the well screen. Due to low volumes and slow recharge it may be necessary to add additional water to this well in order to suspend the tailing material during the re-development process.

1. During the September 2015 and other recent sampling events, paired filtered and non-filtered alkalinity samples were collected to test whether acid or alkaline-generating solids may be affecting alkalinity results. Similar to the results observed in previous sampling programs, the data do not suggest a consistent and frequent difference between the two sampling methods. Accordingly, Hemmera/ELR suggest that the collection of filtered alkalinity samples not be a required procedure for the Mount Nansen site, and that the method be discontinued.

# Closure

We have appreciated the opportunity of working with you on this project and trust that this report is satisfactory to your requirements. Please feel free to contact the undersigned regarding any questions or further information that you may require.

Report prepared by:

ELR

per: Aaron Nicholson, B.Sc., EP

Environmental Scientist

aaron@elr.ca

Report senior reviewed by:

ELR

Chris Jastrebaski, M.Sc., R.P.Bio., P.Biol.

Project Manager

chris@elr.ca

Report senior reviewed by:

Hemmera Envirochem Inc.

Jason Wilkins, P.Ag., EP, CSAP

Director, Land Development and Projects

jwilkins@hemmera.com

# References

ASTM Standard D4448-01. 2013. Standard Guide for Sampling Groundwater Monitoring Wells. ASTM International, West Conshohocken, PA, 2013, www.astm.org.

ASTM Standard D6452-99 2012 Guide for Purging Methods for Wells used for Groundwater Quality Investigations. ASTM International, West Conshohocken, PA, 2012, www.astm.org.

Canadian Council of Ministers of the Environment (CCME). 2014. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Accessed online at http://st-ts.ccme.ca/, July 2014.

Hemmera Envirochem and Ecological Logistics & Research Ltd. (Hemmera). 2015a. Mount Nansen June Groundwater and Sampling Program. Report prepared for Yukon Government Assessment and Abandon Mines Branch.

Hemmera Envirochem and Ecological Logistics & Research Ltd. (Hemmera). 2015b. Mount Nansen March Groundwater and Sampling Program. Report prepared for Yukon Government Assessment and Abandon Mines Branch.

Hemmera Envirochem and Ecological Logistics & Research Ltd. (Hemmera). 2014a. Mount Nansen June Groundwater and Sampling Program. Report prepared for Yukon Government Assessment and Abandon Mines Branch.

Hemmera Envirochem and Ecological Logistics & Research Ltd. (Hemmera). 2014b. Mount Nansen October Groundwater and Sampling Program. Report prepared for Yukon Government Assessment and Abandon Mines Branch.

Rice, E.W., Baird, R.B., Eaton, A.D., and Clesceri, L.S. 2006. Standard Methods for the Examination of Water and Wastewater. 22nd Edition. American Water Works Association.

Yukon Government. 2011. Protocol for the Contaminated Sites Regulation under the Environment Act. Protocol No.7: Groundwater Monitoring Well Installation, Sampling and Decommissioning. Prepared pursuant to Part 6 – Administration, Section 21, Contaminated Sites Regulations, OIC 2002/171.

tables

Appendix A

Site Photographs

Appendix B

Field Forms

Appendix C

Laboratory Reports

Appendix D

Response to Comments Received on Draft Report