# Appendix F
# Background Water Quality of Lower Minto Creek for Application in the Derivation of Post-Closure Water Quality Objectives

minnow environmental inc.

**Background Water Quality of Lower Minto Creek for Application in the Derivation of Post-Closure Water Quality Objectives**

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**Prepared for:**

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# 1.0 INTRODUCTION

## 1.1 Site Description

The Minto Mine is a high-grade copper mine located within Selkirk First Nation (SFN) Category A Settlement Land Parcel R-6A approximately 240 km northwest of Whitehorse, Yukon Territory (62°37'N latitude and 137°15'W longitude; Figure 1.1). It is owned and operated by Minto Explorations Ltd., a wholly owned subsidiary of Capstone Mining Corporation. Development of the mine was initiated in 1997, commercial operations started in October 2007 and the currently anticipated operating life is to 2018. The facility is permitted to conduct open pit and underground mining, and includes a mill with a capacity of 4,200 tonnes of ore per day. The Minto Mine produced 16,500 kilo-tonnes of copper in 2015 (average copper grade 1.38%). Mineral reserves as of January 1st 2016 were approximately 5,500 kilo-tonnes at an average copper grade of 1.87%.

In addition to open pit mines, underground mines and the mill, the Minto Mine site includes a number of waste rock dumps, a concentrate storage shed, tailings storage facilities, a water retention dam with a water storage pond, a water treatment plant, administrative offices, an airstrip and a camp (Figure 1.2). Mill tailings are stored in dry stack tailings storage facilities and in mined-out open pits. Mine-impacted seepage from the tailings storage facilities and under the Mill Valley Fill Extension (MVFE) is collected at the Mill Valley Fill Extension Stage 2 Collection Sump and is pumped to the main pit (Figure 1.2). Non-impacted water and treated mine-impacted water are collected in a Water Storage Pond (WSP; Figure 1.2). Effluent from the WSP is periodically discharged to Minto Creek under conditions specified in the Minto Mine's Water Use Licence (WUL) QZ14-031 (August 2015; YWB 2015). Minto Creek, in turn, discharges to the Yukon River approximately 7.7 km south-east of the WSP (Figure 1.2).

The Minto Mine is actively planning for closure, which could potentially occur as soon as late 2018. Conceptually, closure will include three stages: 1) an active closure period; 2) post-closure 1; and 3) post-closure 2. All major reclamation work will be completed during the active closure period. This will include re-contouring, cover placement, re-vegetation, construction of closure water conveyance channels, construction of wetland water treatment systems, and building demolition. Water will be actively managed during the active closure period. Post-closure 1 follows the completion of all major reclamation work and represents the period when the closure measures completed during the active closure period become fully established (e.g., vegetation is established, cover material self-armors, constructed wetlands are established, water flow through closure conveyances is established). Water treatment during post-closure 1 will be both active and passive. Post-closure 2 follows post-closure 1 and final


N
W E
S

160 0 160

Kilometers

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 8V
Data Source: Department of Natural Resources Canada

Creation Date: June 2016
Project No. 167202.0062

Map of Canada

**Figure 1.1: Location of the Minto Mine**

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**Features**

- Final Effluent Discharge Point
- Waterbody
- Minto Creek Detention Structure
- Building
- Watercourse
- Mine Road
- Water Flow Direction

N S E W

0 175 350 700

Meters

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 8V
Data Source: National Topographic Data Base (NTDB) compiled by Department of Natural Resources Canada at a scale of 1:50,000. All rights reserved.

Mine infrastructure data provided by Access Mining Consultants Inc.
Mine site contours derived from 2012 aerial imagery obtained from Challenger Geomatics.

Creation Date: June 2016
Project No. 167202.0062

**Figure 1.2: Minto Mine Site Layout and Receiving Environment**

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decommissioning (e.g., of the water treatment plant and potentially the camp). It represents the period when all closure measures are fully established, including final water conveyances. Water treatment during post-closure 2 will be by passive treatment only.

## 1.2 Background

The Minto Mine's WUL includes Water Quality Objectives (WQOs) for lower Minto Creek at water quality monitoring station W2 (Figure 1.3). These WQOs apply during the operational period and are anticipated to also apply during the active closure period and in post-closure 1. A separate set of WQOs will be developed for the post-closure 2 period. The Minto Mine's WUL requires a Reclamation and Closure Plan (RCP) that includes WQOs for post-closure that meet the criteria for non-degradation of background concentrations. Two approaches have been provided in the WUL as guidance to developing closure WQOs (YWB 2015; Clause 112):

1) Establish closure WQOs that meet the criteria for non-degradation of background concentrations in Minto and McGinty creeks; and

2) If non-degradation of water quality is not achievable, the closure WQOs shall be set at no more than 50% of the assimilative capacity of Minto Creek using the following formula:

$$Closure\ WQO = BKGD + (0.5*[WQO_{Operations} - BKGD])$$

*where: BKGD = background concentration.*

Both approaches for the development of closure WQOs require a clearly-defined background water quality condition.

## 1.3 Objective

The objective of this report is to define the background water quality data set to be used to develop background water quality for lower Minto Creek and to determine background summary statistics for key analytes to be used in calculating the post-closure WQOs. This document outlines the approach used in considering what data points should be included to define background water quality. This document incorporates the outcomes of discussions among the Minto Mine, SFN, and technical consultants (Appendix A). These discussions covered a number of factors critical to the definition of background water quality, including representative sampling stations, contaminants of potential concern (COPCs), dealing with less than method detection limit (MDL) results, dealing with replicate results, identifying outliers, evaluation of possible data groupings, and designation of summary statistics. The

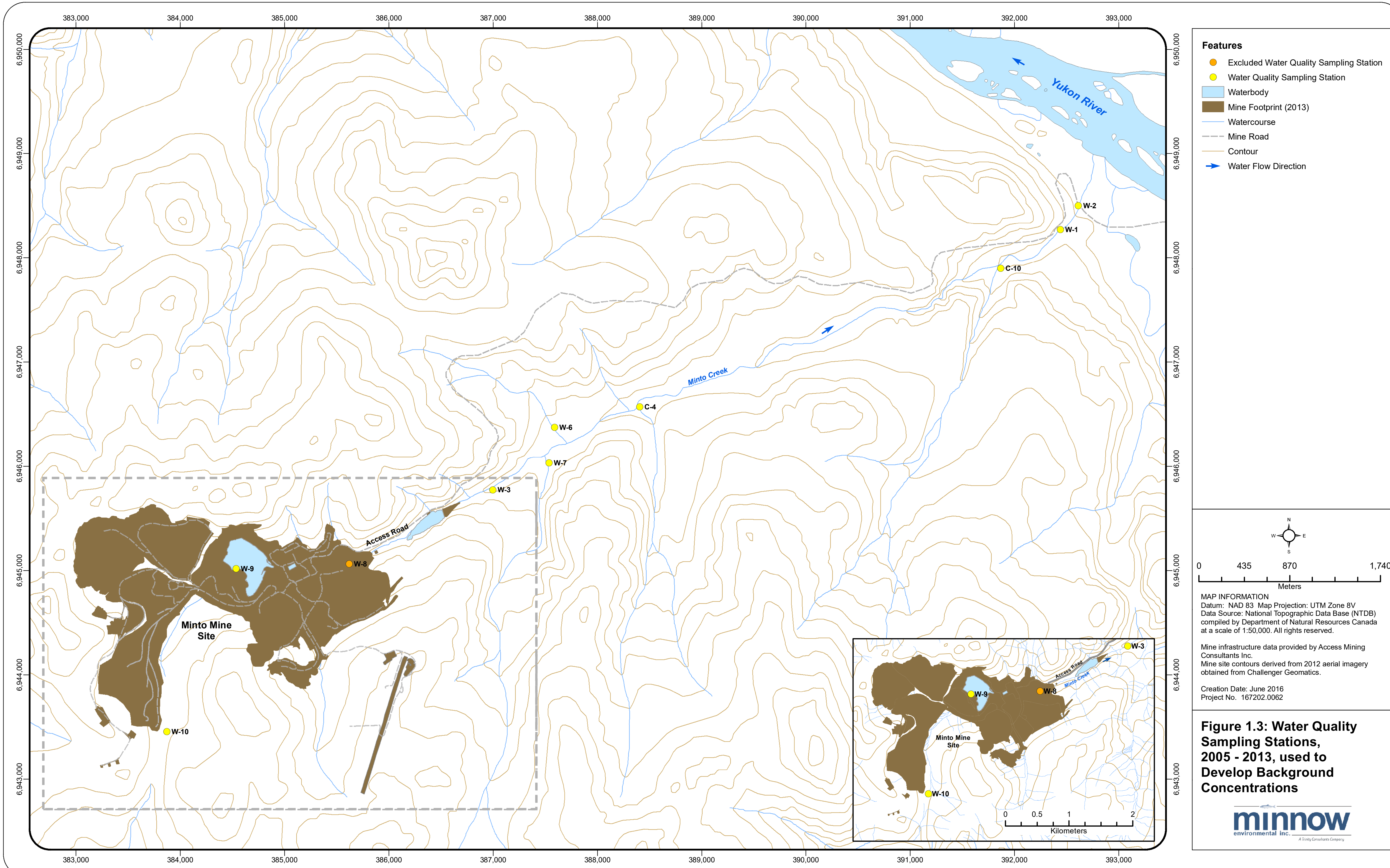



**Figure 1.3: Water Quality Sampling Stations, 2005 - 2013, used to Develop Background Concentrations**

background water quality data set is then used to calculate summary statistics for the COPCs for application as WQOs for the post-closure 2 period.

## 1.4 Report Organization

Section 2.0 provides a detailed overview of data organization and step-wise work-through the process of defining background water quality for the development of post-closure WQOs. Section 3.0 provides the proposed background water quality statistics. All references cited in the report are provided in Section 4.0.

# 2.0 DATA ORGANIZATION

Raw data from the Minto Mine's water quality database were received on May 31st, 2016. The database contained concentrations of water quality analytes measured throughout the open water season from 2005 to 2013. The database was sorted and organized as described below, to obtain a final water quality data set to be used to calculate the background concentrations of COPCs. For a few sampling dates, it was noted that water quality analyses were incomplete (e.g., incomplete dissolved metals in a multi-element scan). Minto Mine and Access Consulting Group were contacted to inquire about any missing data but older data sets were unavailable as they were collected by The North Air Group (Vancouver, BC).

## 2.1 Sampling Stations

The database included six sampling stations (W1, W2, W3, W8, W9 and W10) that were sampled during baseline studies in 2005 and were subsequently influenced by the mine (Figure 1.3; Appendix B). The database also included four reference sampling stations, W6 (2005 – 2013), W7 (2005 – 2013), C4 (2012, 2013) and C10 (2012, 2013; Figure 1.3; Appendix B).

Data collected at sampling station W8 were removed from the final background data set because water quality at station W8 was determined to poorly represent water quality at station W2 (lower Minto Creek; the point of WQO application). Data collected at W6 from 2009 to 2011 were not included, as these water quality samples were accidently collected at the Minto Creek main stem and not at the W6 tributary. These data would not represent background concentrations because the mine was operational from 2009 to 2011.

## 2.2 Contaminants of Potential Concern

The COPCs considered herein are those identified in the Water Use Licence (WUL; QZ14-031; YWB 2015). These COPCs are ammonia, pH (laboratory and field), nitrite, nitrate and the following dissolved metals; aluminum, arsenic, cadmium, chromium, copper, iron, lead, molybdenum, nickel, selenium, silver and zinc. In addition to the COPCs, several additional analytes are considered herein due to their importance as supporting parameters (e.g., parameters that may affect other WQOs). These include dissolved organic carbon (DOC), total and dissolved hardness, total suspended solids (TSS) and total dissolved solids (TDS).

## 2.3 Method Detection Limits

Concentrations that were reported as less than MDL and where the associated MDL exceeded the maximum detected concentration were removed from the data set. Such cases (and consequent removals) were observed for dissolved chromium (11% of samples) and dissolved silver (24% of samples; Table 2.1). The remaining analytes reported as less than method detection limits (MDL) were substituted with half the MDL for calculations of summary statistics.

## 2.4 Replicate Samples

Some water samples were collected multiple times in one day at a given sampling station. To account for this, the average concentration of the analyte at a given station on the same day was used to represent the concentration for that day. The relative percent difference (RPD) of the minimum and maximum daily concentrations were calculated prior to calculating a daily mean concentration (Table 2.2). If the RPD was greater than 25% they were investigated further (Table 2.2).

Many analytes that had RPD greater than 25% were dissolved metals or TSS. Although there were instances where the RPD was greater than 25%, this is expected in multi-element scans. The investigation indicated no systemic problems (e.g., instances where all analytes had RPD greater than 25%), therefore all data were retained in the estimate of the daily mean. Regardless of RPDs between the minimum and maximum concentrations, the mean of concentrations measured on the same day were considered to best represent the concentration on that day.

## 2.5 Outliers

Outliers were evaluated based on data distributions for each analyte. The term "outlier" in the context of this report is used to refer to an observation that is unusually small or large relative to the distribution of observations. Outliers were investigated further to determine whether the value was naturally possible or whether the value could have resulted from an analytical error. The background data distributions for all analytes were non-normally distributed. Outliers were therefore identified using a non-parametric rule (the lower outer fence and upper outer fence) that is frequently used to identify outliers on boxplots (Dawson 2011).

*Lower outer fence = Q1 – 3 (IQR)*
*Upper outer fence = Q3 + 3 (IQR)*
*where: Q1 = 1$^{st}$ Quartile*
*Q3 = 3$^{rd}$ Quartile*
*IQR = Interquartile Range (Q3 – Q1)*

Observations less than the lower outer fence or greater than the upper outer fence were considered outliers. Although the rule is non-parametric, the calculation of the IQR is influenced by data transformations. The outlier evaluation was therefore conducted using untransformed and $log_{10}$-transformed concentrations because many distributions of water

**Table 2.1: Samples with high Method Detection Limits (MDL) that were removed from the background dataset.**

| Analyte | Max Value (All Stations) | MDL greater than Max Value | Station | Total Sample Size | Number of samples that exceeded Max Value |
|---|---|---|---|---|---|
| Dissolved Chromium | 0.0017 | 0.0020 | W7 | 110 | 20 |
| Dissolved Silver | 0.000060 | 0.00010 | W6 | 23 | 1 |
| | | | W7 | 110 | 43 |

**Table 2.2: Relative Percent Difference (RPD) of maximum and minimum values for samples collected at the same sampling stations and date. Highlighted cells had RPD > 25%.**

| Station | Date | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickle (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W2 | 5/27/2005 | | | 100 | 21 | 138 | 0.026 | 0.0015 | 0.057 | 8.06 | | 0.016 | 0.00025 | 0.000025 | 0.00050 | 0.0033 | 0.16 | 0.00025 | 0.00050 | 0.0015 | 0.00050 | 0.000010 | |
| | | | | 72 | 79 | 80 | 0.010 | 0.00050 | 0.034 | 8.03 | | 0.011 | | | | | | | | | | | 0.0025 |
| | **RPD** | | | **32%** | **118%** | **53%** | **89%** | **100%** | **50%** | **0%** | | **41%** | | | | | | | | | | | |
| W10 | 5/27/2005 | | | 46 | 1.5 | 115 | 0.027 | 0.00050 | 0.0094 | 7.47 | | 0.14 | 0.00025 | 0.000025 | 0.00050 | 0.018 | 0.11 | 0.00025 | 0.00050 | 0.0016 | 0.00050 | 0.000010 | 0.0085 |
| | | | | | | | 0.010 | 0.00050 | | | | | 0.00025 | 0.000025 | 0.00050 | 0.00050 | 0.015 | 0.00025 | 0.00050 | 0.00050 | 0.00050 | 0.000010 | 0.0025 |
| | **RPD** | | | | | | **92%** | **0%** | | | | | **0%** | **0%** | **0%** | **189%** | **150%** | **0%** | **0%** | **105%** | **0%** | **0%** | **109%** |
| W7 | 6/15/2006 | | | | | | 0.027 | | | | | | | | | | | | | | | | |
| | | | 100 | | 53 | 114 | | | 0.18 | 7.86 | | 0.013 | 0.00040 | 0.0000050 | 0.00025 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.0010 | 0.00020 | | 0.00050 |
| | **RPD** | | | | | | | | | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | | | | | | 0.016 | | | | | | | | | | | | | | | | |
| | | | 128 | | 9.0 | | | | 0.18 | 7.87 | | 0.0080 | 0.00040 | 0.0000050 | 0.00025 | 0.0020 | 0.10 | 0.000050 | 0.00050 | 0.00210 | 0.00010 | | 0.00050 |
| | **RPD** | | | | | | | | | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | | | | | | 0.027 | | | | | | | | | | | | | | | | |
| | | | 129 | | | 180 | | | 0.12 | 7.92 | | 0.012 | 0.00040 | 0.0000050 | 0.00060 | 0.0010 | 0.080 | 0.000050 | 0.0010 | 0.00090 | 0.00010 | | 0.0030 |
| | **RPD** | | | | | | | | | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | 108 | 76 | 162 | 0.025 | 0.025 | 0.050 | 7.98 | | | | | | | | | | | | | |
| | | | | 120 | 76 | 158 | 0.025 | 0.050 | 0.050 | 7.97 | | | | | | | | | | | | | |
| | | | | 111 | 73 | 166 | 0.025 | 0.025 | 0.050 | 7.97 | | | | | | | | | | | | | |
| | **RPD** | | | **11%** | **4%** | **5%** | **0%** | **67%** | **0%** | **0%** | | | | | | | | | | | | | |
| W7 | 7/18/2007 | 14.3 | 128 | 126 | 4.0 | 170 | 0.025 | 0.025 | 0.30 | 7.72 | | 0.011 | 0.00050 | 0.0000050 | 0.0010 | 0.0020 | 0.040 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | | 0.0060 |
| | | | | 125 | 7.0 | 182 | 0.025 | 0.025 | 0.30 | 7.80 | | | | | | | | | | | | | |
| | | | | 125 | 6.0 | 184 | 0.025 | 0.025 | 0.30 | 7.83 | | | | | | | | | | | | | |
| | **RPD** | | | **1%** | **55%** | **8%** | **0%** | **0%** | **0%** | **1%** | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | 0.025 | | | | | | | | | | | | | | | | |
| | | | | | | | 0.025 | | | | | | | | | | | | | | | | |
| | | | | | | | 0.025 | | | | | | | | | | | | | | | | |
| | | | | 122 | 4.0 | 198 | | 0.025 | 0.20 | 8.04 | | | | | | | | | | | | | |
| | | | | 123 | 4.0 | 192 | | 0.025 | 0.20 | 8.05 | | | | | | | | | | | | | |
| | | | | 128 | 6.0 | 186 | | 0.025 | 0.20 | 8.04 | | | | | | | | | | | | | |
| | **RPD** | | | **5%** | **0%** | **6%** | | **0%** | **0%** | **0%** | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | 130 | 3.0 | 176 | 0.025 | 0.14 | 0.010 | 7.74 | | | | | | | | | | | | | |
| | | | | 128 | 10 | 182 | 0.025 | 0.14 | 0.010 | 7.74 | | | | | | | | | | | | | |
| | | | | 130 | 7.0 | 166 | 0.025 | 0.13 | 0.010 | 7.74 | | | | | | | | | | | | | |
| | | | | | 6.0 | 172 | | 0.13 | 0.010 | 7.68 | | | | | | | | | | | | | |
| | **RPD** | | | **2%** | **108%** | **9%** | **0%** | **7%** | **0%** | **1%** | | | | | | | | | | | | | |
| W7 | 4/22/2008 | | 186 | | 1.0 | 264 | 0.025 | 0.070 | 0.010 | 8.40 | | 0.010 | 0.00010 | 0.000040 | 0.0012 | 0.00050 | 0.010 | 0.000050 | 0.0016 | 0.00050 | 0.00030 | | 0.0010 |
| | | | 193 | | 1.0 | 274 | 0.025 | 0.040 | 0.010 | 8.41 | | 0.010 | 0.00040 | 0.000040 | 0.0014 | 0.0020 | 0.070 | 0.00010 | 0.0017 | 0.0020 | 0.00030 | | 0.0030 |
| | | | 182 | | 1.0 | 270 | 0.025 | 0.070 | 0.010 | 8.40 | | 0.010 | 0.00030 | 0.000040 | 0.00030 | 0.0010 | 0.010 | 0.000050 | 0.0017 | 0.00050 | 0.00030 | | 0.0010 |
| | | | | | 1.0 | 262 | | 0.040 | 0.010 | 8.40 | | | | | | | | | | | | | |
| | **RPD** | | **6%** | | **0%** | **4%** | **0%** | **55%** | **0%** | **0%** | | **0%** | **120%** | **0%** | **129%** | **120%** | **150%** | **67%** | **5%** | **120%** | **0%** | | **100%** |
| W7 | 6/3/2008 | | | 97 | 1.0 | 134 | 0.025 | 0.040 | 0.030 | 8.01 | | | | | | | | | | | | | |
| | | | | 96 | 19 | 132 | 0.025 | 0.040 | 0.040 | 8.01 | | | | | | | | | | | | | |
| | | | | 101 | 26 | 146 | 0.025 | 0.040 | 0.040 | 8.03 | | | | | | | | | | | | | |
| | | | 92 | | | | | | | | | 0.005 | 0.00010 | 0.000040 | 0.0013 | 0.00050 | 0.050 | 0.000050 | 0.0012 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | **RPD** | | | **5%** | **185%** | **10%** | **0%** | **0%** | **29%** | **0%** | | | | | | | | | | | | | |

**Table 2.2: Relative Percent Difference (RPD) of maximum and minimum values for samples collected at the same sampling stations and date. Highlighted cells had RPD > 25%.**

| Station | Date | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickle (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/6/2008 | | | 123 | 92 | 162 | 0.025 | 0.0050 | 0.14 | 7.9 | | | | | | | | | | | | | |
| | | | | 123 | 139 | 168 | 0.025 | 0.0050 | 0.14 | 7.9 | | | | | | | | | | | | | |
| | | | | 125 | 85 | 170 | | 0.0050 | 0.15 | 8.0 | | | | | | | | | | | | | |
| | | 9.0 | 123 | | | | 0.025 | | | | | 0.014 | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.070 | 0.000050 | 0.0010 | 0.0010 | 0.00010 | 0.000060 | 0.0060 |
| RPD | | | | 2% | 48% | 5% | 0% | 0% | 7% | 1% | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | 4.0 | 192 | 0.025 | | | 7.84 | | | | | | | | | | | | | |
| | | | | | 6.0 | 188 | 0.025 | | | 7.83 | | | | | | | | | | | | | |
| | | | | | 7.0 | 168 | 0.025 | | | 7.85 | | | | | | | | | | | | | |
| | | 11 | 123 | | | | | | | | | 0.0090 | 0.00050 | 0.0000050 | 0.00050 | 0.0010 | 0.078 | 0.000050 | 0.0011 | 0.0010 | 0.00030 | 0.0000050 | 0.0010 |
| RPD | | | | | 55% | 13% | 0% | | | 0% | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | | | | | | | | | |
| | | 6.9 | 123 | | 7.0 | 180 | | | 0.12 | 7.87 | 8.24 | | | | | | | | | | | | |
| RPD | | | | | | | | | | | | | | | | | | | | | | | |
| W7 | 10/25/2009 | 8.7 | 126 | 141 | 2.0 | 130 | 0.010 | 0.0025 | 0.15 | 8.10 | 8.23 | 0.0070 | 0.00030 | 0.000040 | 0.00050 | 0.0012 | 0.046 | 0.00010 | 0.0010 | 0.00050 | 0.00020 | 0.000010 | 0.0025 |
| | | | | | 2.0 | 110 | | | | 8.00 | | | | | | | | | | | | | |
| RPD | | | | | 0% | 17% | | | | 1% | | | | | | | | | | | | | |
| W7 | 9/12/2010 | | | 105 | | | | | | | | | | | | | | | | | | | |
| | | 17 | 107 | 102 | 11 | 210 | 0.039 | 0.0025 | 0.030 | 7.98 | 8.02 | 0.016 | 0.00050 | 0.000050 | | 0.0010 | 0.23 | 0.00010 | 0.0010 | 0.0020 | 0.00040 | | 0.0050 |
| RPD | | | | 3% | | | | | | | | | | | | | | | | | | | |
| W7 | 5/6/2012 | 17 | 46 | 45 | 2.4 | 80 | 0.010 | 0.0025 | 0.010 | 6.05 | | 0.030 | 0.00043 | 0.000013 | 0.00050 | 0.0030 | 0.43 | 0.00010 | 0.00050 | 0.0011 | 0.000050 | 0.000010 | 0.0025 |
| | | 17 | 46 | 45 | 4.2 | 88 | 0.011 | 0.0025 | 0.010 | 5.74 | 7.10 | 0.044 | 0.00044 | 0.000016 | 0.00050 | 0.0027 | 0.46 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| RPD | | 2% | 1% | 0% | 55% | 10% | 10% | 0% | 0% | 5% | | 39% | 2% | 21% | 0% | 10% | 8% | 0% | 0% | 9% | 0% | 0% | 0% |
| W7 | 6/19/2013 | 11 | 113 | 114 | 11 | 152 | 0.052 | 0.0025 | 0.14 | 8.08 | | 0.013 | 0.00052 | 0.0000050 | 0.00050 | 0.0012 | 0.29 | 0.00010 | 0.0015 | 0.0013 | 0.00011 | 0.000010 | 0.0025 |
| | | 11 | 114 | 115 | 10 | 164 | 0.040 | 0.0025 | 0.14 | 8.07 | 8.60 | 0.013 | 0.00051 | 0.0000050 | 0.00050 | 0.0012 | 0.29 | 0.00010 | 0.0016 | 0.0012 | 0.00019 | 0.000010 | 0.0025 |
| RPD | | 7% | 1% | 1% | 10% | 8% | 26% | 0% | 1% | 0% | | 7% | 2% | 0% | 0% | 7% | 2% | 0% | 6% | 8% | 53% | 0% | 0% |
| C4 | 10/18/2013 | 13 | 129 | 142 | 16 | 214 | 0.091 | 0.0025 | 0.069 | 8.18 | | 0.022 | 0.001060 | 0.000005 | 0.00050 | 0.0011 | 1.2 | 0.00010 | 0.00050 | 0.0023 | 0.000050 | 0.000010 | 0.0025 |
| | | 13 | 129 | 139 | 16 | 220 | 0.080 | 0.0025 | 0.065 | 8.24 | 7.16 | 0.025 | 0.001070 | 0.000005 | 0.00050 | 0.0012 | 1.2 | 0.00010 | 0.0012 | 0.0025 | 0.000050 | 0.000010 | 0.0025 |
| RPD | | 2% | 0% | 2% | 0% | 3% | 13% | 0% | 6% | 1% | | 12% | 1% | 0% | 0% | 5% | 1% | 0% | 82% | 8% | 0% | 0% | 0% |
| C10 | 9/8/2013 | 16 | 150 | 163 | 25 | 186 | 0.046 | 0.0076 | 0.18 | 7.94 | | 0.025 | 0.001660 | 0.0000050 | 0.00050 | 0.0013 | 1.3 | 0.00010 | 0.00050 | 0.0025 | 0.000050 | 0.000010 | 0.0025 |
| | | 16 | 150 | 162 | 22 | 206 | 0.055 | 0.0070 | 0.19 | 8.13 | 8.16 | 0.024 | 0.001580 | 0.000010 | 0.0017 | 0.0013 | 1.3 | 0.00010 | 0.00050 | 0.0025 | 0.000050 | 0.000010 | 0.0025 |
| RPD | | 1% | 0% | 1% | 16% | 10% | 18% | 8% | 9% | 2% | | 5% | 5% | 67% | 109% | 6% | 2% | 0% | 0% | 0% | 0% | 0% | 0% |

quality analytes are approximately log-normal. Since pH is reported on the logarithmic scale, the outlier rule was applied to the pH data that were untransformed and anti-logged. Any observations that were identified as potential outliers based on both the untransformed and $\log_{10}$-transformed scale (Appendix C) were investigated further. When Q3 could not be estimated because it was below the MDL, the upper outer fence was estimated using the following formula:

$$MDL_{Q3} + 3 * MDL_{Q3}$$

*where:* $MDL_{Q3}$ *= the MDL corresponding to the observation at the third quartile*

One observation - dissolved arsenic at station C4 on November 17th 2013 (0.0056 mg/L) - was identified as an outlier based on the above rules (Table 2.3). Further investigation of this potential outlier included consideration of potential elevations of other analytes and consideration of analyte ratios (i.e., chemical signature). Hardness, dissolved iron and dissolved manganese were also elevated in this sample. Because the potential outlying value appeared to be naturally possible, was consistent with observations of elevation of other analytes, and there was no unequivocal evidence of unusual ratios of arsenic relative to other analytes (Appendix Table D.1), the concentration of dissolved arsenic at station C4 was retained in the background data set.

## 2.6 Baseline Investigation

Water samples collected in 2005 before mine operations were considered baseline data. Concentrations of COPCs were plotted using an individual value plot for all sampling stations to determine if concentrations for each station were similar to station W2 and could be used as baseline data to represent station W2 (Figure 2.1). The median and 95$^{th}$ percentile of the background data sets for each analyte were calculated separately for W2 and all sampling stations (including W2) in 2005 (Table 2.4). There appears to be close agreement between the median and 95$^{th}$ percentiles for the two data sets (i.e., W2 and all sampling stations in 2005; Table 2.4). Total hardness differed most among data sets (was greater at station W2), but summary statistics for many analytes did not differ between W2 and all sampling stations (Table 2.4). In general, the distribution of concentrations of COPCs at station W2 was similar to the distribution of concentrations of COPCs from the other sampling stations in 2005, supporting the use of the designated reference water quality data set as representative of station W2.

**Table 2.3: Outliers identified and rationale for removing or keeping the data point.**

| Station | Date | Identified Outlier | | | |
|---|---|---|---|---|---|
| | | Analyte | Value | Decision | Rationale |
| C4 | 11/17/2013 | Dissolved Arsenic (mg/L) | 0.0056 | Retained | High Hardness, dissolved iron and dissolved manganese in sample. |

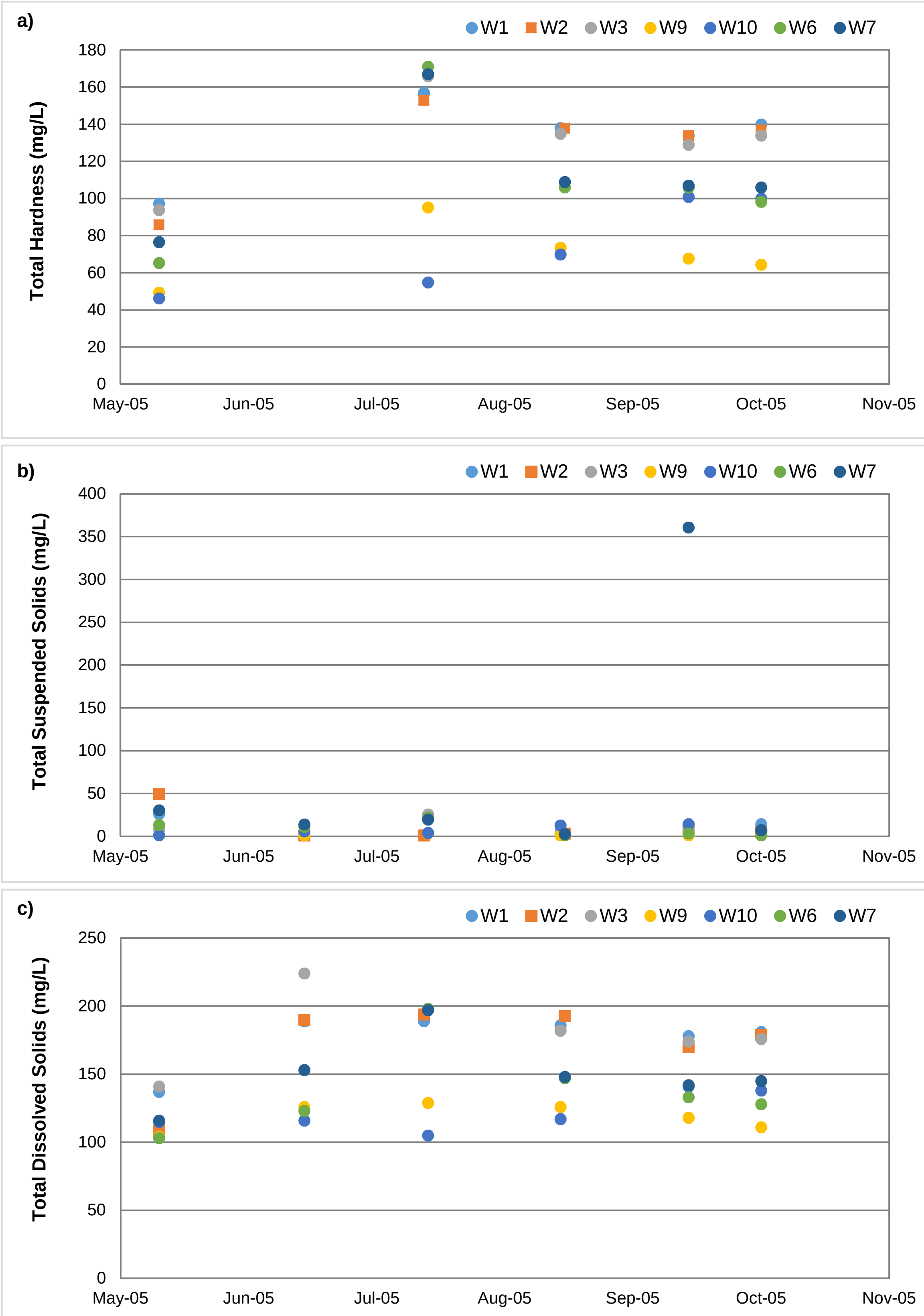



**Figure 2.1: Baseline concentrations of contaminants of potential concern, Minto Mine, 2005. Values less than method detection limits were substituted with half of the MDL value.**

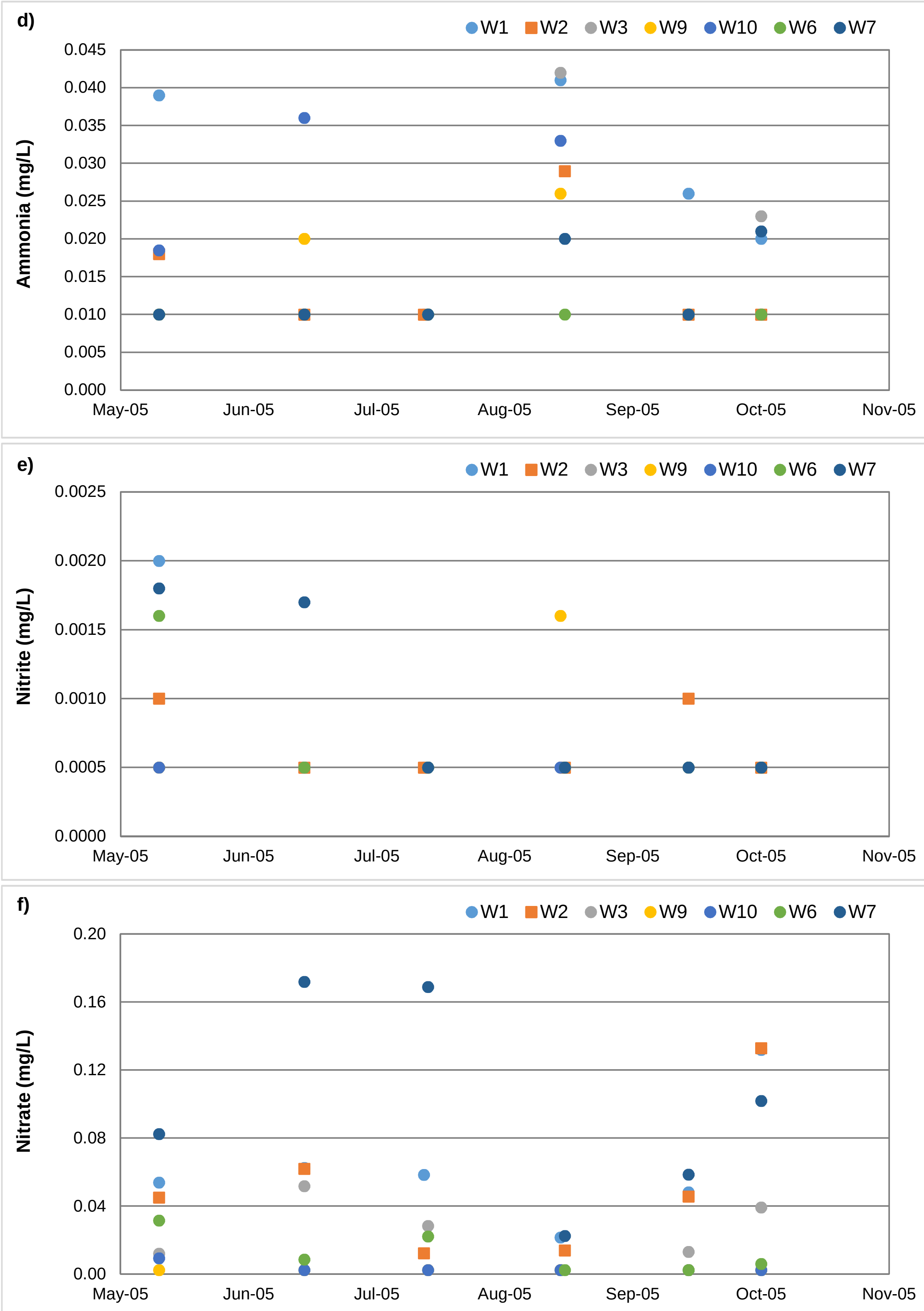



**Figure 2.1: Baseline concentrations of contaminants of potential concern, Minto Mine, 2005. Values less than method detection limits were substituted with half of the MDL value.**

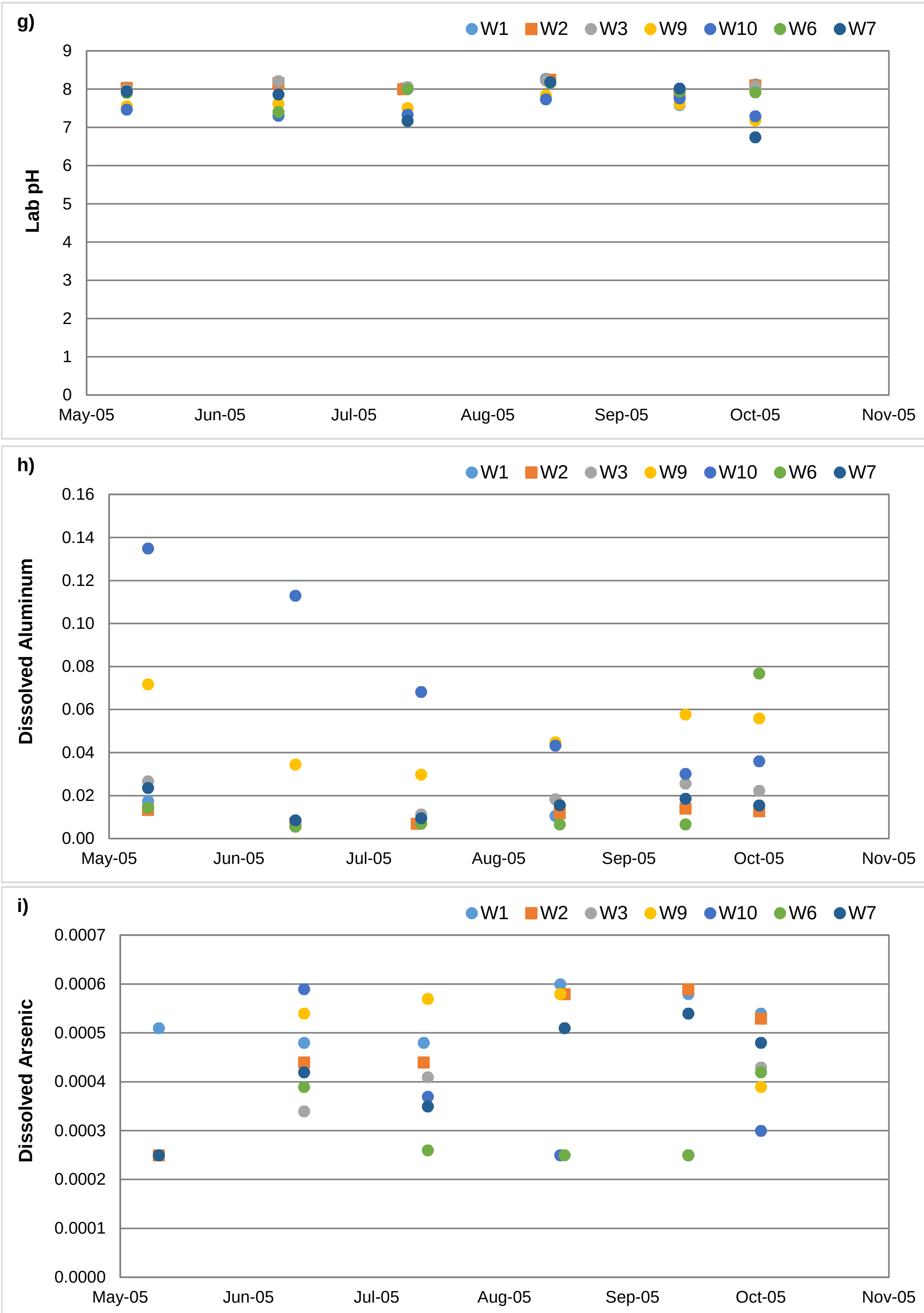



**Figure 2.1: Baseline concentrations of contaminants of potential concern, Minto Mine, 2005. Values less than method detection limits were substituted with half of the MDL value.**

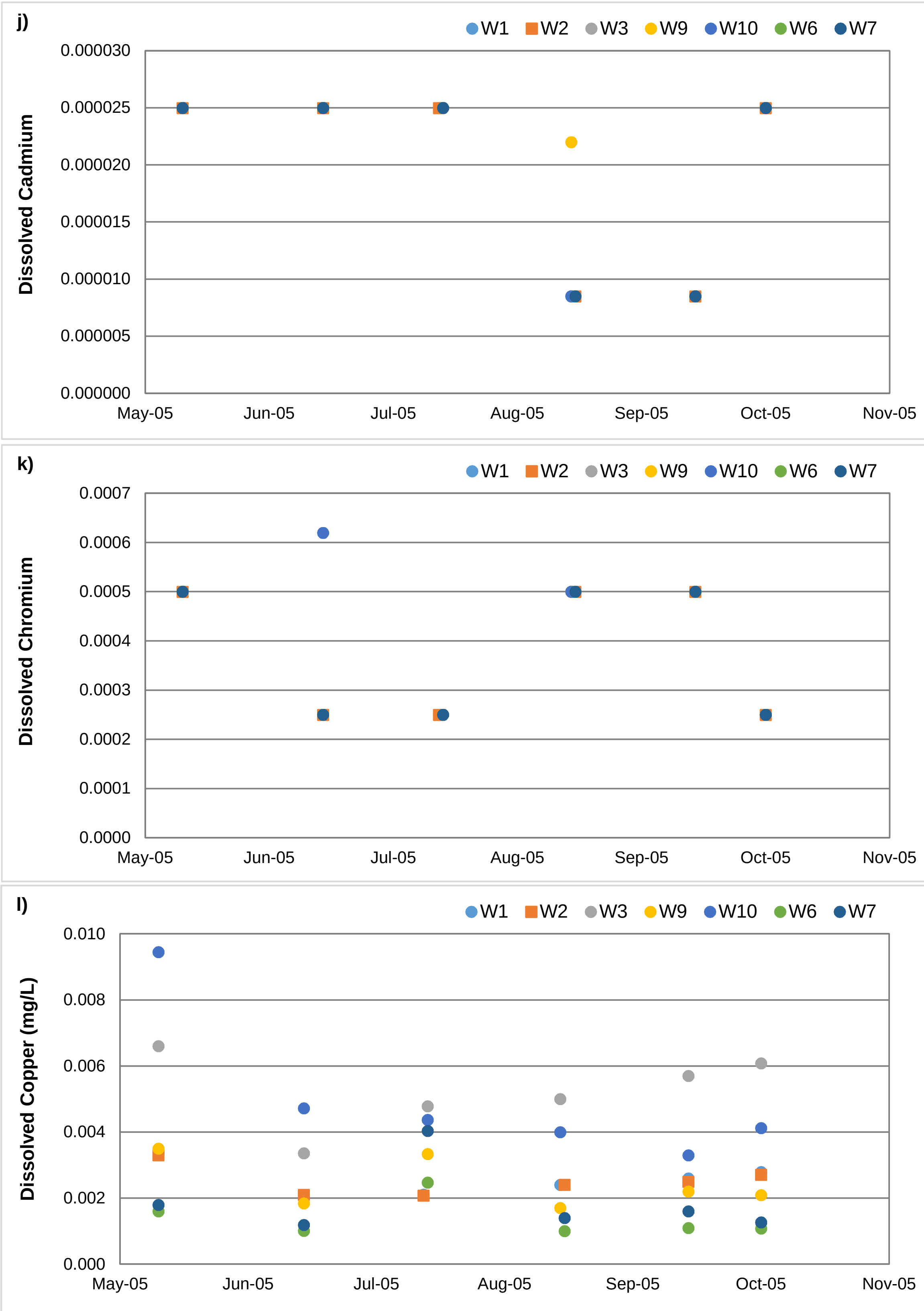
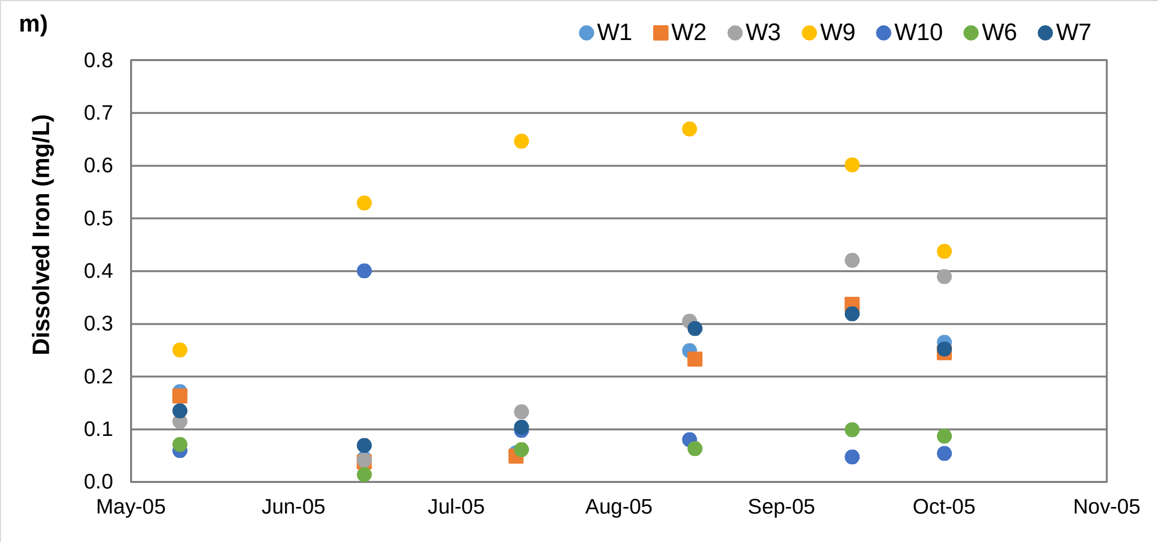
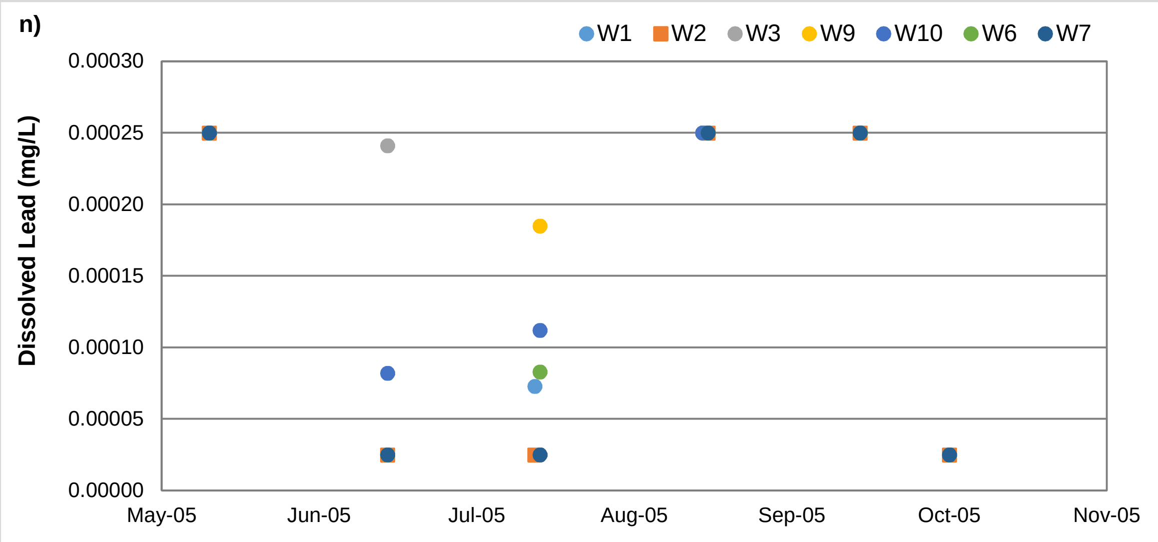



**Figure 2.1: Baseline concentrations of contaminants of potential concern, Minto Mine, 2005. Values less than method detection limits were substituted with half of the MDL value.**



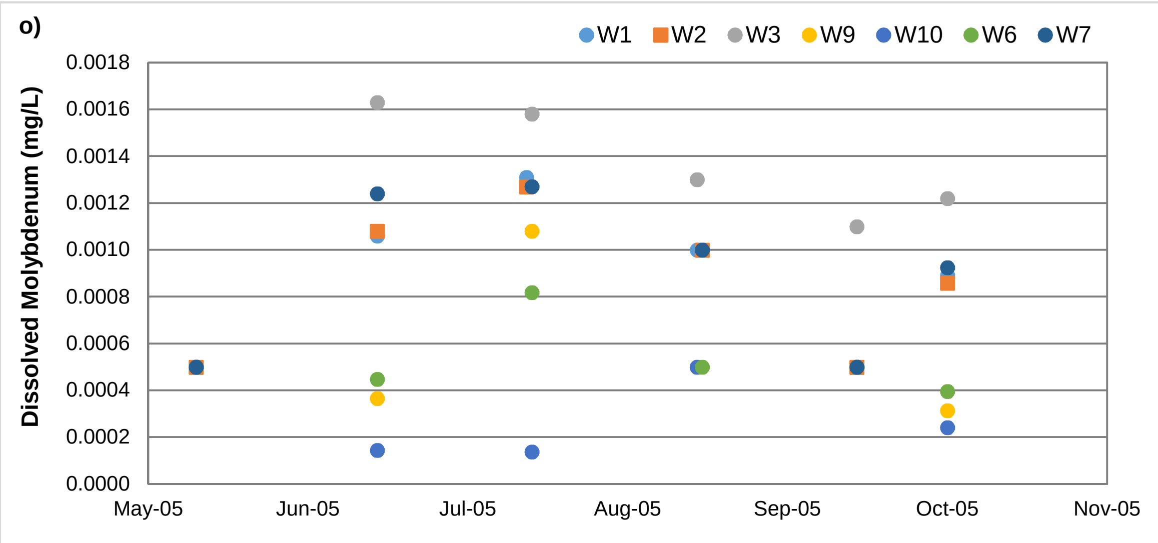
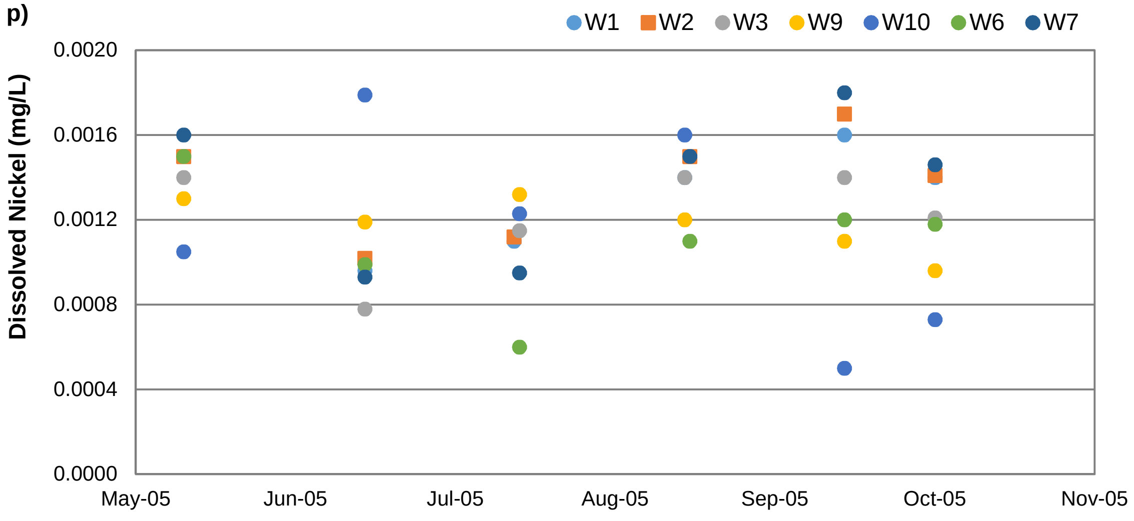
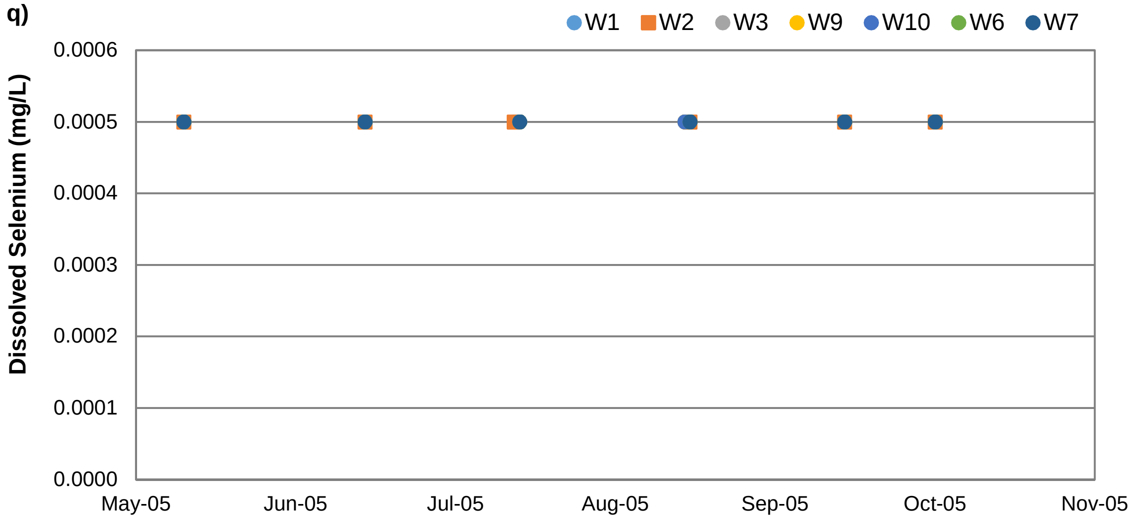




**Figure 2.1: Baseline concentrations of contaminants of potential concern, Minto Mine, 2005. Values less than method detection limits were substituted with half of the MDL value.**

p)




q)




r)

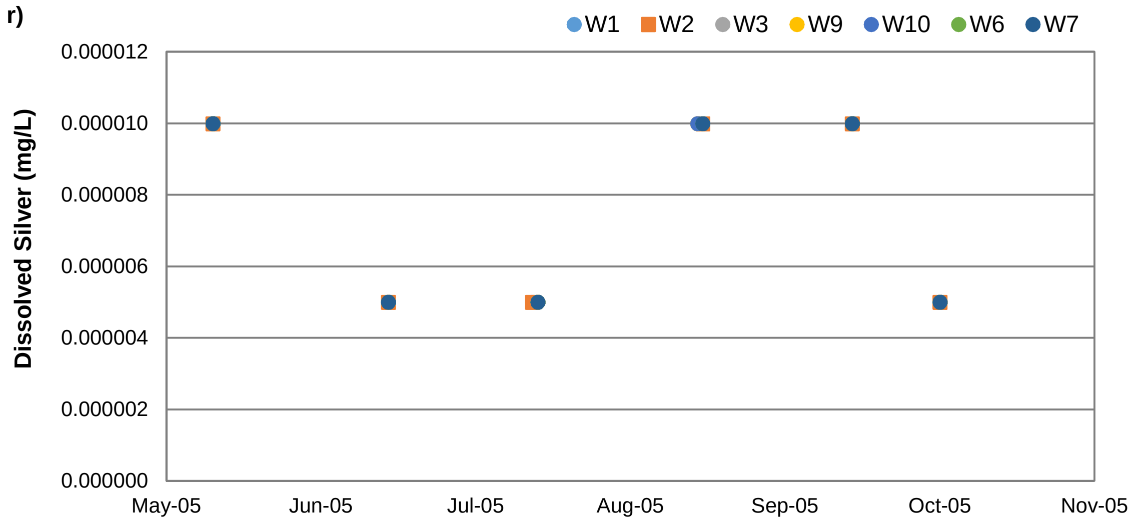



**Figure 2.1: Baseline concentrations of contaminants of potential concern, Minto Mine, 2005. Values less than method detection limits were substituted with half of the MDL value.**

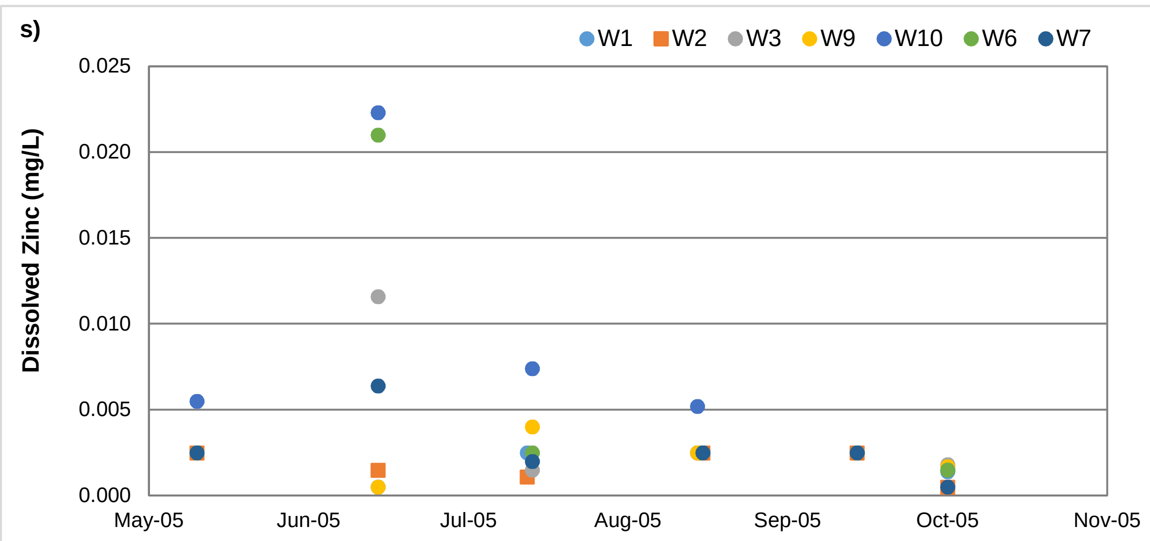



**Figure 2.1: Baseline concentrations of contaminants of potential concern, Minto Mine, 2005. Values less than method detection limits were substituted with half of the MDL value.**

**Table 2.4: Median and 95th Percentile for W2 and All sampling stations (including W2) in 2005.**

| Analyte | W2 | | | All Sampling Stations | | |
|---|---|---|---|---|---|---|
| | Sample Size | Median | 95th Percentile | Sample Size | Median | 95th Percentile |
| Total Hardness (mg/L) | 5 | 137 | 150 | 35 | 106 | 166 |
| TSS (mg/L) | 6 | 4.5 | 40 | 42 | 5.8 | 30 |
| TDS (mg/L) | 6 | 185 | 194 | 42 | 144 | 198 |
| Ammonia (mg/L) | 6 | 0.010 | 0.026 | 42 | 0.010 | 0.039 |
| Nitrite (mg/L) | 6 | 0.00050 | 0.0010 | 42 | 0.00050 | 0.0017 |
| Nitrate (mg/L) | 6 | 0.046 | 0.12 | 42 | 0.018 | 0.13 |
| Lab pH (pH Units) | 6 | 8.08 | 8.24 | 42 | 7.95 | 8.24 |
| Dissolved Aluminum (mg/L) | 6 | 0.012 | 0.014 | 42 | 0.016 | 0.077 |
| Dissolved Arsenic (mg/L) | 6 | 0.00049 | 0.00059 | 42 | 0.00042 | 0.00059 |
| Dissolved Cadmium (mg/L) | 6 | 0.000025 | 0.000025 | 42 | 0.000025 | 0.000025 |
| Dissolved Chromium (mg/L) | 6 | 0.00038 | 0.00050 | 42 | 0.00050 | 0.00050 |
| Dissolved Copper (mg/L) | 6 | 0.0025 | 0.0032 | 42 | 0.0025 | 0.0061 |
| Dissolved Iron (mg/L) | 6 | 0.20 | 0.32 | 42 | 0.15 | 0.60 |
| Dissolved Lead (mg/L) | 6 | 0.00014 | 0.00025 | 42 | 0.00025 | 0.00025 |
| Dissolved Molybdenum (mg/L) | 6 | 0.0009295 | 0.0012 | 42 | 0.00050 | 0.0013 |
| Dissolved Nickel (mg/L) | 6 | 0.0015 | 0.0017 | 42 | 0.0012 | 0.0017 |
| Dissolved Selenium (mg/L) | 6 | 0.00050 | 0.00050 | 42 | 0.00050 | 0.00050 |
| Dissolved Silver (mg/L) | 6 | 0.0000075 | 0.000010 | 42 | 0.0000075 | 0.000010 |
| Dissolved Zinc (mg/L) | 6 | 0.0020 | 0.0025 | 42 | 0.0025 | 0.011 |

## 2.7 Data Grouping

Water quality sampling was typically conducted in batches or “sampling campaigns” such that water quality samples were collected from multiple sampling stations on the same day or within a one week period. Samples collected on the same day may not be fully independent of each other, and therefore different methods of grouping the data were explored. Three options were evaluated: Option 1 did not involve any grouping (i.e., all data were used), Option 2 grouped samples by week, and Option 3 grouped samples by month (Table 2.5; Figure 2.2; Appendix Table D.1). Data were combined for Option 2 by calculating the mean from all sampling stations that were collected within a one week period (Table D.2). Data were combined for Option 3 in two steps: 1) by calculating the mean for each individual sampling station by month; and 2) then calculating the mean of the monthly sampling station means (Table D.3).

## 2.8 Summary Statistics

The designated reference water quality data set, developed as outlined above, was used to calculate summary statistics for each of the three options. For each analyte, the sample size, mean, median and 95th percentile were calculated for all stations combined over time for all three Options (Table 2.6). In addition, annual medians were calculated for each of the three options, and the 95th percentile of those annual medians was calculated (Table 2.7).

**Table 2.5: Data grouping decisions for Option 2 and Option 3.**

| Year | Month | Day | Sampling Station | | | | | | | | | Option 2 | Option 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | W1 | W2 | W3 | W9 | W10 | W6 | W7 | C4 | C10 | | |
| 2005 | May | 27 | X | X | X | X | X | X | X | - | - | • Average of all sampling stations | - |
| | June | 30 | X | X | X | X | X | X | X | - | - | • Average of all sampling stations | - |
| | July | 28 | X | X | - | - | - | - | - | - | - | • Average of all sampling stations from both days | - |
| | | 29 | - | - | X | X | X | X | X | - | - | | |
| | August | 29 | X | - | X | X | X | - | - | - | - | • Average of all sampling stations from both days | - |
| | | 30 | - | X | - | - | - | X | X | - | - | | |
| | September | 28 | X | X | X | X | X | X | X | - | - | • Average of all sampling stations | - |
| | October | 15 | X | X | X | X | X | X | X | - | - | • Average of all sampling stations | - |
| 2006 | June | 2 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | • Average of W7 sampling stations<br>• Take average of W7 (averaged value) and W6 |
| | | 8 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 15 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 23 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 28 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | July | 7 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations |
| | | 12 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 20 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 26 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | August | 2 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations<br>• Take average of W7 (averaged value) and W6 |
| | | 10 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 25 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | |
| | | 30 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | September | 6 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | • Average of W7 sampling stations<br>• Take average of W7 (averaged value) and W6 |
| | | 13 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 20 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 28 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | October | 4 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations |
| | | 12 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| 2007 | June | 5 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations<br>• Take average of W7 (averaged value) and W6 |
| | | 20 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | |
| | July | 18 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | August | 24 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | September | 18 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | - |
| | October | 30 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| 2008 | April | 22 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | June | 3 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations<br>• Take average of W7 (averaged value) and W6 |
| | | 17 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | |
| | August | 6 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | September | 18 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | - |
| | October | 28 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| 2009 | April | 30 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | June | 8 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | July | 28 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | August | 6 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations |
| | | 25 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | | 31 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | October | 7 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations |
| | | 25 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |

**Table 2.5: Data grouping decisions for Option 2 and Option 3.**

| Year | Month | Day | Sampling Station | | | | | | | | | Option 2 | Option 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | W1 | W2 | W3 | W9 | W10 | W6 | W7 | C4 | C10 | | |
| 2010 | April | 19 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations |
| | | 27 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on both days | |
| | | 29 | - | - | - | - | - | - | X | - | - | | |
| | May | 1 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on all four days | • Average of W7 sampling stations |
| | | 3 | - | - | - | - | - | - | X | - | - | | |
| | | 5 | - | - | - | - | - | - | X | - | - | | |
| | | 7 | - | - | - | - | - | - | X | - | - | | |
| | | 9 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on all four days | |
| | | 10 | - | - | - | - | - | - | X | - | - | | |
| | | 12 | - | - | - | - | - | - | X | - | - | | |
| | | 14 | - | - | - | - | - | - | X | - | - | | |
| | | 16 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on all four days | |
| | | 17 | - | - | - | - | - | - | X | - | - | | |
| | | 19 | - | - | - | - | - | - | X | - | - | | |
| | | 21 | - | - | - | - | - | - | X | - | - | | |
| | | 23 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on all four days | |
| | | 25 | - | - | - | - | - | - | X | - | - | | |
| | | 27 | - | - | - | - | - | - | X | - | - | | |
| | | 29 | - | - | - | - | - | - | X | - | - | | |
| | | 31 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on all four days | |
| | June | 2 | - | - | - | - | - | - | X | - | - | | • Average of W7 sampling stations |
| | | 4 | - | - | - | - | - | - | X | - | - | | |
| | | 6 | - | - | - | - | - | - | X | - | - | | |
| | | 14 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on all four days | |
| | | 16 | - | - | - | - | - | - | X | - | - | | |
| | | 18 | - | - | - | - | - | - | X | - | - | | |
| | | 20 | - | - | - | - | - | - | X | - | - | | |
| | | 22 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations on all four days | |
| | | 24 | - | - | - | - | - | - | X | - | - | | |
| | | 26 | - | - | - | - | - | - | X | - | - | | |
| | | 28 | - | - | - | - | - | - | X | - | - | | |
| | July | 5 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | August | 5 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | September | 12 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | October | 8 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| 2011 | April | 27 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | May | 2 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | June | 1 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations |
| | | 16 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | |
| | July | 1 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | August | 2 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of W7 sampling stations |
| | | 16 | - | - | - | - | - | - | X | - | - | • Average of W7 sampling stations | |
| | | 19 | - | - | - | - | - | - | X | - | - | | |
| | September | 12 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | October | 6 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | November | 22 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |

**Table 2.5: Data grouping decisions for Option 2 and Option 3.**

| Year | Month | Day | Sampling Station | | | | | | | | | Option 2 | Option 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | W1 | W2 | W3 | W9 | W10 | W6 | W7 | C4 | C10 | | |
| 2012 | January | 24 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | February | 25 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | March | 5 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | April | 24 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | May | 6 | - | - | - | - | - | - | X | X | - | • Average of all sampling stations from both days | - |
| | | 12 | - | - | - | - | - | - | - | - | X | | |
| | June | 19 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | July | 17 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | • Average sampling stations separately<br>• Using station averages take average for all days |
| | | 30 | - | - | - | - | - | X | X | - | X | • Average of all sampling stations | |
| | August | 1 | - | - | - | - | - | - | - | X | - | • Use C4 sampling station | • Average sampling stations separately<br>• Using station averages take average for all days |
| | | 8 | - | - | - | - | - | - | X | X | - | • Average of all sampling stations from all days | |
| | | 9 | - | - | - | - | - | X | - | - | - | | |
| | | 10 | - | - | - | - | - | - | - | - | X | | |
| | | 23 | - | - | - | - | - | - | X | - | - | • Average of all sampling stations from all days | |
| | | 25 | - | - | - | - | - | X | - | X | - | | |
| | | 27 | - | - | - | - | - | - | - | - | X | | |
| | September | 13 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | - |
| | October | 13 | - | - | - | - | - | X | - | - | - | • Average of all sampling stations from both days | - |
| | | 16 | - | - | - | - | - | - | X | - | - | | |
| | November | 2 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | • Average of all sampling stations from both days |
| | | 12 | - | - | - | - | - | X | - | - | - | • Use W6 sampling station | |
| | December | 29 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| 2013 | April | 30 | - | - | - | - | - | - | X | - | - | • Use W7 sampling station | - |
| | May | 14 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | - |
| | June | 19 | - | - | - | - | - | - | X | - | - | • Average of all sampling stations from both days | - |
| | | 22 | - | - | - | - | - | X | - | X | X | | |
| | July | 12 | - | - | - | - | - | X | - | - | - | • Average of all sampling stations from both days | • Average of all sampling stations |
| | | 13 | - | - | - | - | - | - | X | - | - | | |
| | | 19 | - | - | - | - | - | - | - | X | - | • Average of all sampling stations from both days | |
| | | 23 | - | - | - | - | - | - | - | - | X | | |
| | August | 21 | - | - | - | - | - | - | X | - | - | • Average of all sampling stations from both days | - |
| | | 22 | - | - | - | - | - | X | - | X | X | | |
| | September | 6 | - | - | - | - | - | X | X | X | - | • Average of all sampling stations from both days | - |
| | | 8 | - | - | - | - | - | - | - | - | X | | |
| | October | 7 | - | - | - | - | - | X | - | - | - | • Use W6 sampling station | • Average of all sampling stations |
| | | 18 | - | - | - | - | - | - | - | X | X | • Average of all sampling stations from both days | |
| | | 21 | - | - | - | - | - | - | X | - | - | | |
| | November | 16 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations from both days | - |
| | | 17 | - | - | - | - | - | - | - | X | - | | |
| | December | 7 | - | - | - | - | - | X | X | - | - | • Average of all sampling stations | - |

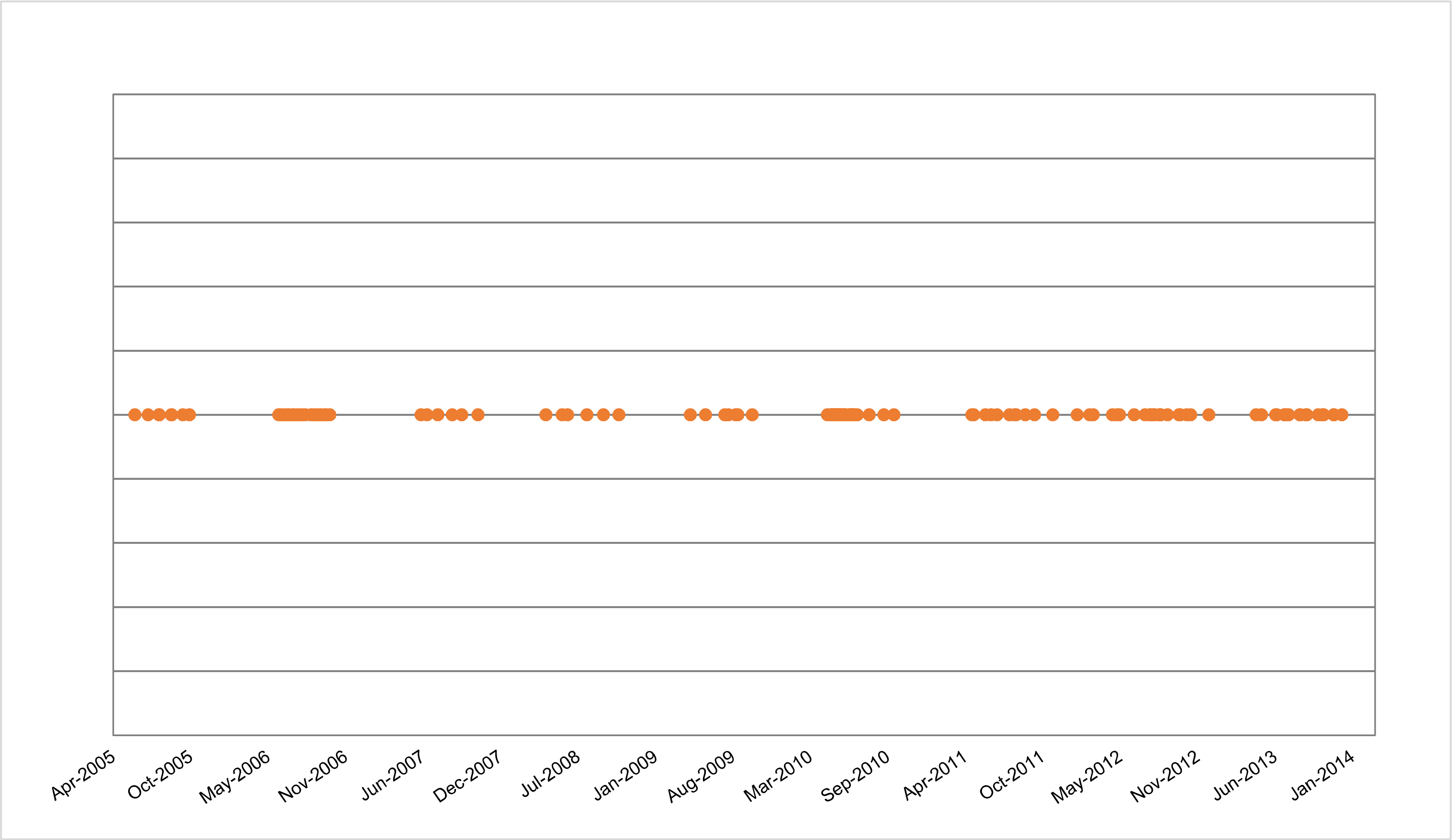



**Figure 2.2: Distribution of water quality sampling events from 2005 to 2013.**

**Table 2.6: Summary statistics for Options 1, 2 and 3.**

| Analytes | Option 1 (No Grouping) | | | | Option 2 (Grouped by Week) | | | | Option 3 (Grouped by Month) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Size | Mean | Median | 95th Percentile | Sample Size | Mean | Median | 95th Percentile | Sample Size | Mean | Median | 95th Percentile |
| DOC (mg/L) | 108 | 12 | 11 | 22 | 59 | 12 | 12 | 21 | 46 | 13 | 12 | 21 |
| Dissolved Hardness (mg/L) | 134 | 113 | 117 | 162 | 80 | 115 | 120 | 169 | 53 | 113 | 118 | 181 |
| Total Hardness (mg/L) | 149 | 120 | 121 | 200 | 66 | 120 | 121 | 185 | 49 | 120 | 124 | 185 |
| TSS (mg/L) | 184 | 114 | 11 | 772 | 89 | 89 | 11 | 485 | 61 | 77 | 11 | 278 |
| TDS (mg/L) | 178 | 153 | 150 | 217 | 83 | 156 | 158 | 216 | 62 | 158 | 160 | 226 |
| Ammonia (mg/L) | 175 | 0.040 | 0.021 | 0.15 | 83 | 0.036 | 0.025 | 0.12 | 56 | 0.037 | 0.025 | 0.12 |
| Nitrite (mg/L) | 161 | 0.0071 | 0.0025 | 0.025 | 67 | 0.010 | 0.0025 | 0.038 | 52 | 0.010 | 0.0025 | 0.040 |
| Nitrate (mg/L) | 181 | 0.085 | 0.067 | 0.21 | 85 | 0.10 | 0.090 | 0.22 | 57 | 0.091 | 0.075 | 0.22 |
| Lab pH (pH Units) | 187 | 7.93 | 8.00 | 8.26 | 91 | 7.92 | 7.97 | 8.20 | 61 | 7.90 | 7.96 | 8.18 |
| Field pH (pH Units) | 93 | 7.73 | 7.76 | 8.30 | 46 | 7.72 | 7.77 | 8.24 | 33 | 7.71 | 7.80 | 8.13 |
| Dissolved Aluminum (mg/L) | 179 | 0.026 | 0.016 | 0.071 | 88 | 0.025 | 0.014 | 0.056 | 59 | 0.023 | 0.019 | 0.053 |
| Dissolved Arsenic (mg/L) | 179 | 0.00057 | 0.00044 | 0.0015 | 88 | 0.00053 | 0.00041 | 0.0013 | 59 | 0.00053 | 0.00041 | 0.0011 |
| Dissolved Cadmium (mg/L) | 179 | 0.000019 | 0.0000085 | 0.000050 | 88 | 0.000020 | 0.0000053 | 0.000050 | 59 | 0.000019 | 0.000010 | 0.000050 |
| Dissolved Chromium (mg/L) | 159 | 0.00054 | 0.00050 | 0.0011 | 81 | 0.00060 | 0.00050 | 0.0013 | 55 | 0.00057 | 0.00050 | 0.0011 |
| Dissolved Copper (mg/L) | 179 | 0.0021 | 0.0016 | 0.0050 | 88 | 0.0021 | 0.0015 | 0.0051 | 59 | 0.0024 | 0.0017 | 0.0054 |
| Dissolved Iron (mg/L) | 179 | 0.38 | 0.11 | 1.2 | 88 | 0.31 | 0.11 | 0.95 | 59 | 0.34 | 0.15 | 0.91 |
| Dissolved Lead (mg/L) | 179 | 0.00012 | 0.00010 | 0.00025 | 88 | 0.00012 | 0.00010 | 0.00028 | 59 | 0.00012 | 0.00010 | 0.00025 |
| Dissolved Molybdenum (mg/L) | 179 | 0.00096 | 0.0010 | 0.0020 | 88 | 0.00097 | 0.0010 | 0.0017 | 59 | 0.00094 | 0.0010 | 0.0015 |
| Dissolved Nickel (mg/L) | 179 | 0.0013 | 0.0011 | 0.0027 | 88 | 0.0013 | 0.0011 | 0.0024 | 59 | 0.0012 | 0.0011 | 0.0020 |
| Dissolved Selenium (mg/L) | 179 | 0.00027 | 0.00020 | 0.00050 | 88 | 0.00023 | 0.00011 | 0.00050 | 59 | 0.00025 | 0.00015 | 0.00050 |
| Dissolved Silver (mg/L) | 137 | 0.0000092 | 0.000010 | 0.000010 | 60 | 0.0000098 | 0.000010 | 0.000010 | 47 | 0.000010 | 0.000010 | 0.000010 |
| Dissolved Zinc (mg/L) | 179 | 0.0032 | 0.0025 | 0.0060 | 88 | 0.0029 | 0.0025 | 0.0060 | 59 | 0.0033 | 0.0025 | 0.0084 |

**Table 2.7: Annual Medians and the 95th percentile of annual medians for Option 1, 2 and 3.**

| Option | Year | Annual Medians | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
| Option 1 (No Group) | 2005 | - | - | 106 | 5.8 | 144 | 0.010 | 0.00050 | 0.018 | 7.95 | - | 0.016 | 0.00042 | 0.000025 | 0.00050 | 0.0025 | 0.15 | 0.00025 | 0.00050 | 0.0012 | 0.00050 | 0.0000075 | 0.0025 |
| | 2006 | - | 128 | - | 4.0 | 164 | 0.015 | 0.0010 | 0.11 | 7.85 | - | 0.0080 | 0.00042 | 0.0000050 | 0.00070 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.00090 | 0.00010 | 0.0000050 | 0.0010 |
| | 2007 | 11 | 110 | 119 | 7.3 | 173 | 0.025 | 0.025 | 0.08 | 7.90 | - | 0.011 | 0.00040 | 0.0000050 | 0.0010 | 0.0020 | 0.050 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | - | 0.0040 |
| | 2008 | 14 | 123 | 98 | 13 | 161 | 0.025 | 0.040 | 0.030 | 7.91 | - | 0.012 | 0.00030 | 0.000005 | 0.0013 | 0.0012 | 0.070 | 0.000050 | 0.0011 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | 2009 | 8.7 | 121 | 141 | 2.8 | 148 | 0.010 | 0.0025 | 0.15 | 8.02 | 7.89 | 0.010 | 0.00030 | 0.000040 | 0.00050 | 0.0020 | 0.050 | 0.00010 | 0.0010 | 0.00050 | 0.00030 | 0.0000050 | 0.0025 |
| | 2010 | 9.2 | 99 | 106 | 18 | 140 | 0.022 | 0.0025 | 0.070 | 8.10 | 7.72 | 0.017 | 0.00040 | 0.000050 | 0.00050 | 0.0017 | 0.07 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | 0.000010 | 0.0050 |
| | 2011 | 18 | 93 | 94 | 22 | 130 | 0.015 | 0.0025 | 0.055 | 7.96 | 7.79 | 0.033 | 0.00060 | 0.000010 | 0.00050 | 0.0019 | 0.35 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | 2012 | 12 | 129 | 145 | 45 | 166 | 0.025 | 0.0025 | 0.078 | 8.11 | 7.84 | 0.019 | 0.00078 | 0.0000050 | 0.00050 | 0.0016 | 0.58 | 0.00010 | 0.0011 | 0.0015 | 0.00012 | 0.000010 | 0.0025 |
| | 2013 | 11 | 129 | 153 | 23 | 176 | 0.049 | 0.0025 | 0.10 | 8.09 | 7.75 | 0.014 | 0.00059 | 0.0000050 | 0.00050 | 0.0012 | 0.36 | 0.00010 | 0.0011 | 0.0013 | 0.000050 | 0.000010 | 0.0025 |
| | **95th Percentile of Annual Medians** | **17** | **129** | **150** | **36** | **175** | **0.040** | **0.034** | **0.13** | **8.11** | **7.88** | **0.027** | **0.00071** | **0.000046** | **0.0012** | **0.0023** | **0.49** | **0.00019** | **0.0011** | **0.0018** | **0.00046** | **0.000010** | **0.0046** |
| Option 2 (Grouped by Week) | 2005 | - | - | 111 | 8.4 | 154 | 0.015 | 0.00061 | 0.040 | 7.83 | - | 0.025 | 0.00042 | 0.000025 | 0.00040 | 0.0028 | 0.21 | 0.00016 | 0.00076 | 0.0013 | 0.00050 | 0.0000075 | 0.0027 |
| | 2006 | - | 126 | - | 4.0 | 170 | 0.014 | 0.0010 | 0.12 | 7.85 | - | 0.0080 | 0.00040 | 0.0000050 | 0.00070 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.00085 | 0.00010 | 0.0000050 | 0.0010 |
| | 2007 | 11 | 110 | 119 | 8.8 | 176 | 0.025 | 0.025 | 0.13 | 7.89 | - | 0.011 | 0.00040 | 0.0000050 | 0.0010 | 0.0020 | 0.050 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | - | 0.0040 |
| | 2008 | 11 | 123 | 98 | 14 | 163 | 0.025 | 0.040 | 0.037 | 7.90 | - | 0.012 | 0.00031 | 0.000023 | 0.0011 | 0.0011 | 0.070 | 0.000050 | 0.0012 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | 2009 | 8.7 | 121 | 141 | 2.8 | 148 | 0.010 | 0.0025 | 0.15 | 8.02 | 7.89 | 0.010 | 0.00030 | 0.000040 | 0.00050 | 0.0020 | 0.050 | 0.00010 | 0.0010 | 0.00050 | 0.00030 | 0.0000050 | 0.0025 |
| | 2010 | 12 | 106 | 106 | 13 | 145 | 0.027 | 0.0036 | 0.070 | 8.06 | 7.69 | 0.017 | 0.00033 | 0.000050 | 0.00050 | 0.0020 | 0.10 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | 0.000010 | 0.0050 |
| | 2011 | 16 | 94 | 95 | 23 | 125 | 0.015 | 0.0025 | 0.050 | 7.98 | 7.79 | 0.029 | 0.00050 | 0.000010 | 0.00050 | 0.0019 | 0.28 | 0.00010 | 0.00050 | 0.0016 | 0.00010 | 0.000010 | 0.0025 |
| | 2012 | 11 | 129 | 154 | 30 | 164 | 0.025 | 0.0025 | 0.083 | 8.08 | 7.80 | 0.021 | 0.00060 | 0.0000050 | 0.00050 | 0.0016 | 0.50 | 0.00010 | 0.0011 | 0.0014 | 0.00012 | 0.000010 | 0.0025 |
| | 2013 | 12 | 129 | 151 | 34 | 179 | 0.078 | 0.0025 | 0.10 | 8.09 | 7.80 | 0.015 | 0.00088 | 0.0000050 | 0.00050 | 0.0012 | 0.59 | 0.00010 | 0.0010 | 0.0018 | 0.000093 | 0.000010 | 0.0025 |
| | **95th Percentile of Annual Medians** | **15** | **129** | **153** | **33** | **178** | **0.058** | **0.034** | **0.14** | **8.09** | **7.87** | **0.027** | **0.00077** | **0.000046** | **0.0011** | **0.0025** | **0.55** | **0.00014** | **0.0011** | **0.0017** | **0.00046** | **0.000010** | **0.0046** |
| Option 3 (Grouped by Month) | 2005 | - | - | 111 | 8.4 | 154 | 0.015 | 0.00061 | 0.038 | 7.83 | - | 0.025 | 0.00042 | 0.000025 | 0.00040 | 0.0028 | 0.21 | 0.00016 | 0.00076 | 0.0013 | 0.00050 | 0.0000075 | 0.0029 |
| | 2006 | - | 120 | - | 3.8 | 175 | 0.017 | 0.0010 | 0.083 | 7.78 | - | 0.0079 | 0.00046 | 0.0000050 | 0.00059 | 0.0011 | 0.10 | 0.000050 | 0.00088 | 0.00083 | 0.00013 | 0.0000050 | 0.0017 |
| | 2007 | 11 | 110 | 124 | 6.5 | 177 | 0.025 | 0.025 | 0.14 | 7.84 | - | 0.011 | 0.00040 | 0.0000050 | 0.0010 | 0.0020 | 0.050 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | - | 0.0040 |
| | 2008 | 11 | 123 | 108 | 15 | 167 | 0.025 | 0.030 | 0.033 | 7.90 | - | 0.013 | 0.00035 | 0.0000050 | 0.0010 | 0.0012 | 0.070 | 0.000050 | 0.0011 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | 2009 | 10 | 96 | 141 | 4.0 | 149 | 0.010 | 0.0025 | 0.16 | 7.90 | 7.73 | 0.019 | 0.00028 | 0.000035 | 0.00055 | 0.0028 | 0.060 | 0.00010 | 0.00092 | 0.00067 | 0.00030 | 0.0000050 | 0.0033 |
| | 2010 | 13 | 107 | 106 | 32 | 150 | 0.037 | 0.0031 | 0.070 | 8.04 | 7.85 | 0.016 | 0.00038 | 0.000050 | 0.00050 | 0.0020 | 0.13 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | 0.000010 | 0.0050 |
| | 2011 | 19 | 79 | 89 | 17 | 125 | 0.016 | 0.0025 | 0.050 | 7.81 | 7.79 | 0.036 | 0.00050 | 0.000016 | 0.00050 | 0.0029 | 0.26 | 0.00010 | 0.00050 | 0.0012 | 0.00010 | 0.000010 | 0.000010 |
| | 2012 | 11 | 128 | 156 | 19 | 167 | 0.024 | 0.0025 | 0.092 | 8.10 | 7.59 | 0.021 | 0.00056 | 0.0000056 | 0.00050 | 0.0018 | 0.45 | 0.00010 | 0.0011 | 0.0014 | 0.00014 | 0.000010 | 0.0025 |
| | 2013 | 12 | 130 | 151 | 40 | 185 | 0.080 | 0.0037 | 0.11 | 8.09 | 7.90 | 0.019 | 0.0011 | 0.0000056 | 0.00050 | 0.0012 | 0.65 | 0.00010 | 0.0011 | 0.0018 | 0.000093 | 0.000010 | 0.0025 |
| | **95th Percentile of Annual Medians** | **17** | **129** | **154** | **37** | **182** | **0.063** | **0.028** | **0.15** | **8.10** | **7.89** | **0.032** | **0.00086** | **0.000044** | **0.00099** | **0.0029** | **0.57** | **0.00014** | **0.0011** | **0.0016** | **0.00046** | **0.000010** | **0.0046** |

# 3.0 BACKGROUND WATER QUALITY SUMMARY STATISTICS

Based primarily on consideration of potential water quality monitoring frequencies at the post-closure 2 stage (proposed spring, summer, fall), Option 3 is put forward as the proposed basis for defining background water quality. Two key sets of background water quality statistics are appropriate for defining background water quality:

1. the 95$^{th}$ percentile of the background data; and
2. the 95$^{th}$ percentile of the annual medians of the background data.

The intended use of the former (Table 3.1; Appendix Table D.4) is as an "individual data point evaluator" and the intended use of the latter (Table 3.1; Appendix Tables D.5 and D.6) is as a "central tendency evaluator".

Although application of the WQOs in defining attainment is the subject of ongoing discussion between the Minto Mine and Selkirk First Nation, a fundamental guiding principle is that, because the summary statistics are 95$^{th}$ percentiles, they will be exceeded at an average rate of 5% in the absence of any mine influence on water quality. Thus, definition of attainment must consider natural exceedance rate, and initial response to any observed exceedance must be focussed on distinguishing a mine related influence from natural variability.

**Table 3.1: Background water quality summary statistics representing lower Minto Creek (Minnow 2016) [1]**

| Analytes | Background Concentration Summary Statistics | |
|---|---|---|
| | Individual Data Point Evaluator (95th percentile) | Central Tendency Evaluator (95th percentile of annual medians) |
| Ammonia (mg/L) | 0.12 | 0.063 |
| Nitrite (mg/L) | 0.040 | 0.028 |
| Nitrate (mg/L) | 0.22 | 0.15 |
| Dissolved Aluminum (mg/L) | 0.053 | 0.032 |
| Dissolved Arsenic (mg/L) | 0.0011 | 0.00086 |
| Dissolved Cadmium (mg/L) | 0.000050 | 0.000044 |
| Dissolved Chromium (mg/L) | 0.0011 | 0.0010 |
| Dissolved Copper (mg/L) | 0.0054 | 0.0029 |
| Dissolved Iron (mg/L) | 0.91 | 0.57 |
| Dissolved Lead (mg/L) | 0.00025 | 0.00014 |
| Dissolved Molybdenum (mg/L) | 0.0015 | 0.0011 |
| Dissolved Nickel (mg/L) | 0.0020 | 0.0016 |
| Dissolved Selenium (mg/L) | 0.00050 | 0.00046 |
| Dissolved Silver (mg/L) | 0.000010 | 0.000010 |
| Dissolved Zinc (mg/L) | 0.0084 | 0.0046 |

[1] for contaminants of potential concern (COPCs)

# 4.0 REFERENCES

Dawson, R. 2011. How significant is a boxplot outlier? Journal of Statistics Education 19: 2.

YWB (Yukon Water Board). 2015. Minto Mine Type A Water Use Licence Number QZ14-031. Issued to Minto Explorations Ltd. August 2015.

# APPENDIX A

# JUNE 2ND, 2016 MEETING MINUTES

**Minto Mine Bilateral Technical Working Group Meeting**
**Characterizing Background Water Quality for Use as Water Quality Objectives**
**SRK Consulting – Vancouver, June 2, 2016**
**Meeting Notes**

**Attendees: Bill Slater, Don MacDonald, Jesse Sinclair, Ryan Herbert, Pierre Stecko, Dylan MacGregor**

**Agenda (developed jointly)**

- Background Dataset
- Dealing with Duplicates
- Multiple locations per sampling date
- Dealing with Outliers
- Method Detection Limits
- Conditions / Binning
- Summary Statistics
- Attainment
- Confirmation of COPC list
- Water Quality Predictions Use

**Key**

Black text = items discussed
Blue text = agreed path forward
Red text = action item

**1. Background Dataset**

- Rationalize stations
- Test differences? Necessary?
- NOTE → W6 samples were taken at the wrong location in 2009-2011 (see extreme copper concentration from April 09) … exclude W6 for this timeframe
- Exclude W8
- "Background Dataset" was agreed upon … see PHOTOGRAPH of whiteboard matrix
- As with Access 2014, removed W6 data from 2009 to 2011 due to uncertainty about sampling location (may have been sampled in Minto Creek mainstem at some times)
- Prepare the dataset per spreadsheet
- Check against Access 2014. The only difference should be the exclusion of W8

**2. Dealing with Duplicates**

- There are duplicates in the database, some instances of greater replication
- Approach to consolidate to one data point per site per sampling

- Average discussed.  Simple decision when they agree well.  What if they do not?
- Average by site and date
- Identify the replicates and compare
- If good agreement, use average

3. **Multiple locations per sampling date**
   - This was an MESL addition to the agenda
   - Objective is to best represent water quality at Station W2
   - Is there pseudo-replication by including numerous reference sites to represent W2 on a given date when an alternative (better?) approach might be to use the reference dataset to identify an surrogate W2 value for that date (or campaign if within a few days)
   - Option 1 → use all data as independent
   - Option 2 → consolidate by sampling date (or campaign) to get one estimate of "W2 background" for that date and then use those data for summary statistics
   - Jesse Sinclair ran scenarios on the spot (using R?)
     - D Copper Option 1 → N 184 95$^{th}$ 6.52 median 1.70
     - D Copper Option 2 → N 124 95$^{th}$ 4.94 median 1.46
     - Not much difference for TDS or NO3
   - Tim Barrett to apply this approach and indicate implications overall (e.g., lower BG for copper [but perhaps better representative of W2])
   - Alternative from Don MacDonald = only consider W2 in 2005?
   - Group … no, now that we have agreed on background dataset, stick with it
   - Check → in baseline ONLY (2005), how would Option 1 versus Option 2 compare to actual W2 (admittedly small dataset!)

4. **Dealing with Outliers**
   - Box plot approach suggested by Tim is appropriate.
   - MESL agrees with boxplot approach, indicates that there is more than one way, but that the 3IQR method is appropriate
   - Go ahead and complete the identification of potential outliers
   - Evaluate concurrent conditions
   - Provide list of outliers to Ryan Herbert at Minto Mine
   - Ryan can help decide what is feasible to investigate.  If we can't investigate may have to make a (or practical to just toss)
   - Prepare a final list of proposed outliers to be eliminated
   - Provide list to SFN / MESL

5. **Method Detection Limits**
   - Significant issue for a number of COPCs
   - Pierre Stecko → issue could potentially be avoided by using non-parametric statistics
   - How does ½ substitution affect results if MDLs decrease in the future?
   - Pierre → acknowledge ABOVE in the document and propose a defensible way to deal with them.  Part of our responsibility is to make sure that this set up in a way that can be easily

picked up in future reviews. Implications of method changes need to be identified and, to the extent possible, guidance provided on how they should be dealt with (e.g., Tim suggests the Kaplan-Meier method).

**6. Conditions / Binning**

- Desirable not to bin
- Evidence of seasonal patterns that indicate a need to "bin"
- Investigated "under ice" versus "ice free"
- Ice April to October = ice free; "under ice" = Nov 1 to Apr 1
- Is under ice necessary? Frozen solid, no source?
- AGREE … no need to apply under ice (background characterization of "under ice" period is not required
- Ascending versus descending hydrograph (divisions from MESL 2013)
- Box plots appear comparable for the analytes that we looked at (copper, nitrate, TDS)
- Compare these two "bins" for each of the COPCs
- Statistical contrast of the two groups
- Discuss with SFN / MESL and make final decisions
- It is possible that some analytes require binning whereas others do not

**7. Summary Statistics**

- Two types – "Individual" (applies to grab sample) and "Central Tendency" (applies to average over a specified time frame [year?])
- Individual
    - 95th percentiles are appropriate
    - See attainment
    - Calculate following agreement on final dataset and approach (all previous items) with SFN / MESL

- Central Tendency
    - Fairly brief discussion on this
    - PS indicated preference for non-parametric if feasible and defensible (e.g., 95th percentile of medians), but key questions is whether data supports this in a defensible way
    - Calculate the 95th percentile on medians; is this defensible with the given data
    - Calculate other measures of central tendency (UCL of the mean)
    - Compare the methods
    - Select more appropriate

**8. Attainment**

- Individual (95th percentiles)
    - Exceedances on 2 consecutive samples. If independent, 5% * 5% probability = 0.25%
    - Sufficient time between sample to have reasonable assurance
    - This approach allows a more rapid response than waiting to evaluate exceedance rates

- Incorporate the final concept(s) into background report
- Central Tendency
  - Evaluate compliance annually. Does the annual median or mean fall within the range of background medians or means.
  - As above, must still recognize small chance of exceedance in the absence of any change.
  - Functionally, this could be an annual review item. Presumably, if the "central tendency" WQO has been exceeded, some "individual" exceedance has also occurred. The annual review should include investigation.
    - One analyte or many?
    - Frequency of exceedance of the "individual WQO"
    - Trending
    - Other?
  - Incorporate the final concept(s) into background report
- Bill Slater → these concepts work well when we are just considering future water quality relative to background, but become more complicated when considering a WQO that is a composite of background and the operation WQO.
- Don MacDonald – SFN would like to see WQO set somewhere between background and 50% of current operational WQO (WUL definition of assimilative capacity).

**COPC List**

- Don MacDonald – Would like to include TDS as a COPC with reasoning around making it easier to apply it is a communication piece with SFN. Don discussed having TDS as a major ion to follow and show the community that there are no problems with the WQ in Minto Creek.
- The group generally agrees that TDS is not expected to be an issue in closure as it relates to effects on aquatic life.
- No agreement on the inclusion of TDS in the COPC list was confirmed.
- Minto's team to discuss internally the merits of including TDS as a COPC.
- Don MacDonald – asked if we need to develop a framework to evaluating COPC's.
- Dylan MacGregor – Given the time remaining (until August $5^{th}$) it was probably not the best use of resources. The group as whole generally agreed.

**Water Quality Prediction Appropriate Use**

- Dylan MacGregor –Will have updated water quality predictions including CWTS performance expectations near end of month. Dylan has concerns regarding how water quality predictions will be used.
- Don MacDonald – we have to use predictions to determine where WQO should be set.
- Dylan MacGregor – we could use the current predictions as we have said we expect to have the CWTS performance to range from 0 to some upper percentage of removal therefore CWTS performance may not have an impact.
- Further discussions need to be had to agree on how best to use WQ predictions.

**TIMING**

- Items 1 to 6 by week of June 13th …
- Discuss week of June 20th ??

# APPENDIX B

# RAW WATER QUALITY DATA

## Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.

| Station Name | Sample Date | Total Coliforms | Fecal Coliforms | E.Coli | COD (mg/L) | Specific Conductivity in Field (µS/cm) | Radium - 226 (Bq/L) | CBOD (mg/L) | LC50 (%) | LT50 (h) | BOD5 (mg/L) | DO (mg/L) | Cond-F (µS/cm) | DO (%) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W1 | 6/30/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W1 | 7/28/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W1 | 8/29/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W1 | 9/28/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W1 | 10/15/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W2 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W2 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W2 | 6/30/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W2 | 7/28/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W2 | 8/30/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W2 | 9/28/2005 |  |  |  |  |  | 0.007 |  |  |  |  |  |  |  |  |
| W2 | 10/15/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W3 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W3 | 6/30/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W3 | 7/29/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W3 | 8/29/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W3 | 9/28/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W3 | 10/15/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W8 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W8 | 6/30/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W8 | 7/29/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W8 | 8/30/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W8 | 9/28/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W8 | 10/15/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W9 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W9 | 6/30/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W9 | 7/29/2005 |  |  |  |  |  | 0.007 |  |  |  |  |  |  |  |  |
| W9 | 8/29/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W9 | 9/28/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W9 | 10/15/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W10 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W10 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W10 | 6/30/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W10 | 7/29/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W10 | 8/29/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W10 | 9/28/2005 |  |  |  |  |  | <0.0050 |  |  |  |  |  |  |  |  |
| W10 | 10/15/2005 |  |  |  |  |  | 0.007 |  |  |  |  |  |  |  |  |
| W6 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 6/30/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 7/29/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 8/30/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 9/28/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 10/15/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 6/2/2006 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 8/25/2006 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 9/6/2006 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 6/20/2007 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 9/18/2007 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 6/17/2008 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 9/18/2008 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 4/14/2009 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 4/30/2009 |  |  |  |  |  |  |  |  |  |  |  | 0.17 | 170 |  |
| W6 | 7/28/2009 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 8/6/2009 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 8/6/2009 |  |  |  |  |  |  |  |  |  |  |  | 4.25 |  |  |
| W6 | 8/18/2009 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 8/25/2009 |  |  |  |  |  |  |  |  |  |  |  | 415 |  |  |
| W6 | 10/7/2009 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 10/7/2009 |  |  |  |  |  |  |  |  |  |  |  | 485 | 108.5 |  |
| W6 | 10/25/2009 |  |  |  |  |  |  |  |  |  |  |  | 502 | 99.4 |  |
| W6 | 4/19/2010 |  |  |  |  |  |  |  |  |  |  |  | 283 |  |  |
| W6 | 5/16/2010 |  |  |  |  |  |  |  |  |  |  |  | 192.4 |  |  |
| W6 | 5/17/2010 |  |  |  |  |  |  |  |  |  |  |  | 124.4 |  |  |
| W6 | 5/19/2010 |  |  |  |  |  |  |  |  |  |  |  | 196.2 |  |  |
| W6 | 5/21/2010 |  |  |  |  |  |  |  |  |  |  |  | 164.3 |  |  |
| W6 | 5/23/2010 |  |  |  |  |  |  |  |  |  |  |  | 216 |  |  |
| W6 | 5/25/2010 |  |  |  |  |  |  |  |  |  |  |  | 177 |  |  |
| W6 | 5/29/2010 |  |  |  |  |  |  |  |  |  |  |  | 152.3 |  |  |
| W6 | 6/2/2010 |  |  |  |  |  |  |  |  |  |  |  | 448 |  |  |
| W6 | 6/4/2010 |  |  |  |  |  |  |  |  |  |  |  | 182.2 |  |  |
| W6 | 6/6/2010 |  |  |  |  |  |  |  |  |  |  |  | 191 |  |  |
| W6 | 6/14/2010 |  |  |  |  |  |  |  |  |  |  |  | 197 |  |  |
| W6 | 6/16/2010 |  |  |  |  |  |  |  |  |  |  |  | 287 |  |  |
| W6 | 6/18/2010 |  |  |  |  |  |  |  |  |  |  |  | 279 |  |  |
| W6 | 6/20/2010 |  |  |  |  |  |  |  |  |  |  |  | 279 |  |  |
| W6 | 6/22/2010 |  |  |  |  |  |  |  |  |  |  |  | 186 | 102 |  |
| W6 | 6/24/2010 |  |  |  |  |  |  |  |  |  |  |  | 187 | 101.2 |  |
| W6 | 6/26/2010 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 6/26/2010 |  |  |  |  |  |  |  |  |  |  |  | 189 | 99.4 |  |
| W6 | 6/28/2010 |  |  |  |  |  |  |  |  |  |  |  | 178 | 101.7 |  |
| W6 | 7/5/2010 |  |  |  |  |  |  |  |  |  |  |  | 164 | 101.4 |  |
| W6 | 8/5/2010 |  |  |  |  |  |  |  |  |  |  |  | 205 | 76.7 |  |
| W6 | 9/9/2010 |  |  |  |  |  |  |  |  |  |  |  | 205 | 79.6 |  |
| W6 | 10/8/2010 |  |  |  |  |  |  |  |  |  |  |  | 209 | 94.2 |  |
| W6 | 8/19/2011 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W6 | 7/17/2012 |  |  |  |  | 193.9 |  |  |  |  |  | 117 | 118.9 | 92.3 | 74.9 |
| W6 | 7/30/2012 |  |  |  |  | 174.4 |  |  |  |  |  | 12.56 | 108.3 | 98.8 | 22.5 |
| W6 | 8/9/2012 |  |  |  |  | 217.6 |  |  |  |  |  | 12.03 | 140.2 | 97.9 | -22.9 |
| W6 | 8/25/2012 |  |  |  |  | 196 |  |  |  |  |  | 11.94 | 120.1 | 92.8 | 134.6 |
| W6 | 9/13/2012 |  |  |  |  | 171.5 |  |  |  |  |  | 13.7 | 95.8 | 94.3 | 64.9 |
| W6 | 10/13/2012 |  |  |  |  | 194.5 |  |  |  |  |  | 13.83 | 101.6 | 94.7 | 27.8 |
| W6 | 11/12/2012 |  |  |  |  | 365.5 |  |  |  |  |  |  | 190 |  | 249.6 |
| W6 | 5/14/2013 |  |  |  |  | 53.6 |  |  |  |  |  | 13.22 | 28.1 | 92.1 | 137.8 |
| W6 | 6/22/2013 |  |  |  |  | 172.6 |  |  |  |  |  | 12.33 |  | 88.6 | 79.4 |
| W6 | 7/12/2013 |  |  |  |  | 180.5 |  |  |  |  |  | 11.38 | 109 | 87.7 | 93.3 |
| W6 | 8/22/2013 |  |  |  |  | 204.1 |  |  |  |  |  | 11.81 | 127.8 | 102.4 | 22.8 |
| W6 | 9/6/2013 |  |  |  |  | 201.8 |  |  |  |  |  | 11.85 | 122.7 | 98.7 | 20.4 |
| W6 | 10/7/2013 |  |  |  |  | 191 |  |  |  |  |  | 14.61 | 104.1 | 102.3 | 36.2 |
| W6 | 11/16/2013 |  |  |  |  | 196.2 |  |  |  |  |  | 8.31 | 102.6 | 68.3 | 98.6 |
| W6 | 12/7/2013 |  |  |  |  |  |  |  |  |  |  |  | 231 |  |  |
| W7 | 5/27/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W7 | 6/30/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W7 | 7/29/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W7 | 8/30/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W7 | 9/28/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W7 | 10/15/2005 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W7 | 6/2/2006 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| W7 | 6/8/2006 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Total Coliforms | Fecal Coliforms | E.Coli | COD (mg/L) | Specific Conductivity in Field (µS/cm) | Radium - 226 (Bq/L) | CBOD (mg/L) | LC50 (%) | LT50 (h) | BOD5 (mg/L) | DO (mg/L) | Cond-F (µS/cm) | DO (%) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/23/2006 | | | | | | | | | | | | | | |
| W7 | 6/28/2006 | | | | | | | | | | | | | | |
| W7 | 7/7/2006 | | | | | | | | | | | | | | |
| W7 | 7/12/2006 | | | | | | | | | | | | | | |
| W7 | 7/20/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 8/2/2006 | | | | | | | | | | | | | | |
| W7 | 8/10/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/30/2006 | | | | | | | | | | | | | | |
| W7 | 9/6/2006 | | | | | | | | | | | | | | |
| W7 | 9/13/2006 | | | | | | | | | | | | | | |
| W7 | 9/20/2006 | | | | | | | | | | | | | | |
| W7 | 9/28/2006 | | | | | | | | | | | | | | |
| W7 | 10/4/2006 | | | | | | | | | | | | | | |
| W7 | 10/12/2006 | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/20/2007 | | | | | | | | | | | | | | |
| W7 | 7/18/2007 | | | | | | | | | | | | | | |
| W7 | 7/18/2007 | | | | | | | | | | | | | | |
| W7 | 7/18/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 9/18/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/17/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 9/18/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 4/30/2009 | | | | | | <0.006 | | | | | | 37.6 | 183 | |
| W7 | 6/8/2009 | | | | | | | | | | | | 211 | | |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | | | | | | | | | | | | 289 | | |
| W7 | 8/24/2009 | | | | | | 0.01 | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | 253 | | |
| W7 | 8/31/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | <0.005 | | | | | | 258 | 109 | |
| W7 | 10/25/2009 | | | | | | <0.005 | | | | | | 269 | 88 | |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | | | | | | | | | | | | 437 | | |
| W7 | 4/27/2010 | | | | | | | | | | | | 67 | 59.2 | |
| W7 | 4/29/2010 | | | | | | | | | | | | 35 | 8.8 | |
| W7 | 5/1/2010 | | | | | | | | | | | | 82 | 102.2 | |
| W7 | 5/3/2010 | | | | | | | | | | | | 89 | 90.2 | |
| W7 | 5/5/2010 | | | | | | | | | | | | | | |
| W7 | 5/7/2010 | | | | | | | | | | | | 118 | 83.3 | |
| W7 | 5/9/2010 | | | | | | | | | | | | 171 | 129.2 | |
| W7 | 5/10/2010 | | | | | | | | | | | | 175 | 133.9 | |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/14/2010 | | | | | | | | | | | | 145 | | |
| W7 | 5/16/2010 | | | | | | | | | | | | 167.4 | | |
| W7 | 5/17/2010 | | | | | | | | | | | | 161.6 | | |
| W7 | 5/19/2010 | | | | | | | | | | | | 199.4 | | |
| W7 | 5/21/2010 | | | | | | | | | | | | 191 | | |
| W7 | 5/23/2010 | | | | | | | | | | | | 216 | | |
| W7 | 5/25/2010 | | | | | | | | | | | | 224 | | |
| W7 | 5/27/2010 | | | | | | | | | | | | 234 | | |
| W7 | 5/29/2010 | | | | | | | | | | | | 243 | | |
| W7 | 5/31/2010 | | | | | | | | | | | | 249 | | |
| W7 | 6/2/2010 | | | | | | | | | | | | 254 | | |
| W7 | 6/4/2010 | | | | | | | | | | | | 667 | | |
| W7 | 6/6/2010 | | | | | | | | | | | | 262 | | |
| W7 | 6/14/2010 | | | | | | | | | | | | 297 | | |
| W7 | 6/16/2010 | | | | | | | | | | | | 364 | | |
| W7 | 6/18/2010 | | | | | | | | | | | | 360 | | |
| W7 | 6/20/2010 | | | | | | | | | | | | 342 | | |
| W7 | 6/22/2010 | | | | | | | | | | | | 205 | 107.1 | |
| W7 | 6/24/2010 | | | | | | | | | | | | 211 | 105.6 | |
| W7 | 6/26/2010 | | | | | | | | | | | | 229 | 107.3 | |
| W7 | 6/28/2010 | | | | | | | | | | | | 245 | 105.1 | |
| W7 | 7/5/2010 | | | | | | | | | | | | 194 | 104.5 | |
| W7 | 8/5/2010 | | | | | | | | | | | | 240 | 78.1 | |
| W7 | 9/12/2010 | | | | | | | | | | | | | | |
| W7 | 9/12/2010 | | | | | | <0.005 | | | | | | 210 | 84.5 | |
| W7 | 10/8/2010 | | | | | | | | | | | | 235 | 100.3 | |
| W7 | 4/27/2011 | | | | | | | | | | | | | | |
| W7 | 5/2/2011 | | | | | | | | | | | | | | |
| W7 | 6/1/2011 | | | | | | | | | | | | | | |
| W7 | 6/16/2011 | | | | | | | | | | | | | | |
| W7 | 7/1/2011 | | | | | | | | | | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Total Coliforms | Fecal Coliforms | E.Coli | COD (mg/L) | Specific Conductivity in Field (µS/cm) | Radium - 226 (Bq/L) | CBOD (mg/L) | LC50 (%) | LT50 (h) | BOD5 (mg/L) | DO (mg/L) | Cond-F (µS/cm) | DO (%) | ORP (mV) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | | | | | | | | | | | | | | |
| W7 | 8/16/2011 | | | | | | | | | | | | | | |
| W7 | 8/19/2011 | | | | | | | | | | | | | | |
| W7 | 9/12/2011 | | | | | | | | | | | 18.55 | 204.1 | 133.5 | |
| W7 | 10/6/2011 | | | | | | | | | | | 12.13 | 250.8 | 83.1 | |
| W7 | 11/22/2011 | | | | | | | | | | | | | | |
| W7 | 1/24/2012 | | | | | | | | | | | | | | |
| W7 | 2/25/2012 | | | | | 296.9 | | | | | | 10.92 | 155.2 | 74.6 | |
| W7 | 3/5/2012 | | | | | 272.6 | | | | | | 11.47 | 142.3 | 78.9 | |
| W7 | 4/24/2012 | | | | | 75.6 | | | | | | 15.55 | 39.5 | 106.3 | |
| W7 | 5/6/2012 | | | | | | | | | | | | | | |
| W7 | 5/6/2012 | | | | | 88.8 | | | | | | 8.53 | 46.4 | 58.4 | 116.8 |
| W7 | 6/19/2012 | | | | | 202.6 | | | | | | 12.45 | 121.6 | 95.1 | 44.5 |
| W7 | 7/17/2012 | | | | | 244.2 | | | | | | 12.31 | 152.9 | 97.4 | 45.6 |
| W7 | 7/30/2012 | | | | | 235.1 | | | | | | 12.64 | 142.6 | 97.6 | 16 |
| W7 | 8/8/2012 | | | | | 268.5 | | | | | | 12.65 | 164.5 | 98.5 | -6.2 |
| W7 | 8/23/2012 | | | | | 264.6 | | | | | | 10.94 | 161.3 | 84.8 | -2.4 |
| W7 | 9/13/2012 | | | | | 224 | | | | | | 13.04 | 126.2 | 94.1 | 76.7 |
| W7 | 10/16/2012 | | | | | 258.9 | | | | | | 17.1 | 137.8 | 118.3 | 18 |
| W7 | 11/2/2012 | | | | | | | | | | | | | | |
| W7 | 12/29/2012 | | | | | 2107 | | | | | | 9.38 | 1090 | 72.5 | 289.9 |
| W7 | 4/30/2013 | | | | | 365.3 | | | | | | | 190.6 | 101.8 | -50 |
| W7 | 5/14/2013 | | | | | 59.7 | | | | | | 13.46 | 31.1 | 92.4 | 109.7 |
| W7 | 6/19/2013 | | | | | | | | | | | | | | |
| W7 | 6/19/2013 | | | | | | | | | | | | 249 | | |
| W7 | 7/13/2013 | | | | | 250.7 | | | | | | 11.92 | 148 | 90 | 108.7 |
| W7 | 8/21/2013 | | | | | 280.6 | | | | | | 12.06 | 168 | 101 | 32.7 |
| W7 | 9/6/2013 | | | | | 277.3 | | | | | | 11.37 | 166.3 | 93.5 | 38.1 |
| W7 | 10/21/2013 | | | | | 286.3 | | | | | | 11.57 | 149.3 | 77.7 | 16.6 |
| W7 | 11/16/2013 | | | | | 197.6 | | | | | | 7.17 | 104.3 | 61.8 | 94.7 |
| W7 | 12/7/2013 | | | | | | | | | | | | 198 | | |
| C4 | 5/6/2012 | | | | | 100.1 | | | | | | 10.69 | 52.4 | 73.1 | 63.9 |
| C4 | 8/1/2012 | | | | | 196.8 | | | | | | 10.45 | 138.1 | 91.3 | -38.1 |
| C4 | 8/8/2012 | | | | | 246.3 | | | | | | 11.52 | 165.3 | 97.1 | -54.1 |
| C4 | 8/25/2012 | | | | | 230.8 | | | | | | 11.18 | 148.8 | 91 | -21.8 |
| C4 | 6/22/2013 | | | | | 223.8 | | | | | | 10.58 | | 87.9 | 93.7 |
| C4 | 7/19/2013 | | | | | | | | | | | | 260 | | |
| C4 | 8/22/2013 | | | | | 246.6 | | | | | | 11.35 | 166.1 | 103.6 | 11.6 |
| C4 | 9/6/2013 | | | | | 246.2 | | | | | | 11.56 | 153.8 | 98.7 | -28.8 |
| C4 | 10/18/2013 | | | | | | | | | | | | | | |
| C4 | 10/18/2013 | | | | | 257.1 | | | | | | 13.73 | 134.1 | 92.3 | -20.1 |
| C4 | 11/17/2013 | | | | | 274.1 | | | | | | 4.27 | 142.7 | 28.4 | 101.5 |
| C10 | 5/12/2012 | | | | | 144 | | | | | | 13.64 | 82 | 99.9 | 45.3 |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 7/30/2012 | | | | | 216.7 | | | | | | 9.03 | 159.3 | 3 | 44.8 |
| C10 | 8/10/2012 | | | | | 269 | | | | | | 12.15 | 179 | 101.3 | -28.1 |
| C10 | 8/27/2012 | | | | | 257.4 | | | | | | 11.33 | 170.7 | 94.1 | 27 |
| C10 | 6/22/2013 | | | | | 242.7 | | | | | | 9.91 | | 91.1 | 85.9 |
| C10 | 7/23/2013 | | | | | 227.6 | | | | | | 11.31 | 153 | 95.3 | 97.7 |
| C10 | 8/22/2013 | | | | | 304.4 | | | | | | 11.25 | 206.6 | 101.4 | 143.1 |
| C10 | 9/8/2013 | | | | | | | | | | | | | | |
| C10 | 9/8/2013 | | | | | 213.8 | | | | | | 10.32 | 146.2 | 96.1 | 103.3 |
| C10 | 10/18/2013 | | | | | 262.4 | | | | | | 14.43 | 137.1 | 96.2 | 84.9 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Field pH (pH units) | Field Turbidity (NTU) | Field Temp (° C) | Sulphide (mg/L) | Dissolved SO4 (mg/L) | Total SO4 (mg/L) | TT CN (mg/L) | Chloride (mg/L) | Bromine (mg/L) | Fluoride (mg/L) | Chromium 6 (mg/L) | Chromium III (mg/L) | Cu-D-IH (mg/L) | Al-D-IH (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | | | | | 19.7 | 12.8 | | <0.50 | | | | | | |
| W1 | 6/30/2005 | | | | | 22.4 | 22.4 | 0.011 | 1.2 | | | | | | |
| W1 | 7/28/2005 | | | | | | 19.1 | 0.0054 | 0.64 | | | | | | |
| W1 | 8/29/2005 | | | | | 12.4 | 12.4 | 0.0065 | 0.52 | | | | | | |
| W1 | 9/28/2005 | | | | | 11.8 | 11.8 | 0.0118 | 0.73 | | | | | | |
| W1 | 10/15/2005 | | | | | | 13.9 | 0.125 | 0.91 | | | | | | |
| W2 | 5/27/2005 | | | | | | 12.8 | | <0.50 | | | | | | |
| W2 | 5/27/2005 | | | | | 9.64 | | | <0.5 | | | | | | |
| W2 | 6/30/2005 | | | | | 22.1 | 22.1 | <0.0050 | 1.23 | | | | | | |
| W2 | 7/28/2005 | | | | | | 19 | <0.0050 | 0.66 | | | | | | |
| W2 | 8/30/2005 | | | | | 12.6 | 12.6 | 0.0053 | 0.53 | | | | | | |
| W2 | 9/28/2005 | | | | | 11.6 | 11.6 | 0.0106 | 0.72 | | | | | | |
| W2 | 10/15/2005 | | | | | | 14 | 0.0101 | 0.88 | | | | | | |
| W3 | 5/27/2005 | | | | | 2.4 | 19.7 | | <0.50 | | | | | | |
| W3 | 6/30/2005 | | | | | 45.5 | 45.5 | <0.0050 | 0.86 | | | | | | |
| W3 | 7/29/2005 | | | | | | 29.6 | <0.0050 | <0.50 | | | | | | |
| W3 | 8/29/2005 | | | | | 25.5 | 25.5 | 0.0091 | <0.50 | | | | | | |
| W3 | 9/28/2005 | | | | | 23.9 | 23.9 | 0.013 | <0.50 | | | | | | |
| W3 | 10/15/2005 | | | | | | 24.7 | 0.014 | <0.50 | | | | | | |
| W8 | 5/27/2005 | | | | | 166 | 7.62 | | <0.50 | | | | | | |
| W8 | 6/30/2005 | | | | | <1 | <1.0 | | 0.86 | | | | | | |
| W8 | 7/29/2005 | | | | | | 7.08 | | <0.50 | | | | | | |
| W8 | 8/30/2005 | | | | | 5.1 | 5.1 | | <0.50 | | | | | | |
| W8 | 9/28/2005 | | | | | 7.72 | 7.72 | | <0.50 | | | | | | |
| W8 | 10/15/2005 | | | | | | 24.8 | | <0.50 | | | | | | |
| W9 | 5/27/2005 | | | | | 35.3 | 11.8 | | <0.50 | | | | | | |
| W9 | 6/30/2005 | | | | | 18.4 | 18.4 | <0.0050 | <5.0 | | | | | | |
| W9 | 7/29/2005 | | | | | | 16.5 | <0.0050 | <0.50 | | | | | | |
| W9 | 8/29/2005 | | | | | 17.9 | 17.9 | 0.0124 | <0.50 | | | | | | |
| W9 | 9/28/2005 | | | | | 16.7 | 16.7 | 0.0128 | <0.50 | | | | | | |
| W9 | 10/15/2005 | | | | | | 17.4 | 0.0164 | <0.50 | | | | | | |
| W10 | 5/27/2005 | | | | | | <0.50 | | <0.50 | | | | | | |
| W10 | 5/27/2005 | | | | | | | | <0.5 | | | | | | |
| W10 | 6/30/2005 | | | | | <10 | <10 | <0.0050 | <5.0 | | | | | | |
| W10 | 7/29/2005 | | | | | | 1.56 | <0.0050 | <0.50 | | | | | | |
| W10 | 8/29/2005 | | | | | 1.82 | 1.82 | 0.0226 | <0.50 | | | | | | |
| W10 | 9/28/2005 | | | | | 4.13 | 4.13 | 0.0136 | <0.50 | | | | | | |
| W10 | 10/15/2005 | | | | | | 4.19 | 0.018 | <0.50 | | | | | | |
| W6 | 5/27/2005 | | | | | 11.8 | 2.4 | | <0.50 | | | | | | |
| W6 | 6/30/2005 | | | | | <1 | <1.0 | | 0.73 | | | | | | |
| W6 | 7/29/2005 | | | | | | 29.2 | | <0.50 | | | | | | |
| W6 | 8/30/2005 | | | | | 2.62 | 2.62 | | <0.50 | | | | | | |
| W6 | 9/28/2005 | | | | | 4.04 | 4.04 | | 0.5 | | | | | | |
| W6 | 10/15/2005 | | | | | | 4.69 | | 0.52 | | | | | | |
| W6 | 6/2/2006 | | | | | 1.88 | | | <0.5 | <0.05 | 0.176 | | | | |
| W6 | 8/25/2006 | | | | | 2.4 | | | | | | | | | |
| W6 | 9/6/2006 | | | | | 2.3 | | | | | | | | | |
| W6 | 6/20/2007 | | | | | 2.1 | | | 0.4 | | | | | | |
| W6 | 9/18/2007 | | | | | 2.51 | | | 0.59 | | | | | | |
| W6 | 6/17/2008 | | | | | 1.64 | | | 0.29 | | | | | | |
| W6 | 9/18/2008 | | | | | 3.29 | | | 0.41 | | | | | | |
| W6 | 4/14/2009 | | | | | 6.28 | | | 6.32 | | | | | | |
| W6 | 4/30/2009 | 8.2 | | 5.6 | | 7.44 | | | 0.76 | | | | | | |
| W6 | 7/28/2009 | | | | | 42.9 | | | 6.17 | | | | | | |
| W6 | 8/6/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | 7.25 | | 9.6 | | 48.4 | | | 9.84 | | | | | | |
| W6 | 8/18/2009 | | | | | | | | | | | | | | |
| W6 | 8/25/2009 | 7.82 | | 10.8 | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | 62.2 | | | 27.8 | | | | | | |
| W6 | 10/7/2009 | 8.14 | | 4.22 | | 63.3 | | | 33.3 | | | | | | |
| W6 | 10/25/2009 | 8.12 | | 2.36 | | | | | | | | | | | |
| W6 | 4/19/2010 | 6.6 | | 1 | | 30.3 | | | <0.02 | | | | | | |
| W6 | 5/16/2010 | 7.52 | | 1.1 | | 6.2 | | | 1 | <0.4 | 0.56 | | | | |
| W6 | 5/17/2010 | 7.7 | | 1.1 | | 8.1 | | | 0.8 | <0.4 | 0.22 | | | | |
| W6 | 5/19/2010 | 7.87 | | 1.1 | | 13 | | | 1 | <0.4 | 0.27 | | | | |
| W6 | 5/21/2010 | 8.01 | | 2.6 | | 7.2 | | | 0.9 | <0.4 | 0.26 | | | | |
| W6 | 5/23/2010 | 7.34 | | 1 | | 16 | | | 2.1 | <0.4 | 0.31 | | | | |
| W6 | 5/25/2010 | 7.48 | | 1 | | 17 | | | 1.4 | <0.4 | 0.29 | | | | |
| W6 | 5/29/2010 | 7.79 | | 1.4 | | 3.5 | | | 0.8 | <0.4 | 0.24 | | | | |
| W6 | 6/2/2010 | 7.38 | | 1.5 | | 49 | | | 6.4 | <0.4 | 0.43 | | | | |
| W6 | 6/4/2010 | 7.87 | | 2.6 | | <0.5 | | | <0.5 | <0.4 | 0.2 | | | | |
| W6 | 6/6/2010 | | | 1.6 | | <0.5 | | | <0.5 | <0.4 | 0.21 | | | | |
| W6 | 6/14/2010 | 6.65 | | 3.8 | | 1.4 | | | <0.5 | <0.4 | 0.23 | | | | |
| W6 | 6/16/2010 | 6.8 | | 2.5 | | <0.5 | | | <0.5 | <0.4 | 0.22 | | | | |
| W6 | 6/18/2010 | 7.03 | | 2.9 | | <0.5 | | | <0.5 | <0.4 | 0.23 | | | | |
| W6 | 6/20/2010 | 6.38 | | 3.1 | | 0.7 | | | <0.5 | <0.4 | 0.23 | | | | |
| W6 | 6/22/2010 | 7.8 | -0.2 | 1.92 | | <0.5 | | | <0.5 | <0.4 | 0.23 | | | | |
| W6 | 6/24/2010 | 7.91 | -1.2 | 2.38 | | <0.5 | | | <0.5 | <0.4 | 0.25 | | | | |
| W6 | 6/26/2010 | | | | | <0.5 | | | <0.5 | <0.4 | 0.24 | | | | |
| W6 | 6/26/2010 | 7.78 | -1 | 2.45 | | | | | | | | | | | |
| W6 | 6/28/2010 | 7.99 | 5.2 | 2.79 | | <0.5 | | | <0.5 | <0.4 | 0.22 | | | | |
| W6 | 7/5/2010 | 7.99 | 23.1 | 3.71 | | <0.5 | | | <0.5 | <0.4 | 0.2 | | | | |
| W6 | 8/5/2010 | 7.96 | -0.4 | 6.72 | | <0.5 | | | 0.5 | <0.4 | 0.23 | | | | |
| W6 | 9/9/2010 | 7.99 | 9.5 | 5.1 | | <0.5 | | | 0.7 | <0.4 | 0.26 | | | | |
| W6 | 10/8/2010 | 7.75 | -1.3 | -0.18 | | 2.1 | | | <0.5 | <0.4 | 0.21 | | | | |
| W6 | 8/19/2011 | | | | | | | | | | | | | | |
| W6 | 7/17/2012 | 7.92 | | 4.8 | | 1.82 | | | 1 | | 0.25 | | | | |
| W6 | 7/30/2012 | 7.89 | | 5.2 | | <0.50 | | | 0.58 | | 0.3 | | | | |
| W6 | 8/9/2012 | 8.09 | | 6.4 | | 0.64 | | | 1.1 | | 0.28 | | | | |
| W6 | 8/25/2012 | 7.76 | | 4.7 | | <0.50 | | | 0.92 | | 0.28 | | | | |
| W6 | 9/13/2012 | 7.95 | | 1.9 | | 0.62 | | | 1.1 | | 0.22 | | | | |
| W6 | 10/13/2012 | 8.3 | | 0 | | 1.52 | | | 0.87 | | 0.23 | | | | |
| W6 | 11/12/2012 | 6.69 | | -0.1 | | 5.81 | | | 1.1 | | 0.23 | | | | |
| W6 | 5/14/2013 | 7.6 | | 0.1 | | <0.50 | | | 1.5 | | 0.083 | | | | |
| W6 | 6/22/2013 | 7.61 | | 1.6 | | 1.88 | | | 1.1 | | 0.22 | | | | |
| W6 | 7/12/2013 | 7.69 | | 4.4 | | 1.27 | | | 1 | | 0.23 | | | | |
| W6 | 8/22/2013 | 7.81 | | 5.4 | | 0.53 | | | 0.84 | | 0.23 | | | | |
| W6 | 9/6/2013 | 7.60 | | 4.5 | | 0.62 | | | 1.2 | | 0.26 | | | | |
| W6 | 10/7/2013 | 7.66 | | 1.2 | | 1.89 | | | 0.8 | | 0.25 | | | | |
| W6 | 11/16/2013 | 7.96 | | -0.1 | | 1.48 | | | 0.78 | | 0.24 | | | | |
| W6 | 12/7/2013 | 7.50 | | 0 | | 5.36 | | | 1.4 | | 0.28 | | | | |
| W7 | 5/27/2005 | | | | | <0.5 | 6.18 | | <0.50 | | | | | | |
| W7 | 6/30/2005 | | | | | 10.2 | 10.2 | | 0.92 | | | | | | |
| W7 | 7/29/2005 | | | | | | 29.9 | | <0.50 | | | | | | |
| W7 | 8/30/2005 | | | | | 6.02 | 6.02 | | <0.50 | | | | | | |
| W7 | 9/28/2005 | | | | | 5.62 | 5.62 | | <0.50 | | | | | | |
| W7 | 10/15/2005 | | | | | | 7.47 | | <0.50 | | | | | | |
| W7 | 6/2/2006 | | | | | 2.98 | | | <0.5 | <0.05 | 0.155 | | | | |
| W7 | 6/8/2006 | | | | | | | | | | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Field pH (pH units) | Field Turbidity (NTU) | Field Temp (° C) | Sulphide (mg/L) | Dissolved SO4 (mg/L) | Total SO4 (mg/L) | TT CN (mg/L) | Chloride (mg/L) | Bromine (mg/L) | Fluoride (mg/L) | Chromium 6 (mg/L) | Chromium III (mg/L) | Cu-D-IH (mg/L) | Al-D-IH (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | | | | | 10.5 | | | | | | | | | |
| W7 | 6/23/2006 | | | | | 15.1 | | | | | | | | | |
| W7 | 6/28/2006 | | | | | | | | | | | | | | |
| W7 | 7/7/2006 | | | | | 10.8 | | | | | | | | | |
| W7 | 7/12/2006 | | | | | 10.4 | | | | | | | | | |
| W7 | 7/20/2006 | | | | | 10.5 | | | | | | | | | |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | | | | | 11.6 | | | | | | | | | |
| W7 | 8/2/2006 | | | | | 10 | | | | | | | | | |
| W7 | 8/10/2006 | | | | | 10 | | | | | | | | | |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | | | | | 11 | | | | | | | | | |
| W7 | 8/30/2006 | | | | | 10.5 | | | | | | | | | |
| W7 | 9/6/2006 | | | | | 10.3 | | | | | | | | | |
| W7 | 9/13/2006 | | | | | 10 | | | | | | | | | |
| W7 | 9/20/2006 | | | | | 11 | | | | | | | | | |
| W7 | 9/28/2006 | | | | | 11 | | | | | | | | | |
| W7 | 10/4/2006 | | | | | 10.9 | | | | | | | | | |
| W7 | 10/12/2006 | | | | | 11.3 | | | | | | | | | |
| W7 | 6/5/2007 | | | | | 11 | | | 0.7 | | | | | | |
| W7 | 6/5/2007 | | | | | 11 | | | 0.7 | | | | | | |
| W7 | 6/5/2007 | | | | | 11 | | | 0.7 | | | | | | |
| W7 | 6/20/2007 | | | | | 12.2 | | | 0.6 | | | | | | |
| W7 | 7/18/2007 | | | | | 11.9 | | | 0.6 | | | | | | |
| W7 | 7/18/2007 | | | | | 11.9 | | | 0.6 | | | | | | |
| W7 | 7/18/2007 | | | | | 11.9 | | | 0.6 | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | 10.3 | | | 0.3 | | | | | | |
| W7 | 8/24/2007 | | | | | 10.2 | | | 0.3 | | | | | | |
| W7 | 8/24/2007 | | | | | 10.3 | | | 0.3 | | | | | | |
| W7 | 9/18/2007 | | | | | 8.21 | | | 0.46 | | | | | | |
| W7 | 10/30/2007 | | | | | 13 | | | 0.96 | | | | | | |
| W7 | 10/30/2007 | | | | | 13.6 | | | 1.32 | | | | | | |
| W7 | 10/30/2007 | | | | | 13 | | | 0.88 | | | | | | |
| W7 | 10/30/2007 | | | | | 13 | | | 0.91 | | | | | | |
| W7 | 4/22/2008 | | | | | 27.6 | | | 0.8 | | | | | | |
| W7 | 4/22/2008 | | | | | 27.8 | | | 0.62 | | | | | | |
| W7 | 4/22/2008 | | | | | 27.8 | | | 0.78 | | | | | | |
| W7 | 4/22/2008 | | | | | 27.8 | | | 0.62 | | | | | | |
| W7 | 6/3/2008 | | | | | 10.4 | | | 0.38 | | | | | | |
| W7 | 6/3/2008 | | | | | 10.4 | | | 0.37 | | | | | | |
| W7 | 6/3/2008 | | | | | 10.4 | | | 0.38 | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/17/2008 | | | | | 12.9 | | | 0.42 | | | | | | |
| W7 | 8/6/2008 | | | | | 9.89 | | | 0.29 | | | | | | |
| W7 | 8/6/2008 | | | | | 9.98 | | | 0.29 | | | | | | |
| W7 | 8/6/2008 | | | | | 9.98 | | | 0.3 | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 9/18/2008 | | | | | 5.44 | | | 0.57 | | | | | | |
| W7 | 10/28/2008 | | | | | 9.43 | | | 0.34 | | | | | | |
| W7 | 10/28/2008 | | | | | 9.36 | | | 0.31 | | | | | | |
| W7 | 10/28/2008 | | | | | 9.44 | | | 0.31 | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 4/30/2009 | 7.6 | | 0.4 | | 0.65 | | | 0.38 | | | | | | |
| W7 | 6/8/2009 | 7.74 | | 3.27 | | 8.6 | | | 4.1 | | | | | | |
| W7 | 7/28/2009 | | | | | 13 | | | 0.82 | | | | | | |
| W7 | 8/6/2009 | 7.5 | | 4.4 | | 13 | | | 0.39 | | | | | | |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | 8.04 | | 3.02 | | | | | | | | | | | |
| W7 | 8/31/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | 8.24 | | -0.8 | | 9.9 | | | 0.61 | | | | | | |
| W7 | 10/25/2009 | 8.23 | | 0.2 | | | | | | | | | | | |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | 7.31 | | 1 | | 8.2 | | | 0.91 | | | | | | |
| W7 | 4/27/2010 | 7.65 | 0 | -0.07 | | 7 | | | 1.4 | <0.4 | 0.08 | | | | |
| W7 | 4/29/2010 | 7.72 | -0.4 | -0.07 | | <5 | | | 0.9 | <0.4 | 0.09 | | | | |
| W7 | 5/1/2010 | 7.15 | 6.9 | -0.06 | | <5 | | | 1.2 | <0.4 | 0.11 | | | | |
| W7 | 5/3/2010 | 7.74 | 6.3 | 0.04 | | <0.5 | | | 0.8 | <0.4 | 0.11 | | | | |
| W7 | 5/5/2010 | | | | | <0.5 | | | 0.9 | <0.4 | 0.13 | | | | |
| W7 | 5/7/2010 | 7.95 | 5.6 | 0.03 | | <0.5 | | | 0.8 | <0.4 | 0.13 | | | | |
| W7 | 5/9/2010 | 8.03 | -0.8 | 0.8 | | 9.1 | | | 1.2 | <0.4 | 0.22 | | | | |
| W7 | 5/10/2010 | 8.06 | -0.9 | 0.07 | | 3.9 | | | 0.6 | <0.4 | 0.2 | | | | |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | | | | | 5.4 | | | <0.5 | <0.4 | 0.11 | | | | |
| W7 | 5/14/2010 | 7.26 | | 1.1 | | 5.2 | | | <0.5 | <0.4 | 0.18 | | | | |
| W7 | 5/16/2010 | 7.32 | | 1.10 | | 7.6 | | | 0.6 | <0.4 | 0.2 | | | | |
| W7 | 5/17/2010 | 7.52 | | 1 | | 5.6 | | | <0.5 | <0.4 | 0.19 | | | | |
| W7 | 5/19/2010 | 7.62 | | 1 | | 9.7 | | | <0.5 | <0.4 | 0.25 | | | | |
| W7 | 5/21/2010 | 8.02 | | 1.2 | | 9.3 | | | 0.8 | <0.4 | 0.26 | | | | |
| W7 | 5/23/2010 | 7.61 | | 1 | | 9.9 | | | 1 | <0.4 | 0.28 | | | | |
| W7 | 5/25/2010 | 7.24 | | 1.2 | | 11 | | | 0.8 | <0.4 | 0.28 | | | | |
| W7 | 5/27/2010 | 7.53 | | 3 | | 12 | | | <0.5 | <0.4 | 0.3 | | | | |
| W7 | 5/29/2010 | 7.73 | | 1 | | 12 | | | 0.7 | <0.4 | 0.32 | | | | |
| W7 | 5/31/2010 | 7.83 | | 1.2 | | 12 | | | 0.7 | <0.4 | 0.32 | | | | |
| W7 | 6/2/2010 | 7.26 | | 1.4 | | 12 | | | <0.5 | <0.4 | 0.31 | | | | |
| W7 | 6/4/2010 | 7.48 | | 3.1 | | 13 | | | 0.8 | <0.4 | 0.31 | | | | |
| W7 | 6/6/2010 | | | 1.9 | | 12 | | | <0.5 | <0.4 | 0.32 | | | | |
| W7 | 6/14/2010 | | | 3.8 | | 13 | | | <0.5 | <0.4 | 0.35 | | | | |
| W7 | 6/16/2010 | 6.78 | | 2.6 | | 14 | | | <0.5 | <0.4 | 0.35 | | | | |
| W7 | 6/18/2010 | 7.03 | | 3 | | 12 | | | <0.5 | <0.4 | 0.34 | | | | |
| W7 | 6/20/2010 | 7.1 | | 3.4 | | 10 | | | 0.5 | <0.4 | 0.31 | | | | |
| W7 | 6/22/2010 | 7.92 | 135 | 3.25 | | 8.2 | | | <0.5 | <0.4 | 0.25 | | | | |
| W7 | 6/24/2010 | 7.95 | 30 | 3.55 | | 6.4 | | | <0.5 | <0.4 | 0.28 | | | | |
| W7 | 6/26/2010 | 8.03 | 9.7 | 3.12 | | 7.8 | | | <0.5 | <0.4 | 0.3 | | | | |
| W7 | 6/28/2010 | 7.89 | 2.3 | 2.94 | | 9.7 | | | <0.5 | <0.4 | 0.29 | | | | |
| W7 | 7/5/2010 | 8.02 | 35.4 | 4.48 | | 2.5 | | | <0.5 | <0.4 | 0.22 | | | | |
| W7 | 8/5/2010 | 7.91 | 3.1 | 5.57 | | | | | | | | | | | |
| W7 | 9/12/2010 | | | | | | | | | | | | | | |
| W7 | 9/12/2010 | 8.02 | 0.8 | 4.06 | | 6.4 | | | 0.7 | <0.4 | 0.22 | | | | |
| W7 | 10/8/2010 | 7.85 | -2.7 | -0.18 | | 8.8 | | | <0.5 | <0.4 | 0.23 | | | | |
| W7 | 4/27/2011 | | | | | <5 | | | 1.9 | | 0.1 | | | | |
| W7 | 5/2/2011 | | | | | <5 | | | 1.7 | | 0.08 | | | | |
| W7 | 6/1/2011 | | | | | 6.1 | | | 0.5 | | 0.24 | | | | |
| W7 | 6/16/2011 | | | | | | | | | | | | | | |
| W7 | 7/1/2011 | | | | | <0.5 | | | | | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Field pH (pH units) | Field Turbidity (NTU) | Field Temp (° C) | Sulphide (mg/L) | Dissolved SO4 (mg/L) | Total SO4 (mg/L) | TT CN (mg/L) | Chloride (mg/L) | Bromine (mg/L) | Fluoride (mg/L) | Chromium 6 (mg/L) | Chromium III (mg/L) | Cu-D-IH (mg/L) | Al-D-IH (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | | | | | | | | 1.8 | | 0.14 | | | | |
| W7 | 8/16/2011 | | | | | | | | | | | | | | |
| W7 | 8/19/2011 | | | | | | | | | | | | | | |
| W7 | 9/12/2011 | 7.92 | | 1.9 | | | | | 1.3 | | | | | | |
| W7 | 10/6/2011 | 7.65 | | 0 | | 8.9 | | | 1 | | | | | | |
| W7 | 11/22/2011 | | | | | | | | 0.8 | | | | | | |
| W7 | 1/24/2012 | | | | | 18 | | | 0.8 | | 0.43 | | | | |
| W7 | 2/25/2012 | 7.16 | | 0.00 | | 17.8 | | | 0.9 | | 0.42 | | | | |
| W7 | 3/5/2012 | 6.72 | | 0 | | 19 | | | 0.5 | | 0.42 | | | | |
| W7 | 4/24/2012 | 7.43 | | 0 | | <0.50 | | | 1.4 | | 0.1 | | | | |
| W7 | 5/6/2012 | | | | | <0.50 | | | 0.58 | | 0.12 | | | | |
| W7 | 5/6/2012 | 7.1 | | 0 | | <0.50 | | | <0.50 | | 0.12 | | | | |
| W7 | 6/19/2012 | 7.59 | | 4.1 | | <0.50 | | | 1.1 | | 0.17 | | | | |
| W7 | 7/17/2012 | 7.76 | | 5.4 | | 4.63 | | | 0.96 | | 0.23 | | | | |
| W7 | 7/30/2012 | 7.86 | | 4.4 | | 5.31 | | | 0.58 | | 0.28 | | | | |
| W7 | 8/8/2012 | 8.44 | | 4.7 | | 5.43 | | | 1.2 | | 0.29 | | | | |
| W7 | 8/23/2012 | 7.79 | | 4.6 | | 5.23 | | | 1.2 | | 0.27 | | | | |
| W7 | 9/13/2012 | 7.98 | | 1.9 | | 3.85 | | | 1.2 | | 0.18 | | | | |
| W7 | 10/16/2012 | 7.89 | | 0.4 | | 7.47 | | | 1.2 | | 0.19 | | | | |
| W7 | 11/2/2012 | | | | | 14.4 | | | 0.82 | | 0.29 | | | | |
| W7 | 12/29/2012 | 7.97 | | -0.3 | | 29.1 | | | 1.9 | | 0.43 | | | | |
| W7 | 4/30/2013 | 8.18 | | 0 | | 24.1 | | | 1.4 | | 0.53 | | | | |
| W7 | 5/14/2013 | 8.2 | | 0 | | <0.50 | | | 1.5 | | 0.064 | | | | |
| W7 | 6/19/2013 | | | | | 8.07 | | | 1.2 | | 0.25 | | | | |
| W7 | 6/19/2013 | 8.6 | | 4.6 | | 7.87 | | | 1.1 | | 0.25 | | | | |
| W7 | 7/13/2013 | 7.74 | | 3.6 | | 9.73 | | | 0.99 | | 0.26 | | | | |
| W7 | 8/21/2013 | 7.81 | | 4.2 | | 8.32 | | | 0.93 | | 0.27 | | | | |
| W7 | 9/6/2013 | 7.75 | | 4 | | 5.66 | | | 1.3 | | 0.24 | | | | |
| W7 | 10/21/2013 | 7.58 | | 0 | | 10.3 | | | 1.3 | | 0.25 | | | | |
| W7 | 11/16/2013 | 7.69 | | -0.1 | | 15.1 | | | 1 | | 0.35 | | | | |
| W7 | 12/7/2013 | 6.30 | | 0 | | 16.7 | | | 1.2 | | 0.31 | | | | |
| C4 | 5/6/2012 | 7.51 | | 0 | | <0.50 | | | 0.54 | | 0.14 | | | | |
| C4 | 8/1/2012 | 7.75 | | 9.3 | | 3.37 | | | 0.89 | | 0.2 | | | | |
| C4 | 8/8/2012 | 7.81 | | 7.8 | | <5.0 | | | <5.0 | | 0.22 | | | | |
| C4 | 8/25/2012 | 7.81 | | 6.3 | | 2.19 | | | 1.4 | | 0.22 | | | | |
| C4 | 6/22/2013 | 7.68 | | 7.3 | | 10.6 | | | 1.4 | | 0.27 | | | | |
| C4 | 7/19/2013 | 8.20 | | 9.6 | | 7.45 | | | 1.5 | | 0.27 | | | | |
| C4 | 8/22/2013 | 7.88 | | 7.7 | | 4.75 | | | 1.5 | | 0.21 | | | | |
| C4 | 9/6/2013 | 7.69 | | 5.3 | | 4.27 | | | 1.3 | | 0.19 | | | | |
| C4 | 10/18/2013 | | | | | 11.1 | | | 1.2 | | 0.19 | | | | |
| C4 | 10/18/2013 | 7.16 | | -0.1 | | 38.1 | | | 2.4 | | 0.2 | | | | |
| C4 | 11/17/2013 | 7.17 | | -0.1 | | 6.33 | | | 2.4 | | 0.29 | | | | |
| C10 | 5/12/2012 | 7.89 | | 2.4 | | <0.50 | | | 1.1 | | 0.2 | | | | |
| C10 | 7/30/2012 | | | | | <0.50 | | | 1.2 | | 0.29 | | | | |
| C10 | 7/30/2012 | 8.16 | | 11.2 | | | | | | | | | | | |
| C10 | 8/10/2012 | 8.71 | | 7.4 | | <0.50 | | | 0.75 | | 4 | | | | |
| C10 | 8/27/2012 | 8.3 | | 7.4 | | <0.50 | | | 2 | | 0.24 | | | | |
| C10 | 6/22/2013 | 8.29 | | 11.7 | | 0.97 | | | 1.3 | | 0.21 | | | | |
| C10 | 7/23/2013 | 8.31 | | 7.8 | | <0.50 | | | 1.3 | | 0.21 | | | | |
| C10 | 8/22/2013 | 8.18 | | 8.2 | | <0.50 | | | 1.6 | | 0.21 | | | | |
| C10 | 9/8/2013 | | | | | <0.50 | | | 1.6 | | 0.2 | | | | |
| C10 | 9/8/2013 | 8.16 | | 9 | | <0.50 | | | 1.3 | | 0.2 | | | | |
| C10 | 10/18/2013 | 7.78 | | 0 | | 3.24 | | | 1.5 | | 0.17 | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Cd-D-IH (mg/L) | Se-D-IH (mg/L) | Ag-D (mg/L) | Dissolved Al (mg/L) | Dissolved As (mg/L) | Dissolved Ba (mg/L) | Dissolved B (mg/L) | Dissolved Be (mg/L) | Dissolved Bi (mg/L) | Dissolved Ca (mg/L) | Dissolved Cd (mg/L) | Dissolved Co (mg/L) | Dissolved Cr (mg/L) | Dissolved Cu (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | | | <0.000020 | 0.0176 | 0.00051 | 0.049 | <0.10 | <0.0010 | | 25 | <0.000050 | <0.00030 | <0.0010 | 0.0034 |
| W1 | 6/30/2005 | | | <0.000010 | 0.0065 | 0.00048 | 0.0554 | <0.010 | <0.00050 | <0.00050 | 37.5 | <0.000050 | <0.00010 | <0.00050 | 0.00204 |
| W1 | 7/28/2005 | | | <0.000010 | 0.0072 | 0.00048 | 0.0575 | <0.010 | <0.00050 | <0.00050 | 40.4 | <0.000050 | <0.00010 | <0.00050 | 0.00211 |
| W1 | 8/29/2005 | | | <0.000020 | 0.0106 | 0.0006 | 0.058 | <0.10 | <0.0010 | | 35.9 | <0.000017 | <0.00030 | <0.0010 | 0.0024 |
| W1 | 9/28/2005 | | | <0.000020 | 0.0143 | 0.00058 | 0.055 | <0.10 | <0.0010 | | 35.3 | <0.000017 | <0.00030 | <0.0010 | 0.0026 |
| W1 | 10/15/2005 | | | <0.000010 | 0.0137 | 0.00054 | 0.0492 | <0.010 | <0.00050 | <0.00050 | 36.8 | <0.000050 | <0.00010 | <0.00050 | 0.00279 |
| W2 | 5/27/2005 | | | <0.000020 | 0.0163 | <0.00050 | 0.05 | <0.10 | <0.0010 | | 25.6 | <0.000050 | <0.00030 | <0.0010 | 0.0033 |
| W2 | 5/27/2005 | | | | 0.0108 | | 0.032 | | | | 20.3 | | | | |
| W2 | 6/30/2005 | | | <0.000010 | 0.0073 | 0.00044 | 0.0574 | <0.010 | <0.00050 | <0.00050 | 36.9 | <0.000050 | <0.00010 | <0.00050 | 0.0021 |
| W2 | 7/28/2005 | | | <0.000010 | 0.0071 | 0.00044 | 0.0604 | <0.010 | <0.00050 | <0.00050 | 39.6 | <0.000050 | <0.00010 | <0.00050 | 0.00208 |
| W2 | 8/30/2005 | | | <0.000020 | 0.0119 | 0.00058 | 0.059 | <0.10 | <0.0010 | | 35.7 | <0.000017 | <0.00030 | <0.0010 | 0.0024 |
| W2 | 9/28/2005 | | | <0.000020 | 0.0141 | 0.00059 | 0.055 | <0.10 | <0.0010 | | 35.2 | <0.000017 | <0.00030 | <0.0010 | 0.0025 |
| W2 | 10/15/2005 | | | <0.000010 | 0.0129 | 0.00053 | 0.0492 | <0.010 | <0.00050 | <0.00050 | 35.9 | <0.000050 | <0.00010 | <0.00050 | 0.00271 |
| W3 | 5/27/2005 | | | <0.000020 | 0.0267 | <0.00050 | 0.041 | <0.10 | <0.0010 | | 22 | <0.000050 | <0.00030 | <0.0010 | 0.0066 |
| W3 | 6/30/2005 | | | <0.000010 | 0.008 | 0.00034 | 0.0507 | <0.010 | <0.00050 | <0.00050 | 38.5 | <0.000050 | <0.00010 | <0.00050 | 0.00336 |
| W3 | 7/29/2005 | | | <0.000010 | 0.0113 | 0.00041 | 0.0553 | <0.010 | <0.00050 | <0.00050 | 38 | <0.000050 | 0.0001 | <0.00050 | 0.00478 |
| W3 | 8/29/2005 | | | <0.000020 | 0.0184 | <0.00050 | 0.057 | <0.10 | <0.0010 | | 31.8 | <0.000017 | <0.00030 | <0.0010 | 0.005 |
| W3 | 9/28/2005 | | | <0.000020 | 0.0257 | <0.00050 | 0.055 | <0.10 | <0.0010 | | 30.4 | <0.000017 | <0.00030 | <0.0010 | 0.0057 |
| W3 | 10/15/2005 | | | <0.000010 | 0.0223 | 0.00043 | 0.0475 | <0.010 | <0.00050 | <0.00050 | 31.6 | <0.000050 | 0.00016 | <0.00050 | 0.00608 |
| W8 | 5/27/2005 | | | <0.000020 | 0.0427 | <0.00050 | 0.039 | <0.10 | <0.0010 | | 16.6 | <0.000050 | <0.00030 | <0.0010 | 0.0141 |
| W8 | 6/30/2005 | | | <0.000010 | 0.0193 | 0.00043 | 0.0466 | <0.010 | <0.00050 | <0.00050 | 24.8 | <0.000050 | <0.00010 | 0.00061 | 0.00942 |
| W8 | 7/29/2005 | | | <0.000010 | 0.0201 | 0.00045 | 0.0538 | <0.010 | <0.00050 | <0.00050 | 30.9 | <0.000050 | 0.00014 | 0.00052 | 0.00863 |
| W8 | 8/30/2005 | | | <0.000020 | 0.0259 | <0.00050 | 0.054 | <0.10 | <0.0010 | | 26.3 | <0.000017 | <0.00030 | <0.0010 | 0.0081 |
| W8 | 9/28/2005 | | | <0.000020 | 0.0305 | <0.00050 | 0.049 | <0.10 | <0.0010 | | 25.3 | <0.000017 | <0.00030 | <0.0010 | 0.0081 |
| W8 | 10/15/2005 | | | 0.000031 | 0.0258 | 0.0005 | 0.0479 | <0.010 | <0.00050 | <0.00050 | 26.8 | <0.000050 | 0.00028 | <0.00050 | 0.00561 |
| W9 | 5/27/2005 | | | <0.000020 | 0.0718 | <0.00050 | 0.042 | <0.10 | <0.0010 | | 12.9 | <0.000050 | <0.00030 | <0.0010 | 0.0035 |
| W9 | 6/30/2005 | | | <0.000010 | 0.0345 | 0.00054 | 0.0525 | <0.010 | <0.00050 | <0.00050 | 18.9 | <0.000050 | 0.00018 | <0.00050 | 0.00184 |
| W9 | 7/29/2005 | | | <0.000010 | 0.0298 | 0.00057 | 0.056 | <0.010 | <0.00050 | <0.00050 | 25.9 | <0.000050 | 0.00018 | <0.00050 | 0.00334 |
| W9 | 8/29/2005 | | | <0.000020 | 0.0449 | 0.00058 | 0.055 | <0.10 | <0.0010 | | 19.1 | 0.000022 | <0.00030 | <0.0010 | 0.0017 |
| W9 | 9/28/2005 | | | <0.000020 | 0.0578 | <0.00050 | 0.049 | <0.10 | <0.0010 | | 17.7 | <0.000017 | <0.00030 | <0.0010 | 0.0022 |
| W9 | 10/15/2005 | | | <0.000010 | 0.056 | 0.00039 | 0.0421 | <0.010 | <0.00050 | <0.00050 | 16.6 | <0.000050 | 0.00016 | <0.00050 | 0.00209 |
| W10 | 5/27/2005 | | | <0.000020 | 0.135 | <0.00050 | 0.052 | <0.10 | <0.0010 | | 13.1 | <0.000050 | <0.00030 | <0.0010 | 0.0184 |
| W10 | 5/27/2005 | | | <0.00002 | | <0.0005 | | <0.1 | <0.001 | | | <0.00005 | <0.0003 | <0.001 | <0.001 |
| W10 | 6/30/2005 | | | <0.000010 | 0.113 | 0.00059 | 0.0396 | <0.010 | <0.00050 | <0.00050 | 13.1 | <0.000050 | 0.00046 | 0.00062 | 0.00472 |
| W10 | 7/29/2005 | | | <0.000010 | 0.0683 | 0.00037 | 0.0369 | <0.010 | <0.00050 | <0.00050 | 14.7 | <0.000050 | 0.00011 | <0.00050 | 0.00437 |
| W10 | 8/29/2005 | | | <0.000020 | 0.0433 | <0.00050 | 0.044 | <0.10 | <0.0010 | | 18.2 | <0.000017 | <0.00030 | <0.0010 | 0.004 |
| W10 | 9/28/2005 | | | <0.000020 | 0.0302 | <0.00050 | 0.057 | <0.10 | <0.0010 | | 25.8 | <0.000017 | <0.00030 | <0.0010 | 0.0033 |
| W10 | 10/15/2005 | | | <0.000010 | 0.0361 | 0.0003 | 0.0487 | <0.010 | <0.00050 | <0.00050 | 25.4 | <0.000050 | <0.00010 | <0.00050 | 0.00412 |
| W6 | 5/27/2005 | | | <0.000020 | 0.0144 | <0.00050 | 0.035 | <0.10 | <0.0010 | | 17.9 | <0.000050 | <0.00030 | <0.0010 | 0.0016 |
| W6 | 6/30/2005 | | | <0.000010 | 0.0056 | 0.00039 | 0.0429 | <0.010 | <0.00050 | <0.00050 | 25.2 | <0.000050 | <0.00010 | <0.00050 | 0.00101 |
| W6 | 7/29/2005 | | | <0.000010 | 0.007 | 0.00026 | 0.0668 | <0.010 | <0.00050 | <0.00050 | 46.9 | <0.000050 | <0.00010 | <0.00050 | 0.00247 |
| W6 | 8/30/2005 | | | <0.000020 | 0.0067 | <0.00050 | 0.053 | <0.10 | <0.0010 | | 29 | <0.000017 | <0.00030 | <0.0010 | 0.001 |
| W6 | 9/28/2005 | | | <0.000020 | 0.0067 | <0.00050 | 0.048 | <0.10 | <0.0010 | | 28.8 | <0.000017 | <0.00030 | <0.0010 | 0.0011 |
| W6 | 10/15/2005 | | | <0.000010 | 0.0769 | 0.00042 | 0.0419 | <0.010 | <0.00050 | <0.00050 | 26.7 | <0.000050 | <0.00010 | <0.00050 | 0.00108 |
| W6 | 6/2/2006 | | | <0.00001 | 0.0252 | 0.00044 | 0.0315 | <0.01 | <0.0005 | <0.0005 | 17.8 | <0.00005 | <0.0001 | <0.0005 | 0.00175 |
| W6 | 8/25/2006 | | | | | | | | | | 31.7 | | | | |
| W6 | 9/6/2006 | | | <0.0001 | 0.008 | 0.0005 | 0.051 | <0.002 | <0.0001 | <0.0005 | 30 | <0.00001 | 0.0001 | 0.0006 | 0.001 |
| W6 | 6/20/2007 | | | | | | | | | | | | | | |
| W6 | 9/18/2007 | | | | | | | | | | | | | | |
| W6 | 6/17/2008 | | | | | | | | | | | | | | |
| W6 | 9/18/2008 | | | <0.00001 | 0.012 | 0.0004 | 0.039 | <0.004 | <0.00004 | | 23.7 | <0.00001 | 0.00022 | 0.0013 | 0.002 |
| W6 | 4/14/2009 | | | <0.00001 | 0.038 | 0.0004 | 0.046 | 0.017 | <0.00004 | <0.0001 | 23.6 | 0.00002 | 0.00033 | 0.0004 | 0.043 |
| W6 | 4/30/2009 | | | <0.00001 | 0.097 | 0.0003 | 0.026 | 0.007 | <0.00004 | <0.0001 | 14.5 | 0.00023 | 0.00014 | 0.0007 | 0.008 |
| W6 | 7/28/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | | | | | | | | | | | | | | |
| W6 | 8/18/2009 | | | <0.00001 | 0.03 | 0.0004 | 0.101 | 0.023 | <0.00004 | <0.001 | 46.1 | <0.00001 | 0.00014 | 0.001 | 0.004 |
| W6 | 8/25/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/25/2009 | | | <0.00002 | 0.023 | 0.0003 | 0.118 | <0.05 | <0.0001 | <0.001 | 57.9 | 0.00001 | <0.0005 | <0.001 | 0.0021 |
| W6 | 4/19/2010 | | | <0.00001 | 0.024 | 0.0002 | 0.048 | 0.009 | <0.00004 | <0.001 | 32.3 | 0.00003 | 0.00016 | <0.0004 | 0.019 |
| W6 | 5/16/2010 | | | <0.00002 | <0.003 | 0.0004 | 0.025 | <0.05 | <0.0001 | <0.001 | 25.4 | <0.00001 | <0.0005 | <0.001 | 0.0015 |
| W6 | 5/17/2010 | | | <0.00002 | 0.009 | 0.0003 | 0.033 | <0.05 | <0.0001 | <0.001 | 20.8 | <0.00001 | <0.0005 | <0.001 | 0.0022 |
| W6 | 5/19/2010 | | | <0.00002 | 0.004 | 0.0003 | 0.039 | <0.05 | <0.0001 | <0.001 | 26 | <0.00001 | <0.0005 | <0.001 | 0.0027 |
| W6 | 5/21/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.04 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | 0.003 |
| W6 | 5/23/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.046 | <0.1 | <0.0002 | <0.001 | 28 | <0.0001 | <0.0005 | <0.002 | 0.003 |
| W6 | 5/25/2010 | | | <0.0001 | <0.01 | <0.001 | 0.045 | <0.1 | <0.0005 | <0.001 | 29 | <0.0001 | <0.0005 | <0.002 | 0.006 |
| W6 | 5/29/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.037 | <0.1 | <0.0002 | <0.001 | 21 | <0.0001 | <0.0005 | <0.002 | 0.003 |
| W6 | 6/2/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.074 | <0.1 | <0.0002 | <0.001 | 56 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W6 | 6/4/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.043 | <0.1 | <0.0002 | <0.001 | 23 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W6 | 6/6/2010 | | | <0.0001 | <0.01 | 0.0004 | 0.046 | <0.1 | <0.0002 | <0.001 | 27 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W6 | 6/14/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.038 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W6 | 6/16/2010 | | | <0.0001 | <0.01 | 0.0005 | 0.044 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | 0.006 |
| W6 | 6/18/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.044 | <0.1 | <0.0002 | <0.001 | 26 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W6 | 6/20/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.043 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W6 | 6/22/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.044 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W6 | 6/24/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.043 | <0.1 | <0.0002 | <0.001 | 26 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W6 | 6/26/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.045 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W6 | 6/26/2010 | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.044 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W6 | 7/5/2010 | | | <0.0001 | 0.015 | 0.0004 | 0.047 | <0.1 | <0.0002 | <0.001 | 22 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W6 | 8/5/2010 | | | <0.0001 | 0.012 | 0.0005 | 0.056 | <0.1 | <0.0002 | <0.001 | 31 | <0.0001 | <0.0005 | <0.002 | 0.002 |
| W6 | 9/9/2010 | | | <0.0001 | 0.011 | 0.0004 | 0.053 | <0.1 | <0.0002 | <0.001 | 30 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W6 | 10/8/2010 | | | <0.00002 | 0.008 | 0.0004 | 0.05 | <0.05 | <0.0001 | <0.001 | 28.8 | <0.00001 | <0.0005 | <0.001 | 0.0008 |
| W6 | 8/19/2011 | | | <0.00002 | 0.01 | 0.0003 | 0.077 | <0.05 | <0.0001 | <0.001 | 53.6 | <0.00001 | <0.0005 | <0.001 | 0.0025 |
| W6 | 7/17/2012 | | | <0.000020 | 0.0161 | 0.00053 | 0.0597 | <0.05 | <0.00010 | <0.0010 | 29.7 | <0.000010 | <0.00050 | <0.0010 | 0.00105 |
| W6 | 7/30/2012 | | | <0.000020 | 0.0186 | 0.00059 | 0.0601 | <0.05 | <0.00010 | <0.0010 | 28.9 | <0.000010 | <0.00050 | <0.0010 | 0.00089 |
| W6 | 8/9/2012 | | | <0.000020 | 0.0173 | 0.00081 | 0.0681 | <0.05 | <0.00010 | <0.0010 | 31.9 | <0.000010 | <0.00050 | <0.0010 | 0.00083 |
| W6 | 8/25/2012 | | | <0.000020 | 0.0138 | 0.00081 | 0.063 | <0.05 | <0.00010 | <0.0010 | 28.9 | <0.000010 | <0.00050 | <0.0010 | 0.00103 |
| W6 | 9/13/2012 | | | <0.000020 | 0.0169 | 0.00047 | 0.0451 | <0.05 | <0.00010 | <0.0010 | 24.1 | <0.000010 | <0.00050 | <0.0010 | 0.00145 |
| W6 | 10/13/2012 | | | | | | | | | | | | | | |
| W6 | 11/12/2012 | | | <0.000020 | 0.0062 | 0.00039 | 0.0697 | <0.05 | <0.00010 | <0.0010 | 41.6 | <0.000010 | <0.00050 | <0.0010 | 0.00143 |
| W6 | 5/14/2013 | | | <0.000020 | 0.0591 | 0.00037 | 0.0195 | <0.05 | <0.00010 | <0.0010 | 8.75 | 0.000012 | <0.00050 | <0.0010 | 0.0035 |
| W6 | 6/22/2013 | | | <0.000020 | 0.0095 | 0.00053 | 0.0493 | <0.05 | <0.00010 | <0.0010 | 26.4 | <0.000010 | <0.00050 | <0.0010 | 0.00096 |
| W6 | 7/12/2013 | | | <0.000020 | 0.0066 | 0.00046 | 0.0438 | <0.05 | <0.00010 | <0.0010 | 24.1 | <0.000010 | <0.00050 | <0.0010 | 0.00095 |
| W6 | 8/22/2013 | | | <0.000020 | 0.0084 | 0.00052 | 0.0495 | <0.05 | <0.00010 | <0.0010 | 28.3 | <0.000010 | <0.00050 | <0.0010 | 0.00119 |
| W6 | 9/6/2013 | | | <0.000020 | 0.0083 | 0.00056 | 0.0499 | <0.05 | <0.00010 | <0.0010 | 28.4 | <0.000010 | <0.00050 | <0.0010 | 0.00089 |
| W6 | 10/7/2013 | | | <0.000020 | 0.0132 | 0.00051 | 0.0518 | <0.05 | <0.00010 | <0.0010 | 30.7 | <0.000010 | <0.00050 | <0.0010 | 0.00097 |
| W6 | 11/16/2013 | | | <0.000020 | 0.0057 | 0.00048 | 0.0582 | <0.05 | <0.00010 | <0.0010 | 33.2 | <0.000010 | <0.00050 | <0.0010 | 0.00084 |
| W6 | 12/7/2013 | | | <0.000020 | 0.0041 | 0.00061 | 0.0725 | <0.05 | <0.00010 | <0.0010 | 44.6 | 0.000011 | <0.00050 | <0.0010 | 0.00156 |
| W7 | 5/27/2005 | | | <0.000020 | 0.0236 | <0.00050 | 0.045 | <0.10 | <0.0010 | | 19.5 | <0.000050 | <0.00030 | <0.0010 | 0.0018 |
| W7 | 6/30/2005 | | | <0.000010 | 0.0086 | 0.00042 | 0.0609 | <0.010 | <0.00050 | <0.00050 | 30 | <0.000050 | <0.00010 | <0.00050 | 0.00119 |
| W7 | 7/29/2005 | | | <0.000010 | 0.0096 | 0.00035 | 0.061 | <0.010 | <0.00050 | <0.00050 | 41.3 | <0.000050 | <0.00010 | <0.00050 | 0.00404 |
| W7 | 8/30/2005 | | | <0.000020 | 0.0156 | 0.00051 | 0.062 | <0.10 | <0.0010 | | 27.8 | <0.000017 | <0.00030 | <0.0010 | 0.0014 |
| W7 | 9/28/2005 | | | <0.000020 | 0.0186 | 0.00054 | 0.055 | <0.10 | <0.0010 | | 27.4 | <0.000017 | <0.00030 | <0.0010 | 0.0016 |
| W7 | 10/15/2005 | | | <0.000010 | 0.0155 | 0.00048 | 0.0502 | <0.010 | <0.00050 | <0.00050 | 27.1 | <0.000050 | 0.00011 | <0.00050 | 0.00127 |
| W7 | 6/2/2006 | | | <0.00001 | 0.0714 | 0.00062 | 0.0341 | <0.01 | <0.0005 | <0.0005 | 14.4 | <0.00005 | 0.00033 | 0.00055 | 0.00212 |
| W7 | 6/8/2006 | | | | | | | | | | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Cd-D-IH (mg/L) | Se-D-IH (mg/L) | Ag-D (mg/L) | Dissolved Al (mg/L) | Dissolved As (mg/L) | Dissolved Ba (mg/L) | Dissolved B (mg/L) | Dissolved Be (mg/L) | Dissolved Bi (mg/L) | Dissolved Ca (mg/L) | Dissolved Cd (mg/L) | Dissolved Co (mg/L) | Dissolved Cr (mg/L) | Dissolved Cu (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | | | <0.0001 | 0.013 | 0.0004 | 0.063 | 0.003 | <0.0001 | <0.0005 | 26.9 | <0.00001 | 0.0001 | <0.0005 | 0.001 |
| W7 | 6/23/2006 | | | <0.0001 | 0.011 | 0.0005 | 0.067 | 0.002 | <0.0001 | <0.0005 | 31.8 | <0.00001 | 0.0001 | 0.0007 | <0.001 |
| W7 | 6/28/2006 | | | <0.0001 | 0.407 | 0.0008 | 0.079 | 0.002 | <0.0001 | <0.0005 | 22.8 | 0.00003 | 0.0009 | 0.0015 | 0.003 |
| W7 | 7/7/2006 | | | <0.0001 | <0.005 | 0.0006 | 0.067 | 0.005 | <0.0001 | 0.0007 | 26.5 | <0.00001 | <0.0001 | 0.0011 | 0.001 |
| W7 | 7/12/2006 | | | <0.0001 | 0.006 | 0.0005 | 0.064 | 0.005 | <0.0001 | 0.0007 | 26.9 | <0.00001 | <0.0001 | 0.001 | 0.001 |
| W7 | 7/20/2006 | | | <0.0001 | 0.006 | 0.0004 | 0.068 | 0.004 | <0.0001 | <0.0005 | 33 | <0.00001 | <0.0001 | 0.0007 | <0.001 |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | | | <0.0001 | 0.008 | 0.0004 | 0.072 | <0.002 | <0.0001 | <0.0005 | 33.4 | <0.00001 | <0.0001 | <0.0005 | 0.002 |
| W7 | 8/2/2006 | | | <0.0001 | 0.008 | <0.0002 | 0.07 | 0.004 | <0.0001 | <0.0005 | 33.3 | <0.00001 | <0.0001 | <0.0005 | 0.001 |
| W7 | 8/10/2006 | | | <0.0001 | 0.009 | 0.0005 | 0.073 | 0.005 | <0.0001 | <0.0005 | 32.9 | <0.00001 | <0.0001 | 0.0007 | 0.001 |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | | | <0.0001 | 0.012 | 0.0004 | 0.071 | 0.005 | <0.0001 | <0.0005 | 32.4 | <0.00001 | 0.0002 | 0.0006 | 0.001 |
| W7 | 8/30/2006 | | | <0.0001 | 0.013 | 0.0004 | 0.067 | 0.004 | <0.0001 | <0.0005 | 33.6 | <0.00001 | 0.0001 | 0.0008 | 0.002 |
| W7 | 9/6/2006 | | | <0.0001 | 0.005 | 0.0005 | 0.068 | 0.005 | <0.0001 | <0.0005 | 33.5 | <0.00001 | <0.0001 | 0.0008 | 0.002 |
| W7 | 9/13/2006 | | | <0.0001 | 0.008 | 0.0003 | 0.064 | 0.005 | <0.0001 | <0.0005 | 32.3 | <0.00001 | <0.0001 | 0.0009 | 0.001 |
| W7 | 9/20/2006 | | | <0.0001 | 0.007 | 0.0005 | 0.069 | 0.005 | <0.0001 | <0.0005 | 33.5 | 0.00028 | <0.0001 | 0.0007 | 0.001 |
| W7 | 9/28/2006 | | | <0.0001 | 0.011 | 0.0004 | 0.071 | 0.003 | <0.0001 | <0.0005 | 33.3 | <0.00001 | <0.0001 | 0.0008 | 0.001 |
| W7 | 10/4/2006 | | | <0.0001 | <0.005 | 0.0003 | 0.068 | 0.004 | <0.0001 | <0.0005 | 32.6 | <0.00001 | <0.0001 | <0.0005 | <0.001 |
| W7 | 10/12/2006 | | | <0.0001 | 0.007 | 0.0004 | 0.067 | 0.005 | <0.0001 | <0.0005 | 34 | <0.00001 | <0.0001 | <0.0005 | 0.001 |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/20/2007 | | | <0.0001 | 0.014 | 0.0004 | 0.06 | 0.005 | <0.0001 | <0.0005 | 29.6 | <0.00001 | <0.0001 | 0.0006 | 0.002 |
| W7 | 7/18/2007 | | | <0.0001 | 0.011 | 0.0005 | 0.066 | 0.005 | <0.0001 | <0.0005 | 32 | <0.00001 | <0.0001 | 0.001 | 0.002 |
| W7 | 7/18/2007 | | | | | | | | | | | | | | |
| W7 | 7/18/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 9/18/2007 | | | <0.0001 | 0.007 | 0.0004 | 0.059 | 0.004 | <0.0001 | <0.0005 | 26.9 | <0.00001 | <0.0001 | 0.0016 | 0.001 |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | | | <0.0010 | <0.02 | <0.0002 | 0.075 | <0.005 | <0.00004 | | 40.9 | <0.00008 | 0.00008 | 0.0012 | <0.001 |
| W7 | 4/22/2008 | | | <0.0010 | <0.02 | 0.0004 | 0.08 | <0.005 | <0.00004 | | 42.2 | <0.00008 | 0.00012 | 0.0014 | 0.002 |
| W7 | 4/22/2008 | | | <0.0010 | <0.02 | 0.0003 | 0.073 | <0.005 | <0.00004 | | 39.9 | <0.00008 | 0.00023 | <0.0006 | 0.001 |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | <0.00001 | <0.01 | <0.0002 | 0.05 | <0.004 | <0.00004 | | 23.2 | <0.00008 | 0.00011 | 0.0013 | <0.001 |
| W7 | 6/17/2008 | | | <0.00001 | 0.02 | <0.0002 | 0.056 | 0.006 | <0.00004 | | | <0.00008 | 0.00014 | 0.0013 | 0.001 |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | 0.00006 | 0.014 | 0.0004 | 0.068 | 0.004 | <0.0001 | <0.0005 | 31.8 | <0.00001 | 0.0001 | 0.0006 | 0.002 |
| W7 | 9/18/2008 | | | <0.00001 | 0.07 | 0.0003 | 0.043 | <0.004 | <0.00004 | | 20 | <0.00001 | 0.00025 | 0.0016 | 0.004 |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | <0.00001 | 0.009 | 0.0005 | 0.061 | 0.006 | <0.00004 | | 30.5 | <0.00001 | 0.0001 | 0.0005 | 0.001 |
| W7 | 4/30/2009 | | | <0.00001 | 0.053 | <0.0002 | 0.01 | <0.004 | <0.00004 | <0.0001 | 5.23 | 0.00008 | 0.0001 | 0.0006 | 0.005 |
| W7 | 6/8/2009 | | | <0.00001 | 0.013 | 0.0003 | 0.052 | <0.004 | <0.00004 | <0.0001 | 23.8 | <0.00001 | 0.00013 | <0.0004 | 0.002 |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | | | | | | | | | | | | | | |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | | | |
| W7 | 8/31/2009 | | | <0.00001 | 0.01 | 0.0004 | 0.056 | <0.004 | <0.00004 | <0.001 | 29.1 | <0.00001 | 0.0001 | 0.0012 | 0.004 |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/25/2009 | | | <0.00002 | 0.007 | 0.0003 | 0.067 | <0.05 | <0.0001 | <0.001 | 32.6 | 0.00004 | <0.0005 | <0.001 | 0.0012 |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | | | <0.00001 | 0.019 | 0.0003 | 0.039 | <0.004 | <0.00004 | <0.001 | 19.9 | 0.00002 | 0.00017 | 0.0004 | 0.006 |
| W7 | 4/27/2010 | | | <0.00002 | 0.075 | 0.0003 | 0.022 | <0.05 | <0.0001 | <0.001 | 9.79 | <0.00001 | <0.0005 | <0.001 | 0.0041 |
| W7 | 4/29/2010 | | | <0.00002 | 0.065 | 0.0003 | 0.023 | <0.05 | <0.0001 | <0.001 | 9.79 | <0.00001 | <0.0005 | <0.001 | 0.0034 |
| W7 | 5/1/2010 | | | <0.00002 | 0.053 | 0.0004 | 0.025 | <0.05 | <0.0001 | <0.001 | 11 | 0.00002 | <0.0005 | <0.001 | 0.0032 |
| W7 | 5/3/2010 | | | <0.00002 | 0.047 | 0.0004 | 0.027 | <0.05 | <0.0001 | <0.001 | 12 | <0.00001 | <0.0005 | <0.001 | 0.0027 |
| W7 | 5/5/2010 | | | <0.00002 | 0.038 | 0.0005 | 0.03 | <0.05 | <0.0001 | <0.001 | 12.9 | <0.00001 | <0.0005 | <0.001 | 0.0025 |
| W7 | 5/7/2010 | | | <0.00002 | 0.028 | 0.0004 | 0.034 | <0.05 | <0.0001 | <0.001 | 14.7 | 0.00001 | <0.0005 | <0.001 | 0.0026 |
| W7 | 5/9/2010 | | | <0.00002 | 0.023 | 0.0004 | 0.044 | <0.05 | <0.0001 | <0.001 | 20.5 | <0.00001 | <0.0005 | <0.001 | 0.0018 |
| W7 | 5/10/2010 | | | <0.00002 | 0.021 | 0.0004 | 0.046 | <0.05 | <0.0001 | <0.001 | 20.7 | 0.00002 | <0.0005 | <0.001 | 0.0022 |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | | | <0.00002 | 0.017 | 0.0004 | 0.046 | <0.05 | <0.0001 | <0.001 | 21.1 | <0.00001 | <0.0005 | <0.001 | 0.0016 |
| W7 | 5/14/2010 | | | <0.00002 | 0.096 | 0.0004 | 0.044 | <0.05 | <0.0001 | <0.001 | 18.7 | 0.00001 | <0.0005 | <0.001 | 0.0031 |
| W7 | 5/16/2010 | | | <0.00002 | 0.012 | 0.0003 | 0.045 | <0.05 | <0.0001 | <0.001 | 22.3 | <0.00001 | <0.0005 | <0.001 | 0.0013 |
| W7 | 5/17/2010 | | | <0.00002 | 0.018 | 0.0004 | 0.043 | <0.05 | <0.0001 | <0.001 | 20.9 | <0.00001 | <0.0005 | <0.001 | 0.0012 |
| W7 | 5/19/2010 | | | <0.00002 | 0.016 | 0.0003 | 0.049 | <0.05 | <0.0001 | <0.001 | 24.4 | <0.00001 | <0.0005 | <0.001 | 0.0017 |
| W7 | 5/21/2010 | | | <0.0001 | 0.013 | <0.0004 | 0.05 | <0.1 | <0.0002 | <0.001 | 24 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 5/23/2010 | | | <0.0001 | 0.017 | <0.0004 | 0.053 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 5/25/2010 | | | <0.0001 | 0.024 | <0.001 | 0.065 | <0.1 | <0.0005 | <0.001 | 30 | <0.0001 | <0.0005 | <0.002 | 0.003 |
| W7 | 5/27/2010 | | | <0.0001 | 0.028 | <0.001 | 0.055 | <0.1 | <0.0005 | <0.001 | 27 | <0.0001 | <0.0005 | <0.002 | 0.003 |
| W7 | 5/29/2010 | | | <0.0001 | 0.017 | 0.0005 | 0.056 | <0.1 | <0.0002 | <0.001 | 29 | <0.0001 | <0.0005 | <0.002 | 0.002 |
| W7 | 5/31/2010 | | | <0.0001 | 0.02 | <0.0004 | 0.058 | <0.1 | <0.0002 | <0.001 | 27 | <0.0001 | <0.0005 | <0.002 | 0.002 |
| W7 | 6/2/2010 | | | <0.0001 | 0.012 | 0.0004 | 0.058 | <0.1 | <0.0002 | <0.001 | 29 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 6/4/2010 | | | <0.0001 | 0.013 | 0.0004 | 0.058 | <0.1 | <0.0002 | <0.001 | 29 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 6/6/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.062 | <0.1 | <0.0002 | <0.001 | 33 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 6/14/2010 | | | <0.0001 | 0.011 | <0.0004 | 0.064 | <0.1 | <0.0002 | <0.001 | 31 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W7 | 6/16/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.064 | <0.1 | <0.0002 | <0.001 | 30 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W7 | 6/18/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.064 | <0.1 | <0.0002 | <0.001 | 30 | <0.0001 | <0.0005 | <0.002 | <0.001 |
| W7 | 6/20/2010 | | | <0.0001 | 0.014 | <0.0004 | 0.06 | <0.1 | <0.0002 | <0.001 | 28 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 6/22/2010 | | | <0.0001 | 0.033 | 0.0005 | 0.055 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | 0.002 |
| W7 | 6/24/2010 | | | <0.0001 | 0.018 | <0.0004 | 0.052 | <0.1 | <0.0002 | <0.001 | 25 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 6/26/2010 | | | <0.0001 | 0.012 | 0.0004 | 0.06 | <0.1 | <0.0002 | <0.001 | 26 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 6/28/2010 | | | <0.0001 | <0.01 | <0.0004 | 0.061 | <0.1 | <0.0002 | <0.001 | 29 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 7/5/2010 | | | <0.0001 | 0.019 | <0.0004 | 0.054 | <0.1 | <0.0002 | <0.001 | 23 | <0.0001 | <0.0005 | <0.002 | 0.002 |
| W7 | 8/5/2010 | | | <0.0001 | 0.011 | 0.0004 | 0.065 | <0.1 | <0.0002 | <0.001 | 30 | <0.0001 | <0.0005 | <0.002 | 0.002 |
| W7 | 9/12/2010 | | | | | | | | | | | | | | |
| W7 | 9/12/2010 | | | <0.0001 | 0.016 | 0.0005 | 0.055 | <0.1 | <0.0002 | <0.001 | 28 | <0.0001 | <0.0005 | <0.002 | 0.001 |
| W7 | 10/8/2010 | | | <0.00002 | 0.011 | 0.0004 | 0.06 | <0.05 | <0.0001 | <0.001 | 29.2 | <0.00001 | <0.0005 | <0.001 | 0.0012 |
| W7 | 4/27/2011 | | | <0.00002 | 0.057 | 0.0003 | 0.024 | <0.05 | <0.0001 | <0.001 | 11.2 | 0.00003 | <0.0005 | <0.001 | 0.0077 |
| W7 | 5/2/2011 | | | <0.00002 | 0.076 | 0.0002 | 0.02 | <0.05 | <0.0001 | <0.001 | 8.48 | 0.00004 | <0.0005 | <0.001 | 0.007 |
| W7 | 6/1/2011 | | | <0.00002 | 0.013 | 0.0003 | 0.056 | <0.05 | <0.0001 | <0.001 | 23.5 | <0.00001 | <0.0005 | <0.001 | 0.0016 |
| W7 | 6/16/2011 | | | <0.00002 | 0.022 | 0.0004 | 0.053 | <0.05 | <0.0001 | <0.001 | 24.9 | <0.00001 | <0.0005 | <0.001 | 0.0019 |
| W7 | 7/1/2011 | | | <0.00002 | 0.034 | 0.0007 | 0.053 | <0.05 | <0.0001 | <0.001 | 20.6 | 0.00001 | <0.0005 | <0.001 | 0.0031 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Cd-D-IH (mg/L) | Se-D-IH (mg/L) | Ag-D (mg/L) | Dissolved Al (mg/L) | Dissolved As (mg/L) | Dissolved Ba (mg/L) | Dissolved B (mg/L) | Dissolved Be (mg/L) | Dissolved Bi (mg/L) | Dissolved Ca (mg/L) | Dissolved Cd (mg/L) | Dissolved Co (mg/L) | Dissolved Cr (mg/L) | Dissolved Cu (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | | | <0.00002 | 0.051 | 0.0007 | 0.048 | <0.05 | <0.0001 | <0.001 | 15.6 | 0.00002 | <0.0005 | <0.001 | 0.0041 |
| W7 | 8/16/2011 | | | <0.00002 | 0.036 | 0.0007 | 0.057 | <0.05 | <0.0001 | <0.001 | 26 | <0.00001 | <0.0005 | <0.001 | 0.0019 |
| W7 | 8/19/2011 | | | <0.00002 | 0.033 | 0.0008 | 0.053 | <0.05 | <0.0001 | <0.001 | 24.2 | 0.00001 | <0.0005 | <0.001 | 0.002 |
| W7 | 9/12/2011 | | | <0.00002 | 0.024 | 0.0007 | 0.061 | <0.05 | <0.0001 | <0.001 | 30.8 | 0.00001 | <0.0005 | <0.001 | 0.0016 |
| W7 | 10/6/2011 | | | <0.00002 | 0.013 | 0.0006 | 0.057 | <0.05 | <0.0001 | <0.001 | 27.9 | 0.00003 | <0.0005 | <0.001 | 0.0012 |
| W7 | 11/22/2011 | | | <0.000020 | 0.0076 | 0.0004 | 0.075 | <0.05 | <0.00010 | <0.0010 | 38.3 | <0.000010 | <0.00050 | <0.0010 | 0.00109 |
| W7 | 1/24/2012 | | | <0.000020 | 0.0053 | 0.00041 | 0.0882 | <0.05 | <0.00010 | <0.0010 | 43 | 0.000035 | <0.00050 | <0.0010 | 0.00114 |
| W7 | 2/25/2012 | | | <0.000020 | 0.0211 | 0.00033 | 0.0796 | <0.05 | <0.00010 | <0.0010 | 41.2 | 0.000064 | <0.00050 | <0.0010 | 0.0154 |
| W7 | 3/5/2012 | | | <0.000020 | 0.0031 | 0.00039 | 0.0803 | <0.05 | <0.00010 | <0.0010 | 41.2 | <0.000010 | <0.00050 | <0.0010 | 0.00122 |
| W7 | 4/24/2012 | | | <0.000020 | 0.0499 | 0.00048 | 0.0319 | <0.05 | <0.00010 | <0.0010 | 10.2 | 0.000023 | <0.00050 | <0.0010 | 0.00523 |
| W7 | 5/6/2012 | | | <0.000020 | 0.0298 | 0.00043 | 0.0319 | <0.05 | <0.00010 | <0.0010 | 12 | 0.000013 | <0.00050 | <0.0010 | 0.00303 |
| W7 | 5/6/2012 | | | <0.000020 | 0.0442 | 0.00044 | 0.0324 | <0.05 | <0.00010 | <0.0010 | 11.9 | 0.000016 | <0.00050 | <0.0010 | 0.00273 |
| W7 | 6/19/2012 | | | <0.000020 | 0.0265 | 0.0007 | 0.0543 | <0.05 | <0.00010 | <0.0010 | 23.5 | <0.000010 | <0.00050 | <0.0010 | 0.00163 |
| W7 | 7/17/2012 | | | <0.000020 | 0.0197 | 0.00086 | 0.0706 | <0.05 | <0.00010 | <0.0010 | 33 | 0.000012 | <0.00050 | <0.0010 | 0.00127 |
| W7 | 7/30/2012 | | | <0.000020 | 0.0171 | 0.00095 | 0.0727 | <0.05 | <0.00010 | <0.0010 | 33.9 | <0.000010 | <0.00050 | <0.0010 | 0.00123 |
| W7 | 8/8/2012 | | | <0.000020 | 0.0184 | 0.001 | 0.0769 | <0.05 | <0.00010 | <0.0010 | 35.9 | <0.000010 | <0.00050 | <0.0010 | 0.00112 |
| W7 | 8/23/2012 | | | <0.000020 | 0.0178 | 0.00088 | 0.0756 | <0.05 | <0.00010 | <0.0010 | 35.7 | <0.000010 | <0.00050 | <0.0010 | 0.0017 |
| W7 | 9/13/2012 | | | <0.000020 | 0.0239 | 0.00074 | 0.0599 | <0.05 | <0.00010 | <0.0010 | 30.1 | <0.000010 | <0.00050 | <0.0010 | 0.00244 |
| W7 | 10/16/2012 | | | <0.000020 | 0.0114 | 0.0006 | 0.0633 | <0.05 | <0.00010 | <0.0010 | 33.2 | <0.000010 | <0.00050 | <0.0010 | 0.00094 |
| W7 | 11/2/2012 | | | <0.000020 | 0.0095 | 0.00053 | 0.0862 | <0.05 | <0.00010 | <0.0010 | 39.3 | 0.000031 | <0.00050 | <0.0010 | 0.00236 |
| W7 | 12/29/2012 | | | <0.000020 | 0.0061 | 0.00051 | 0.119 | <0.05 | <0.00010 | <0.0010 | 56.1 | <0.000010 | <0.00050 | <0.0010 | 0.00232 |
| W7 | 4/30/2013 | | | <0.000020 | 0.0031 | 0.00025 | 0.101 | <0.05 | <0.00010 | <0.0010 | 46.8 | <0.000010 | <0.00050 | <0.0010 | 0.00108 |
| W7 | 5/14/2013 | | | <0.000020 | 0.0436 | 0.00029 | 0.023 | <0.05 | <0.00010 | <0.0010 | 8.81 | 0.00001 | <0.00050 | <0.0010 | 0.00365 |
| W7 | 6/19/2013 | | | <0.000020 | 0.0125 | 0.00052 | 0.0665 | <0.05 | <0.00010 | <0.0010 | 29.9 | <0.000010 | <0.00050 | <0.0010 | 0.00116 |
| W7 | 6/19/2013 | | | <0.000020 | 0.0134 | 0.00051 | 0.0664 | <0.05 | <0.00010 | <0.0010 | 30 | <0.000010 | <0.00050 | <0.0010 | 0.00124 |
| W7 | 7/13/2013 | | | <0.000020 | 0.0138 | 0.00053 | 0.072 | <0.05 | <0.00010 | <0.0010 | 34.9 | <0.000010 | <0.00050 | <0.0010 | 0.00121 |
| W7 | 8/21/2013 | | | <0.000020 | 0.0122 | 0.00056 | 0.0737 | <0.05 | <0.00010 | <0.0010 | 35.2 | <0.000010 | <0.00050 | <0.0010 | 0.00101 |
| W7 | 9/6/2013 | | | <0.000020 | 0.016 | 0.00081 | 0.0718 | <0.05 | <0.00010 | <0.0010 | 34.9 | <0.000010 | <0.00050 | <0.0010 | 0.00113 |
| W7 | 10/21/2013 | | | <0.000020 | 0.0093 | 0.00067 | 0.0715 | <0.05 | <0.00010 | <0.0010 | 38 | <0.000010 | <0.00050 | <0.0010 | 0.00111 |
| W7 | 11/16/2013 | | | <0.000020 | 0.0053 | 0.00048 | 0.08 | <0.05 | <0.00010 | <0.0010 | 39.4 | <0.000010 | <0.00050 | <0.0010 | 0.0008 |
| W7 | 12/7/2013 | | | <0.000020 | 0.0035 | 0.00053 | 0.0919 | <0.05 | <0.00010 | <0.0010 | 43.3 | <0.000010 | <0.00050 | <0.0010 | 0.00078 |
| C4 | 5/6/2012 | | | <0.000020 | 0.0622 | 0.00104 | 0.0488 | <0.05 | <0.00010 | <0.0010 | 12 | 0.000029 | 0.00071 | <0.0010 | 0.00314 |
| C4 | 8/1/2012 | | | <0.000020 | 0.059 | 0.00184 | 0.0984 | <0.05 | <0.00010 | <0.0010 | 31.9 | <0.000010 | 0.00111 | <0.0010 | 0.00181 |
| C4 | 8/8/2012 | | | <0.000020 | 0.0425 | 0.00203 | 0.0987 | <0.05 | <0.00010 | <0.0010 | 33.7 | <0.000010 | 0.00108 | <0.0010 | 0.00132 |
| C4 | 8/25/2012 | | | <0.000020 | 0.04 | 0.00197 | 0.098 | <0.05 | <0.00010 | <0.0010 | 35 | <0.000010 | 0.00113 | <0.0010 | 0.00176 |
| C4 | 6/22/2013 | | | <0.000020 | 0.0342 | 0.00225 | 0.075 | <0.05 | <0.00010 | <0.0010 | 35 | <0.000010 | 0.00063 | <0.0010 | 0.0017 |
| C4 | 7/19/2013 | | | <0.000020 | 0.0317 | 0.00207 | 0.0699 | <0.05 | <0.00010 | <0.0010 | 36 | <0.000010 | 0.00062 | <0.0010 | 0.00137 |
| C4 | 8/22/2013 | | | <0.000020 | 0.0455 | 0.00179 | 0.0794 | <0.05 | <0.00010 | <0.0010 | 33.1 | <0.000010 | 0.00073 | <0.0010 | 0.00143 |
| C4 | 9/6/2013 | | | <0.000020 | 0.0405 | 0.00196 | 0.0798 | <0.05 | <0.00010 | <0.0010 | 34.2 | <0.000010 | 0.00092 | <0.0010 | 0.00161 |
| C4 | 10/18/2013 | | | <0.000020 | 0.0221 | 0.00106 | 0.0735 | <0.05 | <0.00010 | <0.0010 | 34.2 | <0.000010 | 0.00079 | <0.0010 | 0.00112 |
| C4 | 10/18/2013 | | | <0.000020 | 0.0249 | 0.00107 | 0.0732 | <0.05 | <0.00010 | <0.0010 | 34.5 | <0.000010 | 0.00074 | <0.0010 | 0.00118 |
| C4 | 11/17/2013 | | | <0.000020 | 0.033 | 0.00559 | 0.169 | <0.05 | <0.00010 | <0.0010 | 72.1 | 0.000022 | 0.00611 | 0.0013 | 0.00095 |
| C10 | 5/12/2012 | | | <0.000020 | 0.0583 | 0.0012 | 0.0501 | <0.05 | <0.00010 | <0.0010 | 19.9 | 0.000018 | 0.00054 | <0.0010 | 0.00212 |
| C10 | 7/30/2012 | | | <0.000020 | 0.0571 | 0.00142 | 0.0795 | <0.05 | <0.00010 | <0.0010 | 38.8 | <0.000010 | <0.00050 | <0.0010 | 0.00198 |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | | | <0.000020 | 0.0505 | 0.00134 | 0.0786 | <0.05 | <0.00010 | <0.0010 | 39.8 | <0.000010 | <0.00050 | <0.0010 | 0.00189 |
| C10 | 8/27/2012 | | | <0.000020 | 0.0262 | 0.00149 | 0.0804 | <0.05 | <0.00010 | <0.0010 | 41.8 | <0.000010 | <0.00050 | <0.0010 | 0.00148 |
| C10 | 6/22/2013 | | | <0.000020 | 0.0785 | 0.00123 | 0.0721 | <0.05 | <0.00010 | <0.0010 | 45.1 | 0.000019 | <0.00050 | <0.0010 | 0.00313 |
| C10 | 7/23/2013 | | | <0.000020 | 0.0252 | 0.00116 | 0.0668 | <0.05 | <0.00010 | <0.0010 | 37.4 | <0.000010 | <0.00050 | <0.0010 | 0.00135 |
| C10 | 8/22/2013 | | | <0.000020 | 0.0197 | 0.00141 | 0.0724 | <0.05 | <0.00010 | <0.0010 | 48 | <0.000010 | <0.00050 | <0.0010 | 0.00134 |
| C10 | 9/8/2013 | | | <0.000020 | 0.0254 | 0.00166 | 0.0764 | <0.05 | <0.00010 | <0.0010 | 45 | <0.000010 | 0.00058 | <0.0010 | 0.00125 |
| C10 | 9/8/2013 | | | <0.000020 | 0.0241 | 0.00158 | 0.0763 | <0.05 | <0.00010 | <0.0010 | 44.8 | 0.00001 | 0.0006 | 0.0017 | 0.00133 |
| C10 | 10/18/2013 | | | <0.000020 | 0.0108 | 0.00089 | 0.0599 | <0.05 | <0.00010 | <0.0010 | 40.1 | <0.000010 | <0.00050 | <0.0010 | 0.00091 |

## Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.

| Station Name | Sample Date | Dissolved Fe (mg/L) | Dissolved Hg (mg/L) | Dissolved K (mg/L) | Dissolved Li (mg/L) | Dissolved Mg (mg/L) | Dissolved Mn (mg/L) | Dissolved Mo (mg/L) | Dissolved Na (mg/L) | Dissolved Ni (mg/L) | Dissolved Pb (mg/L) | Dissolved P (mg/L) | Dissolved Sb (mg/L) | Dissolved S (mg/L) | Dissolved Se (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | 0.172 | <0.000020 | <2.0 | <0.0050 | 8.46 | 0.00579 | <0.0010 | 4.9 | 0.0015 | <0.00050 | | <0.00050 | | <0.0010 |
| W1 | 6/30/2005 | 0.046 | | <2.0 | <0.0050 | 12.6 | 0.00391 | 0.00106 | 8.8 | 0.00096 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W1 | 7/28/2005 | 0.056 | | <2.0 | <0.0050 | 13.6 | 0.0119 | 0.00131 | 9.2 | 0.0011 | 0.000073 | <0.30 | <0.00010 | | <0.0010 |
| W1 | 8/29/2005 | 0.25 | <0.000020 | <2.0 | <0.0050 | 11.7 | 0.0157 | 0.001 | 6.9 | 0.0014 | <0.00050 | | <0.00050 | | <0.0010 |
| W1 | 9/28/2005 | 0.331 | <0.000020 | <2.0 | <0.0050 | 11.2 | 0.0355 | <0.0010 | 6.2 | 0.0016 | <0.00050 | | <0.00050 | | <0.0010 |
| W1 | 10/15/2005 | 0.266 | | <2.0 | <0.0050 | 11.7 | 0.0228 | 0.000892 | 6.4 | 0.0014 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W2 | 5/27/2005 | 0.164 | <0.000020 | <2.0 | <0.0050 | 8.72 | 0.00507 | <0.0010 | 5 | 0.0015 | <0.00050 | | <0.00050 | | <0.0010 |
| W2 | 5/27/2005 | | | | | 5.19 | 0.00345 | | | | | | | | |
| W2 | 6/30/2005 | 0.039 | | <2.0 | <0.0050 | 12.3 | 0.00684 | 0.00108 | 8.6 | 0.00102 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W2 | 7/28/2005 | 0.05 | | <2.0 | <0.0050 | 13.2 | 0.014 | 0.00127 | 8.7 | 0.00112 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W2 | 8/30/2005 | 0.234 | <0.000020 | <2.0 | <0.0050 | 11.7 | 0.0152 | 0.001 | 7 | 0.0015 | <0.00050 | | <0.00050 | | <0.0010 |
| W2 | 9/28/2005 | 0.338 | <0.000020 | <2.0 | <0.0050 | 11.2 | 0.0341 | <0.0010 | 6.2 | 0.0017 | <0.00050 | | <0.00050 | | <0.0010 |
| W2 | 10/15/2005 | 0.246 | | <2.0 | <0.0050 | 11.5 | 0.0208 | 0.000859 | 6.3 | 0.00141 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W3 | 5/27/2005 | 0.116 | <0.000020 | <2.0 | <0.0050 | 9.48 | 0.0094 | <0.0010 | 5.2 | 0.0014 | <0.00050 | | <0.00050 | | <0.0010 |
| W3 | 6/30/2005 | 0.042 | | <2.0 | <0.0050 | 17.4 | 0.0052 | 0.00163 | 11.7 | 0.00078 | 0.000241 | <0.30 | <0.00010 | | <0.0010 |
| W3 | 7/29/2005 | 0.134 | | <2.0 | <0.0050 | 17.3 | 0.0311 | 0.00158 | 9.7 | 0.00115 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W3 | 8/29/2005 | 0.306 | <0.000020 | <2.0 | <0.0050 | 13.6 | 0.0657 | 0.0013 | 8 | 0.0014 | <0.00050 | | <0.00050 | | <0.0010 |
| W3 | 9/28/2005 | 0.421 | <0.000020 | <2.0 | <0.0050 | 12.8 | 0.102 | 0.0011 | 7.7 | 0.0014 | <0.00050 | | <0.00050 | | <0.0010 |
| W3 | 10/15/2005 | 0.39 | | <2.0 | <0.0050 | 13.4 | 0.112 | 0.00122 | 7.5 | 0.00121 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W8 | 5/27/2005 | 0.194 | <0.000020 | <2.0 | <0.0050 | 5.05 | 0.00284 | <0.0010 | 2.6 | 0.0018 | <0.00050 | | <0.00050 | | <0.0010 |
| W8 | 6/30/2005 | 0.249 | | <2.0 | <0.0050 | 7.68 | 0.0142 | 0.000547 | 4.5 | 0.00144 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W8 | 7/29/2005 | 0.352 | | <2.0 | <0.0050 | 9.39 | 0.0206 | 0.000589 | 3.9 | 0.00157 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W8 | 8/30/2005 | 0.544 | <0.000020 | <2.0 | <0.0050 | 8.28 | 0.0296 | <0.0010 | 3.9 | 0.0016 | <0.00050 | | <0.00050 | | <0.0010 |
| W8 | 9/28/2005 | 0.556 | <0.000020 | <2.0 | <0.0050 | 7.73 | 0.0387 | <0.0010 | 3.9 | 0.0015 | <0.00050 | | <0.00050 | | <0.0010 |
| W8 | 10/15/2005 | 0.711 | | <2.0 | <0.0050 | 7.92 | 0.223 | 0.00169 | 4.8 | 0.00096 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W9 | 5/27/2005 | 0.251 | 0.000038 | <2.0 | <0.0050 | 4.18 | 0.00696 | <0.0010 | 2.3 | 0.0013 | <0.00050 | | <0.00050 | | <0.0010 |
| W9 | 6/30/2005 | 0.53 | | <2.0 | <0.0050 | 6.05 | 0.0378 | 0.000365 | 4.1 | 0.00119 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W9 | 7/29/2005 | 0.647 | | <2.0 | <0.0050 | 7.46 | 0.057 | 0.00108 | 4 | 0.00132 | 0.000185 | <0.30 | <0.00010 | | <0.0010 |
| W9 | 8/29/2005 | 0.67 | <0.000020 | <2.0 | <0.0050 | 6.3 | 0.0606 | <0.0010 | 3.6 | 0.0012 | <0.00050 | | <0.00050 | | <0.0010 |
| W9 | 9/28/2005 | 0.602 | <0.000020 | <2.0 | <0.0050 | 5.69 | 0.0451 | <0.0010 | 3.2 | 0.0011 | <0.00050 | | <0.00050 | | <0.0010 |
| W9 | 10/15/2005 | 0.438 | | <2.0 | <0.0050 | 5.55 | 0.0335 | 0.000313 | 3.1 | 0.00096 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W10 | 5/27/2005 | 0.106 | <0.000020 | <2.0 | <0.0050 | 3.31 | 0.00042 | <0.0010 | <2.0 | 0.0016 | <0.00050 | | <0.00050 | | <0.0010 |
| W10 | 5/27/2005 | <0.03 | <0.00002 | <2.0 | <0.005 | | 0.00271 | <0.001 | <2 | <0.001 | <0.0005 | | <0.0005 | | <0.001 |
| W10 | 6/30/2005 | 0.401 | | <2.0 | <0.0050 | 3.68 | 0.0299 | 0.000144 | 3.5 | 0.00179 | 0.000082 | <0.30 | <0.00010 | | <0.0010 |
| W10 | 7/29/2005 | 0.099 | | <2.0 | <0.0050 | 4.39 | 0.00483 | 0.000137 | 4.7 | 0.00123 | 0.000112 | <0.30 | <0.00010 | | <0.0010 |
| W10 | 8/29/2005 | 0.081 | <0.000020 | <2.0 | <0.0050 | 5.95 | 0.00447 | <0.0010 | 5.4 | 0.0016 | <0.00050 | | <0.00050 | | <0.0010 |
| W10 | 9/28/2005 | 0.048 | <0.000020 | <2.0 | <0.0050 | 8.93 | 0.00069 | <0.0010 | 5.4 | <0.0010 | <0.00050 | | <0.00050 | | <0.0010 |
| W10 | 10/15/2005 | 0.055 | | <2.0 | <0.0050 | 8.98 | 0.000385 | 0.000241 | 4.7 | 0.00073 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W6 | 5/27/2005 | 0.072 | <0.000020 | <2.0 | <0.0050 | 5.01 | 0.00543 | <0.0010 | 2.8 | 0.0015 | <0.00050 | | <0.00050 | | <0.0010 |
| W6 | 6/30/2005 | <0.030 | | <2.0 | <0.0050 | 6.72 | 0.00324 | 0.000448 | 4.8 | 0.00099 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W6 | 7/29/2005 | 0.062 | | <2.0 | <0.0050 | 13.2 | 0.0145 | 0.000818 | 7.3 | 0.0006 | 0.000083 | <0.30 | <0.00010 | | <0.0010 |
| W6 | 8/30/2005 | 0.064 | <0.000020 | <2.0 | <0.0050 | 8.1 | 0.0211 | <0.0010 | 4.6 | 0.0011 | <0.00050 | | <0.00050 | | <0.0010 |
| W6 | 9/28/2005 | 0.1 | <0.000020 | <2.0 | <0.0050 | 8.25 | 0.0245 | <0.0010 | 4.4 | 0.0012 | <0.00050 | | <0.00050 | | <0.0010 |
| W6 | 10/15/2005 | 0.088 | | <2.0 | <0.0050 | 7.66 | 0.0162 | 0.000395 | 4.5 | 0.00118 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W6 | 6/2/2006 | 0.096 | | <2 | <0.005 | 4.95 | 0.00673 | 0.000305 | 3.3 | 0.00182 | <0.00005 | <0.3 | <0.0001 | | <0.001 |
| W6 | 8/25/2006 | | | | | 8.7 | | | | | | | | | |
| W6 | 9/6/2006 | 0.11 | | 0.6 | 0.001 | 7.7 | 0.046 | <0.001 | 4.8 | 0.0006 | <0.0001 | | <0.0002 | 0.9 | <0.0002 |
| W6 | 6/20/2007 | | | | | | | | | | | | | | |
| W6 | 9/18/2007 | | | | | | | | | | | | | | |
| W6 | 6/17/2008 | | | | | | | | | | | | | | |
| W6 | 9/18/2008 | 0.09 | <0.00001 | 0.4 | <0.001 | 6.33 | 0.0099 | 0.00027 | 4.27 | 0.002 | <0.0001 | 0.02 | 0.0008 | | 0.0012 |
| W6 | 4/14/2009 | 0.06 | <0.00001 | 7.4 | 0.004 | 45.8 | 0.0307 | 0.00312 | 35.1 | <0.001 | 0.0002 | 0.13 | 0.003 | 34.5 | 0.0011 |
| W6 | 4/30/2009 | 0.12 | 0.00001 | 1.9 | <0.001 | 4.9 | 0.0147 | 0.00042 | 3 | 0.001 | 0.0003 | 0.05 | 0.0006 | 2.5 | <0.0006 |
| W6 | 7/28/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | | | | | | | | | | | | | | |
| W6 | 8/18/2009 | 0.02 | <0.00001 | 3.5 | 0.002 | 14.2 | 0.0808 | 0.0098 | 14.9 | 0.001 | 0.0005 | 0.01 | 0.0013 | 16.6 | 0.0012 |
| W6 | 8/25/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/25/2009 | 0.01 | <0.00002 | 3.34 | <0.005 | 15.2 | 0.215 | 0.015 | 17.3 | <0.001 | <0.0002 | | 0.0006 | 24 | 0.002 |
| W6 | 4/19/2010 | 0.06 | <0.00001 | 2.3 | 0.002 | 13.2 | 0.0461 | 0.0017 | 8.6 | <0.001 | 0.0002 | 0.02 | 0.0011 | 10.1 | <0.0006 |
| W6 | 5/16/2010 | 0.01 | <0.0002 | 1.39 | <0.005 | 8.38 | <0.001 | <0.001 | 4.49 | <0.001 | <0.0002 | <0.01 | <0.0005 | <3 | 0.0002 |
| W6 | 5/17/2010 | 0.016 | <0.0002 | 1 | <0.005 | 5.28 | <0.001 | <0.001 | 3.32 | <0.001 | <0.0002 | 0.016 | <0.0005 | <3 | <0.0001 |
| W6 | 5/19/2010 | 0.021 | <0.00002 | 1.19 | <0.005 | 7.41 | <0.001 | <0.001 | 5.01 | <0.001 | <0.0002 | 0.013 | <0.0005 | 5 | 0.0001 |
| W6 | 5/21/2010 | <0.02 | <0.0002 | <1 | <0.01 | 5 | <0.001 | <0.001 | 3 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 5/23/2010 | 0.029 | <0.0002 | 1 | <0.01 | 8 | <0.001 | <0.001 | 6 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 5/25/2010 | 0.024 | <0.00002 | 1 | <0.01 | 9 | <0.001 | <0.001 | 8 | <0.003 | <0.0002 | | <0.0005 | <60 | <0.001 |
| W6 | 5/29/2010 | 0.03 | <0.00002 | <1 | <0.01 | 4 | <0.001 | <0.001 | 2 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/2/2010 | <0.02 | <0.0002 | 2 | <0.01 | 20 | 0.01 | 0.003 | 13 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/4/2010 | 0.027 | <0.0002 | <1 | <0.01 | 6 | <0.001 | <0.001 | 3 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/6/2010 | 0.027 | | <1 | <0.01 | 7 | <0.001 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/14/2010 | 0.021 | <0.0002 | <1 | <0.01 | 7 | <0.001 | <0.001 | 5 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/16/2010 | 0.021 | <0.0002 | <1 | <0.01 | 7 | <0.001 | <0.001 | 4 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/18/2010 | 0.021 | <0.0002 | <1 | <0.01 | 7 | <0.001 | <0.001 | 4 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/20/2010 | 0.027 | <0.0002 | <1 | <0.01 | 7 | <0.001 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/22/2010 | 0.025 | <0.0002 | <1 | <0.01 | 7 | <0.001 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/24/2010 | 0.025 | <0.0002 | <1 | <0.01 | 7 | <0.001 | <0.001 | 4 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/26/2010 | 0.025 | <0.0002 | <1 | <0.01 | 7 | 0.001 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 6/26/2010 | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | 0.025 | <0.0002 | <1 | <0.01 | 7 | <0.001 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 7/5/2010 | 0.092 | <0.0002 | <1 | <0.01 | 6 | 0.005 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 8/5/2010 | 0.069 | <0.0002 | <1 | <0.01 | 8 | 0.018 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 9/9/2010 | 0.061 | <0.0002 | <1 | <0.01 | 8 | 0.02 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W6 | 10/8/2010 | 0.054 | <0.00002 | 0.42 | <0.005 | 7.52 | 0.019 | <0.001 | 3.79 | 0.001 | <0.0002 | | <0.0005 | <3 | <0.0001 |
| W6 | 8/19/2011 | 0.025 | <0.00002 | 1.66 | <0.005 | 22.2 | 0.019 | 0.003 | 15.2 | <0.001 | <0.0002 | <0.01 | <0.0005 | 18 | 0.0004 |
| W6 | 7/17/2012 | 0.0679 | <0.000010 | 0.52 | <0.0050 | 7.16 | 0.0542 | <0.0010 | 4.31 | 0.001 | <0.00020 | <0.01 | <0.00050 | <3.0 | 0.00012 |
| W6 | 7/30/2012 | 0.0814 | <0.000010 | 0.542 | <0.0050 | 7.02 | 0.102 | <0.0010 | 4.2 | <0.0010 | <0.00020 | <0.01 | <0.00050 | <3.0 | <0.00010 |
| W6 | 8/9/2012 | 0.0845 | <0.000010 | 0.578 | <0.0050 | 7.95 | 0.134 | <0.0010 | 4.56 | 0.001 | <0.00020 | 0.011 | <0.00050 | <3.0 | 0.0001 |
| W6 | 8/25/2012 | 0.0799 | <0.000010 | 0.648 | <0.0050 | 7.34 | 0.134 | <0.0010 | 4.21 | 0.001 | <0.00020 | 0.012 | <0.00050 | <3.0 | <0.00010 |
| W6 | 9/13/2012 | 0.108 | <0.000010 | 0.411 | <0.0050 | 6.66 | 0.0408 | <0.0010 | 3.89 | 0.0014 | <0.00020 | <0.01 | <0.00050 | <3.0 | <0.00010 |
| W6 | 10/13/2012 | | <0.000010 | | | | | | | | | | | | |
| W6 | 11/12/2012 | 0.0235 | <0.000010 | 0.562 | <0.0050 | 11.8 | 0.0013 | <0.0010 | 6.34 | 0.0014 | <0.00020 | <0.01 | <0.00050 | <3.0 | 0.0001 |
| W6 | 5/14/2013 | 0.183 | <0.000010 | 1.73 | <0.0050 | 2.31 | 0.0433 | <0.0010 | 0.999 | 0.0013 | <0.00020 | 0.044 | <0.00050 | <3.0 | <0.00010 |
| W6 | 6/22/2013 | 0.0718 | <0.000010 | 0.724 | <0.0050 | 7.04 | 0.0293 | <0.0010 | 3.95 | 0.0012 | <0.00020 | <0.01 | <0.00050 | <3.0 | <0.00010 |
| W6 | 7/12/2013 | 0.105 | <0.000010 | 0.482 | <0.0050 | 6.83 | 0.022 | <0.0010 | 4.07 | 0.0011 | <0.00020 | <0.01 | <0.00050 | <3.0 | <0.00010 |
| W6 | 8/22/2013 | 0.103 | <0.000010 | 0.489 | <0.0050 | 7.54 | 0.0286 | <0.0010 | 4.33 | 0.0011 | <0.00020 | <0.01 | <0.00050 | <3.0 | <0.00010 |
| W6 | 9/6/2013 | 0.111 | <0.000010 | 0.554 | <0.0050 | 7.18 | 0.0323 | <0.0010 | 4.02 | 0.0011 | <0.00020 | 0.013 | <0.00050 | <3.0 | <0.00010 |
| W6 | 10/7/2013 | 0.145 | <0.000010 | 0.581 | <0.0050 | 7.36 | 0.048 | <0.0010 | 4.6 | 0.0013 | <0.00020 | 0.011 | <0.00050 | <3.0 | <0.00010 |
| W6 | 11/16/2013 | 0.124 | <0.000010 | 0.589 | <0.0050 | 8.66 | 0.0399 | <0.0010 | 4.77 | 0.001 | <0.00020 | 0.015 | <0.00050 | <3.0 | <0.00010 |
| W6 | 12/7/2013 | 0.0144 | <0.000010 | 0.562 | <0.0050 | 11.7 | 0.0017 | <0.0010 | 6.36 | 0.0011 | <0.00020 | 0.015 | <0.00050 | <3.0 | <0.00010 |
| W7 | 5/27/2005 | 0.136 | <0.000020 | <2.0 | <0.0050 | 6.77 | 0.0193 | <0.0010 | 3.9 | 0.0016 | <0.00050 | | <0.00050 | | <0.0010 |
| W7 | 6/30/2005 | 0.07 | | <2.0 | <0.0050 | 10.2 | 0.0415 | 0.00124 | 6.9 | 0.00093 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W7 | 7/29/2005 | 0.105 | | <2.0 | <0.0050 | 15.6 | 0.0244 | 0.00127 | 8.8 | 0.00095 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W7 | 8/30/2005 | 0.292 | <0.000020 | <2.0 | <0.0050 | 9.7 | 0.0315 | 0.001 | 5.9 | 0.0015 | <0.00050 | | <0.00050 | | <0.0010 |
| W7 | 9/28/2005 | 0.32 | <0.000020 | <2.0 | <0.0050 | 9.32 | 0.0414 | <0.0010 | 5.3 | 0.0018 | <0.00050 | | <0.00050 | | <0.0010 |
| W7 | 10/15/2005 | 0.253 | | <2.0 | <0.0050 | 9.35 | 0.0383 | 0.000925 | 5.5 | 0.00146 | <0.000050 | <0.30 | <0.00010 | | <0.0010 |
| W7 | 6/2/2006 | 0.546 | | <2 | <0.005 | 4.85 | 0.0882 | 0.000697 | 3.8 | 0.0022 | 0.000054 | <0.3 | <0.0001 | | <0.001 |
| W7 | 6/8/2006 | | | | | | | | | | | | | | |

## Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.

| Station Name | Sample Date | Dissolved Fe (mg/L) | Dissolved Hg (mg/L) | Dissolved K (mg/L) | Dissolved Li (mg/L) | Dissolved Mg (mg/L) | Dissolved Mn (mg/L) | Dissolved Mo (mg/L) | Dissolved Na (mg/L) | Dissolved Ni (mg/L) | Dissolved Pb (mg/L) | Dissolved P (mg/L) | Dissolved Sb (mg/L) | Dissolved S (mg/L) | Dissolved Se (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | 0.09 | | <0.4 | <0.001 | 8.9 | 0.044 | 0.001 | 5.9 | 0.001 | <0.0001 | | <0.0002 | 3.5 | 0.0002 |
| W7 | 6/23/2006 | 0.09 | | 1.1 | <0.001 | 10.4 | 0.043 | 0.001 | 5.9 | 0.0013 | <0.0001 | | <0.0002 | 4.3 | 0.0003 |
| W7 | 6/28/2006 | 0.06 | | 0.8 | <0.001 | 9.2 | 0.011 | <0.001 | 6.2 | 0.0036 | 0.0005 | | <0.0002 | 3.4 | <0.0002 |
| W7 | 7/7/2006 | 0.06 | | 0.8 | 0.001 | 10.7 | 0.023 | 0.002 | 6.7 | 0.0015 | <0.0001 | | <0.0002 | 4 | <0.0002 |
| W7 | 7/12/2006 | 0.06 | | 0.9 | 0.001 | 10.5 | 0.022 | 0.001 | 6.6 | 0.0007 | <0.0001 | | <0.0002 | 4 | 0.0002 |
| W7 | 7/20/2006 | 0.11 | | 1 | 0.001 | 11.7 | 0.042 | 0.001 | 6.7 | 0.0006 | 0.0002 | | <0.0002 | 4.1 | <0.0002 |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | 0.1 | | 1 | <0.001 | 10.9 | 0.044 | <0.001 | 7 | 0.0021 | <0.0001 | | <0.0002 | 4.2 | <0.0002 |
| W7 | 8/2/2006 | 0.07 | | 1.1 | <0.001 | 11 | 0.033 | <0.001 | 7.2 | 0.0006 | <0.0001 | | <0.0002 | 4 | <0.0002 |
| W7 | 8/10/2006 | 0.08 | | 1 | 0.001 | 10.8 | 0.039 | 0.001 | 7.2 | 0.0006 | <0.0001 | | <0.0002 | 4 | <0.0002 |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | 0.08 | | 0.9 | 0.001 | 11.7 | 0.037 | 0.001 | 6.7 | 0.0009 | <0.0001 | | <0.0002 | 3.8 | <0.0002 |
| W7 | 8/30/2006 | 0.1 | | 1.2 | 0.002 | 11.7 | 0.038 | 0.001 | 7.7 | 0.0012 | <0.0001 | | <0.0002 | 3.7 | <0.0002 |
| W7 | 9/6/2006 | 0.1 | | 0.8 | 0.002 | 11.2 | 0.036 | 0.001 | 7.5 | 0.001 | <0.0001 | | <0.0002 | 3.7 | <0.0002 |
| W7 | 9/13/2006 | 0.11 | | 0.9 | 0.002 | 11.4 | 0.03 | 0.001 | 7.4 | 0.0009 | <0.0001 | | <0.0002 | 3.5 | <0.0002 |
| W7 | 9/20/2006 | 0.09 | | 1 | 0.002 | 11.6 | 0.04 | 0.001 | 6.6 | <0.0005 | <0.0001 | | <0.0002 | 3.9 | 0.0002 |
| W7 | 9/28/2006 | 0.08 | | 1.1 | 0.001 | 11.1 | 0.035 | 0.001 | 7.4 | 0.0008 | <0.0001 | | <0.0002 | 3.7 | <0.0002 |
| W7 | 10/4/2006 | 0.11 | | 1.1 | 0.001 | 10.9 | 0.035 | 0.001 | 7.3 | 0.0007 | <0.0001 | | <0.0002 | 3.7 | <0.0002 |
| W7 | 10/12/2006 | 0.09 | | 1.1 | 0.001 | 11.4 | 0.043 | 0.001 | 7.4 | 0.0006 | <0.0001 | | <0.0002 | 3.9 | 0.0003 |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/5/2007 | | | | | | | | | | | | | | |
| W7 | 6/20/2007 | 0.05 | <0.0001 | 1 | 0.001 | 9.8 | 0.031 | 0.001 | 7.4 | <0.0005 | <0.0001 | | <0.0002 | 4.2 | <0.0002 |
| W7 | 7/18/2007 | 0.04 | <0.0001 | 0.9 | 0.001 | 11.6 | 0.019 | 0.001 | 7.6 | 0.0007 | <0.0001 | | <0.0002 | 3.9 | <0.0002 |
| W7 | 7/18/2007 | | | | | | | | | | | | | | |
| W7 | 7/18/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 9/18/2007 | 0.08 | <0.0001 | 0.9 | 0.001 | 9.8 | 0.018 | 0.002 | 7.2 | 0.0008 | <0.0001 | | <0.0002 | 2.9 | <0.0002 |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | <0.02 | <0.00001 | 2.68 | 0.002 | 20.4 | 0.025 | 0.00161 | 12.6 | <0.001 | <0.0001 | <0.01 | 0.006 | | <0.0006 |
| W7 | 4/22/2008 | 0.07 | <0.00001 | 2.78 | 0.002 | 21.2 | 0.027 | 0.0017 | 12.7 | 0.002 | 0.0001 | 0.02 | 0.0084 | | <0.0006 |
| W7 | 4/22/2008 | <0.02 | <0.00001 | 2.63 | 0.002 | 19.9 | 0.0242 | 0.00166 | 12.4 | <0.001 | <0.0001 | <0.01 | 0.0016 | | <0.0006 |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | 0.05 | <0.00001 | 0.84 | <0.001 | 8.39 | 0.0418 | 0.00124 | 6.82 | 0.001 | <0.0001 | | 0.0006 | | <0.0006 |
| W7 | 6/17/2008 | 0.07 | | | <0.001 | | 0.0682 | 0.00149 | | 0.001 | <0.0001 | | 0.001 | | 0.0022 |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 8/6/2008 | 0.07 | <0.0001 | 1 | 0.001 | 10.6 | 0.02 | 0.001 | 7.4 | 0.001 | <0.0001 | <0.05 | 0.0014 | 3.5 | <0.0002 |
| W7 | 9/18/2008 | 0.2 | <0.00001 | 0.53 | <0.001 | 6.63 | 0.0198 | 0.00072 | 4.92 | 0.001 | 0.0017 | 0.02 | 0.0008 | | <0.0006 |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 10/28/2008 | 0.078 | <0.00001 | 0.8 | <0.001 | 11.4 | 0.0338 | 0.00108 | 6.4 | 0.001 | <0.0001 | <0.01 | 0.0009 | | <0.0006 |
| W7 | 4/30/2009 | 0.07 | 0.00001 | 1.5 | <0.001 | 1.68 | 0.0114 | 0.00013 | 1.2 | <0.001 | 0.0001 | 0.06 | 0.0007 | 0.4 | <0.0006 |
| W7 | 6/8/2009 | 0.05 | <0.00001 | 0.7 | <0.001 | 8.18 | 0.0129 | 0.00127 | 5.3 | 0.001 | <0.0001 | 0.01 | 0.0011 | 2.8 | <0.0006 |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | | | | | | | | | | | | | | |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | | | |
| W7 | 8/31/2009 | 0.1 | <0.00001 | 0.9 | <0.001 | 9.9 | 0.0128 | 0.0011 | 6.8 | 0.001 | 0.0004 | 0.03 | 0.0009 | 3 | <0.0006 |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/25/2009 | 0.046 | <0.00002 | 0.95 | <0.005 | 10.8 | 0.024 | 0.001 | 6.68 | <0.001 | <0.0002 | | <0.0005 | 4 | 0.0002 |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | 0.09 | <0.00001 | 2.1 | <0.001 | 7.3 | 0.0188 | 0.0008 | 5 | <0.001 | 0.0003 | 0.02 | 0.001 | 2.7 | <0.0006 |
| W7 | 4/27/2010 | 0.15 | <0.00002 | 1.04 | <0.005 | 2.87 | <0.001 | <0.001 | 1.86 | 0.001 | <0.0002 | | <0.0005 | <3 | <0.0001 |
| W7 | 4/29/2010 | 0.18 | <0.00002 | 0.9 | <0.005 | 2.86 | <0.001 | <0.001 | 1.92 | 0.001 | <0.0002 | | <0.0005 | <3 | <0.0001 |
| W7 | 5/1/2010 | 0.26 | <0.00002 | 0.71 | <0.005 | 3.26 | <0.001 | <0.001 | 2.22 | 0.001 | <0.0002 | 0.023 | <0.0005 | <3 | <0.0001 |
| W7 | 5/3/2010 | 0.378 | <0.00002 | 0.64 | <0.005 | 3.67 | <0.001 | <0.001 | 2.6 | 0.001 | <0.0002 | | <0.0005 | <3 | <0.0001 |
| W7 | 5/5/2010 | 0.574 | <0.00002 | 0.57 | <0.005 | 4.09 | <0.001 | <0.001 | 2.85 | 0.001 | <0.0002 | 0.021 | <0.0005 | <3 | <0.0001 |
| W7 | 5/7/2010 | 0.359 | <0.00002 | 0.68 | <0.005 | 4.9 | <0.001 | <0.001 | 3.35 | 0.002 | <0.0002 | 0.017 | <0.0005 | <3 | <0.0001 |
| W7 | 5/9/2010 | 0.297 | <0.00002 | 0.78 | <0.005 | 6.97 | <0.001 | <0.001 | 4.54 | 0.001 | <0.0002 | 0.014 | <0.0005 | <3 | 0.0001 |
| W7 | 5/10/2010 | 0.276 | <0.00002 | 0.8 | <0.005 | 7.08 | <0.001 | <0.001 | 4.69 | 0.001 | <0.0002 | 0.013 | <0.0005 | 3 | 0.0001 |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | 0.173 | 0.00002 | 0.77 | <0.005 | 7.06 | <0.001 | 0.001 | 4.6 | 0.001 | <0.0002 | <0.01 | <0.0005 | <3 | 0.0001 |
| W7 | 5/14/2010 | 0.339 | <0.00002 | 0.71 | <0.005 | 6.27 | 0.039 | <0.001 | 4.05 | 0.002 | <0.0002 | | <0.0005 | <3 | 0.0001 |
| W7 | 5/16/2010 | 0.08 | <0.0002 | 0.8 | <0.005 | 7.28 | <0.001 | 0.001 | 4.75 | <0.001 | <0.0002 | <0.01 | <0.0005 | <3 | 0.0001 |
| W7 | 5/17/2010 | 0.068 | <0.0002 | 0.78 | <0.005 | 6.82 | <0.001 | 0.001 | 4.36 | <0.001 | <0.0002 | <0.01 | <0.0005 | <3 | 0.0001 |
| W7 | 5/19/2010 | 0.069 | <0.00002 | 0.85 | <0.005 | 9.16 | <0.001 | 0.001 | 6.6 | <0.001 | <0.0002 | <0.01 | <0.0005 | 3 | 0.0003 |
| W7 | 5/21/2010 | 0.057 | <0.0002 | <1 | <0.01 | 8 | <0.001 | 0.001 | 6 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 5/23/2010 | 0.069 | <0.0002 | <1 | <0.01 | 9 | <0.001 | 0.001 | 6 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 5/25/2010 | 0.062 | <0.00002 | 1 | <0.01 | 12 | 0.001 | 0.002 | 8 | <0.003 | <0.0002 | | <0.0005 | <60 | <0.001 |
| W7 | 5/27/2010 | 0.069 | <0.00002 | 1 | <0.01 | 11 | 0.014 | 0.002 | 8 | <0.003 | <0.0002 | | <0.0005 | <60 | <0.001 |
| W7 | 5/29/2010 | 0.051 | <0.00002 | 1 | <0.01 | 10 | 0.015 | 0.002 | 6 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 5/31/2010 | 0.05 | <0.00002 | <1 | <0.01 | 10 | 0.012 | 0.002 | 7 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/2/2010 | 0.03 | <0.0002 | <1 | <0.01 | 10 | <0.001 | 0.002 | 6 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/4/2010 | 0.03 | <0.0002 | <1 | <0.01 | 10 | 0.001 | 0.002 | 6 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/6/2010 | 0.024 | | 1 | <0.01 | 11 | 0.004 | 0.002 | 7 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/14/2010 | 0.025 | <0.0002 | 1 | <0.01 | 11 | 0.002 | 0.002 | 8 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/16/2010 | 0.026 | <0.0002 | 1 | <0.01 | 11 | 0.004 | 0.002 | 7 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/18/2010 | 0.023 | <0.0002 | 1 | <0.01 | 11 | <0.001 | 0.002 | 7 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/20/2010 | 0.028 | <0.0002 | <1 | <0.01 | 10 | 0.003 | 0.002 | 7 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/22/2010 | 0.082 | <0.0002 | <1 | <0.01 | 9 | 0.001 | 0.001 | 6 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/24/2010 | 0.056 | <0.0002 | <1 | <0.01 | 9 | 0.001 | 0.001 | 6 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/26/2010 | 0.038 | <0.0002 | <1 | <0.01 | 10 | 0.003 | 0.001 | 7 | 0.004 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 6/28/2010 | 0.028 | <0.0002 | <1 | <0.01 | 10 | 0.002 | 0.001 | 7 | <0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 7/5/2010 | 0.104 | <0.0002 | <1 | <0.01 | 8 | 0.003 | 0.001 | 6 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 8/5/2010 | 0.112 | <0.0002 | <1 | <0.01 | 10 | 0.023 | 0.001 | 6 | 0.001 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 9/12/2010 | | | | | | | | | | | | | | |
| W7 | 9/12/2010 | 0.231 | <0.0002 | <1 | <0.01 | 9 | 0.017 | 0.001 | 5 | 0.002 | <0.0002 | | <0.0005 | <60 | <0.0008 |
| W7 | 10/8/2010 | 0.127 | <0.00002 | 0.71 | <0.005 | 9.34 | 0.027 | 0.001 | 5.34 | 0.001 | <0.0002 | | <0.0005 | 3 | 0.0001 |
| W7 | 4/27/2011 | 0.148 | <0.00002 | 1.75 | <0.005 | 3.57 | 0.027 | <0.001 | 2.12 | 0.001 | <0.0002 | 0.048 | <0.0005 | <3 | <0.0001 |
| W7 | 5/2/2011 | 0.169 | <0.00002 | 1.39 | <0.005 | 2.57 | 0.021 | <0.001 | 1.43 | 0.001 | <0.0002 | | <0.0005 | <3 | <0.0001 |
| W7 | 6/1/2011 | 0.099 | <0.00002 | 0.85 | <0.005 | 8.19 | 0.011 | 0.001 | 5.09 | 0.001 | <0.0002 | 0.011 | <0.0005 | 4 | 0.0001 |
| W7 | 6/16/2011 | 0.207 | <0.00002 | 0.67 | <0.005 | 8.56 | 0.011 | 0.001 | 5.67 | 0.002 | <0.0002 | 0.014 | <0.0005 | <3 | 0.0001 |
| W7 | 7/1/2011 | 0.441 | 0.00005 | 0.39 | <0.005 | 6.25 | 0.037 | <0.001 | 4.4 | 0.002 | <0.0002 | 0.017 | <0.0005 | <3 | 0.0001 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Dissolved Fe (mg/L) | Dissolved Hg (mg/L) | Dissolved K (mg/L) | Dissolved Li (mg/L) | Dissolved Mg (mg/L) | Dissolved Mn (mg/L) | Dissolved Mo (mg/L) | Dissolved Na (mg/L) | Dissolved Ni (mg/L) | Dissolved Pb (mg/L) | Dissolved P (mg/L) | Dissolved Sb (mg/L) | Dissolved S (mg/L) | Dissolved Se (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | 0.614 | <0.00002 | 0.29 | <0.005 | 4.85 | 0.064 | <0.001 | 3.69 | 0.003 | <0.0002 | 0.02 | <0.0005 | <3 | 0.0001 |
| W7 | 8/16/2011 | 0.593 | <0.00002 | 0.46 | <0.005 | 7.96 | 0.054 | <0.001 | 4.81 | 0.002 | <0.0002 | 0.023 | <0.0005 | <3 | 0.0001 |
| W7 | 8/19/2011 | 0.556 | <0.00002 | 0.41 | <0.005 | 7.89 | 0.06 | <0.001 | 4.58 | 0.002 | <0.0002 | 0.032 | <0.0005 | <3 | 0.0001 |
| W7 | 9/12/2011 | 0.616 | <0.00002 | 0.62 | <0.005 | 10.1 | 0.079 | <0.001 | 5.73 | 0.002 | <0.0002 | 0.023 | <0.0005 | <3 | 0.0001 |
| W7 | 10/6/2011 | 0.346 | <0.00002 | 0.62 | <0.005 | 9.89 | 0.07 | 0.001 | 5.68 | 0.001 | <0.0002 | 0.015 | <0.0005 | <3 | 0.0001 |
| W7 | 11/22/2011 | 0.167 | <0.000020 | 0.864 | <0.0050 | 12.8 | 0.0626 | 0.0013 | 6.99 | 0.0012 | <0.00020 | 0.014 | <0.00050 | 4.6 | 0.00016 |
| W7 | 1/24/2012 | 0.0944 | <0.000010 | 1.6 | <0.0050 | 14.9 | 0.0614 | 0.0015 | 8.72 | <0.0010 | <0.00020 | 0.012 | <0.00050 | 7.3 | 0.00043 |
| W7 | 2/25/2012 | 0.0488 | <0.000010 | 1.63 | <0.0050 | 15.1 | 0.007 | 0.0014 | 8.86 | <0.0010 | 0.00024 | 0.031 | <0.00050 | 7.3 | 0.00034 |
| W7 | 3/5/2012 | 0.0124 | <0.000010 | 1.5 | <0.0050 | 14.2 | 0.0015 | 0.0011 | 8.03 | <0.0010 | <0.00020 | <0.01 | <0.00050 | 6.1 | 0.00031 |
| W7 | 4/24/2012 | 0.475 | <0.000010 | 1.18 | <0.0050 | 3.2 | 0.0486 | <0.0010 | 1.9 | 0.0012 | <0.00020 | 0.027 | <0.00050 | <3.0 | <0.00010 |
| W7 | 5/6/2012 | 0.427 | <0.000010 | 0.932 | <0.0050 | 3.95 | 0.0108 | <0.0010 | 2.4 | 0.0011 | <0.00020 | 0.021 | <0.00050 | <3.0 | <0.00010 |
| W7 | 5/6/2012 | 0.462 | <0.000010 | 0.948 | <0.0050 | 4.04 | 0.0113 | <0.0010 | 2.44 | 0.0012 | <0.00020 | 0.021 | <0.00050 | <3.0 | <0.00010 |
| W7 | 6/19/2012 | 0.56 | <0.000010 | 0.583 | <0.0050 | 8.07 | 0.0433 | 0.0013 | 5.29 | 0.002 | <0.00020 | 0.02 | <0.00050 | <3.0 | 0.00015 |
| W7 | 7/17/2012 | 0.965 | <0.000010 | 0.791 | <0.0050 | 11 | 0.0366 | 0.0015 | 6.55 | 0.0016 | <0.00020 | 0.035 | <0.00050 | <3.0 | 0.00013 |
| W7 | 7/30/2012 | 0.964 | <0.000010 | 0.833 | <0.0050 | 12.1 | 0.0534 | 0.0015 | 6.98 | 0.0015 | <0.00020 | 0.032 | <0.00050 | <3.0 | 0.00016 |
| W7 | 8/8/2012 | 1.06 | <0.000010 | 0.882 | <0.0050 | 12.6 | 0.0554 | 0.0016 | 7.09 | 0.0017 | <0.00020 | 0.033 | <0.00050 | <3.0 | 0.00014 |
| W7 | 8/23/2012 | 0.978 | <0.000010 | 0.942 | <0.0050 | 13 | 0.057 | 0.0016 | 7.35 | 0.0016 | <0.00020 | 0.031 | <0.00050 | 3.1 | 0.00015 |
| W7 | 9/13/2012 | 0.734 | <0.000010 | 0.567 | <0.0050 | 9.91 | 0.0956 | <0.0010 | 5.77 | 0.0036 | <0.00020 | 0.023 | <0.00050 | <3.0 | 0.00014 |
| W7 | 10/16/2012 | 0.603 | <0.000010 | 0.675 | <0.0050 | 11.2 | 0.073 | 0.0011 | 6.34 | 0.0015 | <0.00020 | 0.021 | <0.00050 | 3.4 | 0.00014 |
| W7 | 11/2/2012 | 0.183 | <0.000010 | 1.34 | <0.0050 | 14.6 | 0.101 | 0.0013 | 8.07 | 0.0012 | 0.00021 | 0.031 | <0.00050 | 5.2 | 0.00018 |
| W7 | 12/29/2012 | 0.0301 | <0.000010 | 2.54 | <0.0050 | 20.2 | 0.0374 | 0.0012 | 12.2 | 0.0011 | <0.00020 | <0.01 | <0.00050 | 10.9 | 0.00045 |
| W7 | 4/30/2013 | 0.0143 | <0.000010 | 1.92 | <0.0050 | 18.3 | 0.0528 | 0.0013 | 10.1 | <0.0010 | <0.00020 | <0.01 | <0.00050 | 8 | 0.00043 |
| W7 | 5/14/2013 | 0.306 | <0.000010 | 1.03 | <0.0050 | 2.75 | 0.103 | <0.0010 | 1.52 | 0.001 | <0.00020 | 0.027 | <0.00050 | <3.0 | <0.00010 |
| W7 | 6/19/2013 | 0.285 | <0.000010 | 0.94 | <0.0050 | 9.4 | 0.0317 | 0.0015 | 5.9 | 0.0013 | <0.00020 | 0.019 | <0.00050 | 3.2 | 0.00011 |
| W7 | 6/19/2013 | 0.291 | <0.000010 | 0.955 | <0.0050 | 9.47 | 0.0339 | 0.0016 | 5.88 | 0.0012 | <0.00020 | 0.019 | <0.00050 | 3.5 | 0.00019 |
| W7 | 7/13/2013 | 0.416 | <0.000010 | 0.91 | <0.0050 | 11 | 0.026 | 0.0015 | 6.52 | 0.0013 | <0.00020 | 0.016 | <0.00050 | 3.2 | 0.00015 |
| W7 | 8/21/2013 | 0.3 | <0.000010 | 0.934 | <0.0050 | 12.7 | 0.0355 | 0.0015 | 7.34 | 0.0012 | <0.00020 | 0.017 | <0.00050 | 3.2 | 0.00015 |
| W7 | 9/6/2013 | 0.663 | <0.000010 | 0.887 | <0.0050 | 12.3 | 0.081 | 0.0013 | 7.31 | 0.0016 | <0.00020 | 0.026 | <0.00050 | <3.0 | 0.00017 |
| W7 | 10/21/2013 | 0.549 | <0.000010 | 0.878 | <0.0050 | 12.6 | 0.1 | 0.0012 | 7.03 | 0.0012 | <0.00020 | 0.025 | <0.00050 | 4.2 | 0.00017 |
| W7 | 11/16/2013 | 0.169 | <0.000010 | 1.15 | <0.0050 | 13.3 | 0.0809 | 0.0016 | 7.71 | <0.0010 | <0.00020 | 0.017 | <0.00050 | 5.4 | 0.00024 |
| W7 | 12/7/2013 | 0.109 | <0.000010 | 1.38 | <0.0050 | 14.5 | 0.143 | 0.0011 | 8.17 | <0.0010 | <0.00020 | <0.01 | <0.00050 | 5.3 | 0.00024 |
| C4 | 5/6/2012 | 1.11 | <0.000010 | 0.895 | <0.0050 | 3.4 | 0.243 | <0.0010 | 2.4 | 0.0023 | <0.00020 | 0.037 | <0.00050 | <3.0 | <0.00010 |
| C4 | 8/1/2012 | 1.5 | <0.000010 | 0.754 | <0.0050 | 9.12 | 0.622 | 0.0011 | 4.95 | 0.0031 | <0.00020 | 0.049 | <0.00050 | 3 | 0.00011 |
| C4 | 8/8/2012 | 1.6 | <0.000010 | 0.759 | <0.0050 | 9.81 | 0.683 | 0.0011 | 5.16 | 0.0027 | <0.00020 | 0.047 | <0.00050 | <3.0 | 0.00011 |
| C4 | 8/25/2012 | 1.68 | <0.000010 | 0.989 | <0.0050 | 10.3 | 0.682 | 0.0012 | 5.21 | 0.0029 | <0.00020 | 0.06 | <0.00050 | <3.0 | <0.00010 |
| C4 | 6/22/2013 | 1.2 | <0.000010 | 0.983 | <0.0050 | 9.29 | 0.405 | 0.0018 | 5.62 | 0.0027 | <0.00020 | 0.041 | <0.00050 | 3.2 | 0.00013 |
| C4 | 7/19/2013 | 1.56 | <0.000010 | 0.845 | <0.0050 | 9.31 | 0.385 | 0.0017 | 5.66 | 0.0025 | <0.00020 | 0.04 | <0.00050 | <3.0 | 0.00012 |
| C4 | 8/22/2013 | 1.44 | <0.000010 | 0.776 | <0.0050 | 9.87 | 0.448 | 0.0013 | 5.49 | 0.0027 | <0.00020 | 0.043 | <0.00050 | <3.0 | 0.00012 |
| C4 | 9/6/2013 | 1.78 | <0.000010 | 0.777 | <0.0050 | 9.52 | 0.495 | 0.001 | 5.28 | 0.0028 | <0.00020 | 0.048 | <0.00050 | 3.1 | <0.00010 |
| C4 | 10/18/2013 | 1.15 | <0.000010 | 0.754 | <0.0050 | 10.5 | 0.417 | <0.0010 | 5.46 | 0.0023 | <0.00020 | 0.033 | <0.00050 | 4.5 | <0.00010 |
| C4 | 10/18/2013 | 1.16 | <0.000010 | 0.762 | <0.0050 | 10.4 | 0.408 | 0.0012 | 5.38 | 0.0025 | <0.00020 | 0.036 | <0.00050 | 4.4 | <0.00010 |
| C4 | 11/17/2013 | 14.2 | <0.000010 | 0.985 | <0.0050 | 18.8 | 3.09 | 0.0011 | 8.06 | 0.0061 | <0.00020 | 0.117 | <0.00050 | 4.5 | 0.00024 |
| C10 | 5/12/2012 | 1.55 | <0.000010 | 1.08 | <0.0050 | 4.24 | 0.305 | <0.0010 | 2.95 | 0.0019 | 0.00025 | 0.035 | <0.00050 | <3.0 | 0.0001 |
| C10 | 7/30/2012 | 1.15 | <0.000010 | 0.921 | <0.0050 | 8.1 | 0.189 | 0.0014 | 5.64 | 0.0023 | 0.00067 | 0.039 | <0.00050 | <3.0 | 0.00014 |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | 0.883 | <0.000010 | 0.824 | <0.0050 | 8.59 | 0.252 | 0.0019 | 5.34 | 0.0022 | <0.00020 | 0.034 | <0.00050 | <3.0 | 0.0001 |
| C10 | 8/27/2012 | 1 | <0.000010 | 1.02 | <0.0050 | 8.82 | 0.27 | 0.0011 | 5.26 | 0.0023 | <0.00020 | 0.038 | <0.00050 | <3.0 | 0.00012 |
| C10 | 6/22/2013 | 0.802 | <0.000010 | 1.45 | <0.0050 | 8.63 | 0.0628 | 0.0012 | 6.07 | 0.0025 | <0.00020 | 0.053 | <0.00050 | <3.0 | 0.00011 |
| C10 | 7/23/2013 | 0.54 | <0.000010 | 0.848 | <0.0050 | 7.65 | 0.154 | 0.001 | 5.75 | 0.0022 | <0.00020 | 0.025 | <0.00050 | <3.0 | <0.00010 |
| C10 | 8/22/2013 | 0.992 | <0.000010 | 0.979 | <0.0050 | 9.84 | 0.063 | 0.0015 | 6.05 | 0.0023 | <0.00020 | 0.032 | <0.00050 | <3.0 | <0.00010 |
| C10 | 9/8/2013 | 1.26 | <0.000010 | 1.03 | <0.0050 | 9.12 | 0.137 | <0.0010 | 5.65 | 0.0025 | <0.00020 | 0.04 | <0.00050 | <3.0 | <0.00010 |
| C10 | 9/8/2013 | 1.28 | <0.000010 | 1.03 | <0.0050 | 9.37 | 0.139 | <0.0010 | 5.79 | 0.0025 | <0.00020 | 0.043 | <0.00050 | <3.0 | <0.00010 |
| C10 | 10/18/2013 | 0.761 | <0.000010 | 0.844 | <0.0050 | 8.73 | 0.187 | <0.0010 | 5.44 | 0.0019 | <0.00020 | 0.027 | <0.00050 | <3.0 | <0.00010 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Dissolved Si (mg/L) | Dissolved Sn (mg/L) | Dissolved Sr (mg/L) | Dissolved Te (mg/L) | Dissolved Th (mg/L) | Dissolved Ti (mg/L) | Dissolved Tl (mg/L) | Dissolved U (mg/L) | Dissolved V (mg/L) | Dissolved Zn (mg/L) | Dissolved Zr (mg/L) | P-E (mg/L) | TT Ag (mg/L) | TT Al (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00049 | <0.030 | <0.0050 | | | 0.000036 | 0.613 |
| W1 | 6/30/2005 | 5.53 | <0.00010 | 0.3 | | | <0.010 | <0.00010 | 0.00113 | <0.0010 | <0.0010 | | | <0.000010 | 0.0218 |
| W1 | 7/28/2005 | 5.55 | <0.00010 | 0.331 | | | <0.010 | <0.00010 | 0.00133 | <0.0010 | 0.0025 | | | <0.000010 | 0.0174 |
| W1 | 8/29/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00077 | <0.030 | <0.0050 | | | <0.000020 | 0.0524 |
| W1 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00055 | <0.030 | <0.0050 | | | <0.000020 | 0.127 |
| W1 | 10/15/2005 | 6.25 | <0.00010 | 0.257 | | | <0.010 | <0.00010 | 0.000727 | <0.0010 | 0.0014 | | | <0.000010 | 0.15 |
| W2 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | | | | | | <0.000020 | 0.362 |
| W2 | 5/27/2005 | | | | | | <0.01 | | 0.00081 | <0.03 | <0.005 | | | | 1.14 |
| W2 | 6/30/2005 | 5.4 | <0.00010 | 0.307 | | | <0.010 | <0.00010 | 0.0011 | <0.0010 | 0.0015 | | | <0.000010 | 0.0111 |
| W2 | 7/28/2005 | 5.31 | <0.00010 | 0.341 | | | <0.010 | <0.00010 | 0.00127 | <0.0010 | 0.0011 | | | <0.000010 | 0.0127 |
| W2 | 8/30/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00077 | <0.030 | <0.0050 | | | <0.000020 | 0.0475 |
| W2 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00055 | <0.030 | <0.0050 | | | <0.000020 | 0.133 |
| W2 | 10/15/2005 | 6.19 | <0.00010 | 0.256 | | | <0.010 | <0.00010 | 0.000713 | <0.0010 | <0.0010 | | | <0.000010 | 0.0972 |
| W3 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00031 | <0.030 | <0.0050 | | | <0.000020 | 0.152 |
| W3 | 6/30/2005 | 5.89 | <0.00010 | 0.297 | | | <0.010 | <0.00010 | 0.000903 | <0.0010 | 0.0116 | | | <0.000010 | 0.0313 |
| W3 | 7/29/2005 | 5.56 | <0.00010 | 0.279 | | | <0.010 | <0.00010 | 0.000717 | <0.0010 | 0.0015 | | | <0.000030 | 0.732 |
| W3 | 8/29/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00045 | <0.030 | <0.0050 | | | 0.000027 | 0.267 |
| W3 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00034 | <0.030 | <0.0050 | | | 0.000029 | 0.236 |
| W3 | 10/15/2005 | 6.16 | <0.00010 | 0.225 | | | <0.010 | <0.00010 | 0.00042 | <0.0010 | 0.0018 | | | <0.000010 | 0.09 |
| W8 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0506 |
| W8 | 6/30/2005 | 5.25 | <0.00010 | 0.113 | | | <0.010 | <0.00010 | 0.000059 | <0.0010 | 0.0012 | | | <0.000010 | 0.0807 |
| W8 | 7/29/2005 | 4.95 | <0.00010 | 0.132 | | | <0.010 | <0.00010 | 0.000074 | <0.0010 | 0.0019 | | | <0.000010 | 0.033 |
| W8 | 8/30/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0688 |
| W8 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0509 |
| W8 | 10/15/2005 | 6.54 | <0.00010 | 0.171 | | | <0.010 | <0.00010 | 0.000093 | <0.0010 | <0.0010 | | | <0.000010 | 0.116 |
| W9 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0732 |
| W9 | 6/30/2005 | 5.35 | <0.00010 | 0.0957 | | | <0.010 | <0.00010 | 0.000024 | <0.0010 | <0.0010 | | | <0.000010 | 0.0401 |
| W9 | 7/29/2005 | 5.69 | <0.00010 | 0.14 | | | <0.010 | <0.00010 | 0.00005 | <0.0010 | 0.004 | | | <0.000010 | 0.0478 |
| W9 | 8/29/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0564 |
| W9 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0642 |
| W9 | 10/15/2005 | 6.13 | <0.00010 | 0.0806 | | | <0.010 | <0.00010 | 0.000023 | <0.0010 | 0.0017 | | | <0.000010 | 0.0622 |
| W10 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | 0.0085 | | | <0.000020 | 0.151 |
| W10 | 5/27/2005 | | <0.0005 | | | | <0.01 | <0.0002 | 0.00079 | <0.03 | <0.005 | | | <0.00002 | |
| W10 | 6/30/2005 | 5.43 | <0.00010 | 0.0772 | | | <0.010 | <0.00010 | 0.000028 | <0.0010 | 0.0223 | | | <0.000010 | 0.142 |
| W10 | 7/29/2005 | 5.64 | <0.00010 | 0.0921 | | | <0.010 | <0.00010 | <0.000010 | <0.0010 | 0.0074 | | | <0.000030 | 2.59 |
| W10 | 8/29/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | 0.0052 | | | <0.000020 | 0.587 |
| W10 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0818 |
| W10 | 10/15/2005 | 5.82 | <0.00010 | 0.147 | | | <0.010 | <0.00010 | 0.000013 | <0.0010 | 0.0015 | | | <0.000010 | 0.089 |
| W6 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.229 |
| W6 | 6/30/2005 | 7.18 | <0.00010 | 0.102 | | | <0.010 | <0.00010 | 0.000134 | <0.0010 | 0.021 | | | <0.000010 | 0.17 |
| W6 | 7/29/2005 | 5.51 | <0.00010 | 0.274 | | | <0.010 | <0.00010 | 0.0014 | <0.0010 | 0.0025 | | | <0.000020 | 0.598 |
| W6 | 8/30/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0181 |
| W6 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | <0.00020 | <0.030 | <0.0050 | | | <0.000020 | 0.0321 |
| W6 | 10/15/2005 | 6.93 | <0.00010 | 0.108 | | | <0.010 | <0.00010 | 0.000122 | <0.0010 | 0.0015 | | | <0.000010 | 0.0251 |
| W6 | 6/2/2006 | 4.84 | <0.0001 | 0.0682 | | | <0.01 | <0.0001 | 0.000081 | <0.001 | 0.003 | | | 0.000021 | 1.95 |
| W6 | 8/25/2006 | | | | | | | | | | | | | <0.0002 | 0.024 |
| W6 | 9/6/2006 | 7.54 | <0.001 | 0.136 | | | 0.0005 | <0.00005 | <0.0005 | 0.0016 | 0.002 | | | <0.0001 | 0.035 |
| W6 | 6/20/2007 | | | | | | | | | | | | | <0.0001 | 0.042 |
| W6 | 9/18/2007 | | | | | | | | | | | | | <0.0001 | 0.023 |
| W6 | 6/17/2008 | | | | | | | | | | | | | <0.00001 | 0.14 |
| W6 | 9/18/2008 | 6.29 | <0.0001 | 0.098 | <0.0001 | <0.0001 | 0.001 | <0.00001 | <0.0004 | 0.00073 | 0.003 | 0.0002 | | 0.00008 | 0.022 |
| W6 | 4/14/2009 | 3.63 | <0.0001 | 0.419 | <0.0001 | <0.0001 | 0.0032 | <0.00001 | 0.004 | 0.00029 | 0.049 | <0.0001 | | 0.00021 | 1.3 |
| W6 | 4/30/2009 | 2.3 | <0.0001 | 0.099 | <0.0001 | <0.0001 | 0.0044 | <0.00001 | <0.0004 | 0.00047 | 0.006 | 0.0004 | | <0.00001 | 5.31 |
| W6 | 7/28/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | | | | | | | | | | | | | <0.00001 | 0.085 |
| W6 | 8/6/2009 | | | | | | | | | | | | | <0.00001 | 0.07 |
| W6 | 8/18/2009 | 4.06 | <0.0001 | 0.584 | <0.0001 | <0.0004 | 0.0004 | <0.00001 | 0.0008 | 0.0006 | 0.002 | <0.0001 | | | |
| W6 | 8/25/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | <0.00001 | 0.171 |
| W6 | 10/25/2009 | 4.2 | <0.005 | 0.817 | | | <0.005 | <0.00005 | 0.0009 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.065 |
| W6 | 4/19/2010 | 3.81 | <0.0001 | 0.372 | <0.0001 | <0.0004 | <0.01 | <0.00001 | 0.0013 | 0.0006 | 0.005 | <0.0001 | | 0.00002 | 1.25 |
| W6 | 5/16/2010 | 5.52 | <0.005 | 0.199 | | | <0.005 | <0.00005 | <0.0001 | <0.005 | <0.005 | <0.0005 | | 0.00002 | 0.041 |
| W6 | 5/17/2010 | 2.22 | <0.005 | 0.219 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.025 |
| W6 | 5/19/2010 | 2.79 | <0.005 | 0.245 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.03 |
| W6 | 5/21/2010 | 2.14 | <0.005 | 0.243 | | | <0.01 | <0.00005 | 0.0006 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.162 |
| W6 | 5/23/2010 | 2.58 | <0.005 | 0.285 | | | <0.01 | <0.00005 | 0.0006 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.027 |
| W6 | 5/25/2010 | 2.6 | <0.005 | 0.306 | | | <0.01 | <0.00005 | 0.0005 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.061 |
| W6 | 5/29/2010 | <2 | <0.005 | 0.221 | | | <0.01 | <0.00005 | 0.0005 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.09 |
| W6 | 6/2/2010 | 5.16 | <0.005 | 0.623 | | | <0.01 | <0.00005 | 0.0028 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.036 |
| W6 | 6/4/2010 | 5.66 | <0.005 | 0.099 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.049 |
| W6 | 6/6/2010 | 6.95 | <0.005 | 0.115 | | | <0.01 | <0.00005 | 0.0004 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.142 |
| W6 | 6/14/2010 | 7.21 | <0.005 | 0.099 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.274 |
| W6 | 6/16/2010 | 6.57 | <0.005 | 0.117 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.274 |
| W6 | 6/18/2010 | 7.25 | <0.005 | 0.111 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.154 |
| W6 | 6/20/2010 | 6.72 | <0.005 | 0.109 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.138 |
| W6 | 6/22/2010 | 6.78 | <0.005 | 0.109 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.208 |
| W6 | 6/24/2010 | 6.84 | <0.005 | 0.109 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.118 |
| W6 | 6/26/2010 | 6.94 | <0.005 | 0.118 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.143 |
| W6 | 6/26/2010 | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | 7.64 | <0.005 | 0.115 | | | <0.01 | <0.00005 | 0.0002 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.612 |
| W6 | 7/5/2010 | 6.24 | <0.005 | 0.112 | | | <0.01 | <0.00005 | 0.0002 | <0.005 | <0.01 | <0.002 | | <0.0001 | 1.41 |
| W6 | 8/5/2010 | 7.84 | <0.005 | 0.13 | | | <0.01 | <0.00005 | 0.0002 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.157 |
| W6 | 9/9/2010 | 7.77 | <0.005 | 0.13 | | | <0.01 | <0.00005 | 0.0002 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.655 |
| W6 | 10/8/2010 | 6.98 | <0.005 | 0.125 | | | <0.005 | <0.00005 | 0.0002 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.429 |
| W6 | 8/19/2011 | 5.54 | <0.005 | 0.617 | | | <0.005 | <0.00005 | 0.0025 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.033 |
| W6 | 7/17/2012 | 7.25 | <0.0050 | 0.131 | | | <0.0050 | <0.000050 | 0.00034 | <0.0050 | <0.0050 | <0.00050 | | 0.000172 | 20.8 |
| W6 | 7/30/2012 | 6.95 | <0.0050 | 0.135 | | | <0.0050 | <0.000050 | 0.00039 | <0.0050 | <0.0050 | <0.00050 | | 0.000122 | 15.1 |
| W6 | 8/9/2012 | 8.13 | <0.0050 | 0.151 | | | <0.0050 | <0.000050 | 0.00038 | <0.0050 | <0.0050 | <0.00050 | | 0.000054 | 8.03 |
| W6 | 8/25/2012 | 6.56 | <0.0050 | 0.143 | | | <0.0050 | <0.000050 | 0.0004 | <0.0050 | <0.0050 | <0.00050 | | 0.000021 | 5.23 |
| W6 | 9/13/2012 | 6.42 | <0.0050 | 0.11 | | | <0.0050 | <0.000050 | 0.00013 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.271 |
| W6 | 10/13/2012 | | | | | | | | | | | | | <0.000020 | 0.241 |
| W6 | 11/12/2012 | 8.72 | <0.0050 | 0.189 | | | <0.0050 | <0.000050 | 0.00032 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0243 |
| W6 | 5/14/2013 | 2.67 | <0.0050 | 0.0363 | | | <0.0050 | <0.000050 | <0.00010 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.65 |
| W6 | 6/22/2013 | 6.57 | <0.0050 | 0.115 | | | <0.0050 | <0.000050 | 0.00028 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 4.63 |
| W6 | 7/12/2013 | 7.05 | <0.0050 | 0.112 | | | <0.0050 | <0.000050 | 0.00017 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.506 |
| W6 | 8/22/2013 | 7.24 | <0.0050 | 0.132 | | | <0.0050 | <0.000050 | 0.00017 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0846 |
| W6 | 9/6/2013 | 7.48 | <0.0050 | 0.132 | | | <0.0050 | <0.000050 | 0.00016 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.165 |
| W6 | 10/7/2013 | 7.39 | <0.0050 | 0.126 | | | <0.0050 | <0.000050 | 0.00018 | <0.0050 | <0.0050 | <0.00050 | | 0.000045 | 2.18 |
| W6 | 11/16/2013 | 8.28 | <0.0050 | 0.144 | | | <0.0050 | <0.000050 | 0.00019 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.283 |
| W6 | 12/7/2013 | 9.38 | <0.0050 | 0.2 | | | <0.0050 | <0.000050 | 0.00039 | <0.0050 | <0.0050 | <0.00050 | | 0.000049 | 0.0734 |
| W7 | 5/27/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00036 | <0.030 | <0.0050 | | | <0.000020 | 0.489 |
| W7 | 6/30/2005 | 5.72 | <0.00010 | 0.284 | | | <0.010 | <0.00010 | 0.000759 | <0.0010 | 0.0064 | | | <0.000010 | 0.153 |
| W7 | 7/29/2005 | 5.47 | <0.00010 | 0.277 | | | <0.010 | <0.00010 | 0.000994 | <0.0010 | 0.002 | | | <0.000020 | 0.506 |
| W7 | 8/30/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00055 | <0.030 | <0.0050 | | | <0.000020 | 0.0436 |
| W7 | 9/28/2005 | | <0.00050 | | | | <0.010 | <0.00020 | 0.00038 | <0.030 | <0.0050 | | | <0.000020 | 1.65 |
| W7 | 10/15/2005 | 6.44 | <0.00010 | 0.23 | | | <0.010 | <0.00010 | 0.000515 | <0.0010 | <0.0010 | | | <0.000010 | 0.0738 |
| W7 | 6/2/2006 | 4.19 | <0.0001 | 0.11 | | | <0.01 | <0.0001 | 0.000216 | 0.0017 | <0.001 | | | 0.000069 | 11.4 |
| W7 | 6/8/2006 | | | | | | | | | | | | | <0.00001 | 0.648 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Dissolved Si (mg/L) | Dissolved Sn (mg/L) | Dissolved Sr (mg/L) | Dissolved Te (mg/L) | Dissolved Th (mg/L) | Dissolved Ti (mg/L) | Dissolved Tl (mg/L) | Dissolved U (mg/L) | Dissolved V (mg/L) | Dissolved Zn (mg/L) | Dissolved Zr (mg/L) | P-E (mg/L) | TT Ag (mg/L) | TT Al (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | 5.35 | <0.001 | 0.236 | | | 0.0007 | <0.00005 | 0.0007 | 0.0011 | <0.001 | | | <0.0001 | 1.48 |
| W7 | 6/23/2006 | 5.5 | <0.001 | 0.321 | | | 0.0006 | <0.00005 | 0.001 | 0.001 | 0.002 | | | 0.0003 | 5.09 |
| W7 | 6/28/2006 | 6.48 | <0.001 | 0.284 | | | 0.0117 | <0.00005 | 0.0009 | 0.0029 | 0.005 | | | <0.0001 | 1.69 |
| W7 | 7/7/2006 | 6.8 | <0.001 | 0.322 | | | 0.0007 | <0.00005 | 0.0005 | 0.0013 | 0.001 | | | <0.0001 | 0.096 |
| W7 | 7/12/2006 | 5.36 | <0.001 | 0.322 | | | 0.0005 | <0.00005 | 0.0007 | 0.0018 | <0.001 | | | <0.0001 | 0.078 |
| W7 | 7/20/2006 | 6.34 | <0.001 | 0.284 | | | <0.0005 | <0.00005 | 0.001 | 0.0016 | <0.001 | | | <0.0001 | 0.058 |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | 5.35 | <0.001 | 0.274 | | | <0.0005 | <0.00005 | 0.001 | 0.0007 | <0.001 | | | <0.0001 | 0.099 |
| W7 | 8/2/2006 | 5.87 | <0.001 | 0.247 | | | 0.0005 | <0.00005 | 0.001 | 0.0013 | <0.001 | | | 0.0002 | 0.06 |
| W7 | 8/10/2006 | 5.9 | <0.001 | 0.343 | | | 0.0006 | <0.00005 | 0.001 | 0.0015 | 0.001 | | | <0.0001 | 0.034 |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | 6.32 | <0.001 | 0.344 | | | 0.0005 | <0.00005 | 0.0011 | 0.0017 | 0.003 | | | <0.0002 | 0.048 |
| W7 | 8/30/2006 | 5.84 | <0.001 | 0.333 | | | 0.0008 | <0.00005 | 0.001 | 0.0008 | 0.005 | | | <0.0001 | 0.054 |
| W7 | 9/6/2006 | 6.02 | <0.001 | 0.355 | | | 0.0005 | <0.00005 | 0.001 | 0.0018 | 0.002 | | | <0.0001 | 0.049 |
| W7 | 9/13/2006 | 5.56 | <0.001 | 0.321 | | | 0.0006 | <0.00005 | 0.001 | 0.0014 | 0.001 | | | <0.0001 | 0.025 |
| W7 | 9/20/2006 | 5.74 | <0.001 | 0.319 | | | <0.0005 | <0.00005 | 0.001 | 0.0015 | <0.001 | | | <0.0001 | 0.074 |
| W7 | 9/28/2006 | 5.97 | <0.001 | 0.34 | | | <0.0005 | <0.00005 | 0.001 | 0.0015 | 0.002 | | | <0.0002 | 0.042 |
| W7 | 10/4/2006 | 5.93 | <0.001 | 0.326 | | | 0.0007 | <0.00005 | 0.001 | 0.0011 | 0.001 | | | <0.0002 | 0.082 |
| W7 | 10/12/2006 | 6.08 | <0.001 | 0.344 | | | 0.0006 | <0.00005 | 0.0011 | 0.0009 | 0.002 | | | <0.0001 | 0.264 |
| W7 | 6/5/2007 | | | | | | | | | | | | | <0.0001 | 1.56 |
| W7 | 6/5/2007 | | | | | | | | | | | | | <0.0002 | 1.77 |
| W7 | 6/5/2007 | | | | | | | | | | | | | <0.0001 | 1.85 |
| W7 | 6/20/2007 | 5.02 | <0.001 | 0.307 | | | 0.0009 | <0.00005 | 0.0012 | 0.0016 | 0.004 | | | <0.0001 | 0.172 |
| W7 | 7/18/2007 | 6.1 | <0.001 | 0.34 | | | 0.0006 | <0.00005 | 0.0012 | 0.0024 | 0.006 | | | <0.0001 | 0.231 |
| W7 | 7/18/2007 | | | | | | | | | | | | | <0.0001 | 0.216 |
| W7 | 7/18/2007 | | | | | | | | | | | | | <0.0001 | 0.211 |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | <0.0001 | 0.205 |
| W7 | 8/24/2007 | | | | | | | | | | | | | <0.0001 | 0.098 |
| W7 | 8/24/2007 | | | | | | | | | | | | | <0.0001 | 0.092 |
| W7 | 9/18/2007 | 6.17 | <0.001 | 0.31 | | | 0.0006 | <0.00005 | 0.0006 | 0.0044 | 0.002 | | | <0.0001 | 0.33 |
| W7 | 10/30/2007 | | | | | | | | | | | | | <0.0001 | 0.121 |
| W7 | 10/30/2007 | | | | | | | | | | | | | <0.0001 | 0.071 |
| W7 | 10/30/2007 | | | | | | | | | | | | | <0.0001 | 0.076 |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | 3.97 | <0.004 | 0.497 | <0.0001 | <0.0001 | 0.0011 | <0.00001 | 0.0021 | 0.00059 | 0.001 | <0.0001 | | <0.0001 | <0.02 |
| W7 | 4/22/2008 | 4.03 | <0.004 | 0.51 | <0.0001 | <0.0001 | 0.0009 | <0.00001 | 0.0024 | 0.00077 | 0.003 | 0.0001 | | <0.0001 | 0.02 |
| W7 | 4/22/2008 | 3.95 | <0.004 | 0.491 | <0.0001 | <0.0001 | 0.0014 | <0.00001 | 0.0022 | 0.0003 | 0.001 | <0.0001 | | <0.0001 | 0.02 |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | | | | | | | | | | | | | <0.0001 | 0.4 |
| W7 | 6/3/2008 | | | | | | | | | | | | | <0.0001 | 0.38 |
| W7 | 6/3/2008 | | | | | | | | | | | | | <0.0001 | 0.42 |
| W7 | 6/3/2008 | 2.27 | <0.0001 | 0.226 | <0.0001 | <0.0001 | 0.0005 | <0.00001 | 0.001 | 0.00062 | 0.002 | 0.0004 | | | |
| W7 | 6/17/2008 | | <0.0001 | 0.289 | 0.0002 | <0.0001 | 0.0015 | <0.00001 | 0.0014 | 0.00091 | 0.002 | 0.0003 | | <0.00001 | 0.21 |
| W7 | 8/6/2008 | | | | | | | | | | | | | 0.00001 | 0.817 |
| W7 | 8/6/2008 | | | | | | | | | | | | | 0.00001 | 1.27 |
| W7 | 8/6/2008 | | | | | | | | | | | | | 0.00001 | 1.36 |
| W7 | 8/6/2008 | 5.81 | <0.001 | 0.336 | | | <0.0005 | <0.00005 | 0.0011 | 0.001 | 0.006 | | | | |
| W7 | 9/18/2008 | 5.8 | <0.0001 | 0.173 | <0.0001 | <0.0001 | 0.0055 | <0.00001 | <0.0004 | 0.00094 | 0.003 | 0.0004 | | 0.00006 | 0.469 |
| W7 | 10/28/2008 | | | | | | | | | | | | | <0.00001 | 0.084 |
| W7 | 10/28/2008 | | | | | | | | | | | | | <0.00001 | 0.038 |
| W7 | 10/28/2008 | | | | | | | | | | | | | <0.00001 | 0.031 |
| W7 | 10/28/2008 | 6.6 | <0.0001 | 0.276 | <0.0001 | <0.0001 | 0.0011 | <0.00001 | 0.0007 | 0.00067 | 0.001 | 0.0002 | | | |
| W7 | 4/30/2009 | 1.48 | <0.0001 | 0.029 | <0.0001 | <0.0001 | 0.0015 | <0.00001 | <0.0004 | 0.00024 | 0.009 | 0.0002 | | <0.00001 | 0.138 |
| W7 | 6/8/2009 | 4.13 | <0.0001 | 0.24 | <0.0001 | <0.0001 | 0.0011 | <0.00001 | 0.0008 | 0.0008 | 0.002 | 0.0003 | | 0.00002 | 0.595 |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | | | | | | | | | | | | | 0.00002 | 0.071 |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | | | |
| W7 | 8/31/2009 | 6.04 | <0.0001 | 0.256 | <0.0001 | <0.0004 | 0.0004 | <0.00001 | 0.0007 | 0.0007 | 0.001 | 0.0002 | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | <0.00001 | 0.189 |
| W7 | 10/25/2009 | 6.3 | <0.005 | 0.334 | | | <0.005 | <0.00005 | 0.0012 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.052 |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | 4.15 | <0.0001 | 0.212 | <0.0001 | <0.0004 | <0.01 | <0.00001 | 0.0005 | 0.0005 | 0.005 | <0.0001 | | <0.00001 | 0.033 |
| W7 | 4/27/2010 | 2.94 | <0.005 | 0.071 | | | <0.005 | <0.00005 | 0.0001 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.113 |
| W7 | 4/29/2010 | 2.89 | <0.005 | 0.076 | | | <0.005 | <0.00005 | 0.0001 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.11 |
| W7 | 5/1/2010 | 3.27 | <0.005 | 0.088 | | | <0.005 | <0.00005 | 0.0002 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.502 |
| W7 | 5/3/2010 | 3.63 | <0.005 | 0.097 | | | <0.005 | <0.00005 | 0.0002 | <0.005 | <0.005 | <0.0005 | | 0.00003 | 0.406 |
| W7 | 5/5/2010 | 3.84 | <0.005 | 0.116 | | | <0.005 | <0.00005 | 0.0003 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.394 |
| W7 | 5/7/2010 | 3.77 | <0.005 | 0.129 | | | <0.005 | <0.00005 | 0.0003 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.407 |
| W7 | 5/9/2010 | 4.61 | <0.005 | 0.192 | | | <0.005 | <0.00005 | 0.0006 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.183 |
| W7 | 5/10/2010 | 4.62 | <0.005 | 0.195 | | | <0.005 | <0.00005 | 0.0006 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.125 |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | 5 | <0.005 | 0.201 | | | <0.005 | <0.00005 | 0.0006 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.123 |
| W7 | 5/14/2010 | 4.35 | <0.005 | 0.178 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.286 |
| W7 | 5/16/2010 | 4.68 | <0.005 | 0.207 | | | <0.005 | <0.00005 | 0.0007 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.207 |
| W7 | 5/17/2010 | 4.22 | <0.005 | 0.191 | | | <0.005 | <0.00005 | 0.0006 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.219 |
| W7 | 5/19/2010 | 5.24 | <0.005 | 0.21 | | | <0.005 | <0.00005 | 0.0008 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.105 |
| W7 | 5/21/2010 | 4.98 | <0.005 | 0.22 | | | <0.01 | <0.00005 | 0.0008 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.457 |
| W7 | 5/23/2010 | 5.24 | <0.005 | 0.235 | | | <0.01 | <0.00005 | 0.0009 | <0.005 | <0.01 | <0.002 | | <0.0001 | 2.14 |
| W7 | 5/25/2010 | 6.05 | <0.005 | 0.306 | | | <0.01 | <0.00005 | 0.0011 | <0.005 | <0.01 | <0.002 | | <0.0001 | 4.2 |
| W7 | 5/27/2010 | 5.4 | <0.005 | 0.277 | | | <0.01 | <0.00005 | 0.0011 | <0.005 | <0.01 | <0.002 | | <0.0001 | 10.3 |
| W7 | 5/29/2010 | 5.26 | <0.005 | 0.289 | | | <0.01 | <0.00005 | 0.0014 | <0.005 | <0.01 | <0.002 | | <0.0001 | 3.93 |
| W7 | 5/31/2010 | | <0.005 | 0.286 | | | <0.01 | <0.00005 | 0.0014 | <0.005 | <0.01 | <0.002 | | <0.0001 | 4.54 |
| W7 | 6/2/2010 | 5.16 | <0.005 | 0.293 | | | <0.01 | <0.00005 | 0.0015 | <0.005 | <0.01 | <0.002 | | <0.0001 | 2.91 |
| W7 | 6/4/2010 | 4.96 | <0.005 | 0.275 | | | <0.01 | <0.00005 | 0.0014 | <0.005 | <0.01 | <0.002 | | <0.0001 | 1.64 |
| W7 | 6/6/2010 | 5.46 | <0.005 | 0.313 | | | <0.01 | <0.00005 | 0.0015 | <0.005 | <0.01 | <0.002 | | <0.0001 | 2.05 |
| W7 | 6/14/2010 | 5.87 | <0.005 | 0.314 | | | <0.01 | <0.00005 | 0.0015 | <0.005 | <0.01 | <0.002 | | <0.0001 | 1.1 |
| W7 | 6/16/2010 | 5.32 | <0.005 | 0.338 | | | <0.01 | <0.00005 | 0.0015 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.43 |
| W7 | 6/18/2010 | 5.82 | <0.005 | 0.318 | | | <0.01 | <0.00005 | 0.0015 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.504 |
| W7 | 6/20/2010 | 5.69 | <0.005 | 0.3 | | | <0.01 | <0.00005 | 0.0012 | <0.005 | <0.01 | <0.002 | | <0.0001 | 1.17 |
| W7 | 6/22/2010 | 5.86 | <0.005 | 0.249 | | | <0.01 | <0.00005 | 0.0008 | <0.005 | <0.01 | <0.002 | | <0.0001 | 5.52 |
| W7 | 6/24/2010 | 5.79 | <0.005 | 0.259 | | | <0.01 | <0.00005 | 0.0008 | <0.005 | <0.01 | <0.002 | | <0.0001 | 1.21 |
| W7 | 6/26/2010 | 6.05 | <0.005 | 0.305 | | | <0.01 | <0.00005 | 0.001 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.503 |
| W7 | 6/28/2010 | 6.64 | <0.005 | 0.314 | | | <0.01 | <0.00005 | 0.001 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.298 |
| W7 | 7/5/2010 | 6.08 | <0.005 | 0.255 | | | <0.01 | <0.00005 | 0.0006 | <0.005 | <0.01 | <0.002 | | <0.0001 | 1.59 |
| W7 | 8/5/2010 | 6.47 | <0.005 | 0.303 | | | <0.01 | <0.00005 | 0.0007 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.22 |
| W7 | 9/12/2010 | | | | | | | | | | | | | <0.0001 | 0.256 |
| W7 | 9/12/2010 | 7.17 | <0.005 | 0.253 | | | <0.01 | <0.00005 | 0.0005 | <0.005 | <0.01 | <0.002 | | <0.0001 | 0.273 |
| W7 | 10/8/2010 | 6.54 | <0.005 | 0.277 | | | <0.005 | <0.00005 | 0.0007 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.064 |
| W7 | 4/27/2011 | 3.09 | <0.005 | 0.084 | | | <0.005 | <0.00005 | 0.0001 | <0.005 | 0.005 | <0.0005 | | <0.00002 | 0.101 |
| W7 | 5/2/2011 | 2.52 | <0.005 | 0.062 | | | <0.005 | <0.00005 | <0.0001 | <0.005 | 0.01 | <0.0005 | | <0.00002 | 0.25 |
| W7 | 6/1/2011 | 5.26 | <0.005 | 0.25 | | | <0.005 | <0.00005 | 0.0007 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.454 |
| W7 | 6/16/2011 | 6.52 | <0.005 | 0.213 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 2.48 |
| W7 | 7/1/2011 | 6.61 | <0.005 | 0.154 | | | <0.005 | <0.00005 | 0.0003 | <0.005 | <0.005 | <0.0005 | | 0.00004 | 3.4 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Dissolved Si (mg/L) | Dissolved Sn (mg/L) | Dissolved Sr (mg/L) | Dissolved Te (mg/L) | Dissolved Th (mg/L) | Dissolved Ti (mg/L) | Dissolved Tl (mg/L) | Dissolved U (mg/L) | Dissolved V (mg/L) | Dissolved Zn (mg/L) | Dissolved Zr (mg/L) | P-E (mg/L) | TT Ag (mg/L) | TT Al (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | 5.78 | <0.005 | 0.12 | | | <0.005 | <0.00005 | 0.0002 | <0.005 | <0.005 | <0.0005 | | 0.00008 | 9.23 |
| W7 | 8/16/2011 | 6.96 | <0.005 | 0.21 | | | <0.005 | <0.00005 | 0.0004 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.403 |
| W7 | 8/19/2011 | 6.9 | <0.005 | 0.197 | | | <0.005 | <0.00005 | 0.0003 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.444 |
| W7 | 9/12/2011 | 7.71 | <0.005 | 0.266 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.08 |
| W7 | 10/6/2011 | 6.17 | <0.005 | 0.266 | | | <0.005 | <0.00005 | 0.0006 | <0.005 | <0.005 | <0.0005 | | <0.00002 | 0.065 |
| W7 | 11/22/2011 | 8.07 | <0.0050 | 0.366 | | | <0.0050 | <0.000050 | 0.00106 | <0.0050 | <0.0050 | <0.00050 | | <0.00002 | 0.407 |
| W7 | 1/24/2012 | 7.24 | <0.0050 | 0.456 | | | <0.0050 | <0.000050 | 0.00163 | <0.0050 | <0.0050 | <0.00050 | | <0.00002 | 0.01 |
| W7 | 2/25/2012 | 6.43 | <0.0050 | 0.448 | | | <0.0050 | <0.000050 | 0.0015 | <0.0050 | 0.0083 | <0.00050 | | <0.00002 | 0.018 |
| W7 | 3/5/2012 | 5.99 | <0.0050 | 0.468 | | | <0.0050 | <0.000050 | 0.00145 | <0.0050 | <0.0050 | <0.00050 | | <0.00002 | 0.043 |
| W7 | 4/24/2012 | 2.94 | <0.0050 | 0.0774 | | | <0.0050 | <0.000050 | 0.00014 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.766 |
| W7 | 5/6/2012 | 3.66 | <0.0050 | 0.106 | | | <0.0050 | <0.000050 | <0.00010 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.11 |
| W7 | 5/6/2012 | 3.7 | <0.0050 | 0.105 | | | <0.0050 | <0.000050 | <0.00010 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.131 |
| W7 | 6/19/2012 | 6.21 | <0.0050 | 0.191 | | | <0.0050 | <0.000050 | 0.00043 | <0.0050 | <0.0050 | <0.00050 | | 0.00003 | 5.38 |
| W7 | 7/17/2012 | 6.79 | <0.0050 | 0.306 | | | <0.0050 | <0.000050 | 0.00074 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.93 |
| W7 | 7/30/2012 | 6.86 | <0.0050 | 0.329 | | | <0.0050 | <0.000050 | 0.00091 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.2 |
| W7 | 8/8/2012 | 7 | <0.0050 | 0.357 | | | <0.0050 | <0.000050 | 0.00096 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0828 |
| W7 | 8/23/2012 | 7.06 | <0.0050 | 0.35 | | | <0.0050 | <0.000050 | 0.00097 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0342 |
| W7 | 9/13/2012 | 6.7 | <0.0050 | 0.247 | | | <0.0050 | <0.000050 | 0.00052 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.139 |
| W7 | 10/16/2012 | 6.8 | <0.0050 | 0.303 | | | <0.0050 | <0.000050 | 0.00077 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.127 |
| W7 | 11/2/2012 | 6.94 | <0.0050 | 0.407 | | | <0.0050 | <0.000050 | 0.00135 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0576 |
| W7 | 12/29/2012 | 9.63 | <0.0050 | 0.535 | | | <0.0050 | <0.000050 | 0.00133 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0127 |
| W7 | 4/30/2013 | 6.83 | <0.0050 | 0.607 | | | <0.0050 | <0.000050 | 0.00213 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0111 |
| W7 | 5/14/2013 | 2.15 | <0.0050 | 0.063 | | | <0.0050 | <0.000050 | <0.00010 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 1.34 |
| W7 | 6/19/2013 | 5.93 | <0.0050 | 0.276 | | | <0.0050 | <0.000050 | 0.00097 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.256 |
| W7 | 6/19/2013 | 5.92 | <0.0050 | 0.277 | | | <0.0050 | <0.000050 | 0.00098 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.213 |
| W7 | 7/13/2013 | 7.01 | <0.0050 | 0.327 | | | <0.0050 | <0.000050 | 0.00105 | <0.0050 | <0.0050 | <0.00050 | | 0.000024 | 0.127 |
| W7 | 8/21/2013 | 6.79 | <0.0050 | 0.364 | | | <0.0050 | <0.000050 | 0.00107 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.137 |
| W7 | 9/6/2013 | 7.12 | <0.0050 | 0.339 | | | <0.0050 | <0.000050 | 0.00088 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.37 |
| W7 | 10/21/2013 | 7.18 | <0.0050 | 0.353 | | | <0.0050 | <0.000050 | 0.00093 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0931 |
| W7 | 11/16/2013 | 6.47 | <0.0050 | 0.418 | | | <0.0050 | <0.000050 | 0.0015 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.0389 |
| W7 | 12/7/2013 | 7.02 | <0.0050 | 0.439 | | | <0.0050 | <0.000050 | 0.00126 | <0.0050 | <0.0050 | <0.00050 | | 0.000046 | 0.0098 |
| C4 | 5/6/2012 | 4.02 | <0.0050 | 0.0653 | | | <0.0050 | <0.000050 | 0.00015 | <0.0050 | <0.0050 | 0.00054 | | 0.00021 | 29.7 |
| C4 | 8/1/2012 | 8.03 | <0.0050 | 0.206 | | | <0.0050 | <0.000050 | 0.00065 | <0.0050 | <0.0050 | 0.00061 | | 0.000056 | 7.06 |
| C4 | 8/8/2012 | 7.91 | <0.0050 | 0.225 | | | <0.0050 | <0.000050 | 0.00075 | <0.0050 | <0.0050 | 0.00053 | | 0.000051 | 7.01 |
| C4 | 8/25/2012 | 7.53 | <0.0050 | 0.231 | | | <0.0050 | <0.000050 | 0.00076 | <0.0050 | <0.0050 | 0.00058 | | 0.00002 | 4.45 |
| C4 | 6/22/2013 | 6.82 | <0.0050 | 0.184 | | | <0.0050 | <0.000050 | 0.00115 | <0.0050 | <0.0050 | 0.00052 | | 0.000074 | 20.4 |
| C4 | 7/19/2013 | 7.14 | <0.0050 | 0.193 | | | <0.0050 | <0.000050 | 0.001 | <0.0050 | <0.0050 | <0.00050 | | 0.000087 | 13.5 |
| C4 | 8/22/2013 | 7.18 | <0.0050 | 0.209 | | | <0.0050 | <0.000050 | 0.00095 | <0.0050 | <0.0050 | 0.00058 | | 0.000063 | 13.8 |
| C4 | 9/6/2013 | 7.73 | <0.0050 | 0.214 | | | <0.0050 | <0.000050 | 0.00075 | <0.0050 | <0.0050 | 0.00055 | | 0.000021 | 5.43 |
| C4 | 10/18/2013 | 7.06 | <0.0050 | 0.217 | | | <0.0050 | <0.000050 | 0.00068 | <0.0050 | <0.0050 | <0.00050 | | 0.000052 | 0.349 |
| C4 | 10/18/2013 | 7.12 | <0.0050 | 0.218 | | | <0.0050 | <0.000050 | 0.0007 | <0.0050 | <0.0050 | <0.00050 | | 0.000124 | 0.358 |
| C4 | 11/17/2013 | 8.74 | <0.0050 | 0.405 | | | <0.0050 | <0.000050 | 0.00063 | <0.0050 | <0.0050 | 0.00111 | | <0.000020 | 0.0856 |
| C10 | 5/12/2012 | 3.83 | <0.0050 | 0.0919 | | | <0.0050 | <0.000050 | 0.00057 | <0.0050 | <0.0050 | <0.00050 | | 0.000337 | 39.6 |
| C10 | 7/30/2012 | 6.28 | <0.0050 | 0.189 | | | <0.0050 | <0.000050 | 0.00243 | <0.0050 | <0.0050 | <0.00050 | | 0.0002 | 21.3 |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | 6.7 | <0.0050 | 0.2 | | | <0.0050 | <0.000050 | 0.00182 | <0.0050 | <0.0050 | <0.00050 | | 0.000187 | 21.1 |
| C10 | 8/27/2012 | 6.39 | <0.0050 | 0.214 | | | <0.0050 | <0.000050 | 0.00149 | <0.0050 | <0.0050 | <0.00050 | | 0.000217 | 24.8 |
| C10 | 6/22/2013 | 6.15 | <0.0050 | 0.195 | | | <0.0050 | <0.000050 | 0.0011 | <0.0050 | 0.0104 | <0.00050 | | <0.000020 | 1.31 |
| C10 | 7/23/2013 | 6.42 | <0.0050 | 0.177 | | | <0.0050 | <0.000050 | 0.00075 | <0.0050 | <0.0050 | <0.00050 | | 0.000021 | 4.86 |
| C10 | 8/22/2013 | 7.14 | <0.0050 | 0.242 | | | <0.0050 | <0.000050 | 0.00117 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.947 |
| C10 | 9/8/2013 | 7.12 | <0.0050 | 0.255 | | | <0.0050 | <0.000050 | 0.00094 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.509 |
| C10 | 9/8/2013 | 7.01 | <0.0050 | 0.254 | | | <0.0050 | <0.000050 | 0.0009 | <0.0050 | <0.0050 | <0.00050 | | <0.000020 | 0.483 |
| C10 | 10/18/2013 | 5.99 | <0.0050 | 0.201 | | | <0.0050 | <0.000050 | 0.0007 | <0.0050 | <0.0050 | <0.00050 | | 0.000068 | 1.14 |

## Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.

| Station Name | Sample Date | TT As (mg/L) | Ba (mg/L) | Total Be (mg/L) | Total Bi (mg/L) | Total B (mg/L) | Total Ca (mg/L) | Total Cd (mg/L) | Total Co (mg/L) | Total Cr (mg/L) | Total Cu (mg/L) | Total Fe (mg/L) | Total Hg (mg/L) | Total K (mg/L) | Total La (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | 0.0009 | 0.062 | <0.0010 | | <0.10 | 25.9 | <0.000050 | 0.00058 | 0.002 | 0.0059 | 1.05 | <0.000020 | <2.0 | |
| W1 | 6/30/2005 | 0.00047 | 0.0545 | <0.00050 | <0.00050 | <0.010 | 36.7 | <0.000050 | <0.00010 | <0.00050 | 0.00204 | 0.088 | | <2.0 | |
| W1 | 7/28/2005 | 0.00045 | 0.0597 | <0.00050 | <0.00050 | <0.010 | 38.5 | <0.000050 | <0.00010 | <0.00050 | 0.00229 | 0.079 | | <2.0 | |
| W1 | 8/29/2005 | 0.00062 | 0.059 | <0.0010 | | <0.10 | 35 | <0.000017 | <0.00030 | <0.0010 | 0.0026 | 0.387 | <0.000020 | <2.0 | |
| W1 | 9/28/2005 | 0.00068 | 0.059 | <0.0010 | | <0.10 | 35.5 | <0.000017 | <0.00030 | <0.0010 | 0.0039 | 0.691 | <0.000020 | <2.0 | |
| W1 | 10/15/2005 | 0.00062 | 0.054 | <0.00050 | <0.00050 | <0.010 | 34.2 | <0.000050 | 0.00026 | 0.00068 | 0.00458 | 0.526 | | <2.0 | |
| W2 | 5/27/2005 | 0.00075 | 0.058 | <0.0010 | | <0.10 | 24.8 | <0.000050 | 0.00043 | 0.0012 | 0.0049 | 0.778 | <0.000020 | <2.0 | |
| W2 | 5/27/2005 | 0.00104 | 0.053 | <0.001 | | <0.1 | 19.9 | <0.00005 | 0.00087 | 0.0027 | 0.0037 | 1.49 | | | |
| W2 | 6/30/2005 | 0.00045 | 0.0569 | <0.00050 | <0.00050 | <0.010 | 37.5 | <0.000050 | <0.00010 | <0.00050 | 0.00207 | 0.052 | | <2.0 | |
| W2 | 7/28/2005 | 0.00046 | 0.0576 | <0.00050 | <0.00050 | <0.010 | 39.1 | <0.000050 | <0.00010 | <0.00050 | 0.00245 | 0.079 | | <2.0 | |
| W2 | 8/30/2005 | 0.00063 | 0.06 | <0.0010 | | <0.10 | 35.4 | <0.000017 | <0.00030 | <0.0010 | 0.0026 | 0.373 | <0.000020 | <2.0 | |
| W2 | 9/28/2005 | 0.00069 | 0.057 | <0.0010 | | <0.10 | 34.3 | <0.000017 | <0.00030 | <0.0010 | 0.0039 | 0.674 | <0.000020 | <2.0 | |
| W2 | 10/15/2005 | 0.00061 | 0.0528 | <0.00050 | <0.00050 | <0.010 | 34.1 | <0.000050 | 0.00018 | 0.00059 | 0.00404 | 0.436 | | <2.0 | |
| W3 | 5/27/2005 | <0.00050 | 0.042 | <0.0010 | | <0.10 | 20.9 | <0.000050 | <0.00030 | <0.0010 | 0.0078 | 0.32 | <0.000020 | <2.0 | |
| W3 | 6/30/2005 | 0.00037 | 0.0518 | <0.00050 | <0.00050 | <0.010 | 39.1 | <0.000050 | <0.00010 | 0.0005 | 0.00374 | 0.081 | | <2.0 | |
| W3 | 7/29/2005 | 0.00081 | 0.0667 | <0.00050 | <0.00050 | <0.010 | 37.3 | <0.000050 | 0.00062 | 0.002 | 0.0149 | 1.32 | | <2.0 | |
| W3 | 8/29/2005 | 0.00054 | 0.06 | <0.0010 | | <0.10 | 30.8 | <0.000017 | <0.00030 | <0.0010 | 0.0086 | 0.698 | <0.000020 | <2.0 | |
| W3 | 9/28/2005 | 0.00055 | 0.055 | <0.0010 | | <0.10 | 28.7 | <0.000017 | 0.0003 | <0.0010 | 0.01 | 0.794 | <0.000020 | <2.0 | |
| W3 | 10/15/2005 | 0.00045 | 0.0489 | <0.00050 | <0.00050 | <0.010 | 29.4 | <0.000050 | 0.00023 | <0.00050 | 0.00855 | 0.497 | | <2.0 | |
| W8 | 5/27/2005 | <0.00050 | 0.04 | <0.0010 | | <0.10 | 16.9 | <0.000050 | <0.00030 | <0.0010 | 0.0143 | 0.23 | <0.000020 | <2.0 | |
| W8 | 6/30/2005 | 0.00048 | 0.0503 | <0.00050 | <0.00050 | <0.010 | 24.3 | <0.000050 | 0.00021 | 0.00073 | 0.0103 | 0.503 | | <2.0 | |
| W8 | 7/29/2005 | 0.00047 | 0.0546 | <0.00050 | <0.00050 | <0.010 | 30.9 | <0.000050 | 0.00017 | 0.00056 | 0.00891 | 0.435 | | <2.0 | |
| W8 | 8/30/2005 | 0.00052 | 0.055 | <0.0010 | | <0.10 | 25.6 | <0.000017 | <0.00030 | <0.0010 | 0.0094 | 0.722 | <0.000020 | <2.0 | |
| W8 | 9/28/2005 | <0.00050 | 0.049 | <0.0010 | | <0.10 | 24.7 | <0.000017 | <0.00030 | <0.0010 | 0.0088 | 0.706 | <0.000020 | <2.0 | |
| W8 | 10/15/2005 | 0.00054 | 0.0504 | <0.00050 | <0.00050 | <0.010 | 25.1 | <0.000050 | 0.00037 | <0.00050 | 0.0104 | 0.887 | | <2.0 | |
| W9 | 5/27/2005 | <0.00050 | 0.042 | <0.0010 | | <0.10 | 12.9 | <0.000050 | <0.00030 | <0.0010 | 0.0035 | 0.277 | 0.000023 | <2.0 | |
| W9 | 6/30/2005 | 0.00058 | 0.0532 | <0.00050 | <0.00050 | <0.010 | 18.9 | <0.000050 | 0.00019 | <0.00050 | 0.0021 | 0.799 | | <2.0 | |
| W9 | 7/29/2005 | 0.00061 | 0.058 | <0.00050 | <0.00050 | <0.010 | 25.1 | <0.000050 | 0.0002 | 0.0006 | 0.00345 | 0.894 | | <2.0 | |
| W9 | 8/29/2005 | 0.00064 | 0.054 | <0.0010 | | <0.10 | 18.3 | <0.000017 | 0.00031 | <0.0010 | 0.002 | 1.01 | <0.000020 | <2.0 | |
| W9 | 9/28/2005 | 0.00051 | 0.048 | <0.0010 | | <0.10 | 17.2 | <0.000017 | <0.00030 | <0.0010 | 0.0024 | 0.783 | <0.000020 | <2.0 | |
| W9 | 10/15/2005 | 0.00042 | 0.0424 | <0.00050 | <0.00050 | <0.010 | 15.6 | <0.000050 | 0.00016 | 0.00051 | 0.00214 | 0.543 | | <2.0 | |
| W10 | 5/27/2005 | <0.00050 | 0.053 | <0.0010 | | <0.10 | 12.9 | <0.000050 | <0.00030 | <0.0010 | 0.02 | 0.113 | <0.000020 | <2.0 | |
| W10 | 5/27/2005 | <0.0005 | | <0.001 | | <0.1 | | | 0.00088 | <0.001 | | | <0.00002 | <2.0 | |
| W10 | 6/30/2005 | 0.00076 | 0.0459 | <0.00050 | <0.00050 | <0.010 | 13.1 | <0.000050 | 0.00063 | 0.00069 | 0.00534 | 1.01 | | <2.0 | |
| W10 | 7/29/2005 | 0.00095 | 0.0868 | <0.00050 | <0.00050 | <0.010 | 15.5 | 0.000097 | 0.00241 | 0.00499 | 0.0138 | 2.84 | | <2.0 | |
| W10 | 8/29/2005 | <0.00050 | 0.059 | <0.0010 | | <0.10 | 18.5 | 0.000038 | 0.00053 | 0.0012 | 0.0056 | 0.681 | <0.000020 | <2.0 | |
| W10 | 9/28/2005 | <0.00050 | 0.057 | <0.0010 | | <0.10 | 25.4 | <0.000017 | <0.00030 | <0.0010 | 0.0035 | 0.097 | <0.000020 | <2.0 | |
| W10 | 10/15/2005 | 0.0003 | 0.051 | <0.00050 | <0.00050 | <0.010 | 24 | <0.000050 | 0.00011 | <0.00050 | 0.0045 | 0.121 | | <2.0 | |
| W6 | 5/27/2005 | 0.00052 | 0.038 | <0.0010 | | <0.10 | 17.4 | <0.000050 | <0.00030 | <0.0010 | 0.0021 | 0.363 | <0.000020 | <2.0 | |
| W6 | 6/30/2005 | 0.00045 | 0.0462 | <0.00050 | <0.00050 | <0.010 | 24.7 | <0.000050 | 0.00017 | 0.00057 | 0.00148 | 0.266 | | <2.0 | |
| W6 | 7/29/2005 | 0.00063 | 0.0683 | <0.00050 | <0.00050 | <0.010 | 41.1 | <0.000050 | 0.00049 | 0.00145 | 0.0118 | 1.08 | | <2.0 | |
| W6 | 8/30/2005 | <0.00050 | 0.053 | <0.0010 | | <0.10 | 28.6 | <0.000017 | <0.00030 | <0.0010 | 0.0012 | 0.088 | <0.000020 | <2.0 | |
| W6 | 9/28/2005 | <0.00050 | 0.048 | <0.0010 | | <0.10 | 28.2 | <0.000017 | <0.00030 | <0.0010 | 0.0012 | 0.148 | <0.000020 | <2.0 | |
| W6 | 10/15/2005 | 0.00043 | 0.0424 | <0.00050 | <0.00050 | <0.010 | 25.1 | <0.000050 | 0.00011 | <0.00050 | 0.00107 | 0.116 | | <2.0 | |
| W6 | 6/2/2006 | 0.00131 | 0.0679 | <0.0005 | <0.0005 | <0.01 | 18.9 | <0.00005 | 0.00127 | 0.00384 | 0.00531 | 2.74 | | <2 | |
| W6 | 8/25/2006 | 0.0006 | 0.056 | <0.0002 | <0.001 | 0.004 | 31.5 | <0.00002 | <0.0002 | <0.001 | <0.002 | <0.2 | | <0.8 | |
| W6 | 9/6/2006 | 0.0005 | 0.052 | <0.0001 | <0.0005 | 0.003 | 29 | <0.00001 | 0.0001 | 0.0005 | 0.001 | 0.1 | | 0.5 | |
| W6 | 6/20/2007 | 0.0004 | 0.042 | <0.0001 | <0.0005 | 0.004 | 23.2 | <0.00001 | 0.0001 | <0.0005 | 0.002 | 0.1 | <0.0001 | 0.4 | |
| W6 | 9/18/2007 | 0.0004 | 0.046 | <0.0001 | <0.0005 | 0.002 | 25.8 | <0.00001 | 0.0001 | <0.0005 | 0.001 | <0.1 | <0.0001 | 0.4 | |
| W6 | 6/17/2008 | 0.0004 | 0.042 | <0.00004 | | <0.005 | 23.8 | <0.00008 | 0.00018 | 0.0011 | 0.001 | 0.35 | | 0.46 | |
| W6 | 9/18/2008 | <0.0002 | 0.039 | <0.00004 | <0.0001 | <0.005 | 24.6 | <0.00001 | 0.00008 | 0.001 | 0.001 | 0.09 | <0.00001 | 0.4 | |
| W6 | 4/14/2009 | 0.0006 | 0.08 | 0.00006 | <0.0001 | 0.017 | 36 | 0.00024 | 0.00079 | 0.0029 | 0.454 | 2.19 | 0.00002 | 9.2 | |
| W6 | 4/30/2009 | 0.0023 | 0.111 | 0.00014 | <0.0001 | 0.006 | 18.6 | 0.00008 | 0.00275 | 0.0096 | 0.068 | 8 | 0.00002 | 2.6 | |
| W6 | 7/28/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | 0.0008 | 0.098 | <0.00004 | <0.001 | 0.025 | 49.4 | 0.00002 | 0.00016 | 0.0008 | 0.011 | 0.053 | | 3.4 | |
| W6 | 8/6/2009 | 0.0008 | 0.09 | <0.00004 | <0.001 | 0.018 | 49.7 | 0.00003 | 0.00015 | 0.0008 | 0.011 | 0.055 | | 3.4 | |
| W6 | 8/18/2009 | | | | | | | | | | | | | | |
| W6 | 8/25/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | 0.0002 | 0.132 | <0.00004 | <0.001 | 0.039 | 58 | <0.00001 | 0.00025 | 0.001 | 0.004 | 0.059 | <0.00001 | 3.2 | |
| W6 | 10/25/2009 | 0.0003 | 0.129 | <0.0001 | <0.001 | <0.05 | 59.9 | 0.00002 | <0.0005 | <0.001 | 0.0066 | 0.076 | <0.00002 | 3.41 | |
| W6 | 4/19/2010 | 0.0006 | 0.068 | <0.00004 | <0.001 | 0.013 | 35.2 | 0.00003 | 0.00075 | 0.0012 | 0.051 | 1.73 | <0.00001 | 2.7 | |
| W6 | 5/16/2010 | 0.0004 | 0.024 | <0.0001 | <0.001 | <0.05 | 25.1 | <0.00001 | <0.0005 | <0.001 | 0.0051 | 0.08 | <0.0002 | 1.34 | |
| W6 | 5/17/2010 | 0.0002 | 0.028 | <0.0001 | <0.001 | <0.05 | 19.6 | 0.00002 | <0.0005 | <0.001 | 0.0064 | 0.073 | <0.0002 | 0.89 | |
| W6 | 5/19/2010 | <0.001 | 0.045 | <0.0005 | <0.001 | <0.05 | 27.2 | 0.00003 | <0.0005 | 0.001 | 0.007 | 0.069 | <0.00002 | 1.32 | |
| W6 | 5/21/2010 | <0.0004 | 0.046 | <0.0002 | <0.001 | <0.1 | 25 | <0.0001 | <0.0005 | <0.002 | 0.033 | 0.263 | <0.0002 | 1 | |
| W6 | 5/23/2010 | <0.0004 | 0.047 | <0.0002 | <0.001 | <0.1 | 27 | <0.0001 | <0.0005 | <0.002 | 0.007 | 0.083 | <0.0002 | 1 | |
| W6 | 5/25/2010 | <0.001 | 0.049 | <0.0005 | <0.001 | <0.1 | 32 | <0.0001 | <0.0005 | <0.002 | 0.028 | 0.133 | <0.00002 | 1 | |
| W6 | 5/29/2010 | <0.0004 | 0.04 | <0.0002 | <0.001 | <0.1 | 21 | <0.0001 | <0.0005 | <0.002 | 0.022 | 0.21 | <0.00002 | <1 | |
| W6 | 6/2/2010 | <0.0004 | 0.077 | <0.0002 | <0.001 | <0.1 | 61 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.081 | <0.0002 | 2 | |
| W6 | 6/4/2010 | 0.0004 | 0.047 | <0.0002 | <0.001 | <0.1 | 26 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.12 | <0.0002 | <1 | |
| W6 | 6/6/2010 | 0.0005 | 0.053 | <0.0002 | <0.001 | <0.1 | 27 | <0.0001 | <0.0005 | <0.002 | 0.001 | 0.218 | | <1 | |
| W6 | 6/14/2010 | 0.0005 | 0.054 | <0.0002 | <0.001 | <0.1 | 26 | <0.0001 | <0.0005 | <0.002 | 0.004 | 0.378 | <0.0002 | <1 | |
| W6 | 6/16/2010 | 0.0005 | 0.05 | <0.0002 | <0.001 | <0.1 | 25 | <0.0001 | <0.0005 | <0.002 | 0.005 | 0.364 | <0.0002 | <1 | |
| W6 | 6/18/2010 | 0.0005 | 0.048 | <0.0002 | <0.001 | <0.1 | 24 | <0.0001 | <0.0005 | <0.002 | 0.003 | 0.226 | <0.0002 | <1 | |
| W6 | 6/20/2010 | 0.0004 | 0.049 | <0.0002 | <0.001 | <0.1 | 25 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.208 | <0.0002 | <1 | |
| W6 | 6/22/2010 | 0.0006 | 0.051 | <0.0002 | <0.001 | <0.1 | 27 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.326 | <0.0002 | <1 | |
| W6 | 6/24/2010 | 0.0004 | 0.04 | <0.0002 | <0.001 | <0.1 | 21 | <0.0001 | <0.0005 | <0.002 | 0.001 | 0.164 | <0.0002 | <1 | |
| W6 | 6/26/2010 | <0.0004 | 0.047 | <0.0002 | <0.001 | <0.1 | 25 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.215 | <0.0002 | <1 | |
| W6 | 6/26/2010 | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | 0.0006 | 0.056 | <0.0002 | <0.001 | <0.1 | 26 | <0.0001 | <0.0005 | <0.002 | 0.003 | 0.8 | <0.0002 | <1 | |
| W6 | 7/5/2010 | 0.001 | 0.072 | <0.0002 | <0.001 | <0.1 | 24 | <0.0001 | 0.0009 | 0.003 | 0.005 | 1.93 | <0.0002 | <1 | |
| W6 | 8/5/2010 | 0.0005 | 0.056 | <0.0002 | <0.001 | <0.1 | 28 | <0.0001 | <0.0005 | <0.002 | 0.003 | 0.294 | <0.0002 | <1 | |
| W6 | 9/9/2010 | 0.0005 | 0.07 | <0.0002 | <0.001 | <0.1 | 29 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.949 | <0.0002 | <1 | |
| W6 | 10/8/2010 | 0.0003 | 0.065 | <0.0001 | <0.001 | <0.05 | 25.5 | 0.00002 | <0.0005 | 0.001 | 0.0021 | 0.615 | <0.00002 | 0.5 | |
| W6 | 8/19/2011 | 0.0003 | 0.077 | <0.0001 | <0.001 | <0.05 | 51.2 | 0.00001 | <0.0005 | <0.001 | 0.003 | 0.059 | <0.00002 | 2.02 | |
| W6 | 7/17/2012 | 0.00898 | 0.471 | 0.00066 | <0.0010 | <0.05 | 41.2 | 0.000468 | 0.014 | 0.0388 | 0.0402 | 29.8 | <0.000010 | 2.03 | |
| W6 | 7/30/2012 | 0.0066 | 0.348 | 0.00043 | <0.0010 | <0.05 | 38.1 | 0.000195 | 0.00922 | 0.0276 | 0.0286 | 21.6 | 0.000033 | 1.62 | |
| W6 | 8/9/2012 | 0.00362 | 0.223 | 0.00031 | <0.0010 | <0.05 | 36.7 | 0.000109 | 0.00511 | 0.0137 | 0.0147 | 11.2 | <0.000010 | 1.2 | |
| W6 | 8/25/2012 | 0.00395 | 0.372 | 0.00044 | <0.0010 | <0.05 | 45 | 0.000219 | 0.00749 | 0.0085 | 0.0247 | 9.68 | <0.000010 | 0.849 | |
| W6 | 9/13/2012 | 0.00051 | 0.0533 | <0.00010 | <0.0010 | <0.05 | 25.9 | 0.000011 | <0.00050 | <0.0010 | 0.00225 | 0.591 | <0.000010 | 0.42 | |
| W6 | 10/13/2012 | 0.00066 | 0.0631 | <0.00010 | <0.0010 | <0.05 | 30.8 | <0.000010 | <0.00050 | <0.0010 | 0.00189 | 0.517 | <0.000010 | 0.594 | |
| W6 | 11/12/2012 | 0.00042 | 0.0656 | <0.00010 | <0.0010 | <0.05 | 43.3 | <0.000010 | <0.00050 | <0.0010 | 0.00345 | 0.0646 | <0.000010 | 0.507 | |
| W6 | 5/14/2013 | 0.00068 | 0.0286 | <0.00010 | <0.0010 | <0.05 | 9.4 | 0.000029 | 0.0006 | 0.0014 | 0.00697 | 1.06 | <0.000010 | 1.86 | |
| W6 | 6/22/2013 | 0.00264 | 0.127 | 0.00017 | <0.0010 | <0.05 | 30.4 | 0.000048 | 0.00283 | 0.0094 | 0.00985 | 6.84 | <0.000010 | 1.45 | |
| W6 | 7/12/2013 | 0.00066 | 0.0579 | <0.00010 | <0.0010 | <0.05 | 26.7 | <0.000010 | <0.00050 | 0.0011 | 0.00171 | 0.812 | <0.000010 | 0.55 | |
| W6 | 8/22/2013 | 0.00064 | 0.0507 | <0.00010 | <0.0010 | <0.05 | 29.6 | <0.000010 | <0.00050 | <0.0010 | 0.00123 | 0.283 | <0.000010 | 0.52 | |
| W6 | 9/6/2013 | 0.00067 | 0.0563 | <0.00010 | <0.0010 | <0.05 | 31.7 | <0.000010 | <0.00050 | <0.0010 | 0.00119 | 0.404 | <0.000010 | 0.605 | |
| W6 | 10/7/2013 | 0.00138 | 0.0866 | <0.00010 | <0.0010 | <0.05 | 29.2 | 0.000023 | 0.00119 | 0.0043 | 0.0071 | 3.02 | <0.000010 | 0.789 | |
| W6 | 11/16/2013 | 0.00063 | 0.0637 | <0.00010 | <0.0010 | <0.05 | 33.4 | <0.000010 | <0.00050 | <0.0010 | 0.00186 | 0.523 | <0.000010 | 0.652 | |
| W6 | 12/7/2013 | 0.00074 | 0.0801 | <0.00010 | <0.0010 | <0.05 | 49.1 | 0.00002 | <0.00050 | <0.0010 | 0.00602 | 0.12 | <0.000010 | 0.661 | |
| W7 | 5/27/2005 | 0.00063 | 0.054 | <0.0010 | | <0.10 | 19.3 | <0.000050 | 0.00049 | 0.0016 | 0.0031 | 0.776 | <0.000020 | <2.0 | |
| W7 | 6/30/2005 | 0.00049 | 0.0641 | <0.00050 | <0.00050 | <0.010 | 29.7 | <0.000050 | 0.00024 | 0.00065 | 0.00162 | 0.358 | | <2.0 | |
| W7 | 7/29/2005 | 0.00055 | 0.07 | <0.00050 | <0.00050 | <0.010 | 42.4 | <0.000050 | 0.00042 | 0.00127 | 0.0101 | 0.894 | | <2.0 | |
| W7 | 8/30/2005 | 0.00053 | 0.064 | <0.0010 | | <0.10 | 27.8 | <0.000017 | <0.00030 | <0.0010 | 0.0015 | 0.363 | <0.000020 | <2.0 | |
| W7 | 9/28/2005 | 0.00149 | 0.113 | <0.0010 | | <0.10 | 27.8 | 0.000061 | 0.00233 | 0.0037 | 0.0061 | 3.42 | <0.000020 | <2.0 | |
| W7 | 10/15/2005 | 0.00052 | 0.053 | <0.00050 | <0.00050 | <0.010 | 25.5 | <0.000050 | 0.00018 | 0.00062 | 0.00147 | 0.37 | | <2.0 | |
| W7 | 6/2/2006 | 0.00496 | 0.264 | <0.0005 | <0.0005 | <0.01 | 23.9 | 0.000237 | 0.00916 | 0.0234 | 0.0225 | 17.2 | | <2 | |
| W7 | 6/8/2006 | 0.00078 | 0.0586 | <0.0005 | <0.0005 | <0.01 | 20.4 | <0.00005 | 0.00078 | 0.0016 | 0.00403 | 1.09 | | <2 | |

## Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.

| Station Name | Sample Date | TT As (mg/L) | Ba (mg/L) | Total Be (mg/L) | Total Bi (mg/L) | Total B (mg/L) | Total Ca (mg/L) | Total Cd (mg/L) | Total Co (mg/L) | Total Cr (mg/L) | Total Cu (mg/L) | Total Fe (mg/L) | Total Hg (mg/L) | Total K (mg/L) | Total La (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | 0.0008 | 0.082 | <0.0001 | <0.0005 | 0.006 | 25.4 | 0.00002 | 0.0011 | 0.0032 | 0.004 | 1.7 | | 1.1 | |
| W7 | 6/23/2006 | 0.0022 | 0.167 | 0.0002 | <0.0005 | 0.005 | 34.5 | 0.00008 | 0.0037 | 0.0091 | 0.01 | 7.2 | | 1.6 | |
| W7 | 6/28/2006 | 0.001 | 0.09 | <0.0001 | <0.0005 | 0.006 | 27.4 | 0.00003 | 0.001 | 0.0031 | 0.004 | 2.5 | | 1.1 | |
| W7 | 7/7/2006 | 0.0004 | 0.07 | <0.0001 | <0.0005 | 0.005 | 31.2 | <0.00001 | <0.0001 | <0.0005 | 0.001 | 0.2 | | 1 | |
| W7 | 7/12/2006 | 0.0004 | 0.067 | <0.0001 | <0.0005 | 0.005 | 31 | <0.00001 | <0.0001 | <0.0005 | 0.001 | 0.2 | | 1 | |
| W7 | 7/20/2006 | 0.0005 | 0.065 | <0.0001 | <0.0005 | 0.029 | 31.8 | <0.00001 | <0.0001 | <0.0005 | 0.001 | 0.2 | | 0.9 | |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | 0.0005 | 0.072 | <0.0001 | <0.0005 | 0.004 | 33.9 | <0.00001 | 0.0001 | <0.0005 | 0.001 | 0.3 | | 1.1 | |
| W7 | 8/2/2006 | 0.0006 | 0.07 | <0.0001 | <0.0005 | 0.006 | 32.9 | <0.00001 | <0.0001 | <0.0005 | 0.001 | 0.1 | | 1 | |
| W7 | 8/10/2006 | 0.0005 | 0.072 | <0.0001 | <0.0005 | 0.005 | 34.6 | <0.00001 | 0.0004 | <0.0005 | <0.001 | 0.1 | | 1.1 | |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | 0.0004 | 0.069 | <0.0002 | <0.001 | 0.007 | 31.8 | <0.00002 | <0.0002 | <0.001 | <0.002 | <0.2 | | 1.2 | |
| W7 | 8/30/2006 | 0.0005 | 0.07 | <0.0001 | <0.0005 | 0.005 | 30.8 | <0.00001 | <0.0001 | 0.0008 | <0.001 | 0.1 | | 1 | |
| W7 | 9/6/2006 | 0.0004 | 0.07 | <0.0001 | <0.0005 | 0.006 | 31.1 | <0.00001 | 0.0001 | 0.0008 | 0.001 | 0.1 | | 1 | |
| W7 | 9/13/2006 | <0.0002 | 0.037 | <0.0001 | <0.0005 | 0.004 | 32.2 | <0.00001 | <0.0001 | <0.0005 | <0.001 | <0.2 | | 0.9 | |
| W7 | 9/20/2006 | 0.0005 | 0.07 | <0.0001 | <0.0005 | 0.006 | 32.4 | <0.00001 | 0.0001 | <0.0005 | 0.001 | 0.2 | | 0.9 | |
| W7 | 9/28/2006 | <0.0004 | 0.073 | <0.0002 | <0.001 | 0.007 | 32.5 | <0.00002 | <0.0002 | <0.001 | <0.002 | <0.2 | | 1.1 | |
| W7 | 10/4/2006 | 0.0004 | 0.074 | <0.0002 | <0.001 | 0.005 | 31.6 | <0.00002 | <0.0002 | <0.001 | <0.002 | <0.2 | | 0.9 | |
| W7 | 10/12/2006 | 0.0004 | 0.076 | <0.0001 | <0.0005 | 0.006 | 33.5 | <0.00001 | 0.0002 | 0.0007 | 0.002 | 0.5 | | 1 | |
| W7 | 6/5/2007 | 0.0008 | 0.084 | <0.0001 | <0.0005 | 0.009 | 26.4 | 0.00003 | 0.0012 | 0.0031 | 0.003 | 2 | <0.0001 | 1.1 | |
| W7 | 6/5/2007 | 0.0007 | 0.095 | <0.0002 | <0.001 | 0.01 | 28.1 | 0.00003 | 0.001 | 0.0037 | 0.003 | 2.3 | <0.0001 | 1 | |
| W7 | 6/5/2007 | 0.001 | 0.09 | <0.0001 | <0.0005 | 0.008 | 27.2 | 0.00003 | 0.0013 | 0.0036 | 0.004 | 2.5 | <0.0001 | 1.3 | |
| W7 | 6/20/2007 | 0.0004 | 0.066 | <0.0001 | <0.0005 | 0.007 | 30.2 | <0.00001 | 0.0002 | 0.0005 | 0.002 | 0.2 | <0.0001 | 1 | |
| W7 | 7/18/2007 | 0.0005 | 0.071 | <0.0001 | <0.0005 | 0.006 | 32.2 | 0.00002 | 0.0002 | 0.0008 | 0.002 | 0.3 | <0.0001 | 1 | |
| W7 | 7/18/2007 | 0.0003 | 0.073 | <0.0001 | <0.0005 | 0.006 | 31.9 | 0.00001 | 0.0002 | 0.0007 | 0.001 | 0.3 | <0.0001 | 0.9 | |
| W7 | 7/18/2007 | <0.0002 | 0.072 | <0.0001 | <0.0005 | 0.006 | 31.8 | <0.00001 | 0.0001 | 0.0007 | 0.001 | 0.3 | <0.0001 | 0.9 | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | 0.0003 | 0.075 | <0.0001 | <0.0005 | 0.006 | 31.2 | <0.00001 | 0.0002 | 0.0008 | 0.002 | 0.2 | <0.0001 | 1 | |
| W7 | 8/24/2007 | 0.0004 | 0.074 | <0.0001 | <0.0005 | 0.006 | 31.5 | <0.00001 | 0.0001 | 0.0005 | 0.001 | 0.2 | <0.0001 | 1 | |
| W7 | 8/24/2007 | 0.0004 | 0.077 | <0.0001 | <0.0005 | 0.006 | 32.9 | <0.00001 | 0.0001 | 0.0005 | 0.001 | 0.2 | <0.0001 | 1.1 | |
| W7 | 9/18/2007 | 0.0005 | 0.067 | <0.0001 | <0.0005 | 0.005 | 27 | <0.00001 | 0.0003 | 0.0011 | 0.003 | 0.5 | <0.0001 | 0.9 | |
| W7 | 10/30/2007 | 0.0004 | 0.076 | <0.0001 | <0.0005 | 0.007 | 33.5 | 0.00004 | 0.0003 | 0.0007 | 0.012 | 0.3 | <0.0001 | 1.6 | |
| W7 | 10/30/2007 | 0.0002 | 0.075 | <0.0001 | <0.0005 | 0.006 | 33 | 0.00002 | 0.0001 | 0.0008 | 0.005 | 0.2 | <0.0001 | 1.1 | |
| W7 | 10/30/2007 | <0.0002 | 0.074 | <0.0001 | <0.0005 | 0.006 | 33.6 | 0.00002 | 0.0001 | 0.0007 | 0.003 | 0.2 | <0.0001 | 1.1 | |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | 0.0005 | 0.073 | <0.00004 | | 0.006 | 40.2 | <0.00007 | 0.00007 | <0.0005 | 0.004 | 0.05 | <0.00001 | 2.56 | |
| W7 | 4/22/2008 | 0.0012 | 0.077 | <0.00004 | | 0.006 | 43.2 | <0.00007 | 0.00009 | <0.0005 | 0.004 | 0.05 | <0.00001 | 2.77 | |
| W7 | 4/22/2008 | 0.0006 | 0.078 | <0.00004 | | 0.006 | 42.4 | <0.00007 | 0.0001 | <0.0005 | 0.004 | 0.06 | <0.00001 | 2.7 | |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | 0.0007 | 0.061 | <0.00004 | | <0.005 | 24.4 | <0.00007 | 0.0004 | 0.0028 | 0.002 | 0.78 | <0.00001 | 0.94 | |
| W7 | 6/3/2008 | 0.0013 | 0.06 | <0.00004 | | <0.005 | 24.2 | <0.00007 | 0.00041 | 0.0028 | 0.001 | 0.71 | <0.00001 | 0.93 | |
| W7 | 6/3/2008 | 0.0008 | 0.062 | 0.00004 | | <0.005 | 25.2 | <0.00007 | 0.00042 | 0.003 | 0.002 | 0.79 | <0.00001 | 0.94 | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/17/2008 | 0.0006 | 0.064 | <0.00004 | | <0.005 | 29.2 | <0.00008 | 0.00028 | 0.0012 | 0.001 | 0.4 | | 1.01 | |
| W7 | 8/6/2008 | 0.0006 | 0.083 | <0.0001 | <0.0005 | 0.008 | 31.5 | 0.00002 | 0.0006 | 0.002 | 0.002 | 1.02 | <0.0001 | 1 | |
| W7 | 8/6/2008 | 0.0007 | 0.088 | <0.0001 | <0.0005 | 0.007 | 31.4 | 0.00002 | 0.0007 | 0.0026 | 0.003 | 1.36 | <0.0001 | 1.1 | |
| W7 | 8/6/2008 | 0.0008 | 0.093 | <0.0001 | <0.0005 | 0.008 | 31.8 | 0.00002 | 0.0008 | 0.0025 | 0.003 | 1.46 | <0.0001 | 1.1 | |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 9/18/2008 | 0.0005 | 0.06 | <0.00004 | <0.0001 | <0.005 | 23 | 0.00002 | 0.00046 | 0.0022 | 0.003 | 0.91 | <0.00001 | 0.68 | |
| W7 | 10/28/2008 | 0.0004 | 0.057 | <0.00004 | <0.0001 | <0.005 | 32.4 | <0.00001 | 0.00015 | 0.0013 | 0.004 | 0.34 | <0.00001 | 0.9 | |
| W7 | 10/28/2008 | 0.0005 | 0.06 | <0.00004 | <0.0001 | <0.005 | 32.3 | 0.00002 | 0.00011 | 0.0008 | 0.004 | 0.24 | <0.00001 | 0.9 | |
| W7 | 10/28/2008 | 0.0004 | 0.057 | <0.00004 | <0.0001 | <0.005 | 32.4 | <0.00001 | 0.0001 | 0.0005 | 0.003 | 0.17 | <0.00001 | 0.8 | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 4/30/2009 | <0.0002 | 0.012 | <0.00004 | <0.0001 | <0.005 | 5.54 | 0.00008 | 0.0001 | 0.0012 | 0.013 | 0.19 | 0.00002 | 1.5 | |
| W7 | 6/8/2009 | 0.0005 | 0.069 | 0.00004 | <0.0001 | 0.005 | 27 | 0.00001 | 0.00052 | 0.0014 | 0.003 | 0.92 | <0.00001 | 0.9 | |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | 0.0007 | 0.081 | <0.00004 | <0.001 | <0.005 | 35.1 | <0.00001 | 0.00013 | 0.0009 | 0.001 | 0.126 | | 1.1 | |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | | | |
| W7 | 8/31/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | 0.0004 | 0.067 | <0.00004 | <0.001 | 0.008 | 34.2 | 0.00091 | 0.00022 | 0.0014 | 0.006 | 0.357 | <0.00001 | 0.7 | |
| W7 | 10/25/2009 | 0.0004 | 0.077 | <0.0001 | <0.001 | <0.05 | 35.7 | 0.00001 | <0.0005 | <0.001 | 0.0021 | 0.141 | <0.00002 | 1.02 | |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | 0.0004 | 0.04 | <0.00004 | <0.001 | 0.006 | 20.5 | 0.00001 | 0.0001 | 0.0004 | 0.006 | 0.104 | <0.00001 | 2.1 | |
| W7 | 4/27/2010 | 0.0003 | 0.023 | <0.0001 | <0.001 | <0.05 | 9.35 | 0.00003 | <0.0005 | <0.001 | 0.0055 | 0.211 | <0.00002 | 1.01 | |
| W7 | 4/29/2010 | 0.0004 | 0.025 | <0.0001 | <0.001 | <0.05 | 9.54 | 0.00002 | <0.0005 | <0.001 | 0.0037 | 0.259 | <0.00002 | 0.9 | |
| W7 | 5/1/2010 | 0.0006 | 0.035 | <0.0001 | <0.001 | <0.05 | 11.5 | 0.00002 | <0.0005 | 0.002 | 0.0074 | 0.902 | <0.00002 | 0.81 | |
| W7 | 5/3/2010 | 0.0007 | 0.035 | <0.0001 | <0.001 | <0.05 | 12.3 | 0.00003 | <0.0005 | 0.001 | 0.0045 | 0.983 | <0.00002 | 0.72 | |
| W7 | 5/5/2010 | 0.0007 | 0.039 | <0.0001 | <0.001 | <0.05 | 14.3 | 0.00004 | <0.0005 | 0.001 | 0.0058 | 1.14 | <0.00002 | 0.72 | |
| W7 | 5/7/2010 | 0.0005 | 0.041 | <0.0001 | <0.001 | <0.05 | 14.7 | 0.00003 | <0.0005 | <0.001 | 0.0045 | 0.92 | <0.00002 | 0.68 | |
| W7 | 5/9/2010 | 0.0004 | 0.043 | <0.0001 | <0.001 | <0.05 | 18.2 | 0.00005 | <0.0005 | 0.001 | 0.0147 | 0.468 | <0.00002 | 0.74 | |
| W7 | 5/10/2010 | 0.0005 | 0.055 | <0.0001 | <0.001 | <0.05 | 23.3 | 0.00011 | <0.0005 | <0.001 | 0.0059 | 0.452 | <0.00002 | 0.91 | |
| W7 | 5/12/2010 | | | | | | | | | | <.03 | 0.19 | | | |
| W7 | 5/12/2010 | 0.0004 | 0.048 | <0.0001 | <0.001 | <0.05 | 22.1 | 0.00009 | <0.0005 | <0.001 | 0.0075 | 0.378 | <0.00002 | 0.98 | |
| W7 | 5/14/2010 | 0.0004 | 0.046 | <0.0001 | <0.001 | <0.05 | 18.2 | 0.00005 | <0.0005 | <0.001 | 0.0055 | 0.556 | <0.00002 | 0.71 | |
| W7 | 5/16/2010 | 0.0004 | 0.044 | <0.0001 | <0.001 | <0.05 | 19.8 | 0.00005 | <0.0005 | 0.001 | 0.0031 | 0.369 | <0.0002 | 0.72 | |
| W7 | 5/17/2010 | 0.0005 | 0.046 | <0.0001 | <0.001 | <0.05 | 19.6 | 0.00001 | <0.0005 | <0.001 | 0.0035 | 0.405 | <0.0002 | 0.77 | |
| W7 | 5/19/2010 | <0.001 | 0.057 | <0.0005 | <0.001 | <0.05 | 25.6 | 0.00001 | <0.0005 | 0.001 | 0.0049 | 0.248 | <0.00002 | 0.96 | |
| W7 | 5/21/2010 | 0.0005 | 0.06 | <0.0002 | <0.001 | <0.1 | 24 | <0.0001 | <0.0005 | <0.002 | 0.003 | 0.628 | <0.0002 | <1 | |
| W7 | 5/23/2010 | 0.0014 | 0.102 | <0.0002 | <0.001 | <0.1 | 25 | <0.0001 | 0.0019 | 0.004 | 0.008 | 3.49 | <0.0002 | 1 | |
| W7 | 5/25/2010 | 0.002 | 0.121 | <0.0005 | <0.001 | <0.1 | 28 | <0.0001 | 0.0028 | 0.01 | 0.013 | 5.54 | <0.00002 | 2 | |
| W7 | 5/27/2010 | 0.006 | 0.196 | <0.0005 | <0.001 | <0.1 | 31 | 0.0002 | 0.0077 | 0.025 | 0.027 | 15.6 | <0.00002 | 3 | |
| W7 | 5/29/2010 | 0.0025 | 0.131 | 0.0002 | <0.001 | <0.1 | 31 | <0.0001 | 0.0038 | 0.01 | 0.013 | 6.13 | <0.00002 | 2 | |
| W7 | 5/31/2010 | 0.0027 | 0.149 | 0.0002 | <0.001 | <0.1 | 31 | 0.0001 | 0.004 | 0.011 | 0.013 | 6.96 | <0.00002 | 2 | |
| W7 | 6/2/2010 | 0.0016 | 0.098 | <0.0002 | <0.001 | <0.1 | 33 | <0.0001 | 0.0024 | 0.008 | 0.008 | 4.39 | <0.0002 | 2 | |
| W7 | 6/4/2010 | 0.0012 | 0.09 | <0.0002 | <0.001 | <0.1 | 31 | <0.0001 | 0.0013 | 0.004 | 0.009 | 2.42 | <0.0002 | 1 | |
| W7 | 6/6/2010 | 0.0013 | 0.109 | <0.0002 | <0.001 | <0.1 | 33 | <0.0001 | 0.0015 | 0.006 | 0.006 | 3.12 | | 2 | |
| W7 | 6/14/2010 | 0.0009 | 0.099 | <0.0002 | <0.001 | <0.1 | 31 | <0.0001 | 0.001 | 0.002 | 0.004 | 1.62 | <0.0002 | 1 | |
| W7 | 6/16/2010 | 0.0005 | 0.078 | <0.0002 | <0.001 | <0.1 | 31 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.573 | <0.0002 | 1 | |
| W7 | 6/18/2010 | 0.0006 | 0.078 | <0.0002 | <0.001 | <0.1 | 30 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.768 | <0.0002 | 1 | |
| W7 | 6/20/2010 | 0.0009 | 0.085 | <0.0002 | <0.001 | <0.1 | 29 | <0.0001 | 0.0009 | 0.003 | 0.006 | 1.74 | <0.0002 | 1 | |
| W7 | 6/22/2010 | 0.0029 | 0.164 | 0.0003 | <0.001 | <0.1 | 28 | 0.0001 | 0.0048 | 0.012 | 0.014 | 8.61 | <0.0002 | 2 | |
| W7 | 6/24/2010 | 0.0013 | 0.078 | <0.0002 | <0.001 | <0.1 | 27 | <0.0001 | 0.0014 | 0.003 | 0.005 | 2.05 | <0.0002 | 1 | |
| W7 | 6/26/2010 | 0.0005 | 0.066 | <0.0002 | <0.001 | <0.1 | 26 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.761 | <0.0002 | <1 | |
| W7 | 6/28/2010 | 0.0005 | 0.064 | <0.0002 | <0.001 | <0.1 | 28 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.491 | <0.0002 | <1 | |
| W7 | 7/5/2010 | 0.0011 | 0.086 | <0.0002 | <0.001 | <0.1 | 27 | <0.0001 | 0.0012 | 0.003 | 0.01 | 2.4 | <0.0002 | <1 | |
| W7 | 8/5/2010 | 0.0005 | 0.07 | <0.0002 | <0.001 | <0.1 | 29 | <0.0001 | <0.0005 | <0.002 | 0.003 | 0.428 | <0.0002 | <1 | |
| W7 | 9/12/2010 | 0.0005 | 0.061 | <0.0002 | <0.001 | <0.1 | 27 | <0.0001 | <0.0005 | <0.002 | 0.002 | 0.682 | <0.0002 | <1 | |
| W7 | 9/12/2010 | 0.0005 | 0.061 | <0.0002 | <0.001 | <0.1 | 27 | <0.0001 | <0.0005 | <0.002 | 0.003 | 0.594 | <0.0002 | <1 | |
| W7 | 10/8/2010 | 0.0002 | 0.068 | <0.0001 | <0.001 | <0.05 | 32.2 | 0.00003 | <0.0005 | <0.001 | 0.0017 | 0.26 | <0.00002 | 0.77 | |
| W7 | 4/27/2011 | 0.0003 | 0.024 | <0.0001 | <0.001 | <0.05 | 10.9 | 0.00005 | <0.0005 | <0.001 | 0.0119 | 0.187 | <0.00002 | 1.88 | |
| W7 | 5/2/2011 | 0.0003 | 0.024 | <0.0001 | <0.001 | <0.05 | 8.66 | 0.00005 | <0.0005 | <0.001 | 0.0285 | 0.452 | <0.00002 | 1.46 | |
| W7 | 6/1/2011 | 0.0005 | 0.061 | <0.0001 | <0.001 | <0.05 | 22.9 | 0.00002 | <0.0005 | 0.001 | 0.0027 | 0.775 | <0.00002 | 0.86 | |
| W7 | 6/16/2011 | 0.0014 | 0.096 | <0.0001 | <0.001 | <0.05 | 26.4 | 0.00008 | 0.0021 | 0.005 | 0.0075 | 4.02 | <0.00002 | 1.04 | |
| W7 | 7/1/2011 | 0.0025 | 0.135 | 0.0002 | <0.001 | <0.05 | 22.2 | 0.00022 | 0.0035 | 0.009 | 0.0127 | 6.28 | <0.00002 | 0.76 | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | TT As (mg/L) | Ba (mg/L) | Total Be (mg/L) | Total Bi (mg/L) | Total B (mg/L) | Total Ca (mg/L) | Total Cd (mg/L) | Total Co (mg/L) | Total Cr (mg/L) | Total Cu (mg/L) | Total Fe (mg/L) | Total Hg (mg/L) | Total K (mg/L) | Total La (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | 0.0037 | 0.211 | 0.0003 | <0.001 | <0.05 | 20.7 | 0.00017 | 0.0064 | 0.021 | 0.0197 | 13.8 | <0.00002 | 1.11 | |
| W7 | 8/16/2011 | 0.001 | 0.069 | <0.0001 | <0.001 | <0.05 | 25.4 | 0.00004 | 0.0006 | 0.001 | 0.0143 | 1.25 | <0.00002 | 0.53 | |
| W7 | 8/19/2011 | 0.0009 | 0.061 | <0.0001 | <0.001 | <0.05 | 24.1 | 0.00002 | 0.0006 | 0.001 | 0.0028 | 1.21 | <0.00002 | 0.47 | |
| W7 | 9/12/2011 | 0.0008 | 0.061 | <0.0001 | <0.001 | <0.05 | 30.1 | 0.00005 | <0.0005 | <0.001 | 0.0024 | 0.738 | <0.00002 | 0.6 | |
| W7 | 10/6/2011 | 0.0005 | 0.058 | <0.0001 | <0.001 | <0.05 | 28.4 | 0.00001 | <0.0005 | <0.001 | 0.0012 | 0.49 | <0.00002 | 0.62 | |
| W7 | 11/22/2011 | 0.0006 | 0.085 | <0.0001 | <0.001 | <0.05 | 36.4 | 0.00025 | <0.0005 | 0.001 | 0.0108 | 0.865 | <0.000020 | 1.09 | |
| W7 | 1/24/2012 | 0.0004 | 0.087 | <0.0001 | <0.001 | <0.05 | 39.5 | 0.00001 | <0.0005 | <0.001 | 0.0013 | 0.113 | <0.000010 | 1.57 | |
| W7 | 2/25/2012 | 0.0003 | 0.082 | <0.0001 | <0.001 | <0.05 | 41 | 0.00003 | <0.0005 | <0.001 | 0.0055 | 0.043 | <0.000010 | 1.51 | |
| W7 | 3/5/2012 | 0.0004 | 0.083 | <0.0001 | <0.001 | <0.05 | 39.7 | 0.00001 | <0.0005 | <0.001 | 0.0068 | 0.108 | <0.000010 | 1.46 | |
| W7 | 4/24/2012 | 0.00074 | 0.0404 | <0.00010 | <0.0010 | <0.05 | 9.61 | 0.000029 | 0.00056 | 0.0015 | 0.00635 | 1.32 | <0.000010 | 1.2 | |
| W7 | 5/6/2012 | 0.00045 | 0.0317 | <0.00010 | <0.0010 | <0.05 | 11.2 | 0.000015 | <0.00050 | <0.0010 | 0.00299 | 0.551 | <0.000010 | 0.881 | |
| W7 | 5/6/2012 | 0.00049 | 0.0316 | <0.00010 | <0.0010 | <0.05 | 11.1 | 0.000016 | <0.00050 | <0.0010 | 0.00373 | 0.572 | <0.000010 | 0.912 | |
| W7 | 6/19/2012 | 0.00232 | 0.154 | 0.00016 | <0.0010 | <0.05 | 26.4 | 0.000119 | 0.00326 | 0.0112 | 0.0102 | 7.88 | <0.000010 | 1.09 | |
| W7 | 7/17/2012 | 0.00118 | 0.0843 | <0.00010 | <0.0010 | <0.05 | 31.7 | 0.000034 | 0.00075 | 0.0024 | 0.0035 | 2.28 | <0.000010 | 0.824 | |
| W7 | 7/30/2012 | 0.00095 | 0.0737 | <0.00010 | <0.0010 | <0.05 | 32.1 | 0.000014 | <0.00050 | <0.0010 | 0.0045 | 1.32 | <0.000010 | 1.14 | |
| W7 | 8/8/2012 | 0.00085 | 0.0731 | <0.00010 | <0.0010 | <0.05 | 35.7 | <0.000010 | <0.00050 | <0.0010 | 0.00108 | 1.13 | <0.000010 | 0.894 | |
| W7 | 8/23/2012 | 0.00093 | 0.0778 | <0.00010 | <0.0010 | <0.05 | 39.1 | <0.000010 | <0.00050 | <0.0010 | 0.00134 | 1.12 | <0.000010 | 0.929 | |
| W7 | 9/13/2012 | 0.0007 | 0.0629 | <0.00010 | <0.0010 | <0.05 | 31.2 | <0.000010 | <0.00050 | <0.0010 | 0.00208 | 1.15 | <0.000010 | 0.589 | |
| W7 | 10/16/2012 | 0.00065 | 0.0693 | <0.00010 | <0.0010 | <0.05 | 36 | <0.000010 | <0.00050 | <0.0010 | 0.00144 | 0.995 | <0.000010 | 0.748 | |
| W7 | 11/2/2012 | 0.00058 | 0.0848 | <0.00010 | <0.0010 | <0.05 | 37.3 | 0.000015 | <0.00050 | <0.0010 | 0.00231 | 0.289 | <0.000010 | 1.16 | |
| W7 | 12/29/2012 | 0.00042 | 0.104 | <0.00010 | <0.0010 | <0.05 | 49.6 | 0.000015 | <0.00050 | <0.0010 | 0.0028 | 0.0724 | <0.000010 | 2.29 | |
| W7 | 4/30/2013 | 0.00019 | 0.0996 | <0.00010 | <0.0010 | <0.05 | 47.8 | <0.000010 | <0.00050 | <0.0010 | 0.0021 | 0.0288 | <0.000010 | 1.95 | |
| W7 | 5/14/2013 | 0.00072 | 0.0462 | <0.00010 | <0.0010 | <0.05 | 9.61 | 0.000025 | 0.00107 | 0.0027 | 0.0084 | 2.2 | <0.000010 | 1.18 | |
| W7 | 6/19/2013 | 0.00064 | 0.0691 | <0.00010 | <0.0010 | <0.05 | 29.1 | 0.000011 | <0.00050 | <0.0010 | 0.00222 | 0.702 | <0.000010 | 0.847 | |
| W7 | 6/19/2013 | 0.00058 | 0.0683 | <0.00010 | <0.0010 | <0.05 | 29.7 | <0.000010 | <0.00050 | <0.0010 | 0.00191 | 0.657 | <0.000010 | 0.872 | |
| W7 | 7/13/2013 | 0.00063 | 0.0712 | <0.00010 | <0.0010 | <0.05 | 35.1 | <0.000010 | <0.00050 | <0.0010 | 0.00143 | 0.631 | <0.000010 | 0.856 | |
| W7 | 8/21/2013 | 0.0007 | 0.0755 | <0.00010 | <0.0010 | <0.05 | 35.8 | <0.000010 | <0.00050 | <0.0010 | 0.00138 | 0.619 | <0.000010 | 0.951 | |
| W7 | 9/6/2013 | 0.00099 | 0.0815 | <0.00010 | <0.0010 | <0.05 | 38.7 | <0.000010 | <0.00050 | 0.0014 | 0.0017 | 1.48 | <0.000010 | 0.968 | |
| W7 | 10/21/2013 | 0.00061 | 0.0642 | <0.00010 | <0.0010 | <0.05 | 31.8 | <0.000010 | <0.00050 | <0.0010 | 0.00119 | 0.683 | <0.000010 | 0.754 | |
| W7 | 11/16/2013 | 0.00052 | 0.0832 | <0.00010 | <0.0010 | <0.05 | 39.8 | <0.000010 | <0.00050 | <0.0010 | 0.00124 | 0.296 | <0.000010 | 1.14 | |
| W7 | 12/7/2013 | 0.00059 | 0.0967 | <0.00010 | <0.0010 | <0.05 | 46.7 | 0.000013 | <0.00050 | <0.0010 | 0.00141 | 0.227 | <0.000010 | 1.52 | |
| C4 | 5/6/2012 | 0.0125 | 0.56 | 0.00088 | <0.0010 | <0.05 | 23.9 | 0.000416 | 0.0178 | 0.06 | 0.0585 | 45.8 | <0.000010 | 3.02 | |
| C4 | 8/1/2012 | 0.00497 | 0.24 | 0.00031 | <0.0010 | <0.05 | 34.3 | 0.000114 | 0.00591 | 0.0135 | 0.0167 | 13.9 | <0.000010 | 1.34 | |
| C4 | 8/8/2012 | 0.00635 | 0.261 | 0.00033 | <0.0010 | <0.05 | 36.5 | 0.000107 | 0.00701 | 0.0148 | 0.015 | 16.1 | <0.000010 | 1.45 | |
| C4 | 8/25/2012 | 0.00759 | 0.373 | 0.00042 | <0.0010 | <0.05 | 45.6 | 0.000202 | 0.00894 | 0.0079 | 0.0218 | 18.2 | <0.000010 | 1.19 | |
| C4 | 6/22/2013 | 0.0123 | 0.539 | 0.00075 | <0.0010 | <0.05 | 55.7 | 0.000317 | 0.0172 | 0.0426 | 0.0479 | 36.2 | 0.000018 | 2.77 | |
| C4 | 7/19/2013 | 0.00864 | 0.373 | 0.00048 | <0.0010 | <0.05 | 54 | 0.000209 | 0.0113 | 0.0287 | 0.0323 | 24.4 | 0.000015 | 2.21 | |
| C4 | 8/22/2013 | 0.00939 | 0.438 | 0.00055 | <0.0010 | <0.05 | 51 | 0.000308 | 0.0133 | 0.0268 | 0.0347 | 26.2 | 0.000033 | 2.02 | |
| C4 | 9/6/2013 | 0.00462 | 0.189 | 0.00019 | <0.0010 | <0.05 | 43.1 | 0.000066 | 0.00447 | 0.0107 | 0.0103 | 11 | <0.000010 | 1.5 | |
| C4 | 10/18/2013 | 0.00153 | 0.0845 | <0.00010 | <0.0010 | <0.05 | 37.3 | 0.000017 | 0.00102 | 0.0012 | 0.0019 | 2.12 | <0.000010 | 0.858 | |
| C4 | 10/18/2013 | 0.00151 | 0.0837 | <0.00010 | <0.0010 | <0.05 | 36.9 | 0.000012 | 0.00101 | 0.0013 | 0.00263 | 2.1 | <0.000010 | 0.833 | |
| C4 | 11/17/2013 | 0.00545 | 0.17 | <0.00010 | <0.0010 | <0.05 | 70.5 | 0.000022 | 0.00621 | 0.0015 | 0.00357 | 14.7 | <0.000010 | 1.05 | |
| C10 | 5/12/2012 | 0.0208 | 0.942 | 0.00176 | <0.0010 | <0.05 | 51.2 | 0.000982 | 0.0315 | 0.0779 | 0.1 | 73.2 | <0.000010 | 4.64 | |
| C10 | 7/30/2012 | 0.0123 | 0.549 | 0.0008 | <0.0010 | <0.05 | 56.3 | 0.000365 | 0.0151 | 0.0385 | 0.0527 | 37.5 | 0.000062 | 3.36 | |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | 0.0124 | 0.666 | 0.00102 | <0.0010 | <0.05 | 67.1 | 0.000486 | 0.0185 | 0.0378 | 0.0597 | 38.9 | <0.000010 | 3.11 | |
| C10 | 8/27/2012 | 0.0156 | 0.754 | 0.00117 | <0.0010 | <0.05 | 72.2 | 0.000526 | 0.0213 | 0.0455 | 0.0624 | 45.6 | <0.000010 | 3.37 | |
| C10 | 6/22/2013 | 0.00203 | 0.0981 | <0.00010 | <0.0010 | <0.05 | 44.4 | 0.000019 | 0.00109 | 0.0022 | 0.00492 | 3.18 | <0.000010 | 1.46 | |
| C10 | 7/23/2013 | 0.00386 | 0.174 | 0.00022 | <0.0010 | <0.05 | 45.1 | 0.000071 | 0.00371 | 0.0095 | 0.0114 | 9.35 | <0.000010 | 1.71 | |
| C10 | 8/22/2013 | 0.00213 | 0.1 | <0.00010 | <0.0010 | <0.05 | 49.5 | 0.000016 | 0.00099 | 0.0019 | 0.00344 | 2.95 | <0.000010 | 1.18 | |
| C10 | 9/8/2013 | 0.00188 | 0.0869 | <0.00010 | <0.0010 | <0.05 | 48.6 | 0.000019 | 0.00094 | 0.0013 | 0.00241 | 2.71 | <0.000010 | 1.17 | |
| C10 | 9/8/2013 | 0.00194 | 0.0852 | <0.00010 | <0.0010 | <0.05 | 48 | 0.000093 | 0.00086 | 0.0012 | 0.00237 | 2.64 | <0.000010 | 1.17 | |
| C10 | 10/18/2013 | 0.00177 | 0.091 | <0.00010 | <0.0010 | <0.05 | 46.8 | 0.00002 | 0.00139 | 0.0024 | 0.00355 | 3.33 | <0.000010 | 1.1 | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Total Li (mg/L) | Total Mg (mg/L) | Total Mn (mg/L) | Total Mo (mg/L) | Total Na (mg/L) | Total Ni (mg/L) | Total Pb (mg/L) | Total P (mg/L) | Total Sb (mg/L) | Total Se (mg/L) | Total Si (mg/L) | Total Sn (mg/L) | Total Sr (mg/L) | Total S (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | <0.0050 | 8.65 | 0.0612 | 0.0011 | 4.9 | 0.0032 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W1 | 6/30/2005 | <0.0050 | 12.3 | 0.00663 | 0.00107 | 8.6 | 0.00101 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.43 | <0.00010 | 0.293 | |
| W1 | 7/28/2005 | <0.0050 | 12.7 | 0.0164 | 0.00153 | 8.5 | 0.00113 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.21 | <0.00010 | 0.333 | |
| W1 | 8/29/2005 | <0.0050 | 11.5 | 0.0258 | 0.001 | 6.8 | 0.0016 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W1 | 9/28/2005 | <0.0050 | 11.3 | 0.0559 | <0.0010 | 6.3 | 0.0019 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W1 | 10/15/2005 | <0.0050 | 10.9 | 0.0483 | 0.000867 | 5.9 | 0.0024 | 0.00012 | <0.30 | <0.00010 | <0.0010 | 5.99 | <0.00010 | 0.269 | |
| W2 | 5/27/2005 | <0.0050 | 8.37 | 0.0505 | <0.0010 | 4.8 | 0.0026 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W2 | 5/27/2005 | <0.005 | 5.78 | 0.0536 | | | 0.0033 | 0.00066 | | <0.0005 | | | | | |
| W2 | 6/30/2005 | <0.0050 | 12.5 | 0.00785 | 0.00103 | 8.7 | 0.00105 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.48 | <0.00010 | 0.304 | |
| W2 | 7/28/2005 | <0.0050 | 13.1 | 0.014 | 0.00134 | 8.7 | 0.00107 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.32 | <0.00010 | 0.338 | |
| W2 | 8/30/2005 | <0.0050 | 11.6 | 0.025 | 0.0011 | 6.9 | 0.0016 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W2 | 9/28/2005 | <0.0050 | 11 | 0.0543 | <0.0010 | 6 | 0.002 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W2 | 10/15/2005 | <0.0050 | 10.8 | 0.0368 | 0.000916 | 6 | 0.00164 | 0.000078 | <0.30 | <0.00010 | <0.0010 | 5.95 | <0.00010 | 0.267 | |
| W3 | 5/27/2005 | <0.0050 | 9.03 | 0.023 | 0.0011 | 4.9 | 0.0017 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W3 | 6/30/2005 | <0.0050 | 17.6 | 0.0084 | 0.00163 | 12.1 | 0.00087 | 0.000292 | <0.30 | <0.00010 | <0.0010 | 6.04 | <0.00010 | 0.299 | |
| W3 | 7/29/2005 | <0.0050 | 17.2 | 0.0641 | 0.0019 | 9.4 | 0.00257 | 0.000359 | <0.30 | 0.0001 | <0.0010 | 7.03 | 0.00011 | 0.295 | |
| W3 | 8/29/2005 | <0.0050 | 13.2 | 0.0806 | 0.0014 | 7.8 | 0.0017 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W3 | 9/28/2005 | <0.0050 | 12 | 0.12 | 0.0012 | 7.1 | 0.0018 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W3 | 10/15/2005 | <0.0050 | 12.5 | 0.124 | 0.00126 | 7 | 0.00136 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.86 | <0.00010 | 0.233 | |
| W8 | 5/27/2005 | <0.0050 | 5.03 | 0.00512 | <0.0010 | 2.6 | 0.0018 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W8 | 6/30/2005 | <0.0050 | 7.57 | 0.0445 | 0.000512 | 4.5 | 0.00172 | 0.000066 | <0.30 | <0.00010 | <0.0010 | 5.21 | <0.00010 | 0.112 | |
| W8 | 7/29/2005 | <0.0050 | 9.43 | 0.0268 | 0.000565 | 3.9 | 0.00146 | 0.000059 | <0.30 | <0.00010 | <0.0010 | 5.04 | <0.00010 | 0.133 | |
| W8 | 8/30/2005 | <0.0050 | 8.04 | 0.0447 | <0.0010 | 3.8 | 0.0018 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W8 | 9/28/2005 | <0.0050 | 7.45 | 0.0487 | <0.0010 | 3.7 | 0.0017 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W8 | 10/15/2005 | <0.0050 | 7.41 | 0.24 | 0.00171 | 4.5 | 0.00109 | 0.000064 | <0.30 | <0.00010 | <0.0010 | 6.29 | <0.00010 | 0.176 | |
| W9 | 5/27/2005 | <0.0050 | 4.1 | 0.00703 | <0.0010 | 2.3 | 0.0013 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W9 | 6/30/2005 | <0.0050 | 6.04 | 0.0432 | 0.000356 | 4.2 | 0.00125 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.32 | <0.00010 | 0.0956 | |
| W9 | 7/29/2005 | <0.0050 | 7.18 | 0.0638 | 0.00112 | 3.8 | 0.00152 | 0.000099 | <0.30 | <0.00010 | <0.0010 | 5.5 | <0.00010 | 0.146 | |
| W9 | 8/29/2005 | <0.0050 | 6 | 0.0669 | <0.0010 | 3.5 | 0.0013 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W9 | 9/28/2005 | <0.0050 | 5.52 | 0.0485 | <0.0010 | 3.1 | 0.0012 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W9 | 10/15/2005 | <0.0050 | 5.17 | 0.0363 | 0.000349 | 2.9 | 0.00105 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.67 | <0.00010 | 0.0837 | |
| W10 | 5/27/2005 | <0.0050 | 3.25 | 0.00326 | <0.0010 | <2.0 | 0.0018 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W10 | 5/27/2005 | <0.005 | | | <0.001 | <2 | 0.0033 | <0.0005 | | | <0.001 | | <0.0005 | | |
| W10 | 6/30/2005 | <0.0050 | 3.71 | 0.0457 | 0.000177 | 3.6 | 0.00191 | 0.000388 | <0.30 | <0.00010 | <0.0010 | 5.43 | <0.00010 | 0.0778 | |
| W10 | 7/29/2005 | <0.0050 | 5 | 0.174 | 0.000273 | 4.7 | 0.00411 | 0.00178 | <0.30 | 0.00015 | <0.0010 | 9.73 | 0.00026 | 0.108 | |
| W10 | 8/29/2005 | <0.0050 | 6.02 | 0.0422 | <0.0010 | 5.3 | 0.0016 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W10 | 9/28/2005 | <0.0050 | 8.84 | 0.00236 | <0.0010 | 5.4 | <0.0010 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W10 | 10/15/2005 | <0.0050 | 8.41 | 0.00586 | 0.000277 | 4.4 | 0.00086 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 5.52 | <0.00010 | 0.153 | |
| W6 | 5/27/2005 | <0.0050 | 4.88 | 0.0169 | <0.0010 | 2.7 | 0.0021 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W6 | 6/30/2005 | <0.0050 | 6.65 | 0.0113 | 0.000448 | 4.6 | 0.00135 | 0.000134 | <0.30 | <0.00010 | <0.0010 | 7.27 | <0.00010 | 0.1 | |
| W6 | 7/29/2005 | <0.0050 | 15.4 | 0.0536 | 0.00133 | 8.4 | 0.00204 | 0.00035 | <0.30 | <0.00010 | <0.0010 | 6.69 | 0.00013 | 0.286 | |
| W6 | 8/30/2005 | <0.0050 | 7.97 | 0.0224 | <0.0010 | 4.5 | 0.0011 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W6 | 9/28/2005 | <0.0050 | 8.02 | 0.0267 | <0.0010 | 4.2 | 0.0013 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W6 | 10/15/2005 | <0.0050 | 7.18 | 0.0188 | 0.000392 | 4 | 0.00131 | <0.000050 | <0.30 | <0.00010 | <0.0010 | 6.54 | <0.00010 | 0.112 | |
| W6 | 6/2/2006 | <0.005 | 5.63 | 0.0835 | 0.000411 | 3.4 | 0.00535 | 0.000851 | <0.3 | 0.00017 | <0.001 | 7.95 | 0.0001 | 0.0816 | |
| W6 | 8/25/2006 | <0.002 | 7.8 | 0.04 | <0.002 | 4.8 | 0.001 | <0.0002 | | <0.0004 | <0.0004 | 7.39 | <0.002 | 0.14 | 0.9 |
| W6 | 9/6/2006 | 0.001 | 7.3 | 0.042 | <0.001 | 4.6 | 0.0015 | 0.0001 | | <0.0002 | 0.0003 | 7.42 | <0.001 | 0.135 | 1 |
| W6 | 6/20/2007 | <0.001 | 5.6 | 0.011 | <0.001 | 4.3 | 0.0017 | <0.0001 | 0.18 | <0.0002 | 0.0002 | 6.4 | <0.001 | 0.104 | 0.9 |
| W6 | 9/18/2007 | 0.001 | 6.9 | 0.023 | <0.001 | 5 | 0.0012 | <0.0001 | <0.05 | <0.0002 | <0.0002 | 7.2 | <0.001 | 0.125 | 1 |
| W6 | 6/17/2008 | <0.001 | 6.44 | 0.0215 | 0.00045 | 4.8 | 0.001 | <0.0001 | 0.11 | <0.0002 | <0.0006 | 5.34 | <0.0001 | 0.103 | |
| W6 | 9/18/2008 | <0.001 | 6.61 | 0.0098 | 0.00031 | 4.1 | 0.001 | <0.0001 | 0.02 | <0.0002 | <0.0006 | 6.22 | <0.0001 | 0.104 | |
| W6 | 4/14/2009 | 0.005 | 50 | 0.083 | 0.00334 | 33.3 | 0.001 | 0.0011 | 0.34 | 0.0003 | 0.0017 | 6.62 | <0.0001 | 0.524 | 42.4 |
| W6 | 4/30/2009 | 0.004 | 7.92 | 0.167 | 0.00043 | 3.38 | 0.009 | 0.0024 | 0.25 | <0.0002 | <0.0006 | 11.5 | <0.0001 | 0.142 | 2.7 |
| W6 | 7/28/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | 0.002 | 16.7 | 0.1 | 0.0092 | 15.5 | 0.002 | 0.0003 | 0.017 | 0.0002 | <0.0006 | 4.67 | <0.0001 | 0.666 | 14.7 |
| W6 | 8/6/2009 | 0.002 | 16.7 | 0.0874 | 0.0088 | 15.8 | 0.001 | 0.0006 | 0.015 | 0.0003 | 0.0007 | 4.68 | <0.0001 | 0.566 | 15 |
| W6 | 8/18/2009 | | | | | | | | | | | | | | |
| W6 | 8/25/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | 0.002 | 15.4 | 0.28 | 0.016 | 19.4 | 0.002 | 0.0007 | <0.05 | 0.0006 | 0.0018 | 3.6 | <0.0001 | 0.842 | 22.4 |
| W6 | 10/25/2009 | <0.005 | 16.9 | 0.229 | 0.015 | 18.4 | 0.001 | <0.0002 | | 0.0006 | 0.0019 | 4.48 | <0.005 | 0.844 | 27 |
| W6 | 4/19/2010 | 0.002 | 14.7 | 0.119 | 0.0017 | 9.35 | 0.002 | 0.0006 | 0.08 | <0.0002 | <0.0006 | 6.58 | <0.0001 | 0.392 | 10.9 |
| W6 | 5/16/2010 | <0.005 | 8.41 | 0.027 | <0.001 | 4.4 | <0.001 | <0.0002 | 0.021 | <0.0005 | 0.0002 | 5.35 | <0.005 | 0.197 | <3 |
| W6 | 5/17/2010 | <0.005 | 4.84 | 0.05 | <0.001 | 2.96 | <0.001 | <0.0002 | 0.027 | <0.0005 | <0.0001 | 2.02 | <0.005 | 0.19 | <3 |
| W6 | 5/19/2010 | <0.005 | 8.01 | 0.026 | <0.001 | 5.29 | <0.003 | <0.0002 | 0.037 | <0.0005 | 0.0002 | 2.87 | <0.005 | 0.304 | 4 |
| W6 | 5/21/2010 | <0.01 | 6 | 0.092 | <0.001 | 4 | <0.001 | <0.0002 | | <0.0005 | <0.0008 | 2.38 | <0.005 | 0.279 | <60 |
| W6 | 5/23/2010 | <0.01 | 7 | 0.024 | <0.001 | 5 | <0.001 | <0.0002 | | <0.0005 | <0.0008 | 2.36 | <0.005 | 0.284 | <60 |
| W6 | 5/25/2010 | <0.01 | 10 | 0.03 | <0.001 | 8 | <0.003 | 0.0004 | | <0.0005 | <0.001 | 2.95 | <0.005 | 0.328 | <60 |
| W6 | 5/29/2010 | <0.01 | 4 | 0.039 | <0.001 | 2 | <0.001 | <0.0002 | | <0.0005 | <0.0008 | <2 | <0.005 | 0.225 | <60 |
| W6 | 6/2/2010 | <0.01 | 22 | 0.044 | 0.003 | 15 | <0.001 | <0.0002 | | <0.0005 | <0.0008 | 5.61 | <0.005 | 0.704 | <60 |
| W6 | 6/4/2010 | <0.01 | 7 | 0.008 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <0.0008 | 7.13 | <0.005 | 0.116 | <60 |
| W6 | 6/6/2010 | <0.01 | 8 | 0.012 | <0.001 | 4 | 0.001 | 0.0005 | | <0.0005 | <0.0008 | 6.82 | <0.005 | 0.121 | <60 |
| W6 | 6/14/2010 | <0.01 | 7 | 0.014 | <0.001 | 4 | 0.002 | 0.0002 | | <0.0005 | <0.0008 | 7.45 | <0.005 | 0.123 | <60 |
| W6 | 6/16/2010 | <0.01 | 7 | 0.013 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <0.0008 | 7.12 | <0.005 | 0.114 | <60 |
| W6 | 6/18/2010 | <0.01 | 7 | 0.01 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <0.0008 | 6.99 | <0.005 | 0.111 | <60 |
| W6 | 6/20/2010 | <0.01 | 7 | 0.009 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <0.0008 | 7.28 | <0.005 | 0.116 | <60 |
| W6 | 6/22/2010 | <0.01 | 7 | 0.011 | <0.001 | 4 | 0.002 | <0.0002 | | <0.0005 | <0.0008 | 8.49 | <0.005 | 0.119 | <60 |
| W6 | 6/24/2010 | <0.01 | 6 | 0.006 | <0.001 | 3 | <0.001 | 0.0003 | | <0.0005 | <0.0008 | 5.99 | <0.005 | 0.095 | <60 |
| W6 | 6/26/2010 | <0.01 | 7 | 0.009 | <0.001 | 4 | 0.001 | <0.0002 | | <0.0005 | <0.0008 | 6.95 | <0.005 | 0.114 | <60 |
| W6 | 6/26/2010 | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | <0.01 | 6 | 0.023 | <0.001 | 4 | 0.002 | 0.0003 | | <0.0005 | <0.0008 | 9.39 | <0.005 | 0.117 | <60 |
| W6 | 7/5/2010 | <0.01 | 7 | 0.053 | <0.001 | 3 | 0.004 | 0.0006 | | <0.0005 | <0.0008 | 8.82 | <0.005 | 0.112 | <60 |
| W6 | 8/5/2010 | <0.01 | 8 | 0.023 | <0.001 | 4 | 0.002 | <0.0002 | | <0.0005 | <0.0008 | 7.78 | <0.005 | 0.121 | <60 |
| W6 | 9/9/2010 | <0.01 | 8 | 0.045 | <0.001 | 4 | 0.003 | 0.0004 | | <0.0005 | <0.0008 | 8.17 | <0.005 | 0.142 | <60 |
| W6 | 10/8/2010 | <0.005 | 8.87 | 0.043 | <0.001 | 4.58 | 0.002 | 0.0002 | | <0.0005 | <0.0001 | 6.6 | <0.005 | 0.141 | <3 |
| W6 | 8/19/2011 | <0.005 | 20.9 | 0.02 | 0.003 | 14.6 | 0.001 | <0.0002 | <0.01 | <0.0005 | 0.0004 | 4.9 | <0.005 | 0.614 | 18 |
| W6 | 7/17/2012 | 0.0136 | 14.6 | 0.771 | 0.0012 | 4.89 | 0.0348 | 0.00971 | 0.99 | 0.00072 | 0.00068 | 42.3 | <0.0050 | 0.23 | <3.0 |
| W6 | 7/30/2012 | 0.0088 | 12.1 | 0.513 | <0.0010 | 4.72 | 0.0236 | 0.00627 | 0.642 | 0.00051 | 0.00061 | 33.1 | <0.0050 | 0.202 | <3.0 |
| W6 | 8/9/2012 | 0.0061 | 10.7 | 0.376 | <0.0010 | 4.85 | 0.0126 | 0.00343 | 0.373 | <0.00050 | 0.00041 | 21.7 | <0.0050 | 0.174 | <3.0 |
| W6 | 8/25/2012 | <0.0050 | 11.7 | 0.619 | <0.0010 | 4.59 | 0.0192 | 0.00505 | 0.647 | <0.00050 | 0.00016 | 13.4 | <0.0050 | 0.227 | <3.0 |
| W6 | 9/13/2012 | <0.0050 | 6.92 | 0.0619 | <0.0010 | 4.05 | 0.005 | 0.00025 | 0.04 | <0.00050 | <0.00010 | 6.82 | <0.0050 | 0.12 | <3.0 |
| W6 | 10/13/2012 | <0.0050 | 9.61 | 0.0661 | <0.0010 | 5.31 | 0.0016 | 0.00023 | 0.048 | <0.00050 | 0.00014 | 8.91 | <0.0050 | 0.154 | 3.2 |
| W6 | 11/12/2012 | <0.0050 | 11.3 | 0.0021 | <0.0010 | 6.12 | 0.0013 | <0.00020 | 0.015 | <0.00050 | 0.00011 | 9.52 | <0.0050 | 0.185 | <3.0 |
| W6 | 5/14/2013 | <0.0050 | 2.5 | 0.0637 | <0.0010 | 1.07 | 0.0023 | 0.00024 | 0.086 | <0.00050 | <0.00010 | 3.97 | <0.0050 | 0.0391 | <3.0 |
| W6 | 6/22/2013 | <0.0050 | 9.52 | 0.161 | <0.0010 | 4.63 | 0.0102 | 0.00184 | 0.184 | <0.00050 | 0.00022 | 15.9 | <0.0050 | 0.15 | <3.0 |
| W6 | 7/12/2013 | <0.0050 | 6.98 | 0.0413 | <0.0010 | 4.18 | 0.0021 | 0.00021 | 0.032 | <0.00050 | 0.00012 | 7.44 | <0.0050 | 0.129 | <3.0 |
| W6 | 8/22/2013 | <0.0050 | 7.74 | 0.0358 | <0.0010 | 4.67 | 0.0013 | <0.00020 | 0.018 | <0.00050 | <0.00010 | 8 | <0.0050 | 0.134 | <3.0 |
| W6 | 9/6/2013 | <0.0050 | 8.38 | 0.0387 | <0.0010 | 4.75 | 0.0014 | <0.00020 | 0.016 | <0.00050 | 0.00013 | 8.12 | <0.0050 | 0.142 | <3.0 |
| W6 | 10/7/2013 | <0.0050 | 8 | 0.0965 | <0.0010 | 4.45 | 0.0039 | 0.00081 | 0.098 | <0.00050 | 0.00015 | 11.3 | <0.0050 | 0.136 | <3.0 |
| W6 | 11/16/2013 | <0.0050 | 9.65 | 0.0488 | <0.0010 | 5.26 | 0.0014 | <0.00020 | 0.022 | <0.00050 | <0.00010 | 8.78 | <0.0050 | 0.163 | <3.0 |
| W6 | 12/7/2013 | <0.0050 | 14.5 | 0.0036 | <0.0010 | 7.78 | 0.0013 | <0.00020 | 0.031 | <0.00050 | 0.00018 | 9.08 | <0.0050 | 0.225 | <3.0 |
| W7 | 5/27/2005 | <0.0050 | 6.82 | 0.0519 | 0.001 | 3.9 | 0.003 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W7 | 6/30/2005 | <0.0050 | 10.1 | 0.0514 | 0.00119 | 6.8 | 0.00141 | 0.000134 | <0.30 | <0.00010 | <0.0010 | 5.85 | <0.00010 | 0.279 | |
| W7 | 7/29/2005 | <0.0050 | 14.2 | 0.0468 | 0.00121 | 7.7 | 0.00174 | 0.000332 | <0.30 | <0.00010 | <0.0010 | 6.39 | <0.00010 | 0.287 | |
| W7 | 8/30/2005 | <0.0050 | 9.67 | 0.0368 | 0.0011 | 5.9 | 0.0016 | <0.00050 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W7 | 9/28/2005 | <0.0050 | 9.57 | 0.314 | <0.0010 | 4.9 | 0.0068 | 0.0011 | | <0.00050 | <0.0010 | | <0.00050 | | |
| W7 | 10/15/2005 | <0.0050 | 8.77 | 0.0473 | 0.000959 | 5.1 | 0.00176 | 0.000061 | <0.30 | <0.00010 | <0.0010 | 6.09 | <0.00010 | 0.24 | |
| W7 | 6/2/2006 | 0.0079 | 10.7 | 0.589 | 0.000988 | 4.5 | 0.0275 | 0.00547 | 0.77 | 0.00037 | <0.001 | 22.4 | 0.00036 | 0.204 | |
| W7 | 6/8/2006 | <0.005 | 7.12 | 0.0645 | 0.000843 | 4.4 | 0.00402 | 0.00045 | <0.3 | <0.0001 | <0.001 | 5.27 | <0.0001 | 0.174 | |

## Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.

| Station Name | Sample Date | Total Li (mg/L) | Total Mg (mg/L) | Total Mn (mg/L) | Total Mo (mg/L) | Total Na (mg/L) | Total Ni (mg/L) | Total Pb (mg/L) | Total P (mg/L) | Total Sb (mg/L) | Total Se (mg/L) | Total Si (mg/L) | Total Sn (mg/L) | Total Sr (mg/L) | Total S (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | 0.002 | 8.8 | 0.079 | 0.001 | 5.8 | 0.0052 | 0.0006 | | <0.0002 | 0.0002 | 7.24 | <0.001 | 0.276 | 3.2 |
| W7 | 6/23/2006 | 0.005 | 12.5 | 0.226 | 0.001 | 7 | 0.0117 | 0.002 | | <0.0002 | 0.0004 | 12.3 | <0.001 | 0.367 | 4.2 |
| W7 | 6/28/2006 | 0.002 | 9.3 | 0.086 | 0.001 | 6 | 0.0042 | 0.0007 | | <0.0002 | <0.0002 | 8.36 | <0.001 | 0.267 | 3.1 |
| W7 | 7/7/2006 | 0.001 | 10.1 | 0.035 | 0.001 | 7.4 | 0.0019 | <0.0001 | | <0.0002 | 0.0002 | 5.57 | <0.001 | 0.329 | 3.7 |
| W7 | 7/12/2006 | 0.001 | 9.5 | 0.035 | 0.001 | 6.5 | 0.0014 | <0.0001 | | <0.0002 | 0.0002 | 5.73 | <0.001 | 0.323 | 3.8 |
| W7 | 7/20/2006 | 0.001 | 11.2 | 0.042 | 0.001 | 6.4 | 0.0011 | <0.0001 | | <0.0002 | <0.0002 | 5.72 | <0.001 | 0.334 | 3.9 |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | 0.001 | 11.7 | 0.051 | 0.001 | 6.5 | 0.0009 | 0.0001 | | <0.0002 | <0.0002 | 6.21 | <0.001 | 0.362 | 4.1 |
| W7 | 8/2/2006 | 0.001 | 10.8 | 0.033 | 0.001 | 6.9 | 0.001 | <0.0001 | | <0.0002 | 0.0005 | 5.94 | <0.001 | 0.342 | 3.6 |
| W7 | 8/10/2006 | 0.001 | 11.3 | 0.04 | 0.001 | 7.2 | 0.0009 | <0.0001 | | <0.0002 | <0.0002 | 5.82 | <0.001 | 0.362 | 4 |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | <0.002 | 10 | 0.039 | <0.002 | 6.7 | 0.001 | <0.0002 | | <0.0004 | <0.0004 | 5.49 | <0.002 | 0.335 | 3.3 |
| W7 | 8/30/2006 | 0.001 | 10.3 | 0.035 | 0.001 | 6.7 | 0.0013 | <0.0001 | | <0.0002 | <0.0002 | 5.49 | <0.001 | 0.309 | 3.5 |
| W7 | 9/6/2006 | 0.001 | 10.3 | 0.035 | 0.001 | 6.8 | 0.0013 | 0.0002 | | <0.0002 | 0.0004 | 5.74 | <0.001 | 0.332 | 3.7 |
| W7 | 9/13/2006 | <0.001 | 11 | 0.033 | <0.001 | 7.1 | 0.0007 | <0.0001 | | <0.0002 | 0.0002 | 6.36 | <0.001 | 0.187 | 3.6 |
| W7 | 9/20/2006 | 0.001 | 11.7 | 0.042 | 0.001 | 6.6 | 0.0014 | 0.0001 | | <0.0002 | 0.0004 | 5.89 | <0.001 | 0.347 | 3.7 |
| W7 | 9/28/2006 | <0.002 | 11 | 0.037 | <0.002 | 6.9 | 0.002 | <0.0002 | | <0.0004 | 0.0004 | 5.35 | <0.002 | 0.328 | 3.6 |
| W7 | 10/4/2006 | <0.002 | 11 | 0.038 | <0.002 | 7 | 0.002 | <0.0002 | | <0.0004 | 0.0006 | 5.75 | <0.002 | 0.347 | 3.5 |
| W7 | 10/12/2006 | 0.001 | 11.8 | 0.063 | 0.001 | 6.6 | 0.0015 | 0.0002 | | <0.0002 | <0.0002 | 6.51 | <0.001 | 0.35 | 4 |
| W7 | 6/5/2007 | 0.002 | 10.2 | 0.126 | 0.001 | 5.8 | 0.0033 | 0.0006 | 0.14 | <0.0002 | <0.0002 | 7.47 | <0.001 | 0.275 | 3.4 |
| W7 | 6/5/2007 | <0.002 | 11 | 0.14 | <0.002 | 6.1 | 0.0039 | 0.0007 | 0.11 | <0.0004 | <0.0004 | 8.37 | <0.002 | 0.302 | 3.5 |
| W7 | 6/5/2007 | 0.002 | 10.6 | 0.135 | 0.001 | 6 | 0.0041 | 0.0007 | 0.14 | <0.0002 | <0.0002 | 8.3 | <0.001 | 0.276 | 3.5 |
| W7 | 6/20/2007 | 0.001 | 9.8 | 0.044 | 0.002 | 7.2 | 0.0016 | 0.0001 | <0.05 | <0.0002 | 0.0003 | 5.45 | <0.001 | 0.304 | 4.2 |
| W7 | 7/18/2007 | 0.001 | 11 | 0.03 | 0.001 | 7.7 | <0.0005 | 0.0004 | | <0.0002 | 0.0004 | 5.78 | <0.001 | 0.38 | 4 |
| W7 | 7/18/2007 | 0.001 | 11 | 0.035 | 0.001 | 7.6 | 0.0009 | 0.0001 | | <0.0002 | 0.0007 | 5.77 | <0.001 | 0.379 | 3.9 |
| W7 | 7/18/2007 | 0.001 | 11 | 0.026 | 0.001 | 7.6 | 0.0005 | <0.0001 | | <0.0002 | 0.0005 | 5.73 | <0.001 | 0.37 | 3.9 |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | 0.001 | 10.7 | 0.033 | 0.001 | 7.9 | 0.0014 | 0.0001 | <0.05 | <0.0002 | <0.0002 | 5.8 | <0.001 | 0.34 | 3.3 |
| W7 | 8/24/2007 | 0.001 | 10.8 | 0.03 | 0.001 | 7.6 | 0.0013 | <0.0001 | <0.05 | <0.0002 | <0.0002 | 5.92 | <0.001 | 0.34 | 3.3 |
| W7 | 8/24/2007 | 0.001 | 11.2 | 0.031 | 0.002 | 8 | 0.0014 | <0.0001 | <0.05 | <0.0002 | <0.0002 | 6.3 | <0.001 | 0.376 | 3.5 |
| W7 | 9/18/2007 | 0.002 | 9.5 | 0.034 | 0.001 | 7.3 | 0.0015 | 0.0002 | <0.05 | <0.0002 | <0.0002 | 6.34 | <0.001 | 0.309 | 2.8 |
| W7 | 10/30/2007 | 0.001 | 11.2 | 0.054 | 0.002 | 8.1 | 0.0008 | 0.0023 | | <0.0002 | 0.0007 | 5.94 | <0.001 | 0.395 | 4.6 |
| W7 | 10/30/2007 | 0.001 | 11 | 0.046 | 0.001 | 7.7 | 0.001 | 0.0005 | | <0.0002 | 0.0003 | 5.09 | <0.001 | 0.388 | 4.3 |
| W7 | 10/30/2007 | 0.001 | 11.3 | 0.047 | 0.001 | 7.6 | 0.0009 | 0.0003 | | <0.0002 | <0.0002 | 5.97 | <0.001 | 0.385 | 4.2 |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | 0.002 | 19 | 0.0257 | 0.00165 | 11.8 | <0.001 | <0.0001 | 0.02 | <0.0002 | <0.0006 | 3.8 | <0.004 | 0.487 | |
| W7 | 4/22/2008 | 0.002 | 20.6 | 0.0268 | 0.00185 | 12.4 | <0.001 | <0.0001 | 0.02 | <0.0002 | <0.0006 | 4.15 | <0.004 | 0.518 | |
| W7 | 4/22/2008 | 0.002 | 20.2 | 0.0268 | 0.00174 | 12 | 0.001 | <0.0001 | 0.02 | <0.0002 | <0.0006 | 4.03 | <0.004 | 0.514 | |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | 0.001 | 8.68 | 0.0693 | 0.00131 | 6.6 | 0.002 | 0.0002 | 0.05 | <0.0002 | <0.0006 | 2.66 | <0.0001 | 0.234 | |
| W7 | 6/3/2008 | 0.001 | 8.71 | 0.0616 | 0.00129 | 6.8 | 0.002 | 0.0001 | 0.05 | <0.0002 | <0.0006 | 2.68 | <0.0001 | 0.232 | |
| W7 | 6/3/2008 | 0.001 | 9.15 | 0.065 | 0.00129 | 7 | 0.002 | 0.0002 | 0.05 | <0.0002 | 0.0009 | 2.77 | <0.0001 | 0.24 | |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/17/2008 | <0.001 | 10.1 | 0.0833 | 0.00148 | 7.5 | 0.001 | 0.0001 | 0.06 | <0.0002 | 0.0008 | 4.43 | <0.0001 | 0.294 | |
| W7 | 8/6/2008 | 0.002 | 10.8 | 0.064 | 0.001 | 7 | 0.003 | 0.0003 | | <0.0002 | <0.0002 | 6.15 | <0.001 | 0.363 | 3.5 |
| W7 | 8/6/2008 | 0.002 | 10.8 | 0.059 | 0.001 | 7.4 | 0.0034 | 0.0003 | | <0.0002 | <0.0002 | 6.45 | <0.001 | 0.361 | 3.5 |
| W7 | 8/6/2008 | 0.002 | 11 | 0.071 | 0.001 | 7.4 | 0.0036 | 0.0004 | | <0.0002 | <0.0002 | 7.39 | <0.001 | 0.36 | 3.5 |
| W7 | 8/6/2008 | | | | | | | | | | | | | | |
| W7 | 9/18/2008 | <0.001 | 7.62 | 0.0347 | 0.00082 | 5.1 | 0.002 | 0.0003 | 0.04 | <0.0002 | 0.0008 | 7.09 | <0.0001 | 0.201 | |
| W7 | 10/28/2008 | <0.001 | 11.6 | 0.0347 | 0.00107 | 6.52 | 0.001 | 0.0001 | 0.016 | <0.0002 | <0.0006 | 7.13 | <0.0001 | 0.263 | |
| W7 | 10/28/2008 | <0.001 | 11.5 | 0.0396 | 0.00114 | 6.24 | 0.003 | 0.0026 | 0.031 | <0.0002 | <0.0006 | 7.08 | <0.0001 | 0.271 | |
| W7 | 10/28/2008 | <0.001 | 11.5 | 0.0337 | 0.00111 | 6.26 | 0.004 | <0.0001 | 0.013 | <0.0002 | <0.0006 | 7.04 | <0.0001 | 0.274 | |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 4/30/2009 | <0.001 | 1.97 | 0.0153 | 0.00016 | 1.29 | <0.001 | 0.0002 | 0.09 | <0.0002 | <0.0006 | 1.67 | <0.0001 | 0.036 | 0.5 |
| W7 | 6/8/2009 | 0.001 | 9.53 | 0.0449 | 0.00141 | 6.08 | 0.002 | 0.0003 | <0.05 | <0.0002 | <0.0006 | 5.67 | <0.0001 | 0.281 | 3.2 |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | 0.001 | 12.2 | 0.0278 | 0.0015 | 7.17 | 0.001 | 0.0004 | 0.011 | <0.0002 | <0.0006 | 5.7 | <0.0001 | 0.38 | 4.3 |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | | | |
| W7 | 8/31/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | 0.017 | | | | | | |
| W7 | 10/7/2009 | 0.001 | 11.9 | 0.0346 | 0.0013 | 7.38 | 0.002 | 0.0015 | <0.05 | <0.0002 | <0.0006 | 6.46 | <0.0001 | 0.312 | 4 |
| W7 | 10/25/2009 | <0.005 | 12.6 | 0.029 | 0.002 | 7.41 | 0.001 | <0.0002 | | <0.0005 | 0.0001 | 7.24 | <0.005 | 0.361 | <3 |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | <0.001 | 7.53 | 0.0207 | 0.0008 | 5.17 | 0.001 | 0.0001 | 0.1 | <0.0002 | <0.0006 | 4.44 | <0.0001 | 0.218 | 2.8 |
| W7 | 4/27/2010 | <0.005 | 2.83 | 0.007 | <0.001 | 1.89 | 0.001 | <0.0002 | | <0.0005 | <0.0001 | 3.14 | <0.005 | 0.073 | <3 |
| W7 | 4/29/2010 | <0.005 | 3.01 | 0.01 | <0.001 | 1.91 | 0.001 | <0.0002 | | <0.0005 | <0.0001 | 3.2 | <0.005 | 0.077 | <3 |
| W7 | 5/1/2010 | <0.005 | 3.62 | 0.03 | <0.001 | 2.25 | 0.002 | 0.0003 | 0.052 | <0.0005 | <0.0001 | 4.34 | <0.005 | 0.095 | <3 |
| W7 | 5/3/2010 | <0.005 | 3.78 | 0.033 | <0.001 | 2.55 | 0.002 | 0.0003 | | <0.0005 | <0.0001 | 4.17 | <0.005 | 0.108 | <3 |
| W7 | 5/5/2010 | <0.005 | 4.7 | 0.03 | <0.001 | 3.03 | 0.002 | 0.002 | 0.058 | <0.0005 | <0.0001 | 4.7 | <0.005 | 0.12 | <3 |
| W7 | 5/7/2010 | <0.005 | 4.7 | 0.039 | <0.001 | 3.01 | 0.003 | 0.0003 | 0.049 | <0.0005 | <0.0001 | 4.5 | <0.005 | 0.13 | <3 |
| W7 | 5/9/2010 | <0.005 | 6.2 | 0.016 | <0.001 | 3.97 | 0.002 | 0.0003 | 0.027 | <0.0005 | 0.0001 | 4.24 | <0.005 | 0.17 | <3 |
| W7 | 5/10/2010 | <0.005 | 7.83 | 0.018 | 0.001 | 5.1 | 0.002 | 0.0003 | 0.03 | <0.0005 | 0.0002 | 5.37 | <0.005 | 0.22 | <3 |
| W7 | 5/12/2010 | | | <.01 | | | | | | | | | | | |
| W7 | 5/12/2010 | <0.005 | 7.14 | 0.021 | 0.001 | 4.83 | 0.001 | 0.0002 | 0.022 | <0.0005 | 0.0001 | 5.23 | <0.005 | 0.206 | <3 |
| W7 | 5/14/2010 | <0.005 | 6.29 | 0.042 | <0.001 | 4.05 | 0.003 | 0.0002 | | <0.0005 | 0.0001 | 4.69 | <0.005 | 0.177 | <3 |
| W7 | 5/16/2010 | <0.005 | 6.52 | 0.037 | <0.001 | 4.02 | 0.001 | <0.0002 | 0.041 | <0.0005 | 0.0001 | 4.45 | <0.005 | 0.188 | <3 |
| W7 | 5/17/2010 | <0.005 | 6.47 | 0.045 | 0.001 | 3.92 | 0.001 | 0.0002 | 0.031 | <0.0005 | 0.0002 | 4.32 | <0.005 | 0.193 | <3 |
| W7 | 5/19/2010 | <0.005 | 9.58 | 0.019 | 0.001 | 6.7 | <0.003 | <0.0002 | 0.024 | <0.0005 | 0.0002 | 5.4 | <0.005 | 0.261 | <3 |
| W7 | 5/21/2010 | <0.01 | 8 | 0.035 | 0.001 | 5 | 0.002 | 0.0002 | | <0.0005 | <0.0008 | 5.41 | <0.005 | 0.246 | <60 |
| W7 | 5/23/2010 | <0.01 | 10 | 0.13 | 0.001 | 5 | 0.007 | 0.0013 | | <0.0005 | <0.0008 | 8.91 | <0.005 | 0.261 | <60 |
| W7 | 5/25/2010 | <0.01 | 13 | 0.158 | 0.002 | 8 | 0.008 | 0.0018 | | <0.0005 | <0.001 | 13.2 | <0.005 | 0.279 | <60 |
| W7 | 5/27/2010 | <0.01 | 17 | 0.391 | 0.002 | 8 | 0.03 | 0.0052 | | 0.0007 | <0.001 | 24.4 | <0.005 | 0.316 | <60 |
| W7 | 5/29/2010 | <0.01 | 13 | 0.248 | 0.002 | 6 | 0.013 | 0.0025 | | <0.0005 | <0.0008 | 12.9 | <0.005 | 0.314 | <60 |
| W7 | 5/31/2010 | <0.01 | 13 | 0.226 | 0.002 | 7 | 0.015 | 0.0028 | | <0.0005 | <0.0008 | 14.2 | <0.005 | 0.307 | <60 |
| W7 | 6/2/2010 | <0.01 | 13 | 0.148 | 0.002 | 8 | 0.009 | 0.0014 | | <0.0005 | <0.0008 | 10.2 | <0.005 | 0.337 | <60 |
| W7 | 6/4/2010 | <0.01 | 11 | 0.081 | 0.002 | 7 | 0.006 | 0.001 | | <0.0005 | <0.0008 | 8.48 | <0.005 | 0.311 | <60 |
| W7 | 6/6/2010 | <0.01 | 12 | 0.091 | 0.002 | 7 | 0.006 | 0.0012 | | <0.0005 | <0.0008 | 9.38 | <0.005 | 0.337 | <60 |
| W7 | 6/14/2010 | <0.01 | 12 | 0.073 | 0.002 | 7 | 0.004 | 0.0006 | | <0.0005 | <0.0008 | 7.65 | <0.005 | 0.356 | <60 |
| W7 | 6/16/2010 | <0.01 | 12 | 0.036 | 0.002 | 7 | 0.002 | <0.0002 | | <0.0005 | <0.0008 | 6.5 | <0.005 | 0.342 | <60 |
| W7 | 6/18/2010 | <0.01 | 11 | 0.042 | 0.002 | 7 | 0.002 | 0.0003 | | <0.0005 | <0.0008 | 6.69 | <0.005 | 0.323 | <60 |
| W7 | 6/20/2010 | <0.01 | 11 | 0.059 | 0.002 | 7 | 0.004 | 0.0007 | | <0.0005 | <0.0008 | 8.16 | <0.005 | 0.308 | <60 |
| W7 | 6/22/2010 | <0.01 | 11 | 0.26 | 0.001 | 6 | 0.016 | 0.0031 | | <0.0005 | <0.0008 | 18.4 | <0.005 | 0.298 | <60 |
| W7 | 6/24/2010 | <0.01 | 12 | 0.067 | 0.001 | 8 | 0.006 | 0.0006 | | <0.0005 | <0.0008 | 8.82 | <0.005 | 0.285 | <60 |
| W7 | 6/26/2010 | <0.01 | 10 | 0.032 | 0.001 | 6 | 0.002 | 0.0003 | | <0.0005 | <0.0008 | 6.6 | <0.005 | 0.277 | <60 |
| W7 | 6/28/2010 | <0.01 | 9 | 0.021 | 0.001 | 6 | 0.002 | 0.0003 | | <0.0005 | <0.0008 | 7.12 | <0.005 | 0.312 | <60 |
| W7 | 7/5/2010 | <0.01 | 9 | 0.078 | 0.001 | 6 | 0.005 | 0.0008 | | <0.0005 | <0.0008 | 9.55 | <0.005 | 0.263 | <60 |
| W7 | 8/5/2010 | <0.01 | 10 | 0.029 | 0.001 | 6 | 0.003 | <0.0002 | | <0.0005 | <0.0008 | 6.81 | <0.005 | 0.306 | <60 |
| W7 | 9/12/2010 | <0.01 | 9 | 0.052 | <0.001 | 5 | 0.002 | <0.0002 | | <0.0005 | <0.0008 | 7.25 | <0.005 | 0.253 | <60 |
| W7 | 9/12/2010 | <0.01 | 9 | 0.026 | <0.001 | 5 | 0.002 | <0.0002 | | <0.0005 | <0.0008 | 7.18 | <0.005 | 0.248 | <60 |
| W7 | 10/8/2010 | <0.005 | 11.1 | 0.036 | 0.001 | 6.52 | 0.002 | <0.0002 | | <0.0005 | <0.0001 | 7.13 | <0.005 | 0.316 | <3 |
| W7 | 4/27/2011 | <0.005 | 3.72 | 0.03 | <0.001 | 2.16 | <0.001 | <0.0002 | 0.067 | <0.0005 | <0.0001 | 2.96 | <0.005 | 0.089 | <3 |
| W7 | 5/2/2011 | <0.005 | 2.78 | 0.039 | <0.001 | 1.51 | 0.001 | <0.0002 | | <0.0005 | <0.0001 | 2.73 | <0.005 | 0.069 | <3 |
| W7 | 6/1/2011 | <0.005 | 8.93 | 0.035 | 0.001 | 5.45 | 0.002 | 0.0002 | 0.043 | <0.0005 | 0.0001 | 5.82 | <0.005 | 0.25 | <3 |
| W7 | 6/16/2011 | <0.005 | 10.2 | 0.097 | 0.001 | 5.94 | 0.008 | 0.0012 | 0.226 | <0.0005 | 0.0002 | 10.3 | <0.005 | 0.24 | <3 |
| W7 | 7/1/2011 | <0.005 | 7.82 | 0.162 | 0.001 | 5.16 | 0.012 | 0.0021 | 0.267 | <0.0005 | 0.0003 | 11.9 | <0.005 | 0.179 | <3 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Total Li (mg/L) | Total Mg (mg/L) | Total Mn (mg/L) | Total Mo (mg/L) | Total Na (mg/L) | Total Ni (mg/L) | Total Pb (mg/L) | Total P (mg/L) | Total Sb (mg/L) | Total Se (mg/L) | Total Si (mg/L) | Total Sn (mg/L) | Total Sr (mg/L) | Total S (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | 0.005 | 8.29 | 0.304 | <0.001 | 4.04 | 0.019 | 0.0035 | 0.412 | <0.0005 | 0.0003 | 22.3 | <0.005 | 0.161 | <3 |
| W7 | 8/16/2011 | <0.005 | 8.1 | 0.081 | <0.001 | 4.64 | 0.003 | 0.0004 | 0.058 | <0.0005 | 0.0001 | 7 | <0.005 | 0.209 | <3 |
| W7 | 8/19/2011 | <0.005 | 8.05 | 0.078 | <0.001 | 4.62 | 0.003 | 0.0002 | 0.043 | <0.0005 | 0.0001 | 7 | <0.005 | 0.201 | <3 |
| W7 | 9/12/2011 | <0.005 | 10.6 | 0.083 | 0.001 | 6.09 | 0.002 | <0.0002 | 0.033 | <0.0005 | 0.0002 | 7.49 | <0.005 | 0.247 | <3 |
| W7 | 10/6/2011 | <0.005 | 10.2 | 0.073 | 0.001 | 5.59 | 0.001 | <0.0002 | 0.023 | <0.0005 | 0.0001 | 6.27 | <0.005 | 0.264 | <3 |
| W7 | 11/22/2011 | <0.005 | 12.8 | 0.093 | 0.001 | 6.69 | 0.002 | 0.0008 | 0.077 | <0.0005 | 0.0002 | 7.33 | <0.005 | 0.358 | 6.5 |
| W7 | 1/24/2012 | <0.005 | 14.5 | 0.06 | 0.001 | 8.39 | <0.001 | <0.0002 | 0.014 | <0.0005 | 0.0003 | 6.36 | <0.005 | 0.449 | 5.9 |
| W7 | 2/25/2012 | <0.005 | 13.9 | 0.004 | 0.001 | 8.08 | <0.001 | <0.0002 | 0.012 | <0.0005 | 0.0003 | 6.3 | <0.005 | 0.468 | 6 |
| W7 | 3/5/2012 | <0.005 | 14.6 | 0.005 | 0.001 | 8.36 | <0.001 | <0.0002 | 0.016 | <0.0005 | 0.0004 | 6.35 | <0.005 | 0.485 | 5.6 |
| W7 | 4/24/2012 | <0.0050 | 3.17 | 0.0582 | <0.0010 | 1.84 | 0.0019 | 0.00029 | 0.048 | <0.00050 | <0.00010 | 4.08 | <0.0050 | 0.0798 | <3.0 |
| W7 | 5/6/2012 | <0.0050 | 4.06 | 0.0133 | <0.0010 | 2.47 | 0.0013 | <0.00020 | 0.031 | <0.00050 | 0.00014 | 3.65 | <0.0050 | 0.105 | <3.0 |
| W7 | 5/6/2012 | <0.0050 | 4.12 | 0.0145 | <0.0010 | 2.53 | 0.0014 | <0.00020 | 0.034 | <0.00050 | 0.00011 | 3.57 | <0.0050 | 0.103 | <3.0 |
| W7 | 6/19/2012 | <0.0050 | 9.46 | 0.199 | 0.0012 | 5.45 | 0.0107 | 0.00178 | 0.222 | <0.00050 | 0.0002 | 16.3 | <0.0050 | 0.236 | <3.0 |
| W7 | 7/17/2012 | <0.0050 | 11 | 0.0937 | 0.0015 | 6.4 | 0.0032 | 0.00026 | 0.074 | <0.00050 | 0.00019 | 8.31 | <0.0050 | 0.305 | <3.0 |
| W7 | 7/30/2012 | <0.0050 | 11.6 | 0.0683 | 0.0014 | 6.83 | 0.0025 | <0.00020 | 0.044 | <0.00050 | 0.00022 | 6.59 | <0.0050 | 0.318 | 3.3 |
| W7 | 8/8/2012 | <0.0050 | 12.7 | 0.0626 | 0.0014 | 7.25 | 0.0016 | <0.00020 | 0.036 | <0.00050 | 0.00028 | 7.38 | <0.0050 | 0.334 | <3.0 |
| W7 | 8/23/2012 | <0.0050 | 13 | 0.0627 | 0.0016 | 7.39 | 0.0016 | <0.00020 | 0.035 | <0.00050 | 0.00017 | 7.8 | <0.0050 | 0.374 | <3.0 |
| W7 | 9/13/2012 | <0.0050 | 10.5 | 0.126 | <0.0010 | 6 | 0.0022 | <0.00020 | 0.034 | <0.00050 | 0.00021 | 6.83 | <0.0050 | 0.269 | <3.0 |
| W7 | 10/16/2012 | <0.0050 | 13 | 0.101 | 0.0012 | 7.25 | 0.0023 | <0.00020 | 0.046 | <0.00050 | 0.0002 | 7.29 | <0.0050 | 0.327 | <3.0 |
| W7 | 11/2/2012 | <0.0050 | 14.4 | 0.103 | 0.0013 | 7.87 | 0.0014 | <0.00020 | 0.023 | <0.00050 | 0.00023 | 6.3 | <0.0050 | 0.411 | 5.1 |
| W7 | 12/29/2012 | <0.0050 | 19.9 | 0.0405 | 0.0012 | 11.7 | 0.0016 | <0.00020 | 0.022 | <0.00050 | 0.00032 | 7.67 | <0.0050 | 0.488 | 7.9 |
| W7 | 4/30/2013 | <0.0050 | 19 | 0.053 | 0.0013 | 10.1 | <0.0010 | <0.00020 | <0.01 | <0.00050 | 0.00042 | 7.29 | <0.0050 | 0.603 | 8.1 |
| W7 | 5/14/2013 | <0.0050 | 3 | 0.164 | <0.0010 | 1.5 | 0.0029 | 0.00046 | 0.116 | <0.00050 | 0.00011 | 4.78 | <0.0050 | 0.0703 | <3.0 |
| W7 | 6/19/2013 | <0.0050 | 9.98 | 0.0448 | 0.0013 | 6.12 | 0.0018 | <0.00020 | 0.036 | <0.00050 | 0.00018 | 6.43 | <0.0050 | 0.275 | <3.0 |
| W7 | 6/19/2013 | <0.0050 | 9.92 | 0.042 | 0.0014 | 6.28 | 0.0019 | <0.00020 | 0.028 | <0.00050 | 0.00012 | 6.47 | <0.0050 | 0.275 | <3.0 |
| W7 | 7/13/2013 | <0.0050 | 12.1 | 0.0336 | 0.0016 | 7.03 | 0.0017 | <0.00020 | 0.027 | <0.00050 | 0.0002 | 6.88 | <0.0050 | 0.341 | <3.0 |
| W7 | 8/21/2013 | <0.0050 | 13.3 | 0.0492 | 0.0016 | 7.75 | 0.0014 | <0.00020 | 0.028 | <0.00050 | 0.00014 | 6.97 | <0.0050 | 0.364 | <3.0 |
| W7 | 9/6/2013 | <0.0050 | 13.9 | 0.102 | 0.0013 | 8.11 | 0.0019 | <0.00020 | 0.044 | <0.00050 | 0.00017 | 7.96 | <0.0050 | 0.364 | <3.0 |
| W7 | 10/21/2013 | <0.0050 | 11.3 | 0.0934 | 0.0011 | 6.34 | 0.0016 | <0.00020 | 0.027 | <0.00050 | 0.00021 | 6.38 | <0.0050 | 0.303 | <3.0 |
| W7 | 11/16/2013 | <0.0050 | 15.6 | 0.0906 | 0.0017 | 8.83 | <0.0010 | <0.00020 | 0.026 | <0.00050 | 0.00017 | 6.95 | <0.0050 | 0.436 | <3.0 |
| W7 | 12/7/2013 | <0.0050 | 17.5 | 0.162 | 0.0013 | 10.1 | 0.001 | <0.00020 | 0.021 | <0.00050 | 0.00019 | 6.56 | <0.0050 | 0.476 | 5.8 |
| C4 | 5/6/2012 | 0.0188 | 14.4 | 0.936 | 0.0015 | 3.45 | 0.0498 | 0.0126 | 1.11 | 0.00084 | 0.00069 | 57.5 | <0.0050 | 0.168 | <3.0 |
| C4 | 8/1/2012 | <0.0050 | 11.5 | 0.868 | <0.0010 | 5.22 | 0.0139 | 0.00303 | 0.41 | <0.00050 | 0.00019 | 18.8 | <0.0050 | 0.237 | <3.0 |
| C4 | 8/8/2012 | 0.0057 | 12.3 | 1 | 0.001 | 5.55 | 0.0151 | 0.00371 | 0.478 | <0.00050 | 0.00021 | 18 | <0.0050 | 0.26 | <3.0 |
| C4 | 8/25/2012 | <0.0050 | 14.3 | 1.32 | <0.0010 | 5.64 | 0.0179 | 0.00439 | 0.657 | <0.00050 | 0.00016 | 13 | <0.0050 | 0.321 | <3.0 |
| C4 | 6/22/2013 | 0.0152 | 20.2 | 1.24 | 0.0023 | 7.08 | 0.0483 | 0.00977 | 1.28 | 0.00084 | 0.00059 | 40.7 | <0.0050 | 0.337 | 3.6 |
| C4 | 7/19/2013 | 0.0106 | 15.8 | 0.913 | 0.002 | 6.66 | 0.0314 | 0.00631 | 0.591 | 0.00064 | 0.00071 | 32 | <0.0050 | 0.323 | <3.0 |
| C4 | 8/22/2013 | 0.0094 | 17.3 | 1.25 | 0.0014 | 6.83 | 0.0352 | 0.00784 | 1.01 | 0.00058 | 0.00053 | 31 | <0.0050 | 0.346 | <3.0 |
| C4 | 9/6/2013 | <0.0050 | 14.2 | 0.732 | 0.0014 | 6.74 | 0.0124 | 0.00208 | 0.342 | <0.00050 | 0.00016 | 18.3 | <0.0050 | 0.276 | <3.0 |
| C4 | 10/18/2013 | <0.0050 | 11.8 | 0.427 | <0.0010 | 6.15 | 0.0031 | <0.00020 | 0.06 | <0.00050 | <0.00010 | 8.27 | <0.0050 | 0.237 | 4.6 |
| C4 | 10/18/2013 | <0.0050 | 11.3 | 0.425 | <0.0010 | 6.01 | 0.0029 | <0.00020 | 0.065 | <0.00050 | 0.00011 | 8.14 | <0.0050 | 0.236 | 3.6 |
| C4 | 11/17/2013 | <0.0050 | 21.5 | 3.19 | 0.0011 | 8.09 | 0.0077 | <0.00020 | 0.158 | <0.00050 | 0.00027 | 9.05 | <0.0050 | 0.409 | 8.2 |
| C10 | 5/12/2012 | 0.0292 | 21.1 | 2.09 | 0.0021 | 4.3 | 0.074 | 0.0214 | 2.08 | 0.00117 | 0.00116 | 66.7 | <0.0050 | 0.307 | <3.0 |
| C10 | 7/30/2012 | 0.015 | 16.2 | 0.947 | 0.0021 | 6.41 | 0.041 | 0.00995 | 0.967 | 0.00096 | 0.00073 | 42.7 | <0.0050 | 0.315 | <3.0 |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | 0.0172 | 18.8 | 1.31 | 0.0017 | 6.4 | 0.0467 | 0.0125 | 1.15 | 0.00087 | 0.00057 | 44.2 | <0.0050 | 0.363 | <3.0 |
| C10 | 8/27/2012 | 0.0198 | 20.2 | 1.7 | 0.0023 | 6.34 | 0.0524 | 0.013 | 1.39 | 0.00115 | 0.00086 | 44 | <0.0050 | 0.404 | <3.0 |
| C10 | 6/22/2013 | <0.0050 | 9.68 | 0.0986 | 0.0012 | 6.32 | 0.0044 | 0.0006 | 0.083 | <0.00050 | 0.0001 | 8.47 | <0.0050 | 0.223 | <3.0 |
| C10 | 7/23/2013 | <0.0050 | 10.6 | 0.407 | 0.0012 | 6.52 | 0.0099 | 0.00212 | 0.239 | <0.00050 | 0.00024 | 15.9 | <0.0050 | 0.226 | <3.0 |
| C10 | 8/22/2013 | <0.0050 | 10.7 | 0.11 | <0.0010 | 6.49 | 0.0038 | 0.00044 | 0.073 | <0.00050 | 0.00013 | 8.98 | <0.0050 | 0.259 | <3.0 |
| C10 | 9/8/2013 | <0.0050 | 10.2 | 0.172 | 0.0014 | 6.24 | 0.0033 | 0.00025 | 0.063 | <0.00050 | 0.00017 | 7.06 | <0.0050 | 0.256 | <3.0 |
| C10 | 9/8/2013 | <0.0050 | 10.3 | 0.174 | <0.0010 | 6.4 | 0.0032 | 0.00025 | 0.067 | <0.00050 | 0.00014 | 7.27 | <0.0050 | 0.255 | <3.0 |
| C10 | 10/18/2013 | <0.0050 | 10.4 | 0.321 | <0.0010 | 6.3 | 0.0038 | 0.00054 | 0.105 | <0.00050 | 0.00015 | 8.99 | <0.0050 | 0.231 | <3.0 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Total Te (mg/L) | Total Th (mg/L) | Total Ti (mg/L) | Total Tl (mg/L) | Total U (mg/L) | Total V (mg/L) | Total W (mg/L) | Total Zn (mg/L) | Total Zr (mg/L) | Total N (mg/L) | Ammonia (mg/L) | Ammonium (mg/L) | Ammonium (mg/L) | NO2+NO3 (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | | | 0.022 | <0.00020 | 0.0006 | <0.030 | | 0.0096 | | | 0.039 | | | |
| W1 | 6/30/2005 | | | <0.010 | <0.00010 | 0.00113 | <0.0010 | | <0.0010 | | | <0.020 | | | |
| W1 | 7/28/2005 | | | <0.010 | <0.00010 | 0.00122 | <0.0010 | | <0.0010 | | | <0.020 | | | |
| W1 | 8/29/2005 | | | <0.010 | <0.00020 | 0.00077 | <0.030 | | <0.0050 | | | 0.041 | | | |
| W1 | 9/28/2005 | | | <0.010 | <0.00020 | 0.00058 | <0.030 | | <0.0050 | | | 0.026 | | | |
| W1 | 10/15/2005 | | | <0.010 | <0.00010 | 0.000786 | 0.0013 | | 0.001 | | | 0.02 | | | |
| W2 | 5/27/2005 | | | 0.016 | <0.00020 | 0.00054 | <0.030 | | <0.0050 | | | 0.026 | | | |
| W2 | 5/27/2005 | | | 0.057 | | 0.00096 | | | 0.006 | | | <0.02 | | | |
| W2 | 6/30/2005 | | | <0.010 | <0.00010 | 0.00108 | <0.0010 | | <0.0010 | | | <0.020 | | | |
| W2 | 7/28/2005 | | | <0.010 | <0.00010 | 0.00136 | <0.0010 | | <0.0010 | | | <0.020 | | | |
| W2 | 8/30/2005 | | | <0.010 | <0.00020 | 0.00082 | <0.030 | | <0.0050 | | | 0.029 | | | |
| W2 | 9/28/2005 | | | <0.010 | <0.00020 | 0.00059 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W2 | 10/15/2005 | | | <0.010 | <0.00010 | 0.000756 | 0.001 | | 0.0011 | | | <0.020 | | | |
| W3 | 5/27/2005 | | | <0.010 | <0.00020 | 0.00035 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W3 | 6/30/2005 | | | <0.010 | <0.00010 | 0.0009 | <0.0010 | | <0.0020 | | | <0.020 | | | |
| W3 | 7/29/2005 | | | 0.045 | <0.00010 | 0.000778 | 0.0032 | | <0.0070 | | | <0.020 | | | |
| W3 | 8/29/2005 | | | <0.010 | <0.00020 | 0.00051 | <0.030 | | <0.0050 | | | 0.042 | | | |
| W3 | 9/28/2005 | | | <0.010 | <0.00020 | 0.00039 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W3 | 10/15/2005 | | | <0.010 | <0.00010 | 0.00044 | <0.0010 | | <0.0010 | | | 0.023 | | | |
| W8 | 5/27/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W8 | 6/30/2005 | | | <0.010 | <0.00010 | 0.000063 | <0.0010 | | <0.0020 | | | 0.041 | | | |
| W8 | 7/29/2005 | | | <0.010 | <0.00010 | 0.000083 | <0.0010 | | 0.0011 | | | <0.020 | | | |
| W8 | 8/30/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | 0.023 | | | |
| W8 | 9/28/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W8 | 10/15/2005 | | | <0.010 | <0.00010 | 0.0001 | <0.0010 | | 0.0011 | | | 0.026 | | | |
| W9 | 5/27/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W9 | 6/30/2005 | | | <0.010 | <0.00010 | 0.000027 | <0.0010 | | <0.0050 | | | 0.02 | | | |
| W9 | 7/29/2005 | | | <0.010 | <0.00010 | 0.000052 | <0.0010 | | <0.0040 | | | <0.020 | | | |
| W9 | 8/29/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | 0.026 | | | |
| W9 | 9/28/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W9 | 10/15/2005 | | | <0.010 | <0.00010 | 0.000025 | <0.0010 | | <0.0010 | | | <0.020 | | | |
| W10 | 5/27/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | 0.027 | | | |
| W10 | 5/27/2005 | | | <0.01 | <0.0002 | 0.00092 | <0.03 | | <0.005 | | | <0.02 | | | |
| W10 | 6/30/2005 | | | <0.010 | <0.00010 | 0.000034 | 0.0015 | | 0.0289 | | | 0.036 | | | |
| W10 | 7/29/2005 | | | 0.09 | <0.00010 | 0.000097 | 0.0067 | | 0.017 | | | <0.020 | | | |
| W10 | 8/29/2005 | | | 0.018 | <0.00020 | <0.00020 | <0.030 | | 0.0071 | | | 0.033 | | | |
| W10 | 9/28/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W10 | 10/15/2005 | | | <0.010 | <0.00010 | 0.000017 | <0.0010 | | 0.0014 | | | <0.020 | | | |
| W6 | 5/27/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W6 | 6/30/2005 | | | <0.010 | <0.00010 | 0.000151 | 0.0012 | | <0.0030 | | | <0.020 | | | |
| W6 | 7/29/2005 | | | 0.033 | <0.00010 | 0.00106 | 0.0027 | | <0.0060 | | | <0.020 | | | |
| W6 | 8/30/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W6 | 9/28/2005 | | | <0.010 | <0.00020 | <0.00020 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W6 | 10/15/2005 | | | <0.010 | <0.00010 | 0.000129 | <0.0010 | | <0.0010 | | | <0.020 | | | |
| W6 | 6/2/2006 | | | 0.077 | <0.0001 | 0.000215 | 0.0066 | | 0.0085 | | | 0.021 | | | |
| W6 | 8/25/2006 | | | <0.0010 | <0.0001 | <0.001 | 0.0008 | | 0.005 | <0.002 | | | | | |
| W6 | 9/6/2006 | | | 0.0014 | <0.00005 | <0.0005 | 0.0008 | | <0.001 | <0.001 | | | | | |
| W6 | 6/20/2007 | | | <0.0005 | <0.00005 | <0.0005 | 0.0011 | | 0.004 | <0.001 | | <0.05 | | | <0.1 |
| W6 | 9/18/2007 | | | 0.0015 | <0.00005 | <0.0005 | 0.0007 | | 0.008 | <0.001 | | <0.05 | | | <0.1 |
| W6 | 6/17/2008 | <0.0001 | <0.0001 | 0.0059 | <0.00001 | <0.0004 | 0.00094 | | 0.007 | 0.0004 | | <0.05 | | | 0.01 |
| W6 | 9/18/2008 | <0.0001 | <0.0001 | 0.0015 | <0.00001 | <0.0004 | 0.00065 | | 0.004 | 0.0003 | | <0.05 | | | <0.01 |
| W6 | 4/14/2009 | 0.0001 | 0.0001 | 0.064 | <0.00001 | 0.0041 | 0.00381 | | 0.276 | 0.0038 | | | 0.12 | 0.12 | 0.59 |
| W6 | 4/30/2009 | <0.0001 | <0.0001 | 0.222 | 0.00003 | 0.0004 | 0.0142 | | 0.023 | 0.0013 | | | <0.05 | <0.05 | 0.04 |
| W6 | 7/28/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | <0.0001 | <0.0004 | 0.0024 | <0.00001 | 0.0015 | 0.0008 | | 0.003 | <0.0001 | | | | | |
| W6 | 8/6/2009 | <0.0001 | <0.0004 | 0.0019 | <0.00001 | 0.0015 | 0.0007 | | 0.006 | 0.0001 | | | 0.06 | 0.06 | 2.93 |
| W6 | 8/18/2009 | | | | | | | | | | | | | | |
| W6 | 8/25/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | <0.0001 | <0.0004 | 0.0022 | <0.00001 | 0.0005 | 0.0006 | | 0.005 | <0.0001 | | | 0.1 | 0.1 | 8.18 |
| W6 | 10/25/2009 | | | <0.005 | <0.00005 | 0.0009 | <0.005 | | <0.005 | <0.0005 | | 0.134 | | | 7.9 |
| W6 | 4/19/2010 | <0.0001 | <0.0004 | | <0.00001 | 0.0014 | 0.0043 | | 0.014 | 0.0003 | | | <0.05 | <0.05 | 0.54 |
| W6 | 5/16/2010 | | | <0.005 | <0.00005 | 0.0001 | <0.005 | <0.001 | <0.005 | <0.0005 | | 0.046 | | | <0.02 |
| W6 | 5/17/2010 | | | <0.005 | <0.00005 | 0.0004 | <0.005 | <0.001 | <0.005 | <0.0005 | | <0.005 | | | <0.02 |
| W6 | 5/19/2010 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | <0.001 | <0.005 | <0.0005 | | 0.08 | | | <0.02 |
| W6 | 5/21/2010 | | | <0.01 | <0.00005 | 0.0006 | <0.005 | | <0.01 | <0.002 | | 0.006 | | | <0.02 |
| W6 | 5/23/2010 | | | <0.01 | <0.00005 | 0.0006 | <0.005 | | <0.01 | <0.002 | | 0.031 | | | <0.02 |
| W6 | 5/25/2010 | | | <0.01 | <0.00005 | 0.0006 | <0.005 | | <0.01 | <0.002 | | 0.17 | | | <0.02 |
| W6 | 5/29/2010 | | | <0.01 | <0.00005 | 0.0005 | <0.005 | | <0.01 | <0.002 | | 0.08 | | | <0.02 |
| W6 | 6/2/2010 | | | <0.01 | <0.00005 | 0.003 | <0.005 | | <0.01 | <0.002 | | 0.031 | | | 0.97 |
| W6 | 6/4/2010 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | 0.034 | | | <0.02 |
| W6 | 6/6/2010 | | | <0.01 | <0.00005 | 0.0004 | <0.005 | | <0.01 | <0.002 | | 0.06 | | | <0.02 |
| W6 | 6/14/2010 | | | 0.011 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | 0.016 | | | <0.02 |
| W6 | 6/16/2010 | | | 0.012 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | 0.013 | | | 0.03 |
| W6 | 6/18/2010 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | <0.5 | | | <0.02 |
| W6 | 6/20/2010 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | <0.5 | | | 0.02 |
| W6 | 6/22/2010 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | 0.01 | | | <0.02 |
| W6 | 6/24/2010 | | | <0.01 | <0.00005 | 0.0002 | <0.005 | | <0.01 | <0.002 | | 0.012 | | | <0.02 |
| W6 | 6/26/2010 | | | <0.01 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | 0.034 | | | <0.02 |
| W6 | 6/26/2010 | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | | | 0.019 | <0.00005 | 0.0003 | <0.005 | | <0.01 | <0.002 | | 0.031 | | | <0.02 |
| W6 | 7/5/2010 | | | 0.051 | <0.00005 | 0.0004 | <0.005 | | <0.01 | <0.002 | | 0.15 | | | <0.02 |
| W6 | 8/5/2010 | | | <0.01 | <0.00005 | 0.0002 | <0.005 | | <0.01 | <0.002 | | 0.014 | | | <0.02 |
| W6 | 9/9/2010 | | | 0.018 | <0.00005 | 0.0003 | <0.005 | | 0.015 | <0.002 | | <0.005 | | | <0.02 |
| W6 | 10/8/2010 | | | 0.016 | <0.00005 | 0.0003 | <0.005 | | <0.005 | <0.0005 | | 0.053 | | | <0.02 |
| W6 | 8/19/2011 | | | <0.005 | <0.00005 | 0.0025 | <0.005 | | 0.008 | <0.0005 | | 0.006 | | | 1.05 |
| W6 | 7/17/2012 | | | 0.747 | 0.000147 | 0.0022 | 0.0672 | | 0.073 | 0.00302 | | 0.14 | | | 0.026 |
| W6 | 7/30/2012 | | | 0.529 | 0.000108 | 0.0017 | 0.0475 | | 0.0504 | 0.00202 | | 0.07 | | | 0.059 |
| W6 | 8/9/2012 | | | 0.299 | 0.000068 | 0.00102 | 0.0252 | | 0.027 | 0.00116 | | 0.025 | | | 0.029 |
| W6 | 8/25/2012 | | | 0.063 | <0.000050 | 0.00167 | 0.0348 | | 0.0392 | 0.00101 | | 0.023 | | | 0.045 |
| W6 | 9/13/2012 | | | 0.0071 | <0.000050 | 0.00018 | <0.0050 | | <0.0050 | <0.00050 | | 0.011 | | | 0.034 |
| W6 | 10/13/2012 | | | 0.0098 | <0.000050 | 0.00027 | <0.0050 | | <0.0050 | <0.00050 | | 0.016 | | | 0.042 |
| W6 | 11/12/2012 | | | <0.0050 | <0.000050 | 0.00034 | <0.0050 | | <0.0050 | <0.00050 | | 0.025 | | | <0.020 |
| W6 | 5/14/2013 | | | 0.024 | <0.000050 | <0.00010 | <0.0050 | | 0.0057 | <0.00050 | | 0.13 | | | <0.020 |
| W6 | 6/22/2013 | | | 0.2 | 0.000066 | 0.0005 | 0.014 | | 0.0169 | 0.0016 | | 0.024 | | | 0.042 |
| W6 | 7/12/2013 | | | 0.0218 | <0.000050 | 0.00022 | <0.0050 | | <0.0050 | <0.00050 | | 0.012 | | | <0.020 |
| W6 | 8/22/2013 | | | <0.0050 | <0.000050 | 0.00017 | <0.0050 | | <0.0050 | <0.00050 | | 0.014 | | | <0.020 |
| W6 | 9/6/2013 | | | 0.007 | <0.000050 | 0.0002 | <0.0050 | | <0.0050 | <0.00050 | | 0.0061 | | | 0.03 |
| W6 | 10/7/2013 | | | 0.0916 | <0.000050 | 0.0003 | 0.0074 | | 0.0079 | 0.0006 | | 0.044 | | | 0.042 |
| W6 | 11/16/2013 | | | 0.0133 | <0.000050 | 0.00022 | <0.0050 | | <0.0050 | <0.00050 | | 0.015 | | | <0.020 |
| W6 | 12/7/2013 | | | <0.0050 | <0.000050 | 0.00046 | <0.0050 | | <0.0050 | <0.00050 | | 0.0076 | | | <0.020 |
| W7 | 5/27/2005 | | | 0.022 | <0.00020 | 0.00047 | <0.030 | | <0.0050 | | | <0.020 | | | |
| W7 | 6/30/2005 | | | <0.010 | <0.00010 | 0.000769 | 0.0013 | | <0.0020 | | | <0.020 | | | |
| W7 | 7/29/2005 | | | 0.027 | <0.00010 | 0.0012 | 0.0024 | | <0.0050 | | | <0.020 | | | |
| W7 | 8/30/2005 | | | <0.010 | <0.00020 | 0.00058 | <0.030 | | <0.0050 | | | 0.02 | | | |
| W7 | 9/28/2005 | | | 0.06 | <0.00020 | 0.00079 | <0.030 | | 0.0101 | | | <0.020 | | | |
| W7 | 10/15/2005 | | | <0.010 | <0.00010 | 0.000547 | <0.0010 | | 0.0017 | | | 0.021 | | | |
| W7 | 6/2/2006 | | | 0.378 | <0.0001 | 0.00201 | 0.0379 | | 0.0484 | | | 0.062 | | | |
| W7 | 6/8/2006 | | | 0.015 | <0.0001 | 0.000529 | 0.0035 | | 0.0048 | | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Total Te (mg/L) | Total Th (mg/L) | Total Ti (mg/L) | Total Tl (mg/L) | Total U (mg/L) | Total V (mg/L) | Total W (mg/L) | Total Zn (mg/L) | Total Zr (mg/L) | Total N (mg/L) | Ammonia (mg/L) | Ammonium (mg/L) | Ammonium (mg/L) | NO2+NO3 (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | 0.027 | | | |
| W7 | 6/15/2006 | | | 0.0685 | <0.00005 | 0.0008 | 0.0062 | | 0.006 | 0.001 | | | | | |
| W7 | 6/23/2006 | | | 0.257 | <0.00005 | 0.0014 | 0.0173 | | 0.022 | 0.002 | | 0.028 | | | |
| W7 | 6/28/2006 | | | 0.0822 | <0.00005 | 0.0011 | 0.0064 | | 0.006 | 0.001 | | 0.01 | | | |
| W7 | 7/7/2006 | | | 0.0044 | <0.00005 | 0.0011 | 0.001 | | <0.001 | <0.001 | | | | | |
| W7 | 7/12/2006 | | | 0.0036 | <0.00005 | 0.001 | 0.0009 | | 0.015 | <0.001 | | 0.014 | | | |
| W7 | 7/20/2006 | | | 0.0026 | <0.00005 | 0.0012 | 0.0008 | | 0.002 | <0.001 | | 0.012 | | | |
| W7 | 7/26/2006 | | | | | | | | | | | 0.016 | | | |
| W7 | 7/26/2006 | | | 0.006 | <0.00005 | 0.0012 | 0.0011 | | 0.002 | <0.001 | | | | | |
| W7 | 8/2/2006 | | | 0.004 | <0.00005 | 0.001 | 0.001 | | 0.001 | <0.001 | | 0.015 | | | |
| W7 | 8/10/2006 | | | 0.0018 | <0.00005 | 0.0009 | 0.0009 | | 0.002 | <0.001 | | 0.014 | | | |
| W7 | 8/25/2006 | | | | | | | | | | | 0.027 | | | |
| W7 | 8/25/2006 | | | <0.0010 | <0.0001 | 0.001 | 0.0009 | | 0.004 | <0.002 | | | | | |
| W7 | 8/30/2006 | | | 0.003 | <0.00005 | 0.0011 | 0.0008 | | 0.003 | <0.001 | | 0.012 | | | |
| W7 | 9/6/2006 | | | 0.0026 | <0.00005 | 0.0011 | 0.0009 | | 0.001 | <0.001 | | 0.011 | 0.011 | 0.011 | |
| W7 | 9/13/2006 | | | 0.0014 | <0.00005 | 0.0006 | 0.0005 | | <0.001 | <0.001 | | 0.011 | | | |
| W7 | 9/20/2006 | | | 0.0037 | <0.00005 | 0.0011 | 0.0009 | | 0.005 | <0.001 | | 0.008 | | | |
| W7 | 9/28/2006 | | | 0.002 | <0.0001 | 0.001 | 0.0009 | | 0.008 | <0.002 | | 0.011 | | | |
| W7 | 10/4/2006 | | | 0.0042 | <0.0001 | 0.001 | 0.001 | | <0.002 | <0.002 | | 0.079 | | | |
| W7 | 10/12/2006 | | | 0.0124 | <0.00005 | 0.0011 | 0.0014 | | 0.006 | <0.001 | | 0.024 | | | |
| W7 | 6/5/2007 | | | 0.0776 | <0.00005 | 0.0014 | 0.0054 | | 0.009 | 0.001 | | <0.05 | | | <0.1 |
| W7 | 6/5/2007 | | | 0.0898 | <0.0001 | 0.001 | 0.0059 | | 0.01 | <0.002 | | <0.05 | | | 0.28 |
| W7 | 6/5/2007 | | | 0.0915 | <0.00005 | 0.0015 | 0.006 | | 0.012 | 0.001 | | <0.05 | | | <0.1 |
| W7 | 6/20/2007 | | | 0.0055 | <0.00005 | 0.0014 | 0.0016 | | 0.004 | <0.001 | | <0.05 | | | 0.18 |
| W7 | 7/18/2007 | | | 0.0096 | <0.00005 | 0.0012 | 0.0014 | | 0.005 | <0.001 | | <0.05 | | | 0.22 |
| W7 | 7/18/2007 | | | 0.0103 | <0.00005 | 0.0013 | 0.0014 | | 0.006 | <0.001 | | <0.05 | | | 0.2 |
| W7 | 7/18/2007 | | | 0.0096 | <0.00005 | 0.0012 | 0.0013 | | 0.003 | <0.001 | | <0.05 | | | 0.2 |
| W7 | 8/24/2007 | | | | | | | | | | | <0.05 | | | |
| W7 | 8/24/2007 | | | | | | | | | | | <0.05 | | | |
| W7 | 8/24/2007 | | | | | | | | | | | <0.05 | | | |
| W7 | 8/24/2007 | | | <0.0005 | <0.00005 | 0.0012 | 0.0013 | | 0.01 | <0.001 | | | | | 0.14 |
| W7 | 8/24/2007 | | | <0.0005 | <0.00005 | 0.0012 | 0.0011 | | 0.009 | <0.001 | | | | | 0.14 |
| W7 | 8/24/2007 | | | <0.0005 | <0.00005 | 0.0013 | 0.0012 | | 0.006 | <0.001 | | | | | 0.16 |
| W7 | 9/18/2007 | | | 0.016 | <0.00005 | 0.0008 | 0.002 | | 0.008 | <0.001 | | <0.05 | | | 0.06 |
| W7 | 10/30/2007 | | | 0.0066 | <0.00005 | 0.0009 | 0.0011 | | 0.013 | <0.001 | | <0.05 | | | 0.2 |
| W7 | 10/30/2007 | | | 0.0043 | <0.00005 | 0.0009 | 0.0008 | | 0.011 | <0.001 | | <0.05 | | | 0.24 |
| W7 | 10/30/2007 | | | 0.0041 | <0.00005 | 0.0009 | 0.0008 | | 0.01 | <0.001 | | <0.05 | | | 0.19 |
| W7 | 10/30/2007 | | | | | | | | | | | | | | |
| W7 | 4/22/2008 | <0.0001 | <0.0001 | 0.0004 | <0.00001 | 0.0021 | 0.00032 | | 0.004 | <0.0001 | | <0.05 | | | <0.01 |
| W7 | 4/22/2008 | 0.0001 | 0.0002 | 0.0017 | 0.00002 | 0.0021 | 0.0003 | | 0.005 | 0.0001 | | <0.05 | | | <0.01 |
| W7 | 4/22/2008 | <0.0001 | 0.0002 | 0.0003 | 0.00001 | 0.0023 | 0.0003 | | 0.007 | 0.0002 | | <0.05 | | | <0.01 |
| W7 | 4/22/2008 | | | | | | | | | | | | | | |
| W7 | 6/3/2008 | <0.0001 | <0.0001 | 0.0128 | <0.00001 | 0.0011 | 0.00207 | | 0.004 | 0.0004 | | <0.05 | | | 0.03 |
| W7 | 6/3/2008 | <0.0001 | <0.0001 | 0.0122 | <0.00001 | 0.0011 | 0.002 | | 0.005 | 0.0005 | | <0.05 | | | 0.04 |
| W7 | 6/3/2008 | <0.0001 | <0.0001 | 0.0134 | <0.00001 | 0.0011 | 0.00224 | | 0.007 | 0.0005 | | <0.05 | | | 0.04 |
| W7 | 6/3/2008 | | | | | | | | | | | | | | |
| W7 | 6/17/2008 | <0.0001 | <0.0001 | 0.0081 | <0.00001 | 0.0014 | 0.0014 | | 0.007 | 0.0004 | | <0.05 | | | 0.14 |
| W7 | 8/6/2008 | | | 0.0357 | <0.00005 | 0.0012 | 0.0031 | | 0.01 | <0.001 | | <0.05 | | | 0.16 |
| W7 | 8/6/2008 | | | 0.0618 | <0.00005 | 0.0011 | 0.004 | | 0.011 | <0.001 | | <0.05 | | | 0.16 |
| W7 | 8/6/2008 | | | 0.0628 | <0.00005 | 0.0012 | 0.0042 | | 0.01 | <0.001 | | | | | |
| W7 | 8/6/2008 | | | | | | | | | | | <0.05 | | | 0.14 |
| W7 | 9/18/2008 | <0.0001 | <0.0001 | 0.0194 | <0.00001 | 0.0004 | 0.00224 | | 0.009 | 0.0006 | | <0.05 | | | 0.04 |
| W7 | 10/28/2008 | <0.0001 | <0.0001 | 0.0045 | <0.00001 | 0.0007 | 0.00086 | | 0.008 | 0.0003 | | <0.05 | | | 0.13 |
| W7 | 10/28/2008 | <0.0001 | <0.0001 | 0.0026 | <0.00001 | 0.0007 | 0.00073 | | 0.121 | 0.0003 | | <0.05 | | | 0.12 |
| W7 | 10/28/2008 | <0.0001 | <0.0001 | 0.002 | <0.00001 | 0.0007 | 0.00072 | | 0.049 | 0.0003 | | <0.05 | | | 0.13 |
| W7 | 10/28/2008 | | | | | | | | | | | | | | |
| W7 | 4/30/2009 | <0.0001 | <0.0001 | 0.0046 | <0.00001 | <0.0004 | 0.00037 | | 0.008 | 0.0002 | | | <0.05 | <0.05 | <0.01 |
| W7 | 6/8/2009 | <0.0001 | <0.0001 | 0.0256 | <0.00001 | 0.001 | 0.00265 | | 0.002 | 0.0005 | | | <0.05 | <0.05 | 0.15 |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | <0.0001 | <0.0004 | 0.0034 | <0.00001 | 0.0014 | 0.0009 | | 0.003 | 0.0002 | | | <0.05 | <0.05 | 0.18 |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | | | |
| W7 | 8/31/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | <0.01 | <0.01 | |
| W7 | 10/7/2009 | <0.0001 | <0.0004 | 0.0068 | <0.00001 | 0.0009 | 0.001 | | 0.008 | 0.0002 | | | <0.05 | <0.05 | 0.12 |
| W7 | 10/25/2009 | | | <0.005 | <0.00005 | 0.0013 | <0.005 | | <0.005 | <0.0005 | | 0.01 | | | 0.15 |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | <0.0001 | <0.0004 | | <0.00001 | 0.0005 | 0.0005 | | 0.008 | 0.0002 | | | 0.16 | 0.16 | 0.01 |
| W7 | 4/27/2010 | | | <0.005 | <0.00005 | 0.0001 | <0.005 | | <0.005 | <0.0005 | | 0.015 | | | <0.02 |
| W7 | 4/29/2010 | | | <0.005 | <0.00005 | 0.0001 | <0.005 | | <0.005 | <0.0005 | | 0.016 | | | <0.04 |
| W7 | 5/1/2010 | | | 0.015 | <0.00005 | 0.0002 | <0.005 | <0.001 | <0.005 | <0.0005 | | 0.031 | | | 0.08 |
| W7 | 5/3/2010 | | | 0.014 | <0.00005 | 0.0002 | <0.005 | | <0.005 | <0.0005 | | 0.016 | | | <0.02 |
| W7 | 5/5/2010 | | | 0.016 | <0.00005 | 0.0002 | <0.005 | <0.001 | 0.007 | <0.0005 | | <0.01 | | | <0.02 |
| W7 | 5/7/2010 | | | 0.016 | <0.00005 | 0.0003 | <0.005 | <0.001 | <0.005 | <0.0005 | | 0.051 | | | 0.11 |
| W7 | 5/9/2010 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | <0.001 | <0.005 | <0.0005 | | <0.005 | | | 0.07 |
| W7 | 5/10/2010 | | | <0.005 | <0.00005 | 0.0007 | <0.005 | <0.001 | 0.005 | <0.0005 | | 0.015 | | | 0.14 |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | | | <0.005 | <0.00005 | 0.0006 | <0.005 | <0.001 | 0.007 | <0.0005 | | <0.05 | | | 0.03 |
| W7 | 5/14/2010 | | | 0.008 | <0.00005 | 0.0005 | <0.005 | | <0.005 | <0.0005 | | 0.034 | | | <0.02 |
| W7 | 5/16/2010 | | | 0.008 | <0.00005 | 0.0007 | <0.005 | <0.001 | <0.005 | <0.0005 | | 0.068 | | | 0.03 |
| W7 | 5/17/2010 | | | 0.01 | <0.00005 | 0.0007 | <0.005 | <0.001 | <0.005 | <0.0005 | | 0.037 | | | <0.02 |
| W7 | 5/19/2010 | | | 0.007 | <0.00005 | 0.0008 | <0.005 | <0.001 | <0.005 | <0.0005 | | 0.02 | | | 0.06 |
| W7 | 5/21/2010 | | | 0.016 | <0.00005 | 0.0009 | <0.005 | | <0.01 | <0.002 | | 0.017 | | | 0.05 |
| W7 | 5/23/2010 | | | 0.086 | <0.00005 | 0.0012 | 0.007 | | 0.012 | <0.002 | | 0.013 | | | 0.07 |
| W7 | 5/25/2010 | | | 0.143 | 0.00005 | 0.0011 | 0.01 | | 0.017 | <0.002 | | 0.07 | | | 0.1 |
| W7 | 5/27/2010 | | | 0.285 | 0.00017 | 0.0016 | 0.024 | | 0.049 | <0.002 | | 0.052 | | | 0.13 |
| W7 | 5/29/2010 | | | 0.117 | 0.00006 | 0.0017 | 0.012 | | 0.021 | <0.002 | | 0.1 | | | 0.23 |
| W7 | 5/31/2010 | | | 0.14 | 0.00007 | 0.002 | 0.013 | | 0.023 | <0.002 | | <0.05 | | | 0.14 |
| W7 | 6/2/2010 | | | 0.105 | <0.00005 | 0.0018 | 0.01 | | 0.011 | <0.002 | | <0.01 | | | 0.17 |
| W7 | 6/4/2010 | | | 0.057 | <0.00005 | 0.0015 | 0.005 | | <0.01 | <0.002 | | 0.34 | | | 0.18 |
| W7 | 6/6/2010 | | | 0.082 | <0.00005 | 0.0018 | 0.006 | | 0.011 | <0.002 | | 0.1 | | | 0.18 |
| W7 | 6/14/2010 | | | 0.051 | <0.00005 | 0.0018 | <0.005 | | <0.01 | <0.002 | | 0.016 | | | 0.16 |
| W7 | 6/16/2010 | | | 0.016 | <0.00005 | 0.0016 | <0.005 | | <0.01 | <0.002 | | 0.016 | | | 0.17 |
| W7 | 6/18/2010 | | | 0.02 | <0.00005 | 0.0015 | <0.005 | | <0.01 | <0.002 | | | 0.052 | | 0.15 |
| W7 | 6/20/2010 | | | 0.043 | <0.00005 | 0.0014 | <0.005 | | <0.01 | <0.002 | | | | | 0.13 |
| W7 | 6/22/2010 | | | 0.174 | 0.00007 | 0.0012 | 0.017 | | 0.027 | <0.002 | | 0.014 | | | 0.12 |
| W7 | 6/24/2010 | | | 0.049 | <0.00005 | 0.0009 | 0.005 | | <0.01 | <0.002 | | 0.012 | | | 0.08 |
| W7 | 6/26/2010 | | | 0.019 | <0.00005 | 0.0009 | <0.005 | | <0.01 | <0.002 | | 0.009 | | | 0.1 |
| W7 | 6/28/2010 | | | 0.01 | <0.00005 | 0.001 | <0.005 | | <0.01 | <0.002 | | 0.022 | | | 0.13 |
| W7 | 7/5/2010 | | | 0.061 | <0.00005 | 0.0007 | <0.005 | | <0.01 | <0.002 | | 0.027 | | | 0.07 |
| W7 | 8/5/2010 | | | <0.01 | <0.00005 | 0.0008 | <0.005 | | <0.01 | <0.002 | | | | | |
| W7 | 9/12/2010 | | | 0.014 | <0.00005 | 0.0005 | <0.005 | | <0.01 | <0.002 | | | | | |
| W7 | 9/12/2010 | | | 0.012 | <0.00005 | 0.0005 | <0.005 | | <0.01 | <0.002 | | 0.039 | | | 0.03 |
| W7 | 10/8/2010 | | | <0.005 | <0.00005 | 0.0008 | <0.005 | | <0.005 | <0.0005 | | 0.069 | | | 0.07 |
| W7 | 4/27/2011 | | | <0.005 | <0.00005 | 0.0002 | <0.005 | | <0.005 | <0.0005 | | 0.01 | | | <0.02 |
| W7 | 5/2/2011 | | | 0.009 | <0.00005 | 0.0001 | <0.005 | | 0.019 | <0.0005 | | | | | <0.02 |
| W7 | 6/1/2011 | | | 0.022 | <0.00005 | 0.0007 | <0.005 | | <0.005 | <0.0005 | | 0.012 | | | |
| W7 | 6/16/2011 | | | 0.114 | <0.00005 | 0.0007 | 0.008 | | 0.013 | 0.0007 | | 0.013 | | | 0.1 |
| W7 | 7/1/2011 | | | 0.126 | <0.00005 | 0.0009 | 0.015 | | 0.016 | 0.0012 | | 0.016 | | | 0.05 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Total Te (mg/L) | Total Th (mg/L) | Total Ti (mg/L) | Total Tl (mg/L) | Total U (mg/L) | Total V (mg/L) | Total W (mg/L) | Total Zn (mg/L) | Total Zr (mg/L) | Total N (mg/L) | Ammonia (mg/L) | Ammonium (mg/L) | Ammonium (mg/L) | NO2+NO3 (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | | | 0.354 | 0.00008 | 0.0009 | 0.031 | | 0.029 | 0.002 | | | | | 0.06 |
| W7 | 8/16/2011 | | | 0.016 | <0.00005 | 0.0005 | <0.005 | | 0.017 | 0.0005 | | 0.015 | | | 0.06 |
| W7 | 8/19/2011 | | | 0.02 | <0.00005 | 0.0004 | <0.005 | | <0.005 | <0.0005 | | 0.006 | | | 0.04 |
| W7 | 9/12/2011 | | | <0.005 | <0.00005 | 0.0005 | <0.005 | | <0.005 | <0.0005 | | 0.025 | | | 0.05 |
| W7 | 10/6/2011 | | | <0.005 | <0.00005 | 0.0006 | <0.005 | | <0.005 | <0.0005 | | 0.019 | | | 0.11 |
| W7 | 11/22/2011 | | | 0.02 | <0.00005 | 0.001 | <0.005 | | 0.009 | <0.0005 | | 0.0214 | | | 0.136 |
| W7 | 1/24/2012 | | | <0.005 | <0.00005 | 0.0019 | <0.005 | | <0.005 | <0.0005 | | 0.005 | | | 0.324 |
| W7 | 2/25/2012 | | | <0.005 | <0.00005 | 0.0015 | <0.005 | | <0.005 | <0.0005 | | 0.006 | | | 0.289 |
| W7 | 3/5/2012 | | | <0.005 | <0.00005 | 0.0015 | <0.005 | | <0.005 | <0.0005 | | 0.0067 | | | 0.195 |
| W7 | 4/24/2012 | | | 0.0264 | <0.000050 | 0.00018 | <0.0050 | | <0.0050 | <0.00050 | | <0.0050 | | | 0.02 |
| W7 | 5/6/2012 | | | 0.0055 | <0.000050 | <0.00010 | <0.0050 | | <0.0050 | <0.00050 | | 0.01 | | | <0.020 |
| W7 | 5/6/2012 | | | 0.0062 | <0.000050 | <0.00010 | <0.0050 | | <0.0050 | <0.00050 | | 0.011 | | | <0.020 |
| W7 | 6/19/2012 | | | 0.182 | 0.00005 | 0.00072 | 0.0164 | | 0.015 | 0.00125 | | 0.18 | | | 0.098 |
| W7 | 7/17/2012 | | | 0.0379 | <0.000050 | 0.00076 | <0.0050 | | <0.0050 | <0.00050 | | 0.065 | | | 0.089 |
| W7 | 7/30/2012 | | | 0.0092 | <0.000050 | 0.00088 | <0.0050 | | 0.0063 | <0.00050 | | 0.13 | | | 0.124 |
| W7 | 8/8/2012 | | | <0.0050 | <0.000050 | 0.00087 | <0.0050 | | <0.0050 | <0.00050 | | 0.014 | | | 0.13 |
| W7 | 8/23/2012 | | | <0.0050 | <0.000050 | 0.00097 | <0.0050 | | <0.0050 | <0.00050 | | 0.049 | | | 0.21 |
| W7 | 9/13/2012 | | | <0.0050 | <0.000050 | 0.00054 | <0.0050 | | 0.0055 | <0.00050 | | 0.0087 | | | 0.078 |
| W7 | 10/16/2012 | | | 0.0061 | <0.000050 | 0.00084 | <0.0050 | | <0.0050 | <0.00050 | | 0.028 | | | 0.125 |
| W7 | 11/2/2012 | | | <0.0050 | <0.000050 | 0.00137 | <0.0050 | | 0.0062 | <0.00050 | | 0.026 | | | 0.219 |
| W7 | 12/29/2012 | | | <0.0050 | <0.000050 | 0.00121 | <0.0050 | | <0.0050 | <0.00050 | | 0.025 | | | 0.063 |
| W7 | 4/30/2013 | | | <0.0050 | <0.000050 | 0.00209 | <0.0050 | | <0.0050 | <0.00050 | | 0.0082 | | | 0.132 |
| W7 | 5/14/2013 | | | 0.0551 | <0.000050 | 0.00016 | <0.0050 | | 0.0059 | <0.00050 | | 0.066 | | | <0.020 |
| W7 | 6/19/2013 | | | 0.0122 | <0.000050 | 0.001 | <0.0050 | | <0.0050 | <0.00050 | | 0.052 | | | 0.143 |
| W7 | 6/19/2013 | | | 0.0094 | <0.000050 | 0.00097 | <0.0050 | | <0.0050 | <0.00050 | | 0.04 | | | 0.141 |
| W7 | 7/13/2013 | | | 0.0073 | <0.000050 | 0.001 | <0.0050 | | <0.0050 | <0.00050 | | 0.023 | | | 0.17 |
| W7 | 8/21/2013 | | | 0.0086 | <0.000050 | 0.00114 | <0.0050 | | <0.0050 | <0.00050 | | 0.051 | | | 0.157 |
| W7 | 9/6/2013 | | | 0.0127 | <0.000050 | 0.00095 | <0.0050 | | <0.0050 | <0.00050 | | 0.017 | | | 0.128 |
| W7 | 10/21/2013 | | | <0.0050 | <0.000050 | 0.00083 | <0.0050 | | <0.0050 | <0.00050 | | 0.048 | | | 0.168 |
| W7 | 11/16/2013 | | | <0.0050 | <0.000050 | 0.00148 | <0.0050 | | <0.0050 | <0.00050 | | 0.027 | | | 0.257 |
| W7 | 12/7/2013 | | | <0.0050 | <0.000050 | 0.00139 | <0.0050 | | <0.0050 | <0.00050 | | 0.025 | | | 0.206 |
| C4 | 5/6/2012 | | | 1.21 | 0.000244 | 0.00209 | 0.0946 | | 0.0961 | 0.00346 | | 0.088 | | | 0.029 |
| C4 | 8/1/2012 | | | 0.248 | 0.000063 | 0.00116 | 0.0276 | | 0.0272 | 0.0016 | | 0.089 | | | 0.091 |
| C4 | 8/8/2012 | | | 0.254 | 0.000066 | 0.00144 | 0.0292 | | 0.0279 | 0.00138 | | 0.09 | | | 0.107 |
| C4 | 8/25/2012 | | | 0.08 | <0.000050 | 0.00159 | 0.0377 | | 0.0325 | 0.00202 | | 0.005 | | | <0.020 |
| C4 | 6/22/2013 | | | 0.8 | <0.000050 | 0.00305 | 0.0731 | | 0.0872 | 0.00409 | | 0.36 | | | 0.377 |
| C4 | 7/19/2013 | | | 0.466 | 0.000122 | 0.00277 | 0.0477 | | 0.0502 | 0.00309 | | 0.26 | | | 0.089 |
| C4 | 8/22/2013 | | | 0.497 | 0.000103 | 0.00228 | 0.055 | | 0.0597 | 0.003 | | 0.2 | | | 0.095 |
| C4 | 9/6/2013 | | | 0.237 | 0.000053 | 0.00119 | 0.0188 | | 0.0172 | 0.00149 | | 0.12 | | | 0.07 |
| C4 | 10/18/2013 | | | 0.0165 | <0.000050 | 0.00083 | <0.0050 | | <0.0050 | <0.00050 | | 0.091 | | | 0.069 |
| C4 | 10/18/2013 | | | 0.017 | <0.000050 | 0.00079 | <0.0050 | | <0.0050 | <0.00050 | | 0.08 | | | 0.065 |
| C4 | 11/17/2013 | | | 0.006 | <0.000050 | 0.00063 | <0.0050 | | <0.0050 | 0.001 | | 0.28 | | | <0.20 |
| C10 | 5/12/2012 | | | 1.17 | 0.000369 | 0.00532 | 0.142 | | 0.186 | 0.00514 | | 0.18 | | | 0.058 |
| C10 | 7/30/2012 | | | 0.571 | 0.000202 | 0.00449 | 0.0653 | | 0.0956 | 0.0033 | | 0.2 | | | 0.207 |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | | | 0.554 | 0.000202 | 0.00407 | 0.0718 | | 0.105 | 0.00332 | | 0.12 | | | 0.196 |
| C10 | 8/27/2012 | | | 0.805 | 0.000241 | 0.00375 | 0.0836 | | 0.119 | 0.00453 | | <0.0050 | | | 0.103 |
| C10 | 6/22/2013 | | | 0.0562 | <0.000050 | 0.00114 | 0.0053 | | 0.0055 | 0.00094 | | 0.19 | | | 0.172 |
| C10 | 7/23/2013 | | | 0.179 | 0.000067 | 0.00113 | 0.0156 | | 0.0198 | 0.0017 | | 0.14 | | | <0.20 |
| C10 | 8/22/2013 | | | 0.0342 | <0.000050 | 0.00119 | <0.0050 | | <0.0050 | 0.00065 | | 0.056 | | | 0.143 |
| C10 | 9/8/2013 | | | 0.017 | <0.000050 | 0.00099 | <0.0050 | | <0.0050 | <0.00050 | | 0.046 | | | 0.183 |
| C10 | 9/8/2013 | | | 0.0166 | <0.000050 | 0.00099 | <0.0050 | | <0.0050 | <0.00050 | | 0.055 | | | 0.199 |
| C10 | 10/18/2013 | | | 0.0427 | <0.000050 | 0.00091 | <0.0050 | | 0.0054 | 0.00051 | | 0.1 | | | 0.167 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | N-NO2 (mg/L) | N-NO3 (mg/L) | N-TKN (mg/L) | P-PO4-T (mg/L) | P-TDP (mg/L) | P-TRP (Ortho) (mg/L) | C-TIC (mg/L) | C-TOC (mg/L) | C-DOC (mg/L) | Cation Sum (meq/L) | Anion Sum (meq/L) | Hardness (CaCO3) (mg/L) | Acidity (pH 4.5) (mg/L) | Acidity pH 8.3 (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | 0.002 | 0.0539 | | | | | | | | | | | | |
| W1 | 6/30/2005 | <0.0010 | 0.0626 | | | | | | | | | | | | |
| W1 | 7/28/2005 | <0.0010 | 0.0584 | | | | | | | | | | | | |
| W1 | 8/29/2005 | <0.0010 | 0.0217 | | | | | | | | | | | | |
| W1 | 9/28/2005 | <0.0010 | 0.0482 | | | | | | | | | | | | |
| W1 | 10/15/2005 | <0.0010 | 0.132 | | | | | | | | | | | | |
| W2 | 5/27/2005 | 0.0015 | 0.0565 | | | | | | | | | | | | |
| W2 | 5/27/2005 | <0.001 | 0.0339 | | | | | | | | | | | | |
| W2 | 6/30/2005 | <0.0010 | 0.0621 | | | | | | | | | | | | |
| W2 | 7/28/2005 | <0.0010 | 0.0124 | | | | | | | | | | | | |
| W2 | 8/30/2005 | <0.0010 | 0.0141 | | | | | | | | | | | | |
| W2 | 9/28/2005 | 0.001 | 0.0458 | | | | | | | | | | | | |
| W2 | 10/15/2005 | <0.0010 | 0.133 | | | | | | | | | | | | |
| W3 | 5/27/2005 | <0.0010 | 0.0121 | | | | | | | | | | | | |
| W3 | 6/30/2005 | <0.0010 | 0.0519 | | | | | | | | | | | | |
| W3 | 7/29/2005 | <0.0010 | 0.0284 | | | | | | | | | | | | |
| W3 | 8/29/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W3 | 9/28/2005 | <0.0010 | 0.0132 | | | | | | | | | | | | |
| W3 | 10/15/2005 | <0.0010 | 0.0393 | | | | | | | | | | | | |
| W8 | 5/27/2005 | <0.0010 | 0.0225 | | | | | | | | | | | | |
| W8 | 6/30/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W8 | 7/29/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W8 | 8/30/2005 | 0.0011 | <0.0050 | | | | | | | | | | | | |
| W8 | 9/28/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W8 | 10/15/2005 | <0.0010 | 0.0374 | | | | | | | | | | | | |
| W9 | 5/27/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W9 | 6/30/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W9 | 7/29/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W9 | 8/29/2005 | 0.0016 | <0.0050 | | | | | | | | | | | | |
| W9 | 9/28/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W9 | 10/15/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W10 | 5/27/2005 | <0.0010 | 0.0094 | | | | | | | | | | | | |
| W10 | 5/27/2005 | <0.001 | | | | | | | | | | | | | |
| W10 | 6/30/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W10 | 7/29/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W10 | 8/29/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W10 | 9/28/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W10 | 10/15/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W6 | 5/27/2005 | 0.0016 | 0.0316 | | | | | | | | | | | | |
| W6 | 6/30/2005 | <0.0010 | 0.0086 | | | | | | | | | | | | |
| W6 | 7/29/2005 | <0.0010 | 0.0223 | | | | | | | | | | | | |
| W6 | 8/30/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W6 | 9/28/2005 | <0.0010 | <0.0050 | | | | | | | | | | | | |
| W6 | 10/15/2005 | <0.0010 | 0.0061 | | | | | | | | | | | | |
| W6 | 6/2/2006 | <0.001 | 0.0241 | | | | | | | | | | | | |
| W6 | 8/25/2006 | | <0.03 | | | | | | | | | | | | |
| W6 | 9/6/2006 | | <0.03 | | | | | | | | | | | | |
| W6 | 6/20/2007 | <0.05 | 0.1 | 0.6 | 0.14 | <0.02 | | | | | | | | | |
| W6 | 9/18/2007 | <0.02 | <0.02 | 0.3 | 0.04 | <0.02 | | | | | | | | | |
| W6 | 6/17/2008 | 0.07 | 0.01 | 0.44 | 0.07 | | | | | | | | | | |
| W6 | 9/18/2008 | <0.01 | <0.01 | 0.47 | <0.05 | | 0.1 | | 17.3 | 17.7 | | | | | |
| W6 | 4/14/2009 | | | 5.73 | 0.06 | | | | | | | | | | |
| W6 | 4/30/2009 | | | 1.22 | 0.05 | | | | | | | | | | |
| W6 | 7/28/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | | 2.92 | 0.5 | 0.02 | | <0.05 | | | | | | | | |
| W6 | 8/18/2009 | | | | | | | | | | | | | | |
| W6 | 8/25/2009 | | | | | | | | 9.2 | 7.9 | | | | | |
| W6 | 10/7/2009 | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | | 8.09 | 0.54 | 0.05 | | | | 6.4 | 6.3 | | | | | |
| W6 | 10/25/2009 | 0.061 | 7.8 | | | | <0.005 | | | | | | | | |
| W6 | 4/19/2010 | | | 0.53 | 0.05 | | | | | | | | | | |
| W6 | 5/16/2010 | <0.005 | <0.02 | | | | <0.005 | | | 5.3 | | | | | |
| W6 | 5/17/2010 | <0.005 | <0.02 | | | | <0.005 | | | 2.9 | | | | | |
| W6 | 5/19/2010 | <0.005 | <0.02 | | | | <0.005 | | | 3.4 | | | | | |
| W6 | 5/21/2010 | <0.005 | <0.02 | | | | <0.005 | | | 1.6 | | | | | |
| W6 | 5/23/2010 | <0.005 | <0.02 | | | | <0.005 | | | 5.2 | | | | | |
| W6 | 5/25/2010 | <0.005 | <0.02 | | | | <0.005 | | | 5.7 | | | | | |
| W6 | 5/29/2010 | <0.005 | <0.02 | | | | <0.005 | | | 1.4 | | | | | |
| W6 | 6/2/2010 | <0.005 | 0.97 | | | | <0.005 | | | 3.7 | | | | | |
| W6 | 6/4/2010 | <0.005 | <0.02 | | | | <0.005 | | | 6.7 | | | | | |
| W6 | 6/6/2010 | <0.005 | <0.02 | | | | <0.005 | | | | | | | | |
| W6 | 6/14/2010 | <0.005 | <0.02 | | | | <0.005 | | | 7.2 | | | | | |
| W6 | 6/16/2010 | <0.005 | 0.03 | | | | <0.005 | | | 7.9 | | | | | |
| W6 | 6/18/2010 | <0.005 | <0.02 | | | | <0.005 | | | 7.7 | | | | | |
| W6 | 6/20/2010 | <0.005 | 0.02 | | | | <0.005 | | | 7.8 | | | | | |
| W6 | 6/22/2010 | <0.005 | <0.02 | | | | <0.005 | | 8.6 | 7.8 | | | | | |
| W6 | 6/24/2010 | <0.005 | <0.02 | | | | <0.005 | | 8.2 | 7.9 | | | | | |
| W6 | 6/26/2010 | <0.005 | <0.02 | | | | <0.005 | | 7.8 | 7.7 | | | | | |
| W6 | 6/26/2010 | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | <0.005 | <0.02 | | | | <0.005 | | | 7.8 | | | | | |
| W6 | 7/5/2010 | <0.005 | <0.02 | | | | <0.005 | | | 15 | | | | | |
| W6 | 8/5/2010 | <0.005 | <0.02 | | | | <0.005 | | | 13 | | | | | |
| W6 | 9/9/2010 | <0.005 | <0.02 | | | | <0.005 | | | 12.9 | | | | | |
| W6 | 10/8/2010 | <0.005 | <0.02 | | | | <0.005 | | | 13.2 | | | | | |
| W6 | 8/19/2011 | <0.005 | 1.05 | | | | | | | 8.4 | | | | | |
| W6 | 7/17/2012 | <0.0050 | 0.026 | | 1.01 | | | | | 7.98 | | | | | |
| W6 | 7/30/2012 | 0.0072 | 0.052 | | 0.599 | | | | | 8.08 | | | | | |
| W6 | 8/9/2012 | 0.0066 | 0.022 | | | | | | | | | | | | |
| W6 | 8/25/2012 | <0.0050 | 0.045 | | | | | | | 7.68 | | | | | |
| W6 | 9/13/2012 | <0.0050 | 0.034 | | | | | | 13.1 | 14.4 | | | | | |
| W6 | 10/13/2012 | <0.0050 | 0.042 | | | | | | | 9.91 | | | | | |
| W6 | 11/12/2012 | <0.0050 | <0.020 | | | | | | | 8.74 | | | | | |
| W6 | 5/14/2013 | <0.0050 | <0.020 | | | | | | | 22.2 | | | | | |
| W6 | 6/22/2013 | 0.0132 | 0.028 | | | | | | | 7.79 | | | | | |
| W6 | 7/12/2013 | <0.0050 | <0.020 | | | | | | | 8.29 | | | | | |
| W6 | 8/22/2013 | <0.0050 | <0.020 | | | | | | | 7.4 | | | | | |
| W6 | 9/6/2013 | <0.0050 | 0.03 | | | | | | | 6.36 | | | | | |
| W6 | 10/7/2013 | <0.0050 | 0.042 | | | | | | | 8.17 | | | | | |
| W6 | 11/16/2013 | <0.0050 | <0.020 | | | | | | | 8.79 | | | | | |
| W6 | 12/7/2013 | <0.0050 | <0.020 | | | | | | | 8.77 | | | | | |
| W7 | 5/27/2005 | 0.0018 | 0.0824 | | | | | | | | | | | | |
| W7 | 6/30/2005 | 0.0017 | 0.172 | | | | | | | | | | | | |
| W7 | 7/29/2005 | <0.0010 | 0.169 | | | | | | | | | | | | |
| W7 | 8/30/2005 | <0.0010 | 0.0226 | | | | | | | | | | | | |
| W7 | 9/28/2005 | <0.0010 | 0.0586 | | | | | | | | | | | | |
| W7 | 10/15/2005 | <0.0010 | 0.102 | | | | | | | | | | | | |
| W7 | 6/2/2006 | 0.0015 | 0.0449 | | | | | | | | | | | | |
| W7 | 6/8/2006 | | | | | | | | | | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | N-NO2 (mg/L) | N-NO3 (mg/L) | N-TKN (mg/L) | P-PO4-T (mg/L) | P-TDP (mg/L) | P-TRP (Ortho) (mg/L) | C-TIC (mg/L) | C-TOC (mg/L) | C-DOC (mg/L) | Cation Sum (meq/L) | Anion Sum (meq/L) | Hardness (CaCO3) (mg/L) | Acidity (pH 4.5) (mg/L) | Acidity pH 8.3 (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | | 0.18 | | | | | | | | | | | | |
| W7 | 6/23/2006 | | 0.23 | | | | | | | | | | | | |
| W7 | 6/28/2006 | | 0.112 | | | | | | | | | | | | |
| W7 | 7/7/2006 | | 0.205 | | | | | | | | | | | | |
| W7 | 7/12/2006 | | 0.18 | | | | | | | | | | | | |
| W7 | 7/20/2006 | | 0.19 | | | | | | | | | | | | |
| W7 | 7/26/2006 | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | | 0.18 | | | | | | | | | | | | |
| W7 | 8/2/2006 | | 0.15 | | | | | | | | | | | | |
| W7 | 8/10/2006 | | 0.16 | | | | | | | | | | | | |
| W7 | 8/25/2006 | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | | 0.12 | | | | | | | | | | | | |
| W7 | 8/30/2006 | | 0.11 | | | | | | | | | | | | |
| W7 | 9/6/2006 | | 0.08 | | | | | | | | | | | | |
| W7 | 9/13/2006 | | 0.094 | | | | | | | | | | | | |
| W7 | 9/20/2006 | | 0.11 | | | | | | | | | | | | |
| W7 | 9/28/2006 | | 0.08 | | | | | | | | | | | | |
| W7 | 10/4/2006 | | 0.1 | | | | | | | | | | | | |
| W7 | 10/12/2006 | | 0.12 | | | | | | | | | | | | |
| W7 | 6/5/2007 | <0.05 | <0.1 | 0.5 | 0.15 | <0.02 | | | | | | | | | |
| W7 | 6/5/2007 | 0.05 | <0.1 | 0.11 | 0.12 | <0.02 | | | | | | | | | |
| W7 | 6/5/2007 | <0.05 | <0.1 | 0.4 | 0.13 | <0.02 | | | | | | | | | |
| W7 | 6/20/2007 | <0.05 | 0.3 | 0.3 | 0.05 | <0.02 | | | | 8.2 | | | | | |
| W7 | 7/18/2007 | <0.05 | 0.3 | 0.31 | <0.05 | <0.02 | 0.05 | | | 14.3 | | | | | |
| W7 | 7/18/2007 | <0.05 | 0.3 | 0.36 | 0.05 | <0.02 | 0.05 | | | | | | | | |
| W7 | 7/18/2007 | <0.05 | 0.3 | 0.33 | 0.06 | <0.02 | 0.05 | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | <0.05 | 0.2 | 0.3 | 0.04 | <0.02 | | | | | | | | | |
| W7 | 8/24/2007 | <0.05 | 0.2 | 0.26 | 0.04 | <0.02 | | | | | | | | | |
| W7 | 8/24/2007 | <0.05 | 0.2 | 0.24 | 0.04 | <0.02 | | | | | | | | | |
| W7 | 9/18/2007 | <0.02 | 0.05 | 0.38 | 0.07 | <0.02 | | | | 11 | | | | | |
| W7 | 10/30/2007 | 0.14 | <0.02 | 0.51 | <0.02 | <0.02 | <0.01 | | | | | | | | |
| W7 | 10/30/2007 | 0.14 | <0.02 | 0.46 | 0.02 | <0.02 | <0.01 | | | | | | | | |
| W7 | 10/30/2007 | 0.13 | <0.02 | 0.54 | 0.02 | <0.02 | <0.01 | | | | | | | | |
| W7 | 10/30/2007 | 0.13 | <0.02 | | 0.02 | <0.02 | <0.01 | | | | | | | | |
| W7 | 4/22/2008 | 0.07 | <0.02 | 2.02 | <0.05 | | 0.09 | | | | | | | | |
| W7 | 4/22/2008 | 0.04 | <0.02 | 0.34 | <0.05 | | 0.09 | | | | | | | | |
| W7 | 4/22/2008 | 0.07 | <0.02 | 0.24 | <0.05 | | 0.09 | | | | | | | | |
| W7 | 4/22/2008 | 0.04 | <0.02 | | | | | | | | | | | | |
| W7 | 6/3/2008 | 0.04 | 0.03 | 0.38 | <0.05 | | 0.04 | | | | | | | | |
| W7 | 6/3/2008 | 0.04 | 0.04 | 0.45 | <0.05 | | 0.04 | | | | | | | | |
| W7 | 6/3/2008 | 0.04 | 0.04 | 0.4 | <0.05 | | 0.04 | | | | | | | | |
| W7 | 6/3/2008 | | | | | <0.01 | | | | | | | | | |
| W7 | 6/17/2008 | 0.05 | 0.14 | 0.34 | 0.06 | | | | 6.8 | | | | | | |
| W7 | 8/6/2008 | <0.01 | 0.14 | 0.38 | <0.05 | | 0.06 | | | | | | | | |
| W7 | 8/6/2008 | <0.01 | 0.14 | 0.32 | 0.08 | | 0.06 | | | | | | | | |
| W7 | 8/6/2008 | <0.01 | 0.15 | | <0.05 | | | | | | | | | | |
| W7 | 8/6/2008 | | | 0.32 | 0.05 | | 0.06 | | 9.3 | 9 | | | | | |
| W7 | 9/18/2008 | <0.01 | 0.03 | 0.51 | <0.05 | | 0.09 | | 17.6 | 17.4 | | | | | |
| W7 | 10/28/2008 | | | 0.33 | <0.05 | | 0.08 | | | | | | | | |
| W7 | 10/28/2008 | | | 0.37 | <0.05 | | 0.08 | | | | | | | | |
| W7 | 10/28/2008 | | | 0.32 | <0.05 | | 0.08 | | | | | | | | |
| W7 | 10/28/2008 | | | | | | | | 10.7 | 11 | | | | | |
| W7 | 4/30/2009 | | | 0.76 | 0.06 | | | | 17.6 | 17.6 | | | | | |
| W7 | 6/8/2009 | | | 0.49 | 0.03 | | | | 9.4 | 9.2 | | | | | |
| W7 | 7/28/2009 | | | | | | | | | | | | | | |
| W7 | 8/6/2009 | | 0.18 | 0.24 | 0.02 | | <0.05 | | | | | | | | |
| W7 | 8/24/2009 | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | 9.4 | 8.2 | | | | | |
| W7 | 8/31/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | | 0.12 | 0.35 | 0.07 | | | | 8.1 | 6.9 | | | | | |
| W7 | 10/25/2009 | <0.005 | 0.15 | | | | <0.005 | | 7.5 | 8.7 | | | | | |
| W7 | 10/25/2009 | | | | | | | | | | | | | | |
| W7 | 4/19/2010 | | | 0.82 | 0.06 | | | | | | | | | | |
| W7 | 4/27/2010 | <0.005 | <0.02 | | | | 0.008 | | | 22.7 | | | | | |
| W7 | 4/29/2010 | <0.01 | <0.04 | | | | <0.005 | | | 19.3 | | | | | |
| W7 | 5/1/2010 | 0.008 | 0.07 | | | | <0.005 | | | 19 | | | | | |
| W7 | 5/3/2010 | <0.005 | <0.02 | | | | <0.005 | | | 22.2 | | | | | |
| W7 | 5/5/2010 | <0.005 | <0.02 | | | | <0.005 | | | 14.5 | | | | | |
| W7 | 5/7/2010 | 0.007 | 0.1 | | | | <0.005 | | | 12.8 | | | | | |
| W7 | 5/9/2010 | <0.005 | 0.07 | | | | <0.005 | | | 13.2 | | | | | |
| W7 | 5/10/2010 | 0.006 | 0.13 | | | | <0.005 | | | 11.7 | | | | | |
| W7 | 5/12/2010 | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | <0.005 | 0.03 | | | | <0.005 | | | 10.4 | | | | | |
| W7 | 5/14/2010 | <0.005 | <0.02 | | | | <0.005 | | | 9.2 | | | | | |
| W7 | 5/16/2010 | <0.005 | 0.03 | | | | <0.005 | | | 8.8 | | | | | |
| W7 | 5/17/2010 | <0.005 | <0.02 | | | | <0.005 | | | 7.2 | | | | | |
| W7 | 5/19/2010 | <0.005 | 0.06 | | | | <0.005 | | | 7.5 | | | | | |
| W7 | 5/21/2010 | <0.005 | 0.05 | | | | <0.005 | | | 8.7 | | | | | |
| W7 | 5/23/2010 | 0.006 | 0.06 | | | | <0.005 | | | 8.2 | | | | | |
| W7 | 5/25/2010 | 0.025 | 0.08 | | | | <0.005 | | | 8.1 | | | | | |
| W7 | 5/27/2010 | <0.005 | 0.13 | | | | <0.005 | | | 8.1 | | | | | |
| W7 | 5/29/2010 | 0.011 | 0.22 | | | | <0.005 | | | 6.3 | | | | | |
| W7 | 5/31/2010 | 0.023 | 0.12 | | | | <0.005 | | | 7.2 | | | | | |
| W7 | 6/2/2010 | 0.023 | 0.14 | | | | <0.005 | | | 4.9 | | | | | |
| W7 | 6/4/2010 | 0.014 | 0.16 | | | | <0.005 | | | 6.4 | | | | | |
| W7 | 6/6/2010 | 0.013 | 0.16 | | | | <0.005 | | | | | | | | |
| W7 | 6/14/2010 | <0.005 | 0.16 | | | | <0.005 | | | 5.9 | | | | | |
| W7 | 6/16/2010 | <0.005 | 0.17 | | | | <0.005 | | | 6.1 | | | | | |
| W7 | 6/18/2010 | <0.005 | 0.15 | | | | <0.005 | | | 6.2 | | | | | |
| W7 | 6/20/2010 | 0.008 | 0.13 | | | | <0.005 | | | 7.6 | | | | | |
| W7 | 6/22/2010 | <0.005 | 0.12 | | | | <0.005 | | 10.5 | 10.4 | | | | | |
| W7 | 6/24/2010 | 0.007 | 0.07 | | | | <0.005 | | 10.5 | 10.2 | | | | | |
| W7 | 6/26/2010 | <0.005 | 0.1 | | | | <0.005 | | 9.2 | 9.3 | | | | | |
| W7 | 6/28/2010 | <0.005 | 0.13 | | | | <0.005 | | | 8.7 | | | | | |
| W7 | 7/5/2010 | <0.005 | 0.07 | | | | <0.005 | | | 16.1 | | | | | |
| W7 | 8/5/2010 | | | | | | | | | 13.2 | | | | | |
| W7 | 9/12/2010 | | | | | | | | | | | | | | |
| W7 | 9/12/2010 | <0.005 | 0.03 | | | | <0.005 | | 17.4 | 16.7 | | | | | |
| W7 | 10/8/2010 | <0.005 | 0.07 | | | | <0.005 | | | 12.7 | | | | | |
| W7 | 4/27/2011 | <0.005 | <0.02 | | | | | | 22 | 23 | | | | | |
| W7 | 5/2/2011 | <0.005 | <0.02 | | | | | | | 22 | | | | | |
| W7 | 6/1/2011 | | | | | | | | | 10.7 | | | | | |
| W7 | 6/16/2011 | <0.005 | 0.1 | | | | | | | 12.6 | | | | | |
| W7 | 7/1/2011 | 0.007 | 0.05 | | | | | | | 21.1 | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | N-NO2 (mg/L) | N-NO3 (mg/L) | N-TKN (mg/L) | P-PO4-T (mg/L) | P-TDP (mg/L) | P-TRP (Ortho) (mg/L) | C-TIC (mg/L) | C-TOC (mg/L) | C-DOC (mg/L) | Cation Sum (meq/L) | Anion Sum (meq/L) | Hardness (CaCO3) (mg/L) | Acidity (pH 4.5) (mg/L) | Acidity pH 8.3 (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | <0.005 | 0.06 | | | | | | | 24.2 | | | | | |
| W7 | 8/16/2011 | <0.005 | 0.06 | | | | | | | 18.3 | | | | | |
| W7 | 8/19/2011 | <0.005 | 0.04 | | | | | | | 18.8 | | | | | |
| W7 | 9/12/2011 | <0.005 | 0.05 | | | | | | 14 | 13.2 | | | | | |
| W7 | 10/6/2011 | <0.005 | 0.11 | | | | | | 11.5 | 11.7 | | | | | |
| W7 | 11/22/2011 | <0.005 | 0.136 | | | | | | 7.69 | 7.73 | | | | | |
| W7 | 1/24/2012 | <0.005 | 0.324 | | | | | | | 5.33 | | | | | |
| W7 | 2/25/2012 | <0.005 | 0.289 | | | | <0.0050 | | | 6.08 | | | | | |
| W7 | 3/5/2012 | <0.005 | 0.195 | | | | | | | 5.17 | | | | | |
| W7 | 4/24/2012 | 0.0101 | <0.020 | | 0.0566 | | | | 13.3 | 13.6 | | | | | |
| W7 | 5/6/2012 | <0.0050 | <0.020 | | 0.0297 | | | | | 17.4 | | | | | |
| W7 | 5/6/2012 | <0.0050 | <0.020 | | 0.0303 | | | | | 17 | | | | | |
| W7 | 6/19/2012 | 0.0148 | 0.083 | | 0.176 | | | | 19.2 | 16.2 | | | | | |
| W7 | 7/17/2012 | <0.0050 | 0.089 | | 0.078 | | | | | 13.3 | | | | | |
| W7 | 7/30/2012 | <0.0050 | 0.124 | | 0.0432 | | | | | 12.7 | | | | | |
| W7 | 8/8/2012 | <0.0050 | 0.13 | | | | | | | 12.6 | | | | | |
| W7 | 8/23/2012 | <0.050 | 0.21 | | 0.0322 | | | | 11.3 | 10.3 | | | | | |
| W7 | 9/13/2012 | <0.0050 | 0.078 | | | | | | 16.3 | 16.3 | | | | | |
| W7 | 10/16/2012 | <0.0050 | 0.125 | | | | | | 12.1 | 12.6 | | | | | |
| W7 | 11/2/2012 | <0.0050 | 0.219 | | 0.0227 | | | | | 8.19 | | | | | |
| W7 | 12/29/2012 | <0.0050 | 0.063 | | | | | | | 10.2 | | | | | |
| W7 | 4/30/2013 | <0.0050 | 0.132 | | | | | | 4.71 | 4.64 | | | | | |
| W7 | 5/14/2013 | <0.0050 | <0.020 | | | | | | | 15.3 | | | | | |
| W7 | 6/19/2013 | <0.0050 | 0.143 | | | | | | | 11.3 | | | | | |
| W7 | 6/19/2013 | <0.0050 | 0.141 | | | | | | | 10.5 | | | | | |
| W7 | 7/13/2013 | <0.0050 | 0.17 | | | | | | | 9.88 | | | | | |
| W7 | 8/21/2013 | <0.0050 | 0.157 | | | | | | | 9.84 | | | | | |
| W7 | 9/6/2013 | <0.0050 | 0.128 | | | | | | | 11 | | | | | |
| W7 | 10/21/2013 | <0.0050 | 0.168 | | | | | | | 11.9 | | | | | |
| W7 | 11/16/2013 | <0.0050 | 0.257 | | | | | | | 7.47 | | | | | |
| W7 | 12/7/2013 | <0.0050 | 0.206 | | | | | | | 7.3 | | | | | |
| C4 | 5/6/2012 | <0.0050 | 0.029 | | 1.21 | | | | | 10.5 | | | | | |
| C4 | 8/1/2012 | 0.0177 | 0.074 | | 0.386 | | | | | 16.2 | | | | | |
| C4 | 8/8/2012 | 0.012 | 0.095 | | | | | | | | | | | | |
| C4 | 8/25/2012 | <0.0050 | <0.020 | | | | | | | <0.50 | | | | | |
| C4 | 6/22/2013 | 0.0066 | 0.371 | | | | | | | 17.4 | | | | | |
| C4 | 7/19/2013 | 0.0069 | 0.082 | | | | | | | | | | | | |
| C4 | 8/22/2013 | 0.0084 | 0.086 | | | | | | | 18.9 | | | | | |
| C4 | 9/6/2013 | <0.0050 | 0.07 | | | | | | | 15.1 | | | | | |
| C4 | 10/18/2013 | <0.0050 | 0.069 | | | | | | | 12.7 | | | | | |
| C4 | 10/18/2013 | <0.0050 | 0.065 | | | | | | | 12.5 | | | | | |
| C4 | 11/17/2013 | <0.050 | <0.20 | | | | | | | 31.6 | | | | | |
| C10 | 5/12/2012 | 0.0114 | 0.047 | | 2.25 | | | | | 13.3 | | | | | |
| C10 | 7/30/2012 | 0.0229 | 0.184 | | 0.903 | | | | | 17.8 | | | | | |
| C10 | 7/30/2012 | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | 0.0111 | 0.184 | | | | | | | | | | | | |
| C10 | 8/27/2012 | 0.0086 | 0.095 | | | | | | | 17.8 | | | | | |
| C10 | 6/22/2013 | 0.0198 | 0.152 | | | | | | | 15.3 | | | | | |
| C10 | 7/23/2013 | <0.050 | <0.20 | | | | | | | | | | | | |
| C10 | 8/22/2013 | 0.0072 | 0.135 | | | | | | | 17.2 | | | | | |
| C10 | 9/8/2013 | 0.0076 | 0.175 | | | | | | | 16 | | | | | |
| C10 | 9/8/2013 | 0.007 | 0.192 | | | | | | | 16.2 | | | | | |
| C10 | 10/18/2013 | <0.0050 | 0.167 | | | | | | | 14.3 | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Lab pH (pH units) | Lab Conductance (µS/cm) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | Hardness-E (mg/L) | Turbidity (NTU) | Temp-obs-pH (°C) | IB (%) | TDS (mg/L) | TSS (mg/L) | Total Alkalinity (mg/L) | Alkalinity-P (mg/L) | Alkalinity-OH (mg/L) | Alkalinity-Carb (mg/L) | Alkalinity-Bicrb (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | 8.05 | 195 | | 97.3 | | | | | 137 | 26.5 | 78.7 | | | 89.2 | |
| W1 | 6/30/2005 | 8.17 | 290 | | | | | | | 189 | <3.0 | 141 | | | 141 | |
| W1 | 7/28/2005 | 8.03 | 312 | | 157 | | | | | 189 | <3.0 | | | | 151 | |
| W1 | 8/29/2005 | 8.28 | 266 | | 138 | | | | | 186 | 4 | 138 | | | 138 | |
| W1 | 9/28/2005 | 7.59 | 244 | | 134 | | | | | 178 | 9.5 | 117 | | | 117 | |
| W1 | 10/15/2005 | 8.13 | 253 | | 140 | | | | | 181 | 14.5 | | | | 121 | |
| W2 | 5/27/2005 | 8.06 | 198 | | 99.8 | | | | | 138 | 20.5 | | | | 89.3 | |
| W2 | 5/27/2005 | 8.03 | 148 | | 72.2 | | | | | 80 | 79 | 67.1 | | | | |
| W2 | 6/30/2005 | 8.17 | 287 | | | | | | | 190 | <3.0 | 140 | | | 140 | |
| W2 | 7/28/2005 | 8.01 | 305 | | 153 | | | | | 194 | <3.0 | | | | 146 | |
| W2 | 8/30/2005 | 8.26 | 268 | | 138 | | | | | 193 | 3.5 | 143 | | | 143 | |
| W2 | 9/28/2005 | 7.9 | 243 | | 134 | | | | | 170 | 9 | 115 | | | 115 | |
| W2 | 10/15/2005 | 8.11 | 249 | | 137 | | | | | 179 | 5.5 | | | | 120 | |
| W3 | 5/27/2005 | 7.99 | 188 | | 93.9 | | | | | 141 | 8.5 | 61.2 | | | 78.7 | |
| W3 | 6/30/2005 | 8.22 | 341 | | | | | | | 224 | <3.0 | 153 | | | 153 | |
| W3 | 7/29/2005 | 8.06 | 322 | | 166 | | | | | 198 | 25.7 | | | | 143 | |
| W3 | 8/29/2005 | 8.24 | 267 | | 135 | | | | | 182 | 7.5 | 122 | | | 122 | |
| W3 | 9/28/2005 | 7.99 | 238 | | 129 | | | | | 174 | 8 | 101 | | | 101 | |
| W3 | 10/15/2005 | 8.08 | 245 | | 134 | | | | | 176 | <3.0 | | | | 106 | |
| W8 | 5/27/2005 | 7.78 | 113 | | 62.3 | | | | | 111 | <3.0 | 174 | | | 49.1 | |
| W8 | 6/30/2005 | 7.83 | 176 | | | | | | | 144 | <3.0 | 89 | | | 89 | |
| W8 | 7/29/2005 | 7.45 | 203 | | 116 | | | | | 141 | 24.7 | | | | 104 | |
| W8 | 8/30/2005 | 8.12 | 179 | | 99.8 | | | | | 147 | <3.0 | 99.2 | | | 99.2 | |
| W8 | 9/28/2005 | 7.96 | 165 | | 95 | | | | | 135 | <3.0 | 74.7 | | | 74.7 | |
| W8 | 10/15/2005 | 7.06 | 190 | | 99.4 | | | | | 140 | 5.5 | | | | 87.1 | |
| W9 | 5/27/2005 | 7.56 | 93.2 | | 49.4 | | | | | 104 | <3.0 | 142 | | | 32 | |
| W9 | 6/30/2005 | 7.63 | 145 | | | | | | | 126 | <3.0 | 56.1 | | | 56.1 | |
| W9 | 7/29/2005 | 7.51 | 176 | | 95.3 | | | | | 129 | 3.7 | | | | 74.2 | |
| W9 | 8/29/2005 | 7.84 | 146 | | 73.6 | | | | | 126 | <3.0 | 57.7 | | | 57.7 | |
| W9 | 9/28/2005 | 7.62 | 125 | | 67.8 | | | | | 118 | <3.0 | 44 | | | 44 | |
| W9 | 10/15/2005 | 7.19 | 121 | | 64.4 | | | | | 111 | <3.0 | | | | 51.8 | |
| W10 | 5/27/2005 | 7.47 | 75.4 | | 46.3 | | | | | 115 | <3.0 | | | | 36.7 | |
| W10 | 5/27/2005 | | | | | | | | | | | | | | | |
| W10 | 6/30/2005 | 7.31 | 84.2 | | | | | | | 116 | 6 | 41.5 | | | 41.5 | |
| W10 | 7/29/2005 | 7.34 | 111 | | 54.9 | | | | | 105 | 4.2 | | | | 58.2 | |
| W10 | 8/29/2005 | 7.74 | 145 | | 70 | | | | | 117 | 13 | 79.1 | | | 79.1 | |
| W10 | 9/28/2005 | 7.77 | 181 | | 101 | | | | | 141 | 14.5 | 92.3 | | | 92.3 | |
| W10 | 10/15/2005 | 7.3 | 175 | | 100 | | | | | 138 | 6.5 | | | | 96.4 | |
| W6 | 5/27/2005 | 7.91 | 127 | | 65.4 | | | | | 103 | 13.5 | 32 | | | 61.2 | |
| W6 | 6/30/2005 | 7.41 | 174 | | | | | | | 123 | 11.5 | 99.1 | | | 99.1 | |
| W6 | 7/29/2005 | 8.01 | 319 | | 171 | | | | | 198 | 22.2 | | | | 147 | |
| W6 | 8/30/2005 | 8.17 | 200 | | 106 | | | | | 147 | <3.0 | 109 | | | 109 | |
| W6 | 9/28/2005 | 7.95 | 192 | | 106 | | | | | 133 | 3.5 | 93 | | | 93 | |
| W6 | 10/15/2005 | 7.92 | 180 | | 98.3 | | | | | 128 | <3.0 | | | | 99.3 | |
| W6 | 6/2/2006 | 7.64 | 112 | | | | | | | 96 | 115 | 76.6 | | | | |
| W6 | 8/25/2006 | 8.01 | 223 | 120 | | | | | | 160 | | 120 | | <5 | <6 | 146 |
| W6 | 9/6/2006 | 7.86 | 212 | 110 | | | | | | | 4 | 112 | | <5 | <6 | 137 |
| W6 | 6/20/2007 | 7.77 | 151 | | 81 | | 0.6 | | | 130 | 16 | 83 | | <5 | <6 | 100 |
| W6 | 9/18/2007 | 7.95 | 194 | | 93 | | 0.2 | | | 172 | 8 | 112 | | <5 | <6 | 137 |
| W6 | 6/17/2008 | 7.82 | 175 | | 86 | | 0.9 | | | 120 | 17 | 93 | | <5 | <6 | 100 |
| W6 | 9/18/2008 | 7.8 | 174 | | | | <0.1 | | | 150 | 4 | 87 | | <5 | <6 | 100 |
| W6 | 4/14/2009 | 7.92 | 624 | 248 | | | 24 | | | 464 | 138 | 201 | | <5 | <6 | 240 |
| W6 | 4/30/2009 | 7.34 | 104 | 56 | | | 39 | | | 112 | 190 | 41 | | <5 | <6 | 50 |
| W6 | 7/28/2009 | 7.86 | 338 | 148 | | | 27 | | | 228 | 38 | 92 | | <5 | <6 | 100 |
| W6 | 8/6/2009 | | | | | | | | | | | | | | | |
| W6 | 8/6/2009 | 8.05 | 413 | 177 | | | 0.3 | | | 296 | <2 | 155 | | <5 | <6 | 190 |
| W6 | 8/18/2009 | | | 173 | | | | | | | | | | | | |
| W6 | 8/25/2009 | | | | | | | | | | | | | | | |
| W6 | 10/7/2009 | 7.86 | 478 | 195 | | | 0.5 | | | 314 | <2 | 95 | | <5 | <6 | 100 |
| W6 | 10/7/2009 | 7.83 | 475 | 195 | | | 0.6 | | | 352 | <3 | 96 | | <5 | <6 | 100 |
| W6 | 10/25/2009 | 8.1 | 501 | 207 | 219 | | 1.8 | | | 270 | <4 | 120 | <0.5 | <0.5 | <0.5 | 150 |
| W6 | 4/19/2010 | 7.93 | 292 | | 135 | | 38 | | | 196 | 29 | 117 | | <5 | <6 | 140 |
| W6 | 5/16/2010 | 8.1 | 200 | 98 | 97.2 | | 0.7 | | | 130 | <4 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 5/17/2010 | 7.8 | 152 | 73.7 | 68.8 | | 1.6 | | | 120 | <4 | 71 | <0.5 | <0.5 | <0.5 | 87 |
| W6 | 5/19/2010 | 8.1 | 192 | 95.5 | 101 | | 1.2 | | | 120 | 3 | 90 | <0.5 | <0.5 | <0.5 | 110 |
| W6 | 5/21/2010 | 8 | 160 | 82.6 | 88.1 | | 2.9 | | | 84 | 10 | 80 | <0.5 | <0.5 | <0.5 | 97 |
| W6 | 5/23/2010 | 8.1 | 219 | 102 | 96.4 | | 2 | | | 150 | 9 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 5/25/2010 | 7.9 | 221 | 108 | 120 | | 1.6 | | | 120 | 4 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 5/29/2010 | 8 | 141 | 69.2 | 70.1 | | 2.8 | | | 84 | 10 | 74 | <0.5 | <0.5 | <0.5 | 90 |
| W6 | 6/2/2010 | 8.4 | 466 | 221 | 243 | | 0.7 | | | 280 | 2 | 200 | 5.2 | <0.5 | 6.3 | 230 |
| W6 | 6/4/2010 | 8.1 | 189 | 81 | 92.6 | | 1.7 | | | 96 | 1 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 6/6/2010 | 8 | 187 | 98.3 | 98.8 | | 3.1 | | | 120 | 5 | 100 | <0.5 | <0.5 | <0.5 | 130 |
| W6 | 6/14/2010 | 8.2 | 184 | 92.4 | 94.5 | | 3.6 | | | 130 | 13 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 6/16/2010 | 8.2 | 188 | 92 | 90.8 | | 2.7 | | | 120 | 5 | 100 | <0.5 | <0.5 | <0.5 | 130 |
| W6 | 6/18/2010 | 8.2 | 191 | 93.9 | 89.2 | | 1.7 | | | 120 | 6 | 100 | <0.5 | <0.5 | <0.5 | 130 |
| W6 | 6/20/2010 | 8.2 | 182 | 88.8 | 92.7 | | 2.7 | | | 110 | 5 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 6/22/2010 | 8.17 | 190 | 92.6 | 94.3 | | 3.4 | | | 120 | 8 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 6/24/2010 | 8.11 | 189 | 92.6 | 74.4 | | 2.1 | | | 96 | 4 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 6/26/2010 | 8.11 | 189 | 90.3 | 90.7 | | 3 | | | 92 | 5 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 6/26/2010 | | | | | | | | | | | | | | | |
| W6 | 6/28/2010 | 7.87 | 189 | 89.5 | 91.4 | | 6.8 | | | 130 | 19 | 99 | <0.5 | <0.5 | <0.5 | 120 |
| W6 | 7/5/2010 | 7.95 | 170 | 79.5 | 86.9 | | 23 | | | 130 | 60 | 87 | <0.5 | <0.5 | <0.5 | 110 |
| W6 | 8/5/2010 | 8.06 | 207 | 108 | 101 | | 2.2 | | | 130 | 8 | 110 | <0.5 | <0.5 | <0.5 | 130 |
| W6 | 9/9/2010 | 8.07 | 210 | 108 | 107 | | 10.2 | | | 160 | 31 | 110 | <0.5 | <0.5 | <0.5 | 130 |
| W6 | 10/8/2010 | 8.07 | 209 | 103 | 100 | | 6.7 | | | 140 | 46 | 110 | <0.5 | <0.5 | <0.5 | 130 |
| W6 | 8/19/2011 | 8.3 | 485 | 225 | 214 | | | | | 280 | 2 | 190 | <0.5 | <0.5 | <0.5 | 240 |
| W6 | 7/17/2012 | 7.98 | 201 | 104 | 163 | | | | | 122 | 1130 | 103 | <0.50 | <0.50 | <0.50 | 126 |
| W6 | 7/30/2012 | 8.09 | 202 | 101 | 145 | | | | | 124 | 614 | 103 | <0.50 | <0.50 | <0.50 | 126 |
| W6 | 8/9/2012 | 8.17 | 220 | 112 | 136 | | | | | 144 | 566 | 116 | <0.50 | <0.50 | <0.50 | 141 |
| W6 | 8/25/2012 | 8 | 212 | 103 | 161 | | | | | 138 | 1160 | 109 | <0.50 | <0.50 | <0.50 | 133 |
| W6 | 9/13/2012 | 8.04 | 174 | 87.7 | 93.1 | | | | | 118 | 50.3 | 87.1 | <0.50 | <0.50 | <0.50 | 106 |
| W6 | 10/13/2012 | 7.92 | 193 | | 117 | | | | | 150 | 44.7 | 99.1 | <0.50 | <0.50 | <0.50 | 121 |
| W6 | 11/12/2012 | 7.93 | 275 | 153 | 155 | | | | | 162 | 2.2 | 138 | <0.50 | <0.50 | <0.50 | 168 |
| W6 | 5/14/2013 | 7.48 | 55.1 | 31.4 | 33.8 | | | | | 84 | 13.1 | 25.5 | <0.50 | <0.50 | <0.50 | 31.1 |
| W6 | 6/22/2013 | 8.07 | 195 | 94.9 | 115 | | | | | 118 | 172 | 97.8 | <0.50 | <0.50 | <0.50 | 119 |
| W6 | 7/12/2013 | 7.9 | 180 | 88.2 | 95.3 | | | | | 136 | 25.2 | 93.8 | <0.50 | <0.50 | <0.50 | 115 |
| W6 | 8/22/2013 | 8.04 | 205 | 102 | 106 | | | | | 144 | 19.7 | 107 | <0.50 | <0.50 | <0.50 | 130 |
| W6 | 9/6/2013 | 7.95 | 204 | 101 | 114 | | | | | 130 | 5.2 | 105 | <0.50 | <0.50 | <0.50 | 129 |
| W6 | 10/7/2013 | 8.08 | 191 | 107 | 106 | | | | | 176 | 74.4 | 98.1 | <0.50 | <0.50 | <0.50 | 120 |
| W6 | 11/16/2013 | 8.11 | 245 | 119 | 123 | | | | | 120 | 33.4 | 121 | <0.50 | <0.50 | <0.50 | 147 |
| W6 | 12/7/2013 | 8.21 | 326 | 159 | 182 | | | | | 194 | 3.6 | 164 | <0.50 | <0.50 | <0.50 | 200 |
| W7 | 5/27/2005 | 7.95 | 152 | | 76.6 | | | | | 116 | 30.5 | 36.7 | | | 68.4 | |
| W7 | 6/30/2005 | 7.87 | 233 | | | | | | | 153 | 14 | 117 | | | 117 | |
| W7 | 7/29/2005 | 7.18 | 323 | | 167 | | | | | 197 | 19.7 | | | | 146 | |
| W7 | 8/30/2005 | 8.19 | 211 | | 109 | | | | | 148 | 3 | 113 | | | 113 | |
| W7 | 9/28/2005 | 8.02 | 190 | | 107 | | | | | 142 | 361 | 95.9 | | | 95.9 | |
| W7 | 10/15/2005 | 6.75 | 194 | | 106 | | | | | 145 | 7.5 | | | | 107 | |
| W7 | 6/2/2006 | 7.61 | 98.8 | | | | | | | 104 | 705 | 49.4 | | | | |
| W7 | 6/8/2006 | | | | | | | | | | | | | | | |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Lab pH (pH units) | Lab Conductance (µS/cm) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | Hardness-E (mg/L) | Turbidity (NTU) | Temp-obs-pH (°C) | IB (%) | TDS (mg/L) | TSS (mg/L) | Total Alkalinity (mg/L) | Alkalinity-P (mg/L) | Alkalinity-OH (mg/L) | Alkalinity-Carb (mg/L) | Alkalinity-Bicrb (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 6/15/2006 | | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | 7.86 | 193 | 100 | | | | | | 114 | 53 | 95 | | <5 | <6 | 116 |
| W7 | 6/23/2006 | 7.78 | 246 | 122 | | | | | | 176 | 328 | 130 | | <5 | <6 | 159 |
| W7 | 6/28/2006 | 7.9 | 213 | 107 | | | | | | 120 | 103 | 106 | | <5 | <6 | 129 |
| W7 | 7/7/2006 | 7.91 | 205 | 110 | | | | | | 184 | 3 | 120 | | <5 | <6 | 146 |
| W7 | 7/12/2006 | 7.77 | 238 | 110 | | | | | | | <2 | 120 | | <5 | <6 | 146 |
| W7 | 7/20/2006 | 7.88 | 233 | 130 | | | | | | | 2 | 122 | | <5 | <6 | 149 |
| W7 | 7/26/2006 | | | | | | | | | | | | | | | |
| W7 | 7/26/2006 | 7.87 | 259 | 128 | | | | | | | 9 | 121 | | <5 | <6 | 147 |
| W7 | 8/2/2006 | 7.79 | 256 | 128 | | | | | | | 4 | 125 | | <5 | <6 | 152 |
| W7 | 8/10/2006 | 7.8 | 259 | 126 | | | | | | | <2 | 125 | | <5 | <6 | 152 |
| W7 | 8/25/2006 | | | | | | | | | | | | | | | |
| W7 | 8/25/2006 | 7.92 | 261 | 129 | | | | | | 180 | | 131 | | <5 | <6 | 160 |
| W7 | 8/30/2006 | 7.79 | 258 | 132 | | | | | | 200 | <2 | 129 | | <5 | <6 | 157 |
| W7 | 9/6/2006 | 7.88 | 258 | 130 | | | | | | | 4 | 129 | | <5 | <6 | 157 |
| W7 | 9/13/2006 | 7.84 | 254 | 130 | | | | | | | 5 | 128 | | <5 | <6 | 157 |
| W7 | 9/20/2006 | 7.85 | 263 | 132 | | | | | | | 3 | 127 | | <5 | <6 | 154 |
| W7 | 9/28/2006 | 7.26 | 266 | 129 | | | | | | 182 | | 128 | | <5 | <6 | 156 |
| W7 | 10/4/2006 | 7.94 | 258 | 126 | | | | | | | 2 | 122 | | <5 | <6 | 149 |
| W7 | 10/12/2006 | 7.39 | 266 | 132 | | | | | | 164 | 4 | 130 | | <5 | <6 | 158 |
| W7 | 6/5/2007 | 7.98 | 208 | | 108 | | 2.4 | | | 162 | 76 | 118 | | <5 | <6 | 144 |
| W7 | 6/5/2007 | 7.97 | 207 | | 120 | | 3.1 | | | 158 | 76 | 121 | | <5 | <6 | 147 |
| W7 | 6/5/2007 | 7.97 | 207 | | 111 | | 2.2 | | | 166 | 73 | 105 | | <5 | <6 | 128 |
| W7 | 6/20/2007 | 7.84 | 230 | 110 | | | 0.5 | | | 164 | 6 | 116 | | <5 | <6 | 142 |
| W7 | 7/18/2007 | 7.72 | 250 | 128 | 126 | | 0.6 | | | 170 | 4 | 128 | | <5 | <6 | 156 |
| W7 | 7/18/2007 | 7.8 | 249 | | 125 | | 1 | | | 182 | 7 | 128 | | <5 | <6 | 156 |
| W7 | 7/18/2007 | 7.83 | 249 | | 125 | | 1.4 | | | 184 | 6 | 128 | | <5 | <6 | 157 |
| W7 | 8/24/2007 | | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | | | | | | | | | | | | | | | |
| W7 | 8/24/2007 | 8.04 | 246 | | 122 | | <0.1 | | | 198 | 4 | 139 | | <5 | <6 | 170 |
| W7 | 8/24/2007 | 8.05 | 245 | | 123 | | <0.1 | | | 192 | 4 | 136 | | <5 | <6 | 166 |
| W7 | 8/24/2007 | 8.04 | 244 | | 128 | | <0.1 | | | 186 | 6 | 136 | | <5 | <6 | 165 |
| W7 | 9/18/2007 | 8 | 224 | 110 | | | 0.2 | | | 182 | 20 | 124 | | <5 | <6 | 151 |
| W7 | 10/30/2007 | 7.74 | 268 | | 130 | | 0.9 | | | 176 | 3 | 128 | | <5 | <6 | 157 |
| W7 | 10/30/2007 | 7.74 | 274 | | 128 | | 1.9 | | | 182 | 10 | 131 | | <5 | <6 | 160 |
| W7 | 10/30/2007 | 7.74 | 269 | | 130 | | 1.9 | | | 166 | 7 | 128 | | <5 | <6 | 157 |
| W7 | 10/30/2007 | 7.68 | 272 | | | | 1.2 | | | 172 | 6 | 128 | | <5 | <6 | 157 |
| W7 | 4/22/2008 | 8.4 | 364 | 186 | | | 0.3 | | | 264 | <2 | 187 | | <5 | <6 | 218 |
| W7 | 4/22/2008 | 8.41 | 362 | 193 | | | 0.3 | | | 274 | <2 | 185 | | <5 | <6 | 215 |
| W7 | 4/22/2008 | 8.4 | 366 | 182 | | | 0.4 | | | 270 | <2 | 186 | | <5 | <6 | 216 |
| W7 | 4/22/2008 | 8.4 | 367 | | | | 0.5 | | | 262 | <2 | 188 | | <5 | <6 | 218 |
| W7 | 6/3/2008 | 8.01 | 201 | | 97 | | 1.3 | | | 134 | <2 | 94 | | <5 | <6 | 100 |
| W7 | 6/3/2008 | 8.01 | 203 | | 96 | | 1.3 | | | 132 | 19 | 95 | | <5 | <6 | 100 |
| W7 | 6/3/2008 | 8.03 | 205 | | 101 | | 1.1 | | | 146 | 26 | 95 | | <5 | <6 | 100 |
| W7 | 6/3/2008 | | | 92 | | | | | | | | | | | | |
| W7 | 6/17/2008 | 7.95 | 237 | | | | 1 | | | 156 | 10 | 115 | | <5 | <6 | 140 |
| W7 | 8/6/2008 | 7.9 | 234 | | 123 | | 1.4 | | | 162 | 92 | 128 | | <5 | <6 | 160 |
| W7 | 8/6/2008 | 7.91 | 235 | | 123 | | 1.4 | | | 168 | 139 | 127 | | <5 | <6 | 150 |
| W7 | 8/6/2008 | 7.96 | 233 | | 125 | | 1.2 | | | 170 | 85 | 127 | | <5 | <6 | 160 |
| W7 | 8/6/2008 | | | 123 | | | | | | | | | | | | |
| W7 | 9/18/2008 | 7.89 | 170 | | | | 1.8 | | | 170 | 28 | 82 | | <5 | <6 | 100 |
| W7 | 10/28/2008 | 7.84 | 217 | | | | 0.6 | | | 192 | 4 | 108 | | <5 | <6 | 130 |
| W7 | 10/28/2008 | 7.83 | 217 | | | | 0.7 | | | 188 | 6 | 108 | | <5 | <6 | 130 |
| W7 | 10/28/2008 | 7.85 | 218 | | | | 0.8 | | | 168 | 7 | 108 | | <5 | <6 | 130 |
| W7 | 10/28/2008 | | | 123 | | | | | | | | | | | | |
| W7 | 4/30/2009 | 6.84 | 36 | 20 | | | 1.6 | | | 52 | <2 | 12 | | <5 | <6 | 20 |
| W7 | 6/8/2009 | 7.9 | 208 | 93 | | | 1.4 | | | 156 | 32 | 95 | | <5 | <6 | 100 |
| W7 | 7/28/2009 | 8.07 | 270 | 137 | | | 0.2 | | | 184 | 4 | 128 | | <5 | <6 | 160 |
| W7 | 8/6/2009 | 8.35 | 260 | 121 | | | 0.2 | | | 202 | 2 | 159 | | <5 | <6 | 190 |
| W7 | 8/24/2009 | | | | | | | | | | | | | | | |
| W7 | 8/25/2009 | | | | | | | | | | | | | | | |
| W7 | 8/31/2009 | | | 110 | | | | | | | | | | | | |
| W7 | 10/7/2009 | | | | | | | | | | | | | | | |
| W7 | 10/7/2009 | 7.87 | 249 | 123 | | | 0.2 | | | 180 | 7 | 116 | | <5 | <6 | 140 |
| W7 | 10/25/2009 | 8.1 | 266 | 126 | 141 | | 0.7 | | | 130 | <4 | 130 | <0.5 | <0.5 | <0.5 | 160 |
| W7 | 10/25/2009 | 8 | 264 | | | | 0.3 | | | 110 | <4 | | | | | |
| W7 | 4/19/2010 | 7.81 | 167 | | 80 | | 1.2 | | | 142 | <7 | 82 | | <5 | <6 | 100 |
| W7 | 4/27/2010 | 7.6 | 64 | 36.3 | 35 | | 1.2 | | | 62 | <4 | 32 | <0.5 | <0.5 | <0.5 | 39 |
| W7 | 4/29/2010 | 7.5 | 66 | 36.2 | 36.2 | | 1.8 | | | 62 | <4 | 31 | <0.5 | <0.5 | <0.5 | 38 |
| W7 | 5/1/2010 | 7.7 | 78 | 40.8 | 43.6 | | 8.6 | | | 74 | 15 | 40 | <0.5 | <0.5 | <0.5 | 49 |
| W7 | 5/3/2010 | 7.7 | 85 | 44.9 | 46.2 | | 7.9 | | | 80 | 12 | 42 | <0.5 | <0.5 | <0.5 | 51 |
| W7 | 5/5/2010 | 7.8 | 102 | 49.1 | 55.1 | | 8.7 | | | 76 | 12 | 53 | <0.5 | <0.5 | <0.5 | 64 |
| W7 | 5/7/2010 | 7.8 | 113 | 56.9 | 56 | | 4.1 | | | 62 | 18 | 58 | <0.5 | <0.5 | <0.5 | 70 |
| W7 | 5/9/2010 | 8 | 180 | 79.9 | 71 | | 2.2 | | | 130 | <4 | 86 | <0.5 | <0.5 | <0.5 | 110 |
| W7 | 5/10/2010 | 8.1 | 163 | 80.9 | 90.3 | | 1 | | | 130 | <4 | 83 | <0.5 | <0.5 | <0.5 | 100 |
| W7 | 5/12/2010 | | | | | | | | | | | | | | | |
| W7 | 5/12/2010 | 8 | 166 | 81.6 | 84.6 | | 1.2 | | | 100 | <4 | 83 | <0.5 | <0.5 | <0.5 | 100 |
| W7 | 5/14/2010 | 8.1 | 149 | 72.6 | 71.4 | | 7.7 | | | 130 | 15 | 73 | <0.5 | <0.5 | <0.5 | 89 |
| W7 | 5/16/2010 | 8.3 | 590 | 85.6 | 76.3 | | 3.8 | | | 120 | 12 | 260 | <0.5 | <0.5 | <0.5 | 320 |
| W7 | 5/17/2010 | 8.2 | 160 | 80.4 | 75.6 | | 4 | | | 130 | 11 | 80 | <0.5 | <0.5 | <0.5 | 98 |
| W7 | 5/19/2010 | 8.2 | 195 | 98.6 | 103 | | 1.5 | | | 120 | 4 | 98 | <0.5 | <0.5 | <0.5 | 120 |
| W7 | 5/21/2010 | 8.1 | 191 | 91.5 | 95.6 | | 6.5 | | | 120 | 22 | 96 | <0.5 | <0.5 | <0.5 | 120 |
| W7 | 5/23/2010 | 8.1 | 204 | 98.1 | 103 | | 29.3 | | | 150 | 33 | 100 | <0.5 | <0.5 | <0.5 | 130 |
| W7 | 5/25/2010 | 7.9 | 211 | 125 | 124 | | 85.5 | | | 140 | 140 | 100 | <0.5 | <0.5 | <0.5 | 130 |
| W7 | 5/27/2010 | 8 | 231 | 113 | 148 | | 307 | | | 140 | 350 | 110 | <0.5 | <0.5 | <0.5 | 140 |
| W7 | 5/29/2010 | 8.2 | 232 | 111 | 129 | | 170 | | | 160 | 200 | 110 | <0.5 | <0.5 | <0.5 | 140 |
| W7 | 5/31/2010 | 8.2 | 236 | 109 | 130 | | 155 | | | 160 | 290 | 120 | <0.5 | <0.5 | <0.5 | 140 |
| W7 | 6/2/2010 | 8.2 | 243 | 113 | 135 | | 68.2 | | | 140 | 81 | 120 | <0.5 | <0.5 | <0.5 | 150 |
| W7 | 6/4/2010 | 8.2 | 240 | 111 | 125 | | 51.6 | | | 140 | 60 | 120 | <0.5 | <0.5 | <0.5 | 150 |
| W7 | 6/6/2010 | 8.2 | 250 | 128 | 133 | | 45.2 | | | 170 | 39 | 130 | <0.5 | <0.5 | <0.5 | 150 |
| W7 | 6/14/2010 | 8.29 | 250 | 122 | 128 | | 17 | | | 150 | 43 | 130 | <0.5 | <0.5 | <0.5 | 160 |
| W7 | 6/16/2010 | 8.3 | 259 | 120 | 128 | | 6.4 | | | 150 | 17 | 130 | <0.5 | <0.5 | <0.5 | 160 |
| W7 | 6/18/2010 | 8.17 | 256 | 122 | 123 | | 7.8 | | | 140 | 28 | 130 | <0.5 | <0.5 | <0.5 | 160 |
| W7 | 6/20/2010 | 8.2 | 240 | 112 | 118 | | 18.9 | | | 140 | 33 | 120 | <0.5 | <0.5 | <0.5 | 150 |
| W7 | 6/22/2010 | 8.03 | 208 | 97.6 | 115 | | 134 | | | 140 | 300 | 110 | <0.5 | <0.5 | <0.5 | 130 |
| W7 | 6/24/2010 | 8.03 | 214 | 99.7 | 116 | | 24.5 | | | 130 | 64 | 110 | <0.5 | <0.5 | <0.5 | 130 |
| W7 | 6/26/2010 | 8.26 | 230 | 106 | 106 | | 8.2 | | | 120 | 21 | 120 | <0.5 | <0.5 | <0.5 | 140 |
| W7 | 6/28/2010 | 8.03 | 248 | 114 | 107 | | 3 | | | 150 | 9 | 120 | <0.5 | <0.5 | <0.5 | 150 |
| W7 | 7/5/2010 | 8.06 | 202 | 92.5 | 106 | | 19 | | | 150 | 53 | 100 | <0.5 | <0.5 | <0.5 | 120 |
| W7 | 8/5/2010 | | | 118 | 116 | | | | | 170 | | | | | | |
| W7 | 9/12/2010 | | | | 105 | | | | | | | | | | | |
| W7 | 9/12/2010 | 7.98 | 212 | 107 | 102 | | 3.4 | | | 210 | 11 | 100 | <0.5 | <0.5 | <0.5 | 130 |
| W7 | 10/8/2010 | 8.1 | 233 | 111 | 126 | | 1.6 | | | 150 | 3 | 120 | <0.5 | <0.5 | <0.5 | 140 |
| W7 | 4/27/2011 | 7.41 | 79 | 42.6 | 42.6 | | | | | 72 | <1 | 34 | <0.5 | <0.5 | <0.5 | 41 |
| W7 | 5/2/2011 | 7.11 | 57 | 31.8 | 33.1 | | | | | 40 | 7 | 27 | <0.5 | <0.5 | <0.5 | 33 |
| W7 | 6/1/2011 | 8.09 | 196 | 92.3 | 94 | | | | | 120 | 23 | 96 | <0.5 | <0.5 | <0.5 | 120 |
| W7 | 6/16/2011 | 8 | 195 | 97.4 | 108 | | | | | 130 | 85 | 92 | <0.5 | <0.5 | <0.5 | 110 |
| W7 | 7/1/2011 | 7.76 | 146 | 77.1 | 87.5 | | | | | 120 | 150 | 73 | <0.5 | <0.5 | <0.5 | 89 |

**Table B.1: Raw water quality data from Minto Mine, 2005 - 2013.**

| Station Name | Sample Date | Lab pH (pH units) | Lab Conductance (µS/cm) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | Hardness-E (mg/L) | Turbidity (NTU) | Temp-obs-pH (°C) | IB (%) | TDS (mg/L) | TSS (mg/L) | Total Alkalinity (mg/L) | Alkalinity-P (mg/L) | Alkalinity-OH (mg/L) | Alkalinity-Carb (mg/L) | Alkalinity-Bicrb (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/2/2011 | 7.67 | 113 | 58.9 | 85.8 | | | | | 110 | 400 | 54 | <0.5 | <0.5 | <0.5 | 66 |
| W7 | 8/16/2011 | 7.9 | 191 | 97.6 | 96.8 | | | | | 150 | 22 | 94 | <0.5 | <0.5 | <0.5 | 110 |
| W7 | 8/19/2011 | 8.12 | 185 | 93 | 93.4 | | | | | 140 | 22 | 92 | <0.5 | <0.5 | <0.5 | 110 |
| W7 | 9/12/2011 | 8.03 | 217 | 118 | 119 | | | | | 170 | 1 | 110 | <0.5 | <0.5 | <0.5 | 130 |
| W7 | 10/6/2011 | 8.07 | 233 | 110 | 113 | | | | | 150 | <4 | 120 | <0.5 | <0.5 | <0.5 | 140 |
| W7 | 11/22/2011 | 7.96 | 280 | 148 | 144 | | | | | 156 | 26.7 | 134 | <0.50 | <0.50 | <0.50 | 163 |
| W7 | 1/24/2012 | 8.13 | 349 | 169 | 158 | | | | | 226 | <4.0 | 165 | <0.50 | <0.50 | <0.50 | 201 |
| W7 | 2/25/2012 | 7.99 | 339 | 165 | 160 | | | | | 216 | <4.0 | 155 | <0.50 | <0.50 | <0.50 | 189 |
| W7 | 3/5/2012 | 8.17 | 343 | 161 | 159 | | | | | 176 | 3.2 | 154 | <0.50 | <0.50 | <0.50 | 188 |
| W7 | 4/24/2012 | 7.63 | 75 | 38.7 | 37 | | | | | 100 | 11.2 | 36.2 | <0.50 | <0.50 | <0.50 | 44.1 |
| W7 | 5/6/2012 | 6.05 | 93.2 | 46.1 | 44.8 | | | | | 80 | 2.4 | 27.3 | <0.50 | <0.50 | <0.50 | 33.3 |
| W7 | 5/6/2012 | 5.74 | 92.3 | 46.4 | 44.7 | | | | | 88 | 4.2 | 8.45 | <0.50 | <0.50 | <0.50 | 10.3 |
| W7 | 6/19/2012 | 8.12 | 178 | 91.8 | 105 | | | | | 128 | 165 | 87.4 | <0.50 | <0.50 | <0.50 | 107 |
| W7 | 7/17/2012 | 8.15 | 254 | 128 | 124 | | | | | 164 | 34.1 | 128 | <0.50 | <0.50 | <0.50 | 156 |
| W7 | 7/30/2012 | 8.2 | 272 | 135 | 128 | | | | | 180 | 9.2 | 138 | <0.50 | <0.50 | <0.50 | 168 |
| W7 | 8/8/2012 | 8.26 | 278 | 141 | 141 | | | | | 192 | 3.3 | 143 | <0.50 | <0.50 | <0.50 | 175 |
| W7 | 8/23/2012 | 8.25 | 285 | 142 | 151 | | | | | 200 | 1.5 | 147 | <0.50 | <0.50 | <0.50 | 179 |
| W7 | 9/13/2012 | 8.13 | 230 | 116 | 121 | | | | | 154 | 15.3 | 115 | <0.50 | <0.50 | <0.50 | 140 |
| W7 | 10/16/2012 | 8.17 | 261 | 129 | 143 | | | | | 166 | 9.9 | 132 | <0.50 | <0.50 | <0.50 | 161 |
| W7 | 11/2/2012 | 7.93 | 319 | 158 | 153 | | | | | 214 | 2.2 | 150 | <0.50 | <0.50 | <0.50 | 183 |
| W7 | 12/29/2012 | 8.13 | 444 | 223 | 206 | | | | | 262 | <1.0 | 207 | <0.50 | <0.50 | <0.50 | 253 |
| W7 | 4/30/2013 | 8.27 | 387 | 192 | 198 | | | | | 246 | 5.8 | 187 | <0.50 | <0.50 | <0.50 | 228 |
| W7 | 5/14/2013 | 7.58 | 61.3 | 33.3 | 36.4 | | | | | 70 | 55.3 | 29.4 | <0.50 | <0.50 | <0.50 | 35.9 |
| W7 | 6/19/2013 | 8.08 | 238 | 113 | 114 | | | | | 152 | 11.2 | 113 | <0.50 | <0.50 | <0.50 | 138 |
| W7 | 6/19/2013 | 8.07 | 237 | 114 | 115 | | | | | 164 | 10.1 | 113 | <0.50 | <0.50 | <0.50 | 138 |
| W7 | 7/13/2013 | 8.1 | 263 | 132 | 137 | | | | | 156 | 5 | 127 | <0.50 | <0.50 | <0.50 | 155 |
| W7 | 8/21/2013 | 8.23 | 286 | 140 | 144 | | | | | 172 | 3.8 | 143 | <0.50 | <0.50 | <0.50 | 175 |
| W7 | 9/6/2013 | 8.02 | 280 | 138 | 154 | | | | | 280 | 11.8 | 140 | <0.50 | <0.50 | <0.50 | 170 |
| W7 | 10/21/2013 | 8.16 | 288 | 147 | 126 | | | | | 168 | 7.4 | 138 | <0.50 | <0.50 | <0.50 | 168 |
| W7 | 11/16/2013 | 8.24 | 324 | 153 | 164 | | | | | 164 | 1.5 | 153 | <0.50 | <0.50 | <0.50 | 187 |
| W7 | 12/7/2013 | 8.14 | 354 | 168 | 189 | | | | | 220 | <1.0 | 166 | <0.50 | <0.50 | <0.50 | 203 |
| C4 | 5/6/2012 | 7.59 | 88.8 | 43.9 | 119 | | | | | 84 | 1260 | 40.1 | <0.50 | <0.50 | <0.50 | 48.9 |
| C4 | 8/1/2012 | 8.04 | 228 | 117 | 133 | | | | | 166 | 246 | 115 | <0.50 | <0.50 | <0.50 | 140 |
| C4 | 8/8/2012 | 8.14 | 248 | 125 | 142 | | | | | 170 | 253 | 126 | <0.50 | <0.50 | <0.50 | 153 |
| C4 | 8/25/2012 | 7.94 | 254 | 130 | 173 | | | | | 192 | 855 | 128 | <0.50 | <0.50 | <0.50 | 156 |
| C4 | 6/22/2013 | 7.97 | 253 | 126 | 222 | | | | | 204 | 886 | 120 | <0.50 | <0.50 | <0.50 | 147 |
| C4 | 7/19/2013 | 8.12 | 253 | 128 | 200 | | | | | 184 | 487 | 125 | <0.50 | <0.50 | <0.50 | 152 |
| C4 | 8/22/2013 | 7.98 | 245 | 123 | 199 | | | | | 182 | 784 | 118 | <0.50 | <0.50 | <0.50 | 144 |
| C4 | 9/6/2013 | 7.93 | 248 | 125 | 166 | | | | | 176 | 172 | 120 | <0.50 | <0.50 | <0.50 | 146 |
| C4 | 10/18/2013 | 8.18 | 260 | 129 | 142 | | | | | 214 | 16.3 | 126 | <0.50 | <0.50 | <0.50 | 154 |
| C4 | 10/18/2013 | 8.24 | 260 | 129 | 139 | | | | | 220 | 16.3 | 126 | <0.50 | <0.50 | <0.50 | 154 |
| C4 | 11/17/2013 | 7.9 | 477 | 258 | 264 | | | | | 272 | 22.4 | 244 | <0.50 | <0.50 | <0.50 | 298 |
| C10 | 5/12/2012 | 7.73 | 136 | 67.2 | 215 | | | | | 132 | 2210 | 65.1 | <0.50 | <0.50 | <0.50 | 79.4 |
| C10 | 7/30/2012 | 8.23 | 254 | 130 | 207 | | | | | 180 | 995 | 132 | <0.50 | <0.50 | <0.50 | 161 |
| C10 | 7/30/2012 | | | | | | | | | | | | | | | |
| C10 | 8/10/2012 | 8.11 | 273 | 135 | 245 | | | | | 216 | 1320 | 146 | <0.50 | <0.50 | <0.50 | 178 |
| C10 | 8/27/2012 | 8.37 | 284 | 141 | 264 | | | | | 184 | 1650 | 154 | 2.03 | <0.50 | 2.44 | 183 |
| C10 | 6/22/2013 | 8.26 | 276 | 148 | 151 | | | | | 192 | 43.4 | 143 | <0.50 | <0.50 | <0.50 | 175 |
| C10 | 7/23/2013 | 8.19 | 251 | 125 | 156 | | | | | 174 | 199 | 133 | <0.50 | <0.50 | <0.50 | 162 |
| C10 | 8/22/2013 | 8.23 | 309 | 160 | 168 | | | | | 218 | 65.5 | 159 | <0.50 | <0.50 | <0.50 | 194 |
| C10 | 9/8/2013 | 7.94 | 287 | 150 | 163 | | | | | 186 | 25.4 | 147 | <0.50 | <0.50 | <0.50 | 180 |
| C10 | 9/8/2013 | 8.13 | 289 | 150 | 162 | | | | | 206 | 21.7 | 151 | <0.50 | <0.50 | <0.50 | 184 |
| C10 | 10/18/2013 | 8.25 | 263 | 136 | 160 | | | | | 212 | 61.2 | 136 | <0.50 | <0.50 | <0.50 | 166 |

# APPENDIX C

# BOXPLOT OUTLIER EXAMINATION

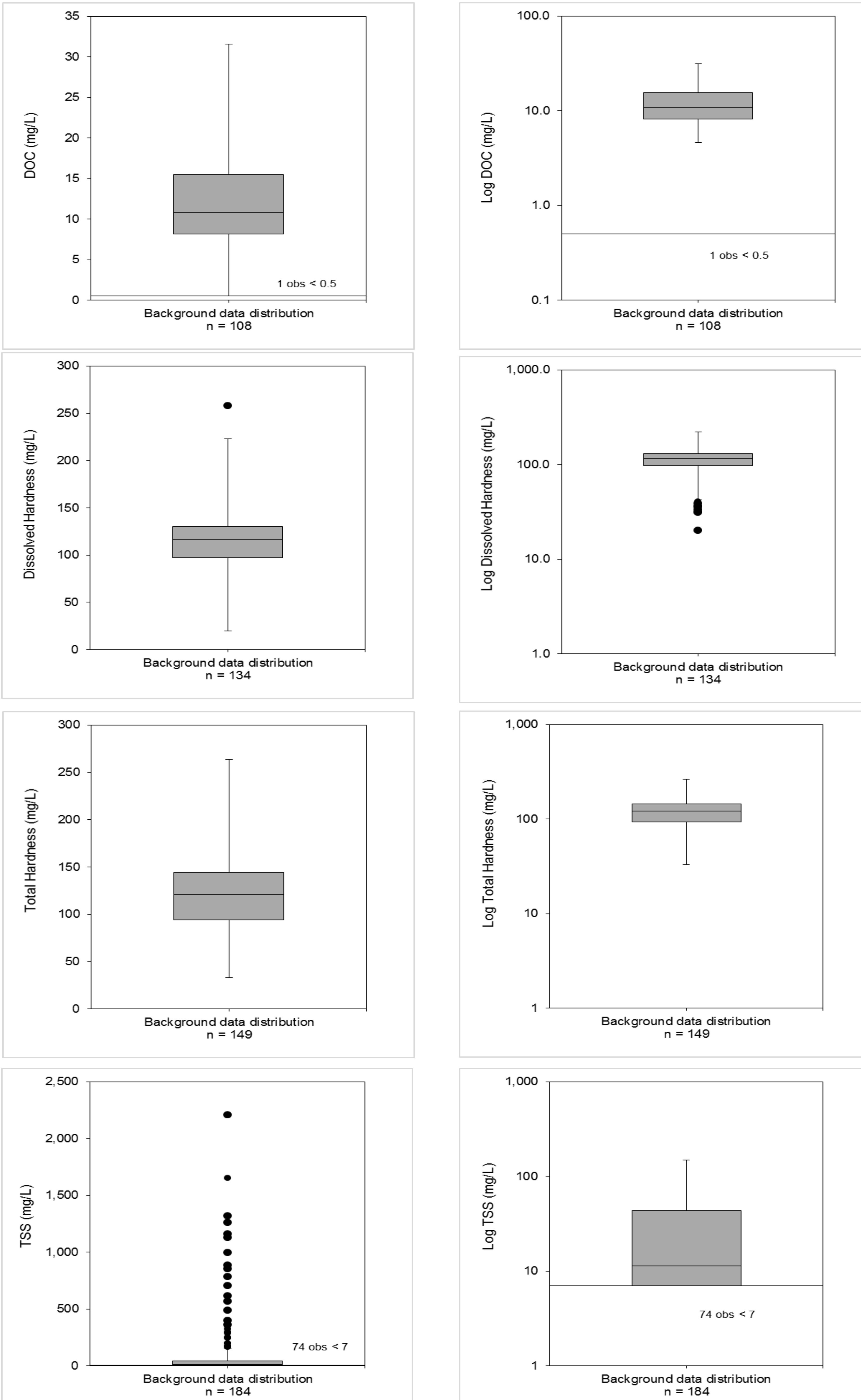



**Figure C.1: Boxplots of analytes on non-transformed and log transformed scales. Black dots represent possible outliers. Line represents highest < MDL and any < MDL below this are represented as number of observations below this line.**

NOTE: Possible outliers were only considered if they were detected on both non-transformed and log transformed scales

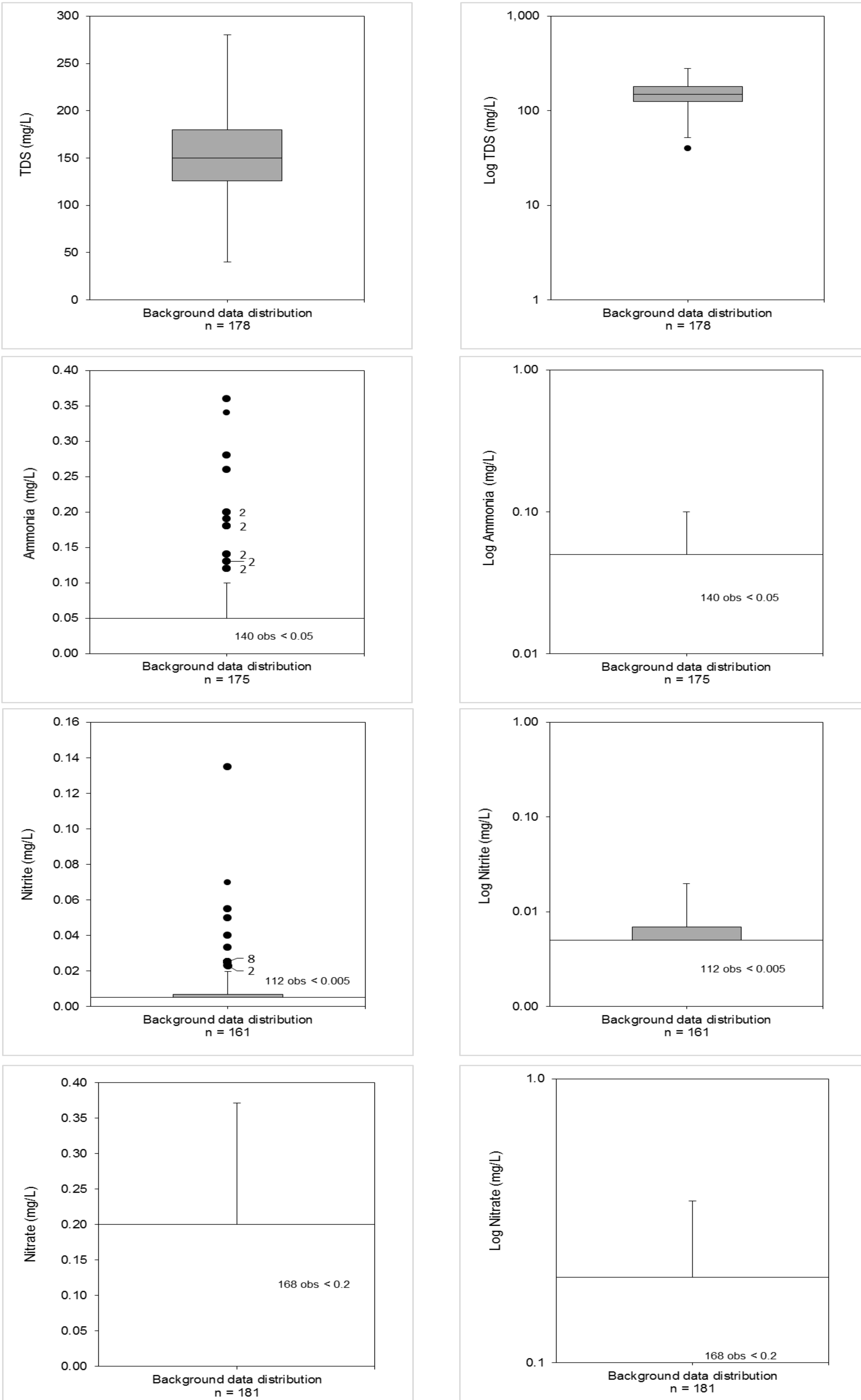



**Figure C.1: Boxplots of analytes on non-transformed and log transformed scales. Black dots represent possible outliers. Line represents highest < MDL and any < MDL below this are represented as number of observations below this line.**

NOTE: Possible outliers were only considered if they were detected on both non-transformed and log transformed scales

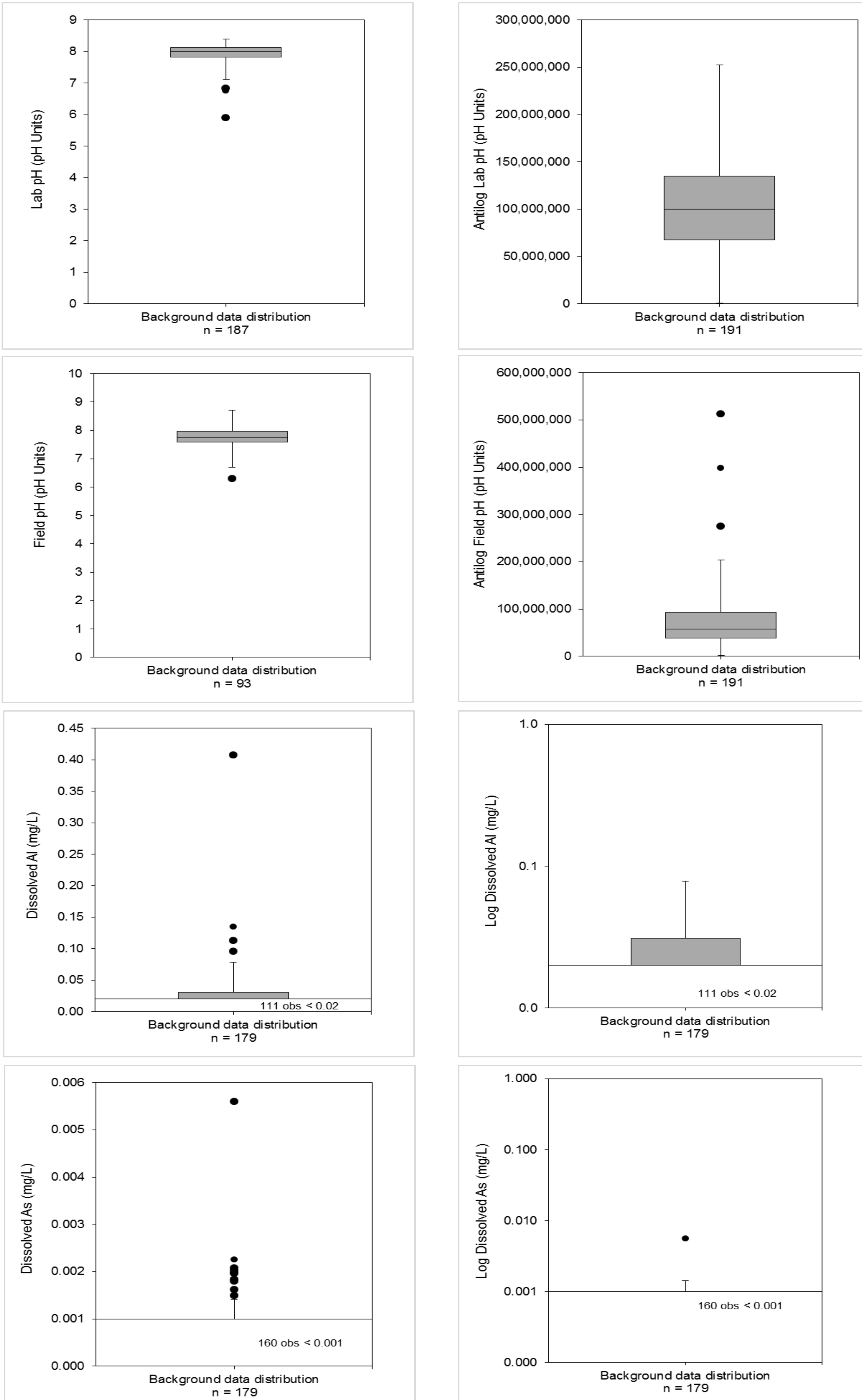



**Figure C.1: Boxplots of analytes on non-transformed and log transformed scales. Black dots represent possible outliers. Line represents highest < MDL and any < MDL below this are represented as number of observations below this line.**

NOTE: Possible outliers were only considered if they were detected on both non-transformed and log transformed scales

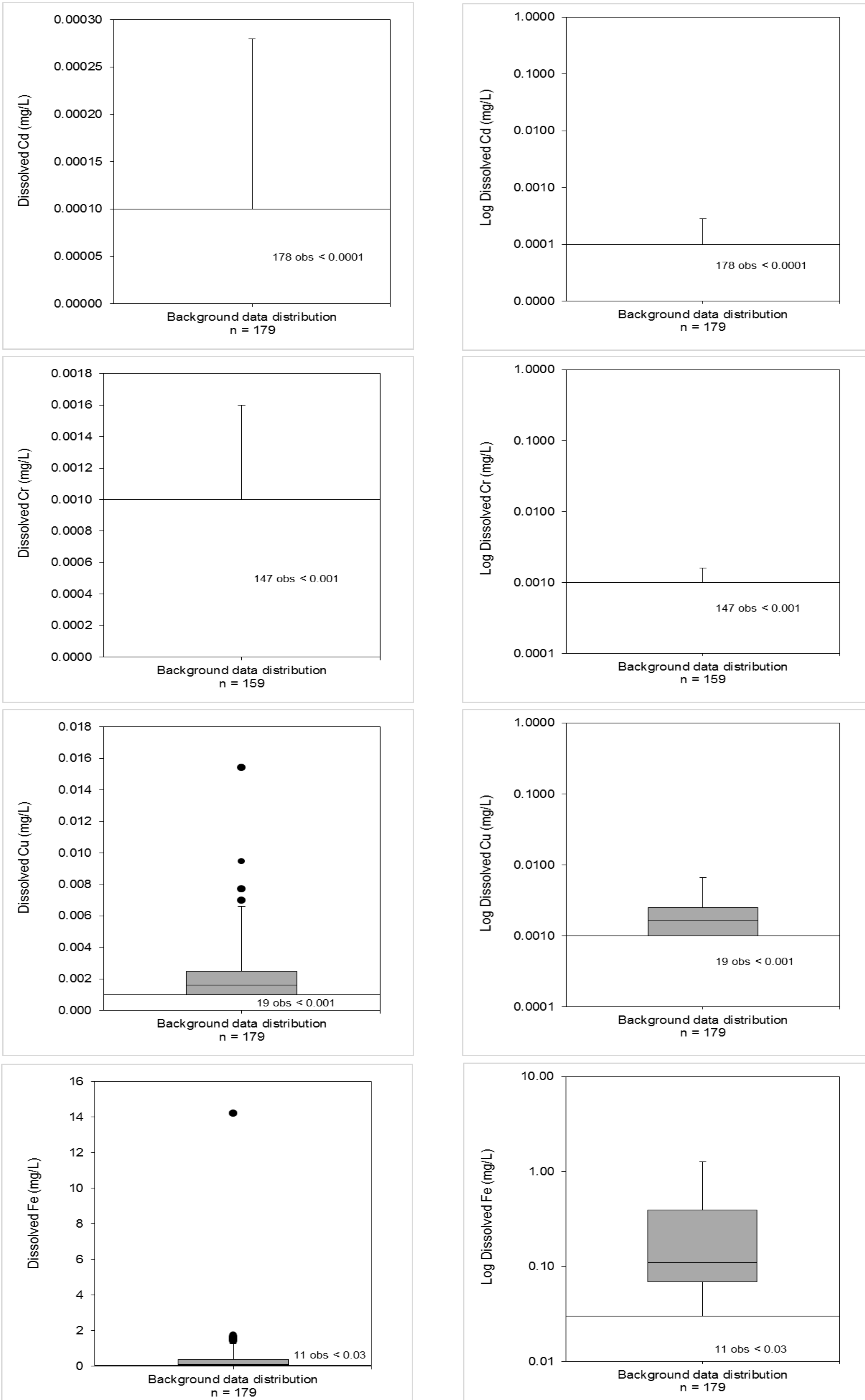



**Figure C.1: Boxplots of analytes on non-transformed and log transformed scales. Black dots represent possible outliers. Line represents highest < MDL and any < MDL below this are represented as number of observations below this line.**

NOTE: Possible outliers were only considered if they were detected on both non-transformed and log transformed scales

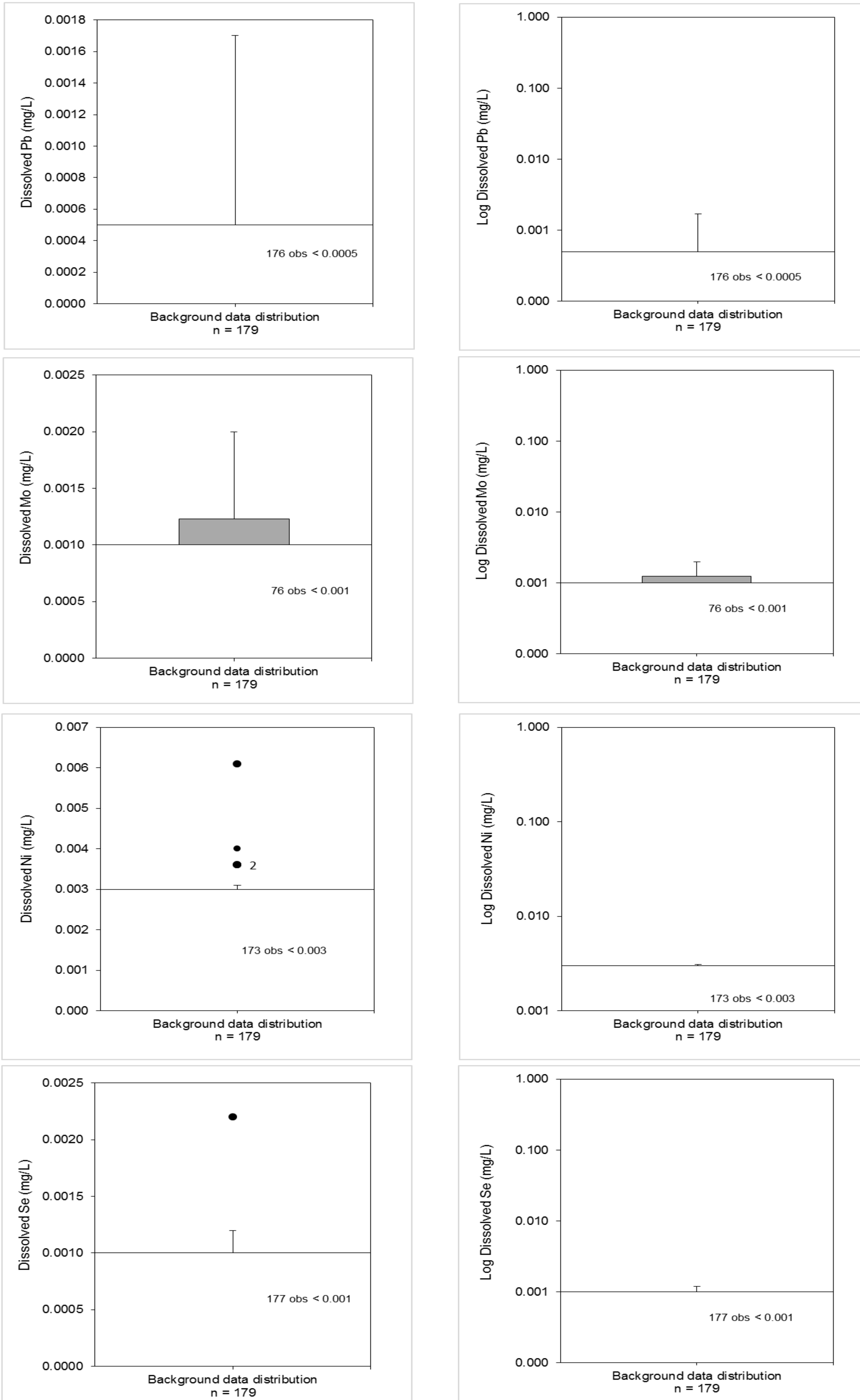



**Figure C.1: Boxplots of analytes on non-transformed and log transformed scales. Black dots represent possible outliers. Line represents highest < MDL and any < MDL below this are represented as number of observations below this line.**

NOTE: Possible outliers were only considered if they were detected on both non-transformed and log transformed scales

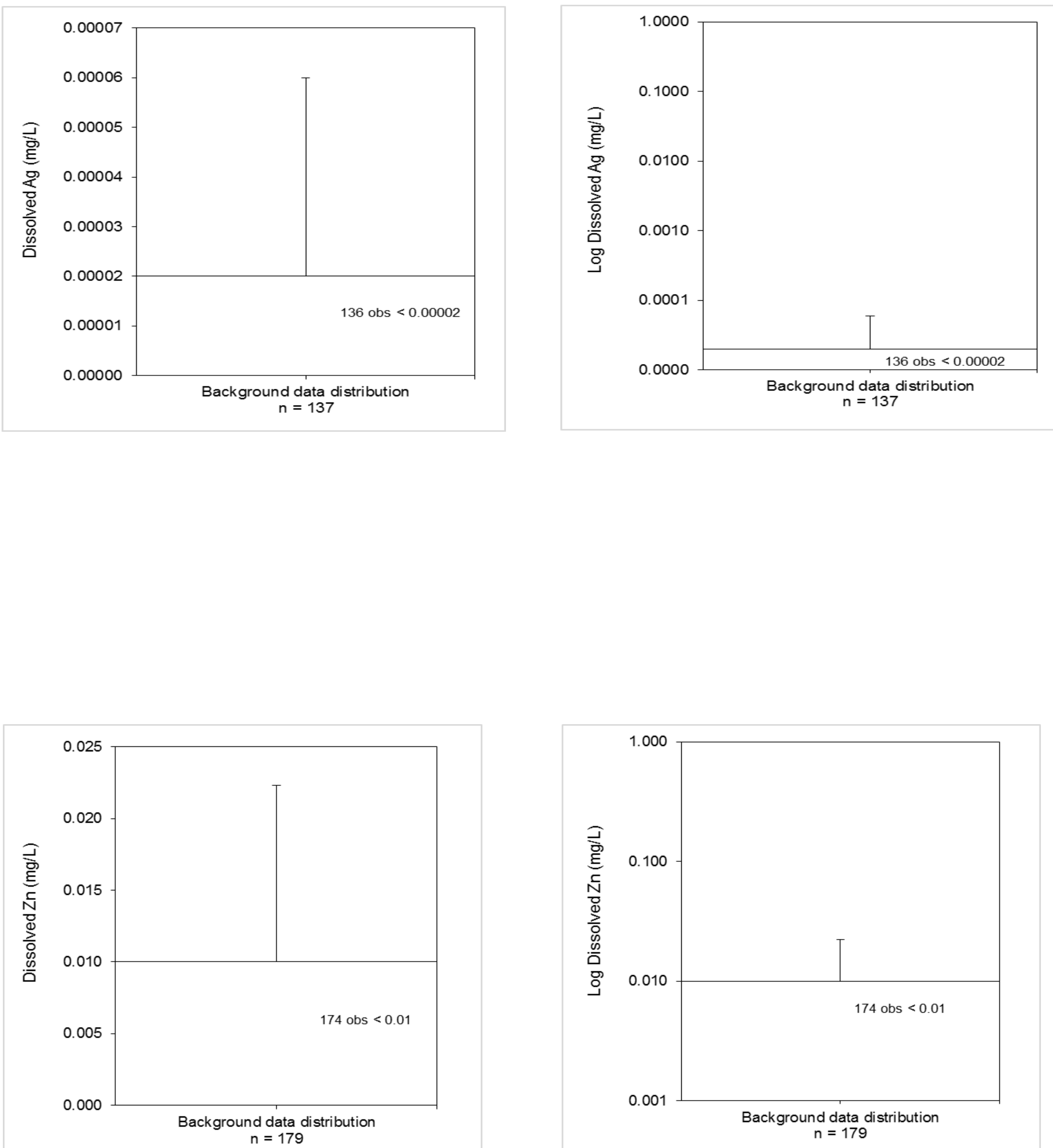



**Figure C.1: Boxplots of analytes on non-transformed and log transformed scales. Black dots represent possible outliers. Line represents highest < MDL and any < MDL below this are represented as number of observations below this line.**

NOTE: Possible outliers were only considered if they were detected on both non-transformed and log transformed scales

# APPENDIX D

# WATER QUALITY DATA SUMMARY CALCULATIONS

**Table D.1: Comparisons of dissolved arsenic ratios, relative to other analytes. Highlighted cells represent the sample with the potential arsenic concentration outlier**

| Station | Date | Arsenic Relative to: | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
| C4 | 11/17/2013 | 0.00018 | 0.000022 | 0.000021 | 0.00025 | 0.000021 | 0.020 | 0.22 | 0.056 | 0.00071 | 0.00078 | 0.17 | 254 | 4.3 | 5.9 | 0.00039 | 56 | 5.1 | 0.92 | 23 | 559 | 2.2 |
| Summary Statistics | Average | 0.00013 | 0.0000059 | 0.0000051 | 0.00010 | 0.0000038 | 0.034 | 0.32 | 0.026 | 0.000072 | 0.000093 | 0.038 | 76 | 1.2 | 0.40 | 0.0044 | 7.0 | 0.75 | 0.45 | 5.0 | 73 | 0.27 |
| | Minimum | 0.0000057 | 0.00000078 | 0.0000010 | 0.00000047 | 0.00000064 | 0.0012 | 0.0020 | 0.00067 | 0.000012 | 0.000013 | 0.0019 | 1.3 | 0.077 | 0.020 | 0.00039 | 0.18 | 0.067 | 0.10 | 0.045 | 6.7 | 0.011 |
| | Maximum | 0.0079 | 0.000024 | 0.000021 | 0.0011 | 0.000021 | 0.60 | 1.2 | 0.24 | 0.00071 | 0.00078 | 0.24 | 450 | 4.5 | 5.9 | 0.042 | 56 | 5.1 | 2.0 | 39 | 559 | 2.2 |
| | Median | 0.000047 | 0.0000046 | 0.0000044 | 0.000036 | 0.0000031 | 0.022 | 0.20 | 0.0083 | 0.000058 | 0.000064 | 0.033 | 60 | 1.0 | 0.25 | 0.0029 | 5.0 | 0.50 | 0.40 | 2.5 | 58 | 0.19 |
| | 95th Percentile | 0.00010 | 0.000016 | 0.000010 | 0.00037 | 0.000010 | 0.081 | 1.1 | 0.10 | 0.00018 | 0.00025 | 0.084 | 282 | 3.0 | 1.0 | 0.013 | 19 | 1.7 | 0.83 | 18 | 180 | 0.84 |
| | Standard Deviation | 0.00076 | 0.0000043 | 0.0000030 | 0.00016 | 0.0000026 | 0.058 | 0.32 | 0.044 | 0.000068 | 0.000096 | 0.032 | 89 | 0.87 | 0.51 | 0.0052 | 6.6 | 0.66 | 0.24 | 6.7 | 60 | 0.29 |

## Table D.2: Background data for Option 1 with median and 95th Percentile values.

| Station | Date | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W1 | 5/27/2005 | | | 97 | 27 | 137 | 0.039 | 0.0020 | 0.054 | 8.05 | | 0.018 | 0.00051 | 0.000025 | 0.00050 | 0.0034 | 0.17 | 0.00025 | 0.00050 | 0.0015 | 0.00050 | 0.000010 | 0.0025 |
| W1 | 6/30/2005 | | | | 1.5 | 189 | 0.010 | 0.00050 | 0.063 | 8.17 | | 0.0065 | 0.00048 | 0.000025 | 0.00025 | 0.0020 | 0.046 | 0.000025 | 0.0011 | 0.00096 | 0.00050 | 0.0000050 | 0.0005 |
| W1 | 7/28/2005 | | | 157 | 1.5 | 189 | 0.010 | 0.00050 | 0.058 | 8.03 | | 0.0072 | 0.00048 | 0.000025 | 0.00025 | 0.0021 | 0.056 | 0.000073 | 0.0013 | 0.0011 | 0.00050 | 0.0000050 | 0.0025 |
| W1 | 8/29/2005 | | | 138 | 4.0 | 186 | 0.041 | 0.00050 | 0.022 | 8.28 | | 0.011 | 0.00060 | 0.0000085 | 0.00050 | 0.0024 | 0.25 | 0.00025 | 0.0010 | 0.0014 | 0.00050 | 0.000010 | 0.0025 |
| W1 | 9/28/2005 | | | 134 | 10 | 178 | 0.026 | 0.00050 | 0.048 | 7.59 | | 0.014 | 0.00058 | 0.0000085 | 0.00050 | 0.0026 | 0.33 | 0.00025 | 0.00050 | 0.0016 | 0.00050 | 0.000010 | 0.0025 |
| W1 | 10/15/2005 | | | 140 | 15 | 181 | 0.020 | 0.00050 | 0.13 | 8.13 | | 0.014 | 0.00054 | 0.000025 | 0.00025 | 0.0028 | 0.27 | 0.000025 | 0.00089 | 0.0014 | 0.00050 | 0.0000050 | 0.0014 |
| W2 | 5/27/2005 | | | 86 | 50 | 109 | 0.018 | 0.0010 | 0.045 | 8.05 | | 0.014 | 0.00025 | 0.000025 | 0.00050 | 0.0033 | 0.16 | 0.00025 | 0.00050 | 0.0015 | 0.00050 | 0.000010 | 0.0025 |
| W2 | 6/30/2005 | | | | 1.5 | 190 | 0.010 | 0.00050 | 0.062 | 8.17 | | 0.0073 | 0.00044 | 0.000025 | 0.00025 | 0.0021 | 0.039 | 0.000025 | 0.0011 | 0.0010 | 0.00050 | 0.0000050 | 0.0015 |
| W2 | 7/28/2005 | | | 153 | 1.5 | 194 | 0.010 | 0.00050 | 0.012 | 8.01 | | 0.0071 | 0.00044 | 0.000025 | 0.00025 | 0.0021 | 0.05 | 0.000025 | 0.0013 | 0.0011 | 0.00050 | 0.0000050 | 0.0011 |
| W2 | 8/30/2005 | | | 138 | 3.5 | 193 | 0.029 | 0.00050 | 0.014 | 8.26 | | 0.012 | 0.00058 | 0.0000085 | 0.00050 | 0.0024 | 0.23 | 0.00025 | 0.0010 | 0.0015 | 0.00050 | 0.000010 | 0.0025 |
| W2 | 9/28/2005 | | | 134 | 9.0 | 170 | 0.010 | 0.0010 | 0.046 | 7.90 | | 0.014 | 0.00059 | 0.0000085 | 0.00050 | 0.0025 | 0.34 | 0.00025 | 0.00050 | 0.0017 | 0.00050 | 0.000010 | 0.0025 |
| W2 | 10/15/2005 | | | 137 | 5.5 | 179 | 0.010 | 0.00050 | 0.13 | 8.11 | | 0.013 | 0.00053 | 0.000025 | 0.00025 | 0.0027 | 0.25 | 0.000025 | 0.00086 | 0.0014 | 0.00050 | 0.0000050 | 0.00050 |
| W3 | 5/27/2005 | | | 94 | 8.5 | 141 | 0.010 | 0.00050 | 0.012 | 7.99 | | 0.027 | 0.00025 | 0.000025 | 0.00050 | 0.0066 | 0.12 | 0.00025 | 0.00050 | 0.0014 | 0.00050 | 0.000010 | 0.0025 |
| W3 | 6/30/2005 | | | | 1.5 | 224 | 0.010 | 0.00050 | 0.052 | 8.22 | | 0.0080 | 0.00034 | 0.000025 | 0.00025 | 0.0034 | 0.042 | 0.00024 | 0.0016 | 0.00078 | 0.00050 | 0.0000050 | 0.012 |
| W3 | 7/29/2005 | | | 166 | 26 | 198 | 0.010 | 0.00050 | 0.028 | 8.06 | | 0.011 | 0.00041 | 0.000025 | 0.00025 | 0.0048 | 0.13 | 0.000025 | 0.0016 | 0.0012 | 0.00050 | 0.0000050 | 0.0015 |
| W3 | 8/29/2005 | | | 135 | 7.5 | 182 | 0.042 | 0.00050 | 0.0025 | 8.24 | | 0.018 | 0.00025 | 0.0000085 | 0.00050 | 0.0050 | 0.31 | 0.00025 | 0.0013 | 0.0014 | 0.00050 | 0.000010 | 0.0025 |
| W3 | 9/28/2005 | | | 129 | 8.0 | 174 | 0.010 | 0.00050 | 0.013 | 7.99 | | 0.026 | 0.00025 | 0.0000085 | 0.00050 | 0.0057 | 0.42 | 0.00025 | 0.0011 | 0.0014 | 0.00050 | 0.000010 | 0.0025 |
| W3 | 10/15/2005 | | | 134 | 1.5 | 176 | 0.023 | 0.00050 | 0.039 | 8.08 | | 0.022 | 0.00043 | 0.000025 | 0.00025 | 0.0061 | 0.39 | 0.000025 | 0.0012 | 0.0012 | 0.00050 | 0.0000050 | 0.0018 |
| W9 | 5/27/2005 | | | 49 | 1.5 | 104 | 0.010 | 0.00050 | 0.0025 | 7.56 | | 0.072 | 0.00025 | 0.000025 | 0.00050 | 0.0035 | 0.25 | 0.00025 | 0.00050 | 0.0013 | 0.00050 | 0.000010 | 0.0025 |
| W9 | 6/30/2005 | | | | 1.5 | 126 | 0.020 | 0.00050 | 0.0025 | 7.63 | | 0.035 | 0.00054 | 0.000025 | 0.00025 | 0.0018 | 0.53 | 0.000025 | 0.00037 | 0.0012 | 0.00050 | 0.0000050 | 0.00050 |
| W9 | 7/29/2005 | | | 95 | 3.7 | 129 | 0.010 | 0.00050 | 0.0025 | 7.51 | | 0.030 | 0.00057 | 0.000025 | 0.00025 | 0.0033 | 0.65 | 0.00019 | 0.0011 | 0.0013 | 0.00050 | 0.0000050 | 0.0040 |
| W9 | 8/29/2005 | | | 74 | 1.5 | 126 | 0.026 | 0.0016 | 0.0025 | 7.84 | | 0.045 | 0.00058 | 0.000022 | 0.00050 | 0.0017 | 0.67 | 0.00025 | 0.00050 | 0.0012 | 0.00050 | 0.000010 | 0.0025 |
| W9 | 9/28/2005 | | | 68 | 1.5 | 118 | 0.010 | 0.00050 | 0.0025 | 7.62 | | 0.058 | 0.00025 | 0.0000085 | 0.00050 | 0.0022 | 0.60 | 0.00025 | 0.00050 | 0.0011 | 0.00050 | 0.000010 | 0.0025 |
| W9 | 10/15/2005 | | | 64 | 1.5 | 111 | 0.010 | 0.00050 | 0.0025 | 7.19 | | 0.056 | 0.00039 | 0.000025 | 0.00025 | 0.0021 | 0.44 | 0.000025 | 0.00031 | 0.00096 | 0.00050 | 0.0000050 | 0.0017 |
| W10 | 5/27/2005 | | | 46 | 1.5 | 115 | 0.019 | 0.00050 | 0.0094 | 7.47 | | 0.14 | 0.00025 | 0.000025 | 0.00050 | 0.0095 | 0.061 | 0.00025 | 0.00050 | 0.0011 | 0.00050 | 0.000010 | 0.0055 |
| W10 | 6/30/2005 | | | | 6.0 | 116 | 0.036 | 0.00050 | 0.0025 | 7.31 | | 0.11 | 0.00059 | 0.000025 | 0.00062 | 0.0047 | 0.40 | 0.000082 | 0.00014 | 0.0018 | 0.00050 | 0.0000050 | 0.022 |
| W10 | 7/29/2005 | | | 55 | 4.2 | 105 | 0.010 | 0.00050 | 0.0025 | 7.34 | | 0.068 | 0.00037 | 0.000025 | 0.00025 | 0.0044 | 0.099 | 0.00011 | 0.00014 | 0.0012 | 0.00050 | 0.0000050 | 0.0074 |
| W10 | 8/29/2005 | | | 70 | 13 | 117 | 0.033 | 0.00050 | 0.0025 | 7.74 | | 0.043 | 0.00025 | 0.0000085 | 0.00050 | 0.0040 | 0.081 | 0.00025 | 0.00050 | 0.0016 | 0.00050 | 0.000010 | 0.0052 |
| W10 | 9/28/2005 | | | 101 | 15 | 141 | 0.010 | 0.00050 | 0.0025 | 7.77 | | 0.030 | 0.00025 | 0.0000085 | 0.00050 | 0.0033 | 0.048 | 0.00025 | 0.00050 | 0.00050 | 0.00050 | 0.000010 | 0.0025 |
| W10 | 10/15/2005 | | | 100 | 6.5 | 138 | 0.010 | 0.00050 | 0.0025 | 7.30 | | 0.036 | 0.00030 | 0.000025 | 0.00025 | 0.0041 | 0.055 | 0.00003 | 0.00024 | 0.00073 | 0.00050 | 0.0000050 | 0.0015 |
| W6 | 5/27/2005 | | | 65 | 14 | 103 | 0.010 | 0.0016 | 0.032 | 7.91 | | 0.014 | 0.00025 | 0.000025 | 0.00050 | 0.0016 | 0.072 | 0.00025 | 0.00050 | 0.0015 | 0.00050 | 0.000010 | 0.0025 |
| W6 | 6/30/2005 | | | | 12 | 123 | 0.010 | 0.00050 | 0.0086 | 7.41 | | 0.0056 | 0.00039 | 0.000025 | 0.00025 | 0.0010 | 0.015 | 0.000025 | 0.00045 | 0.00099 | 0.00050 | 0.0000050 | 0.021 |
| W6 | 7/29/2005 | | | 171 | 22 | 198 | 0.010 | 0.00050 | 0.022 | 8.01 | | 0.0070 | 0.00026 | 0.000025 | 0.00025 | 0.0025 | 0.062 | 0.000083 | 0.00082 | 0.00060 | 0.00050 | 0.0000050 | 0.0025 |
| W6 | 8/30/2005 | | | 106 | 1.5 | 147 | 0.010 | 0.00050 | 0.0025 | 8.17 | | 0.0067 | 0.00025 | 0.0000085 | 0.00050 | 0.0010 | 0.064 | 0.00025 | 0.00050 | 0.0011 | 0.00050 | 0.000010 | 0.0025 |
| W6 | 9/28/2005 | | | 106 | 3.5 | 133 | 0.010 | 0.00050 | 0.0025 | 7.95 | | 0.0067 | 0.00025 | 0.0000085 | 0.00050 | 0.0011 | 0.10 | 0.00025 | 0.00050 | 0.0012 | 0.00050 | 0.000010 | 0.0025 |
| W6 | 10/15/2005 | | | 98 | 1.5 | 128 | 0.010 | 0.00050 | 0.0061 | 7.92 | | 0.077 | 0.00042 | 0.000025 | 0.00025 | 0.0011 | 0.088 | 0.000025 | 0.00040 | 0.00118 | 0.00050 | 0.0000050 | 0.0015 |
| W6 | 6/2/2006 | | | | 115 | 96 | 0.021 | 0.00050 | 0.024 | 7.64 | | 0.025 | 0.00044 | 0.000025 | 0.00025 | 0.0018 | 0.096 | 0.000025 | 0.00031 | 0.00182 | 0.00050 | 0.0000050 | 0.0030 |
| W6 | 8/25/2006 | | 120 | | | 160 | | | 0.015 | 8.01 | | | | | | | | | | | | | |
| W6 | 9/6/2006 | | 110 | | 4.0 | | | | 0.015 | 7.86 | | 0.0080 | 0.00050 | 0.0000050 | 0.00060 | 0.0010 | 0.11 | 0.000050 | 0.00050 | 0.00060 | 0.00010 | | 0.0020 |
| W6 | 6/20/2007 | | | 81 | 16 | 130 | 0.025 | 0.025 | 0.10 | 7.77 | | | | | | | | | | | | | |
| W6 | 9/18/2007 | | | 93 | 8.0 | 172 | 0.025 | 0.010 | 0.010 | 7.95 | | | | | | | | | | | | | |
| W6 | 6/17/2008 | | | 86 | 17 | 120 | 0.025 | 0.070 | 0.010 | 7.82 | | | | | | | | | | | | | |
| W6 | 9/18/2008 | 18 | | | 4.0 | 150 | 0.025 | 0.0050 | 0.0050 | 7.80 | | 0.012 | 0.00040 | 0.0000050 | 0.0013 | 0.0020 | 0.090 | 0.000050 | 0.00027 | 0.0020 | 0.0012 | 0.0000050 | 0.0030 |
| W6 | 7/17/2012 | 8.0 | 104 | 163 | 1130 | 122 | 0.14 | 0.0025 | 0.026 | 7.98 | 7.92 | 0.016 | 0.00053 | 0.0000050 | 0.00050 | 0.0011 | 0.068 | 0.00010 | 0.00050 | 0.0010 | 0.00012 | 0.000010 | 0.0025 |
| W6 | 7/30/2012 | 8.1 | 101 | 145 | 614 | 124 | 0.070 | 0.0072 | 0.052 | 8.09 | 7.89 | 0.019 | 0.00059 | 0.0000050 | 0.00050 | 0.00089 | 0.081 | 0.00010 | 0.00050 | 0.00050 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 8/9/2012 | | 112 | 136 | 566 | 144 | 0.025 | 0.0066 | 0.022 | 8.17 | 8.09 | 0.017 | 0.00081 | 0.0000050 | 0.00050 | 0.00083 | 0.085 | 0.00010 | 0.00050 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| W6 | 8/25/2012 | 7.7 | 103 | 161 | 1160 | 138 | 0.023 | 0.0025 | 0.045 | 8.00 | 7.76 | 0.014 | 0.00081 | 0.0000050 | 0.00050 | 0.0010 | 0.080 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 9/13/2012 | 14 | 88 | 93 | 50 | 118 | 0.011 | 0.0025 | 0.034 | 8.04 | 7.95 | 0.017 | 0.00047 | 0.0000050 | 0.00050 | 0.0015 | 0.11 | 0.00010 | 0.00050 | 0.0014 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 10/13/2012 | 10 | | 117 | 45 | 150 | 0.016 | 0.0025 | 0.042 | 7.92 | 8.30 | | | | | | | | | | | | |

## Table D.2: Background data for Option 1 with median and 95th Percentile values.

| Station | Date | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W6 | 11/12/2012 | 8.7 | 153 | 155 | 2.2 | 162 | 0.025 | 0.0025 | 0.010 | 7.93 | 6.69 | 0.0062 | 0.00039 | 0.0000050 | 0.00050 | 0.0014 | 0.024 | 0.00010 | 0.00050 | 0.0014 | 0.00010 | 0.000010 | 0.0025 |
| W6 | 5/14/2013 | 22 | 31 | 34 | 13 | 84 | 0.13 | 0.0025 | 0.010 | 7.48 | 7.60 | 0.059 | 0.00037 | 0.000012 | 0.00050 | 0.0035 | 0.18 | 0.00010 | 0.00050 | 0.0013 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 6/22/2013 | 7.8 | 95 | 115 | 172 | 118 | 0.024 | 0.013 | 0.028 | 8.07 | 7.61 | 0.0095 | 0.00053 | 0.0000050 | 0.00050 | 0.00096 | 0.072 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 7/12/2013 | 8.3 | 88 | 95 | 25 | 136 | 0.012 | 0.0025 | 0.010 | 7.90 | 7.69 | 0.0066 | 0.00046 | 0.0000050 | 0.00050 | 0.00095 | 0.11 | 0.00010 | 0.00050 | 0.0011 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 8/22/2013 | 7.4 | 102 | 106 | 20 | 144 | 0.014 | 0.0025 | 0.010 | 8.04 | 7.81 | 0.0084 | 0.00052 | 0.0000050 | 0.00050 | 0.0012 | 0.10 | 0.00010 | 0.00050 | 0.0011 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 9/6/2013 | 6.4 | 101 | 114 | 5.2 | 130 | 0.0061 | 0.0025 | 0.030 | 7.95 | 7.60 | 0.0083 | 0.00056 | 0.0000050 | 0.00050 | 0.00089 | 0.11 | 0.00010 | 0.00050 | 0.0011 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 10/7/2013 | 8.2 | 107 | 106 | 74 | 176 | 0.044 | 0.0025 | 0.042 | 8.08 | 7.66 | 0.013 | 0.00051 | 0.0000050 | 0.00050 | 0.00097 | 0.15 | 0.00010 | 0.00050 | 0.0013 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 11/16/2013 | 8.8 | 119 | 123 | 33 | 120 | 0.015 | 0.0025 | 0.010 | 8.11 | 7.96 | 0.0057 | 0.00048 | 0.0000050 | 0.00050 | 0.00084 | 0.12 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W6 | 12/7/2013 | 8.8 | 159 | 182 | 3.6 | 194 | 0.0076 | 0.0025 | 0.010 | 8.21 | 7.50 | 0.0041 | 0.00061 | 0.000011 | 0.00050 | 0.0016 | 0.014 | 0.00010 | 0.00050 | 0.0011 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 5/27/2005 | | | 77 | 31 | 116 | 0.010 | 0.0018 | 0.082 | 7.95 | | 0.024 | 0.00025 | 0.000025 | 0.00050 | 0.0018 | 0.14 | 0.00025 | 0.00050 | 0.0016 | 0.00050 | 0.000010 | 0.0025 |
| W7 | 6/30/2005 | | | | 14 | 153 | 0.010 | 0.0017 | 0.17 | 7.87 | | 0.0086 | 0.00042 | 0.000025 | 0.00025 | 0.0012 | 0.070 | 0.000025 | 0.0012 | 0.00093 | 0.00050 | 0.0000050 | 0.0064 |
| W7 | 7/29/2005 | | | 167 | 20 | 197 | 0.010 | 0.00050 | 0.17 | 7.18 | | 0.0096 | 0.00035 | 0.000025 | 0.00025 | 0.0040 | 0.11 | 0.000025 | 0.0013 | 0.00095 | 0.00050 | 0.0000050 | 0.0020 |
| W7 | 8/30/2005 | | | 109 | 3.0 | 148 | 0.020 | 0.00050 | 0.023 | 8.19 | | 0.016 | 0.00051 | 0.0000085 | 0.00050 | 0.0014 | 0.29 | 0.00025 | 0.0010 | 0.0015 | 0.00050 | 0.000010 | 0.0025 |
| W7 | 9/28/2005 | | | 107 | 361 | 142 | 0.010 | 0.00050 | 0.059 | 8.02 | | 0.019 | 0.00054 | 0.0000085 | 0.00050 | 0.0016 | 0.32 | 0.00025 | 0.00050 | 0.0018 | 0.00050 | 0.000010 | 0.0025 |
| W7 | 10/15/2005 | | | 106 | 7.5 | 145 | 0.021 | 0.00050 | 0.10 | 6.75 | | 0.016 | 0.00048 | 0.000025 | 0.00025 | 0.0013 | 0.25 | 0.000025 | 0.00093 | 0.0015 | 0.00050 | 0.0000050 | 0.00050 |
| W7 | 6/2/2006 | | | | 705 | 104 | 0.062 | 0.0015 | 0.045 | 7.61 | | 0.071 | 0.00062 | 0.000025 | 0.00055 | 0.0021 | 0.55 | 0.000054 | 0.00070 | 0.0022 | 0.00050 | 0.0000050 | 0.00050 |
| W7 | 6/8/2006 | | | | | | | | | | | | | | | | | | | | | | |
| W7 | 6/15/2006 | | 100 | | 53 | 114 | 0.027 | | 0.18 | 7.86 | | 0.013 | 0.00040 | 0.0000050 | 0.00025 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.0010 | 0.00020 | | 0.00050 |
| W7 | 6/23/2006 | | 122 | | 328 | 176 | 0.028 | | 0.23 | 7.78 | | 0.011 | 0.00050 | 0.0000050 | 0.00070 | 0.00050 | 0.090 | 0.000050 | 0.0010 | 0.0013 | 0.00030 | | 0.0020 |
| W7 | 6/28/2006 | | 107 | | 103 | 120 | 0.010 | | 0.11 | 7.90 | | 0.41 | 0.00080 | 0.000030 | 0.0015 | 0.0030 | 0.060 | 0.00050 | 0.00050 | 0.0036 | 0.00010 | | 0.0050 |
| W7 | 7/7/2006 | | 110 | | 3.0 | 184 | | | 0.21 | 7.91 | | 0.0025 | 0.00060 | 0.0000050 | 0.0011 | 0.0010 | 0.060 | 0.000050 | 0.0020 | 0.0015 | 0.00010 | | 0.0010 |
| W7 | 7/12/2006 | | 110 | | 1.0 | | 0.014 | | 0.18 | 7.77 | | 0.0060 | 0.00050 | 0.0000050 | 0.0010 | 0.0010 | 0.060 | 0.000050 | 0.0010 | 0.00070 | 0.00020 | | 0.00050 |
| W7 | 7/20/2006 | | 130 | | 2.0 | | 0.012 | | 0.19 | 7.88 | | 0.0060 | 0.00040 | 0.0000050 | 0.00070 | 0.00050 | 0.11 | 0.00020 | 0.0010 | 0.00060 | 0.00010 | | 0.00050 |
| W7 | 7/26/2006 | | 128 | | 9.0 | | 0.016 | | 0.18 | 7.87 | | 0.0080 | 0.00040 | 0.0000050 | 0.00025 | 0.0020 | 0.10 | 0.000050 | 0.00050 | 0.0021 | 0.00010 | | 0.00050 |
| W7 | 8/2/2006 | | 128 | | 4.0 | | 0.015 | | 0.15 | 7.79 | | 0.0080 | 0.00010 | 0.0000050 | 0.00025 | 0.0010 | 0.070 | 0.000050 | 0.00050 | 0.00060 | 0.00010 | | 0.00050 |
| W7 | 8/10/2006 | | 126 | | 1.0 | | 0.014 | | 0.16 | 7.80 | | 0.0090 | 0.00050 | 0.0000050 | 0.00070 | 0.0010 | 0.080 | 0.000050 | 0.0010 | 0.00060 | 0.00010 | | 0.0010 |
| W7 | 8/25/2006 | | 129 | | | 180 | 0.027 | | 0.12 | 7.92 | | 0.012 | 0.00040 | 0.0000050 | 0.00060 | 0.0010 | 0.080 | 0.000050 | 0.0010 | 0.00090 | 0.00010 | | 0.0030 |
| W7 | 8/30/2006 | | 132 | | 1.0 | 200 | 0.012 | | 0.11 | 7.79 | | 0.013 | 0.00040 | 0.0000050 | 0.00080 | 0.0020 | 0.10 | 0.000050 | 0.0010 | 0.0012 | 0.00010 | | 0.0050 |
| W7 | 9/6/2006 | | 130 | | 4.0 | | 0.011 | | 0.080 | 7.88 | | 0.0050 | 0.00050 | 0.0000050 | 0.00080 | 0.0020 | 0.10 | 0.000050 | 0.0010 | 0.0010 | 0.00010 | | 0.0020 |
| W7 | 9/13/2006 | | 130 | | 5.0 | | 0.011 | | 0.094 | 7.84 | | 0.0080 | 0.00030 | 0.0000050 | 0.00090 | 0.0010 | 0.11 | 0.000050 | 0.0010 | 0.00090 | 0.00010 | | 0.0010 |
| W7 | 9/20/2006 | | 132 | | 3.0 | | 0.0080 | | 0.11 | 7.85 | | 0.0070 | 0.00050 | 0.00028 | 0.00070 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.00025 | 0.00020 | | 0.00050 |
| W7 | 9/28/2006 | | 129 | | | 182 | 0.011 | | 0.080 | 7.26 | | 0.011 | 0.00040 | 0.0000050 | 0.00080 | 0.0010 | 0.080 | 0.000050 | 0.0010 | 0.00080 | 0.00010 | | 0.0020 |
| W7 | 10/4/2006 | | 126 | | 2.0 | | 0.079 | | 0.10 | 7.94 | | 0.0025 | 0.00030 | 0.0000050 | 0.00025 | 0.00050 | 0.11 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | | 0.0010 |
| W7 | 10/12/2006 | | 132 | | 4.0 | 164 | 0.024 | | 0.12 | 7.39 | | 0.0070 | 0.00040 | 0.0000050 | 0.00025 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.00060 | 0.00030 | | 0.0020 |
| W7 | 6/5/2007 | | | 113 | 75 | 162 | 0.025 | 0.033 | 0.050 | 7.97 | | | | | | | | | | | | | |
| W7 | 6/20/2007 | 8.2 | 110 | | 6.0 | 164 | 0.025 | 0.025 | 0.30 | 7.84 | | 0.014 | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.050 | 0.000050 | 0.0010 | 0.00025 | 0.00010 | | 0.0040 |
| W7 | 7/18/2007 | 14 | 128 | 125 | 5.7 | 179 | 0.025 | 0.025 | 0.30 | 7.78 | | 0.011 | 0.00050 | 0.0000050 | 0.0010 | 0.0020 | 0.040 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | | 0.0060 |
| W7 | 8/24/2007 | | | 124 | 4.7 | 192 | 0.025 | 0.025 | 0.20 | 8.04 | | | | | | | | | | | | | |
| W7 | 9/18/2007 | 11 | 110 | | 20 | 182 | 0.025 | 0.010 | 0.050 | 8.00 | | 0.0070 | 0.00040 | 0.0000050 | 0.0016 | 0.0010 | 0.080 | 0.000050 | 0.0020 | 0.00080 | 0.00010 | | 0.0020 |
| W7 | 10/30/2007 | | | 129 | 6.5 | 174 | 0.025 | 0.14 | 0.010 | 7.73 | | | | | | | | | | | | | |
| W7 | 4/22/2008 | | 187 | | 1.0 | 268 | 0.025 | 0.055 | 0.010 | 8.40 | | 0.010 | 0.00027 | 0.000040 | 0.00097 | 0.0012 | 0.030 | 0.000067 | 0.0017 | 0.0010 | 0.00030 | | 0.0017 |
| W7 | 6/3/2008 | | 92 | 98 | 15 | 137 | 0.025 | 0.040 | 0.037 | 8.02 | | 0.0050 | 0.00010 | 0.000040 | 0.0013 | 0.00050 | 0.050 | 0.000050 | 0.0012 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| W7 | 6/17/2008 | | | | 10 | 156 | 0.025 | 0.050 | 0.14 | 7.95 | | 0.020 | 0.00010 | 0.000040 | 0.0013 | 0.0010 | 0.070 | 0.000050 | 0.0015 | 0.0010 | 0.00220 | 0.0000050 | 0.0020 |
| W7 | 8/6/2008 | 9.0 | 123 | 124 | 105 | 167 | 0.025 | 0.0050 | 0.14 | 7.92 | | 0.014 | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.070 | 0.000050 | 0.0010 | 0.0010 | 0.00010 | 0.000060 | 0.0060 |
| W7 | 9/18/2008 | 17 | | | 28 | 170 | 0.025 | 0.0050 | 0.030 | 7.89 | | 0.070 | 0.00030 | 0.0000050 | 0.0016 | 0.0040 | 0.20 | 0.0017 | 0.00072 | 0.0010 | 0.00030 | 0.0000050 | 0.0030 |
| W7 | 10/28/2008 | 11 | 123 | | 5.7 | 183 | 0.025 | | | 7.84 | | 0.0090 | 0.00050 | 0.0000050 | 0.00050 | 0.0010 | 0.078 | 0.000050 | 0.0011 | 0.0010 | 0.00030 | 0.0000050 | 0.0010 |
| W7 | 4/30/2009 | 18 | 20 | | 1.0 | 52 | | | | 6.84 | 7.60 | 0.053 | 0.00010 | 0.000080 | 0.00060 | 0.0050 | 0.070 | 0.00010 | 0.00013 | 0.00050 | 0.00030 | 0.0000050 | 0.0090 |
| W7 | 6/8/2009 | 9.2 | 93 | | 32 | 156 | | | | 7.90 | 7.74 | 0.013 | 0.00030 | 0.0000050 | 0.00020 | 0.0020 | 0.050 | 0.000050 | 0.0013 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| W7 | 7/28/2009 | | 137 | | 4.0 | 184 | | | | 8.07 | | | | | | | | | | | | | |

**Table D.2: Background data for Option 1 with median and 95th Percentile values.**

| Station | Date | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 8/6/2009 | | 121 | | 2.0 | 202 | | | 0.18 | 8.35 | 7.50 | | | | | | | | | | | | |
| W7 | 8/25/2009 | 8.2 | | | | | | | | | 8.04 | | | | | | | | | | | | |
| W7 | 8/31/2009 | | 110 | | | | | | | | | 0.010 | 0.00040 | 0.0000050 | 0.0012 | 0.0040 | 0.10 | 0.00040 | 0.0011 | 0.0010 | 0.00030 | 0.0000050 | 0.0010 |
| W7 | 10/7/2009 | 7.8 | 125 | 141 | 3.7 | 140 | 0.010 | 0.0025 | 0.14 | 7.99 | 8.24 | 0.0070 | 0.00030 | 0.000040 | 0.00050 | 0.0012 | 0.046 | 0.00010 | 0.0010 | 0.00050 | 0.00020 | 0.000010 | 0.0025 |
| W7 | 10/25/2009 | 8.7 | 126 | 141 | 2.0 | 120 | 0.010 | 0.0025 | 0.15 | 8.05 | 8.23 | 0.0070 | 0.00030 | 0.000040 | 0.00050 | 0.0012 | 0.046 | 0.00010 | 0.0010 | 0.00050 | 0.00020 | 0.000010 | 0.0025 |
| W7 | 4/19/2010 | | | 80 | 3.5 | 142 | | | | 7.81 | 7.31 | 0.019 | 0.00030 | 0.000020 | 0.00040 | 0.0060 | 0.090 | 0.00030 | 0.00080 | 0.00050 | 0.00030 | 0.0000050 | 0.0050 |
| W7 | 4/27/2010 | 23 | 36 | 35 | 2.0 | 62 | 0.015 | 0.0025 | 0.010 | 7.60 | 7.65 | 0.075 | 0.00030 | 0.0000050 | 0.00050 | 0.0041 | 0.15 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 4/29/2010 | 19 | 36 | 36 | 2.0 | 62 | 0.016 | 0.0050 | 0.020 | 7.50 | 7.72 | 0.065 | 0.00030 | 0.0000050 | 0.00050 | 0.0034 | 0.18 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 5/1/2010 | 19 | 41 | 44 | 15 | 74 | 0.031 | 0.0080 | 0.070 | 7.70 | 7.15 | 0.053 | 0.00040 | 0.000020 | 0.00050 | 0.0032 | 0.26 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 5/3/2010 | 22 | 45 | 46 | 12 | 80 | 0.016 | 0.0025 | 0.010 | 7.70 | 7.74 | 0.047 | 0.00040 | 0.0000050 | 0.00050 | 0.0027 | 0.38 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 5/5/2010 | 15 | 49 | 55 | 12 | 76 | 0.0050 | 0.0025 | 0.010 | 7.80 | | 0.038 | 0.00050 | 0.0000050 | 0.00050 | 0.0025 | 0.57 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 5/7/2010 | 13 | 57 | 56 | 18 | 62 | 0.051 | 0.0070 | 0.10 | 7.80 | 7.95 | 0.028 | 0.00040 | 0.000010 | 0.00050 | 0.0026 | 0.36 | 0.00010 | 0.00050 | 0.0020 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 5/9/2010 | 13 | 80 | 71 | 2.0 | 130 | 0.0025 | 0.0025 | 0.070 | 8.00 | 8.03 | 0.023 | 0.00040 | 0.0000050 | 0.00050 | 0.0018 | 0.30 | 0.00010 | 0.00050 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 5/10/2010 | 12 | 81 | 90 | 2.0 | 130 | 0.015 | 0.0060 | 0.13 | 8.10 | 8.06 | 0.021 | 0.00040 | 0.000020 | 0.00050 | 0.0022 | 0.28 | 0.00010 | 0.00050 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 5/12/2010 | 10 | 82 | 85 | 2.0 | 100 | 0.025 | 0.0025 | 0.030 | 8.00 | | 0.017 | 0.00040 | 0.0000050 | 0.00050 | 0.0016 | 0.17 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 5/14/2010 | 9.2 | 73 | 71 | 15 | 130 | 0.034 | 0.0025 | 0.010 | 8.10 | 7.26 | 0.096 | 0.00040 | 0.000010 | 0.00050 | 0.0031 | 0.34 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 5/16/2010 | 8.8 | 86 | 76 | 12 | 120 | 0.068 | 0.0025 | 0.030 | 8.30 | 7.32 | 0.012 | 0.00030 | 0.0000050 | 0.00050 | 0.0013 | 0.080 | 0.00010 | 0.0010 | 0.00050 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 5/17/2010 | 7.2 | 80 | 76 | 11 | 130 | 0.037 | 0.0025 | 0.010 | 8.20 | 7.52 | 0.018 | 0.00040 | 0.0000050 | 0.00050 | 0.0012 | 0.068 | 0.00010 | 0.0010 | 0.00050 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 5/19/2010 | 7.5 | 99 | 103 | 4.0 | 120 | 0.020 | 0.0025 | 0.060 | 8.20 | 7.62 | 0.016 | 0.00030 | 0.0000050 | 0.00050 | 0.0017 | 0.069 | 0.00010 | 0.0010 | 0.00050 | 0.00030 | 0.000010 | 0.0025 |
| W7 | 5/21/2010 | 8.7 | 92 | 96 | 22 | 120 | 0.017 | 0.0025 | 0.050 | 8.10 | 8.02 | 0.013 | 0.00020 | 0.000050 | | 0.0010 | 0.057 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| W7 | 5/23/2010 | 8.2 | 98 | 103 | 33 | 150 | 0.013 | 0.0060 | 0.060 | 8.10 | 7.61 | 0.017 | 0.00020 | 0.000050 | | 0.0010 | 0.069 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| W7 | 5/25/2010 | 8.1 | 125 | 124 | 140 | 140 | 0.070 | 0.025 | 0.080 | 7.90 | 7.24 | 0.024 | 0.00050 | 0.000050 | | 0.0030 | 0.062 | 0.00010 | 0.0020 | 0.0015 | 0.00050 | | 0.0050 |
| W7 | 5/27/2010 | 8.1 | 113 | 148 | 350 | 140 | 0.052 | 0.0025 | 0.13 | 8.00 | 7.53 | 0.028 | 0.00050 | 0.000050 | | 0.0030 | 0.069 | 0.00010 | 0.0020 | 0.0015 | 0.00050 | | 0.0050 |
| W7 | 5/29/2010 | 6.3 | 111 | 129 | 200 | 160 | 0.10 | 0.011 | 0.22 | 8.20 | 7.73 | 0.017 | 0.00050 | 0.000050 | | 0.0020 | 0.051 | 0.00010 | 0.0020 | 0.0010 | 0.00040 | | 0.0050 |
| W7 | 5/31/2010 | 7.2 | 109 | 130 | 290 | 160 | 0.025 | 0.023 | 0.12 | 8.20 | 7.83 | 0.020 | 0.00020 | 0.000050 | | 0.0020 | 0.050 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/2/2010 | 4.9 | 113 | 135 | 81 | 140 | 0.0050 | 0.023 | 0.14 | 8.20 | 7.26 | 0.012 | 0.00040 | 0.000050 | | 0.0010 | 0.030 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/4/2010 | 6.4 | 111 | 125 | 60 | 140 | 0.34 | 0.014 | 0.16 | 8.20 | 7.48 | 0.013 | 0.00040 | 0.000050 | | 0.0010 | 0.030 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/6/2010 | | 128 | 133 | 39 | 170 | 0.10 | 0.013 | 0.16 | 8.20 | | 0.0050 | 0.00020 | 0.000050 | | 0.0010 | 0.024 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/14/2010 | 5.9 | 122 | 128 | 43 | 150 | 0.016 | 0.0025 | 0.16 | 8.29 | | 0.011 | 0.00020 | 0.000050 | | 0.00050 | 0.025 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/16/2010 | 6.1 | 120 | 128 | 17 | 150 | 0.016 | 0.0025 | 0.17 | 8.30 | 6.78 | 0.0050 | 0.00020 | 0.000050 | | 0.00050 | 0.026 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/18/2010 | 6.2 | 122 | 123 | 28 | 140 | | 0.0025 | 0.15 | 8.17 | 7.03 | 0.0050 | 0.00020 | 0.000050 | | 0.00050 | 0.023 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/20/2010 | 7.6 | 112 | 118 | 33 | 140 | | 0.0080 | 0.13 | 8.20 | 7.10 | 0.014 | 0.00020 | 0.000050 | | 0.0010 | 0.028 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 6/22/2010 | 10 | 98 | 115 | 300 | 140 | 0.014 | 0.0025 | 0.12 | 8.03 | 7.92 | 0.033 | 0.00050 | 0.000050 | | 0.0020 | 0.082 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| W7 | 6/24/2010 | 10 | 100 | 116 | 64 | 130 | 0.012 | 0.0070 | 0.070 | 8.03 | 7.95 | 0.018 | 0.00020 | 0.000050 | | 0.0010 | 0.056 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| W7 | 6/26/2010 | 9.3 | 106 | 106 | 21 | 120 | 0.0090 | 0.0025 | 0.10 | 8.26 | 8.03 | 0.012 | 0.00040 | 0.000050 | | 0.0010 | 0.038 | 0.00010 | 0.0010 | 0.0040 | 0.00040 | | 0.0050 |
| W7 | 6/28/2010 | 8.7 | 114 | 107 | 9.0 | 150 | 0.022 | 0.0025 | 0.13 | 8.03 | 7.89 | 0.0050 | 0.00020 | 0.000050 | | 0.0010 | 0.028 | 0.00010 | 0.0010 | 0.00050 | 0.00040 | | 0.0050 |
| W7 | 7/5/2010 | 16 | 93 | 106 | 53 | 150 | 0.027 | 0.0025 | 0.070 | 8.06 | 8.02 | 0.019 | 0.00020 | 0.000050 | | 0.0020 | 0.10 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| W7 | 8/5/2010 | 13 | 118 | 116 | | 170 | | | | | 7.91 | 0.011 | 0.00040 | 0.000050 | | 0.0020 | 0.11 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| W7 | 9/12/2010 | 17 | 107 | 104 | 11 | 210 | 0.039 | 0.0025 | 0.030 | 7.98 | 8.02 | 0.016 | 0.00050 | 0.000050 | | 0.0010 | 0.23 | 0.00010 | 0.0010 | 0.0020 | 0.00040 | | 0.0050 |
| W7 | 10/8/2010 | 13 | 111 | 126 | 3.0 | 150 | 0.069 | 0.0025 | 0.070 | 8.10 | 7.85 | 0.011 | 0.00040 | 0.0000050 | 0.00050 | 0.0012 | 0.13 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 4/27/2011 | 23 | 43 | 43 | 0.5 | 72 | 0.010 | 0.0025 | 0.010 | 7.41 | | 0.057 | 0.00030 | 0.000030 | 0.00050 | 0.0077 | 0.15 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0050 |
| W7 | 5/2/2011 | 22 | 32 | 33 | 7.0 | 40 | | 0.0025 | 0.010 | 7.11 | | 0.076 | 0.00020 | 0.000040 | 0.00050 | 0.0070 | 0.17 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.010 |
| W7 | 6/1/2011 | 11 | 92 | 94 | 23 | 120 | 0.012 | | | 8.09 | | 0.013 | 0.00030 | 0.0000050 | 0.00050 | 0.0016 | 0.099 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 6/16/2011 | 13 | 97 | 108 | 85 | 130 | 0.013 | 0.0025 | 0.10 | 8.00 | | 0.022 | 0.00040 | 0.0000050 | 0.00050 | 0.0019 | 0.21 | 0.00010 | 0.0010 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 7/1/2011 | 21 | 77 | 88 | 150 | 120 | 0.016 | 0.0070 | 0.050 | 7.76 | | 0.034 | 0.00070 | 0.000010 | 0.00050 | 0.0031 | 0.44 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 8/2/2011 | 24 | 59 | 86 | 400 | 110 | | 0.0025 | 0.060 | 7.67 | | 0.051 | 0.00070 | 0.000020 | 0.00050 | 0.0041 | 0.61 | 0.00010 | 0.00050 | 0.0030 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 8/16/2011 | 18 | 98 | 97 | 22 | 150 | 0.015 | 0.0025 | 0.060 | 7.90 | | 0.036 | 0.00070 | 0.0000050 | 0.00050 | 0.0019 | 0.59 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 8/19/2011 | 19 | 93 | 93 | 22 | 140 | 0.0060 | 0.0025 | 0.040 | 8.12 | | 0.033 | 0.00080 | 0.000010 | 0.00050 | 0.0020 | 0.56 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 9/12/2011 | 13 | 118 | 119 | 1.0 | 170 | 0.025 | 0.0025 | 0.050 | 8.03 | 7.92 | 0.024 | 0.00070 | 0.000010 | 0.00050 | 0.0016 | 0.62 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |

**Table D.2: Background data for Option 1 with median and 95th Percentile values.**

| Station | Date | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W7 | 10/6/2011 | 12 | 110 | 113 | 2.0 | 150 | 0.019 | 0.0025 | 0.11 | 8.07 | 7.65 | 0.013 | 0.00060 | 0.000030 | 0.00050 | 0.0012 | 0.35 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| W7 | 11/22/2011 | 7.7 | 148 | 144 | 27 | 156 | 0.021 | 0.0025 | 0.14 | 7.96 | | 0.0076 | 0.00040 | 0.0000050 | 0.00050 | 0.0011 | 0.17 | 0.00010 | 0.0013 | 0.0012 | 0.00016 | 0.000010 | 0.0025 |
| W7 | 1/24/2012 | 5.3 | 169 | 158 | 2.0 | 226 | 0.0050 | 0.0025 | 0.32 | 8.13 | | 0.0053 | 0.00041 | 0.000035 | 0.00050 | 0.0011 | 0.094 | 0.00010 | 0.0015 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| W7 | 2/25/2012 | 6.1 | 165 | 160 | 2.0 | 216 | 0.0060 | 0.0025 | 0.29 | 7.99 | 7.16 | 0.021 | 0.00033 | 0.000064 | 0.00050 | 0.015 | 0.049 | 0.00024 | 0.0014 | 0.00050 | 0.00034 | 0.000010 | 0.0083 |
| W7 | 3/5/2012 | 5.2 | 161 | 159 | 3.2 | 176 | 0.0067 | 0.0025 | 0.20 | 8.17 | 6.72 | 0.0031 | 0.00039 | 0.0000050 | 0.00050 | 0.0012 | 0.012 | 0.00010 | 0.0011 | 0.00050 | 0.00031 | 0.000010 | 0.0025 |
| W7 | 4/24/2012 | 14 | 39 | 37 | 11 | 100 | 0.0025 | 0.010 | 0.010 | 7.63 | 7.43 | 0.050 | 0.00048 | 0.000023 | 0.00050 | 0.0052 | 0.48 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 5/6/2012 | 17 | 46 | 45 | 3.3 | 84 | 0.011 | 0.0025 | 0.010 | 5.90 | 7.10 | 0.037 | 0.00044 | 0.000015 | 0.00050 | 0.0029 | 0.44 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 6/19/2012 | 16 | 92 | 105 | 165 | 128 | 0.18 | 0.015 | 0.083 | 8.12 | 7.59 | 0.027 | 0.00070 | 0.0000050 | 0.00050 | 0.0016 | 0.56 | 0.00010 | 0.0013 | 0.0020 | 0.00015 | 0.000010 | 0.0025 |
| W7 | 7/17/2012 | 13 | 128 | 124 | 34 | 164 | 0.065 | 0.0025 | 0.089 | 8.15 | 7.76 | 0.020 | 0.00086 | 0.000012 | 0.00050 | 0.0013 | 0.97 | 0.00010 | 0.0015 | 0.0016 | 0.00013 | 0.000010 | 0.0025 |
| W7 | 7/30/2012 | 13 | 135 | 128 | 9.2 | 180 | 0.13 | 0.0025 | 0.12 | 8.20 | 7.86 | 0.017 | 0.00095 | 0.0000050 | 0.00050 | 0.0012 | 0.96 | 0.00010 | 0.0015 | 0.0015 | 0.00016 | 0.000010 | 0.0025 |
| W7 | 8/8/2012 | 13 | 141 | 141 | 3.3 | 192 | 0.014 | 0.0025 | 0.13 | 8.26 | 8.44 | 0.018 | 0.0010 | 0.0000050 | 0.00050 | 0.0011 | 1.1 | 0.00010 | 0.0016 | 0.0017 | 0.00014 | 0.000010 | 0.0025 |
| W7 | 8/23/2012 | 10 | 142 | 151 | 1.5 | 200 | 0.049 | 0.025 | 0.21 | 8.25 | 7.79 | 0.018 | 0.00088 | 0.0000050 | 0.00050 | 0.0017 | 0.98 | 0.00010 | 0.0016 | 0.0016 | 0.00015 | 0.000010 | 0.0025 |
| W7 | 9/13/2012 | 16 | 116 | 121 | 15 | 154 | 0.0087 | 0.0025 | 0.078 | 8.13 | 7.98 | 0.024 | 0.00074 | 0.0000050 | 0.00050 | 0.0024 | 0.73 | 0.00010 | 0.00050 | 0.0036 | 0.00014 | 0.000010 | 0.0025 |
| W7 | 10/16/2012 | 13 | 129 | 143 | 10 | 166 | 0.028 | 0.0025 | 0.13 | 8.17 | 7.89 | 0.011 | 0.00060 | 0.0000050 | 0.00050 | 0.00094 | 0.60 | 0.00010 | 0.0011 | 0.0015 | 0.00014 | 0.000010 | 0.0025 |
| W7 | 11/2/2012 | 8.2 | 158 | 153 | 2.2 | 214 | 0.026 | 0.0025 | 0.22 | 7.93 | | 0.0095 | 0.00053 | 0.000031 | 0.00050 | 0.0024 | 0.18 | 0.00021 | 0.0013 | 0.0012 | 0.00018 | 0.000010 | 0.0025 |
| W7 | 12/29/2012 | 10 | 223 | 206 | 0.50 | 262 | 0.025 | 0.0025 | 0.063 | 8.13 | 7.97 | 0.0061 | 0.00051 | 0.0000050 | 0.00050 | 0.0023 | 0.030 | 0.00010 | 0.0012 | 0.0011 | 0.00045 | 0.000010 | 0.0025 |
| W7 | 4/30/2013 | 4.6 | 192 | 198 | 5.8 | 246 | 0.0082 | 0.0025 | 0.13 | 8.27 | 8.18 | 0.0031 | 0.00025 | 0.0000050 | 0.00050 | 0.0011 | 0.014 | 0.00010 | 0.0013 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| W7 | 5/14/2013 | 15 | 33 | 36 | 55 | 70 | 0.066 | 0.0025 | 0.010 | 7.58 | 8.20 | 0.044 | 0.00029 | 0.000010 | 0.00050 | 0.0037 | 0.31 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| W7 | 6/19/2013 | 11 | 114 | 115 | 11 | 158 | 0.046 | 0.0025 | 0.14 | 8.08 | 8.60 | 0.013 | 0.00052 | 0.0000050 | 0.00050 | 0.0012 | 0.29 | 0.00010 | 0.0016 | 0.0013 | 0.00015 | 0.000010 | 0.0025 |
| W7 | 7/13/2013 | 10 | 132 | 137 | 5.0 | 156 | 0.023 | 0.0025 | 0.17 | 8.10 | 7.74 | 0.014 | 0.00053 | 0.0000050 | 0.00050 | 0.0012 | 0.42 | 0.00010 | 0.0015 | 0.0013 | 0.00015 | 0.000010 | 0.0025 |
| W7 | 8/21/2013 | 10 | 140 | 144 | 3.8 | 172 | 0.051 | 0.0025 | 0.16 | 8.23 | 7.81 | 0.012 | 0.00056 | 0.0000050 | 0.00050 | 0.0010 | 0.30 | 0.00010 | 0.0015 | 0.0012 | 0.00015 | 0.000010 | 0.0025 |
| W7 | 9/6/2013 | 11 | 138 | 154 | 12 | 280 | 0.017 | 0.0025 | 0.13 | 8.02 | 7.75 | 0.016 | 0.00081 | 0.0000050 | 0.00050 | 0.0011 | 0.66 | 0.00010 | 0.0013 | 0.0016 | 0.00017 | 0.000010 | 0.0025 |
| W7 | 10/21/2013 | 12 | 147 | 126 | 7.4 | 168 | 0.048 | 0.0025 | 0.17 | 8.16 | 7.58 | 0.0093 | 0.00067 | 0.0000050 | 0.00050 | 0.0011 | 0.55 | 0.00010 | 0.0012 | 0.0012 | 0.00017 | 0.000010 | 0.0025 |
| W7 | 11/16/2013 | 7.5 | 153 | 164 | 1.5 | 164 | 0.027 | 0.0025 | 0.26 | 8.24 | 7.69 | 0.0053 | 0.00048 | 0.0000050 | 0.00050 | 0.00080 | 0.17 | 0.00010 | 0.0016 | 0.00050 | 0.00024 | 0.000010 | 0.0025 |
| W7 | 12/7/2013 | 7.3 | 168 | 189 | 0.50 | 220 | 0.025 | 0.0025 | 0.21 | 8.14 | 6.30 | 0.0035 | 0.00053 | 0.0000050 | 0.00050 | 0.00078 | 0.11 | 0.00010 | 0.0011 | 0.00050 | 0.00024 | 0.000010 | 0.0025 |
| C4 | 5/6/2012 | 11 | 44 | 119 | 1,260 | 84 | 0.088 | 0.0025 | 0.029 | 7.59 | 7.51 | 0.062 | 0.00104 | 0.000029 | 0.00050 | 0.0031 | 1.1 | 0.00010 | 0.00050 | 0.0023 | 0.000050 | 0.000010 | 0.0025 |
| C4 | 8/1/2012 | 16 | 117 | 133 | 246 | 166 | 0.089 | 0.018 | 0.074 | 8.04 | 7.75 | 0.059 | 0.00184 | 0.0000050 | 0.00050 | 0.0018 | 1.5 | 0.00010 | 0.0011 | 0.0031 | 0.00011 | 0.000010 | 0.0025 |
| C4 | 8/8/2012 | | 125 | 142 | 253 | 170 | 0.090 | 0.012 | 0.095 | 8.14 | 7.81 | 0.043 | 0.00203 | 0.0000050 | 0.00050 | 0.0013 | 1.6 | 0.00010 | 0.0011 | 0.0027 | 0.00011 | 0.000010 | 0.0025 |
| C4 | 8/25/2012 | 0.25 | 130 | 173 | 855 | 192 | 0.0050 | 0.0025 | 0.010 | 7.94 | 7.81 | 0.040 | 0.0020 | 0.0000050 | 0.00050 | 0.0018 | 1.7 | 0.00010 | 0.0012 | 0.0029 | 0.000050 | 0.000010 | 0.0025 |
| C4 | 6/22/2013 | 17 | 126 | 222 | 886 | 204 | 0.36 | 0.0066 | 0.37 | 7.97 | 7.68 | 0.034 | 0.0023 | 0.0000050 | 0.00050 | 0.0017 | 1.2 | 0.00010 | 0.0018 | 0.0027 | 0.00013 | 0.000010 | 0.0025 |
| C4 | 7/19/2013 | | 128 | 200 | 487 | 184 | 0.26 | 0.0069 | 0.082 | 8.12 | 8.20 | 0.032 | 0.0021 | 0.0000050 | 0.00050 | 0.0014 | 1.6 | 0.00010 | 0.0017 | 0.0025 | 0.00012 | 0.000010 | 0.0025 |
| C4 | 8/22/2013 | 19 | 123 | 199 | 784 | 182 | 0.20 | 0.0084 | 0.086 | 7.98 | 7.88 | 0.046 | 0.0018 | 0.0000050 | 0.00050 | 0.0014 | 1.4 | 0.00010 | 0.0013 | 0.0027 | 0.00012 | 0.000010 | 0.0025 |
| C4 | 9/6/2013 | 15 | 125 | 166 | 172 | 176 | 0.12 | 0.0025 | 0.070 | 7.93 | 7.69 | 0.041 | 0.0020 | 0.0000050 | 0.00050 | 0.0016 | 1.8 | 0.00010 | 0.0010 | 0.0028 | 0.000050 | 0.000010 | 0.0025 |
| C4 | 10/18/2013 | 13 | 129 | 141 | 16 | 217 | 0.086 | 0.0025 | 0.067 | 8.21 | 7.16 | 0.024 | 0.0011 | 0.0000050 | 0.00050 | 0.0012 | 1.2 | 0.00010 | 0.00085 | 0.0024 | 0.000050 | 0.000010 | 0.0025 |
| C4 | 11/17/2013 | 32 | 258 | 264 | 22 | 272 | 0.28 | 0.025 | 0.10 | 7.90 | 7.17 | 0.033 | 0.0056 | 0.000022 | 0.0013 | 0.00095 | 14 | 0.00010 | 0.0011 | 0.0061 | 0.00024 | 0.000010 | 0.0025 |
| C10 | 5/12/2012 | 13 | 67 | 215 | 2,210 | 132 | 0.18 | 0.011 | 0.047 | 7.73 | 7.89 | 0.058 | 0.0012 | 0.000018 | 0.00050 | 0.0021 | 1.6 | 0.00025 | 0.00050 | 0.0019 | 0.00010 | 0.000010 | 0.0025 |
| C10 | 7/30/2012 | 18 | 130 | 207 | 995 | 180 | 0.20 | 0.023 | 0.18 | 8.23 | | 0.057 | 0.0014 | 0.0000050 | 0.00050 | 0.0020 | 1.2 | 0.00067 | 0.0014 | 0.0023 | 0.00014 | 0.000010 | 0.0025 |
| C10 | 8/10/2012 | | 135 | 245 | 1,320 | 216 | 0.12 | 0.011 | 0.18 | 8.11 | 8.71 | 0.051 | 0.0013 | 0.0000050 | 0.00050 | 0.0019 | 0.88 | 0.00010 | 0.0019 | 0.0022 | 0.00010 | 0.000010 | 0.0025 |
| C10 | 8/27/2012 | 18 | 141 | 264 | 1,650 | 184 | 0.0025 | 0.0086 | 0.095 | 8.37 | 8.30 | 0.026 | 0.0015 | 0.0000050 | 0.00050 | 0.0015 | 1.0 | 0.00010 | 0.0011 | 0.0023 | 0.00012 | 0.000010 | 0.0025 |
| C10 | 6/22/2013 | 15 | 148 | 151 | 43 | 192 | 0.19 | 0.020 | 0.15 | 8.26 | 8.29 | 0.079 | 0.0012 | 0.000019 | 0.00050 | 0.0031 | 0.80 | 0.00010 | 0.0012 | 0.0025 | 0.00011 | 0.000010 | 0.010 |
| C10 | 7/23/2013 | | 125 | 156 | 199 | 174 | 0.14 | 0.025 | 0.10 | 8.19 | 8.31 | 0.025 | 0.0012 | 0.0000050 | 0.00050 | 0.0014 | 0.54 | 0.00010 | 0.0010 | 0.0022 | 0.000050 | 0.000010 | 0.0025 |
| C10 | 8/22/2013 | 17 | 160 | 168 | 66 | 218 | 0.056 | 0.0072 | 0.14 | 8.23 | 8.18 | 0.020 | 0.0014 | 0.0000050 | 0.00050 | 0.0013 | 0.99 | 0.00010 | 0.0015 | 0.0023 | 0.000050 | 0.000010 | 0.0025 |
| C10 | 9/8/2013 | 16 | 150 | 163 | 24 | 196 | 0.051 | 0.0073 | 0.18 | 8.04 | 8.16 | 0.025 | 0.0016 | 0.0000075 | 0.0011 | 0.0013 | 1.3 | 0.00010 | 0.00050 | 0.0025 | 0.000050 | 0.000010 | 0.0025 |
| C10 | 10/18/2013 | 14 | 136 | 160 | 61 | 212 | 0.10 | 0.0025 | 0.17 | 8.25 | 7.78 | 0.011 | 0.00089 | 0.0000050 | 0.00050 | 0.00091 | 0.76 | 0.00010 | 0.00050 | 0.0019 | 0.000050 | 0.000010 | 0.0025 |
| | **Median:** | **11** | **117** | **121** | **11** | **150** | **0.021** | **0.0025** | **0.067** | **8.00** | **7.76** | **0.016** | **0.00044** | **0.0000085** | **0.00050** | **0.0016** | **0.11** | **0.00010** | **0.0010** | **0.0011** | **0.00020** | **0.000010** | **0.0025** |
| | **95th Percentile:** | **22** | **162** | **200** | **772** | **217** | **0.15** | **0.025** | **0.21** | **8.26** | **8.30** | **0.071** | **0.0015** | **0.000050** | **0.0011** | **0.0050** | **1.2** | **0.00025** | **0.0020** | **0.0027** | **0.00050** | **0.000010** | **0.0060** |

**Table D.3: Background data for Option 2 with median and 95th Percentile values.**

| Year | Month | Day | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | May | 27 | | | 78 | 22 | 118 | 0.016 | 0.0012 | 0.038 | 7.92 | | 0.028 | 0.00029 | 0.000025 | 0.00050 | 0.0034 | 0.15 | 0.00025 | 0.00050 | 0.0015 | 0.00050 | 0.000010 | 0.0025 |
| | June | 30 | | | | 5.4 | 160 | 0.015 | 0.00067 | 0.052 | 7.83 | | 0.026 | 0.00046 | 0.000025 | 0.00030 | 0.0023 | 0.16 | 0.000064 | 0.00085 | 0.0011 | 0.00050 | 0.0000050 | 0.0091 |
| | July | 28/29 | | | 138 | 11 | 173 | 0.010 | 0.00050 | 0.042 | 7.73 | | 0.020 | 0.00041 | 0.000025 | 0.00025 | 0.0033 | 0.16 | 0.000075 | 0.0011 | 0.0011 | 0.00050 | 0.0000050 | 0.0030 |
| | August | 29/30 | | | 110 | 4.9 | 157 | 0.029 | 0.00066 | 0.010 | 8.10 | | 0.022 | 0.00043 | 0.000010 | 0.00050 | 0.0026 | 0.27 | 0.00025 | 0.00083 | 0.0014 | 0.00050 | 0.000010 | 0.0029 |
| | September | 28 | | | 111 | 58 | 151 | 0.012 | 0.00057 | 0.025 | 7.83 | | 0.024 | 0.00039 | 0.0000085 | 0.00050 | 0.0027 | 0.31 | 0.00025 | 0.00059 | 0.0013 | 0.00050 | 0.000010 | 0.0025 |
| | October | 15 | | | 111 | 5.5 | 151 | 0.015 | 0.00050 | 0.060 | 7.64 | | 0.033 | 0.00044 | 0.000025 | 0.00025 | 0.0029 | 0.25 | 0.000025 | 0.00069 | 0.0012 | 0.00050 | 0.0000050 | 0.0013 |
| 2006 | June | 2 | | | | 410 | 100 | 0.042 | 0.0010 | 0.035 | 7.63 | | 0.048 | 0.00053 | 0.000025 | 0.00040 | 0.0019 | 0.32 | 0.000040 | 0.00050 | 0.0020 | 0.00050 | 0.0000050 | 0.0018 |
| | | 8 | | | | | | | | | | | | | | | | | | | | | | |
| | | 15 | | 100 | | 53 | 114 | 0.027 | | 0.18 | 7.86 | | 0.013 | 0.00040 | 0.0000050 | 0.00025 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.0010 | 0.00020 | | 0.00050 |
| | | 23 | | 122 | | 328 | 176 | 0.028 | | 0.23 | 7.78 | | 0.011 | 0.00050 | 0.0000050 | 0.00070 | 0.00050 | 0.090 | 0.000050 | 0.0010 | 0.0013 | 0.00030 | | 0.0020 |
| | | 28 | | 107 | | 103 | 120 | 0.010 | | 0.11 | 7.90 | | 0.41 | 0.00080 | 0.000030 | 0.0015 | 0.0030 | 0.060 | 0.00050 | 0.00050 | 0.0036 | 0.00010 | | 0.0050 |
| | July | 7 | | 110 | | 3.0 | 184 | | | 0.21 | 7.91 | | 0.0025 | 0.00060 | 0.0000050 | 0.0011 | 0.0010 | 0.060 | 0.000050 | 0.0020 | 0.0015 | 0.00010 | | 0.0010 |
| | | 12 | | 110 | | 1.0 | | 0.014 | | 0.18 | 7.77 | | 0.0060 | 0.00050 | 0.0000050 | 0.0010 | 0.0010 | 0.060 | 0.000050 | 0.0010 | 0.00070 | 0.00020 | | 0.00050 |
| | | 20 | | 130 | | 2.0 | | 0.012 | | 0.19 | 7.88 | | 0.0060 | 0.00040 | 0.0000050 | 0.00070 | 0.00050 | 0.11 | 0.00020 | 0.0010 | 0.00060 | 0.00010 | | 0.00050 |
| | | 26 | | 128 | | 9.0 | | 0.016 | | 0.18 | 7.87 | | 0.0080 | 0.00040 | 0.0000050 | 0.00025 | 0.0020 | 0.10 | 0.000050 | 0.00050 | 0.0021 | 0.00010 | | 0.00050 |
| | August | 2 | | 128 | | 4.0 | | 0.015 | | 0.15 | 7.79 | | 0.0080 | 0.00010 | 0.0000050 | 0.00025 | 0.0010 | 0.070 | 0.000050 | 0.00050 | 0.00060 | 0.00010 | | 0.00050 |
| | | 10 | | 126 | | 1.0 | | 0.014 | | 0.16 | 7.80 | | 0.0090 | 0.00050 | 0.0000050 | 0.00070 | 0.0010 | 0.080 | 0.000050 | 0.0010 | 0.00060 | 0.00010 | | 0.0010 |
| | | 25 | | 125 | | | 170 | 0.027 | | 0.068 | 7.97 | | 0.012 | 0.00040 | 0.0000050 | 0.00060 | 0.0010 | 0.080 | 0.000050 | 0.0010 | 0.00090 | 0.00010 | | 0.0030 |
| | | 30 | | 132 | | 1.0 | 200 | 0.012 | | 0.11 | 7.79 | | 0.013 | 0.00040 | 0.0000050 | 0.00080 | 0.0020 | 0.10 | 0.000050 | 0.0010 | 0.0012 | 0.00010 | | 0.0050 |
| | September | 6 | | 120 | | 4.0 | | 0.011 | | 0.048 | 7.87 | | 0.0065 | 0.00050 | 0.0000050 | 0.00070 | 0.0015 | 0.11 | 0.000050 | 0.00075 | 0.00080 | 0.00010 | | 0.0020 |
| | | 13 | | 130 | | 5.0 | | 0.011 | | 0.094 | 7.84 | | 0.0080 | 0.00030 | 0.0000050 | 0.00090 | 0.0010 | 0.11 | 0.000050 | 0.0010 | 0.00090 | 0.00010 | | 0.0010 |
| | | 20 | | 132 | | 3.0 | | 0.008 | | 0.11 | 7.85 | | 0.0070 | 0.00050 | 0.00028 | 0.00070 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.00025 | 0.00020 | | 0.00050 |
| | | 28 | | 129 | | | 182 | 0.011 | | 0.080 | 7.26 | | 0.011 | 0.00040 | 0.0000050 | 0.00080 | 0.0010 | 0.080 | 0.000050 | 0.0010 | 0.00080 | 0.00010 | | 0.0020 |
| | October | 4 | | 126 | | 2.0 | | 0.079 | | 0.10 | 7.94 | | 0.0025 | 0.00030 | 0.0000050 | 0.00025 | 0.00050 | 0.11 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | | 0.0010 |
| | | 12 | | 132 | | 4.0 | 164 | 0.024 | | 0.12 | 7.39 | | 0.0070 | 0.00040 | 0.0000050 | 0.00025 | 0.0010 | 0.090 | 0.000050 | 0.0010 | 0.00060 | 0.00030 | | 0.0020 |
| 2007 | June | 5 | | | 113 | 75 | 162 | 0.025 | 0.033 | 0.050 | 7.97 | | | | | | | | | | | | | |
| | | 20 | 8.2 | 110 | 81 | 11 | 147 | 0.025 | 0.025 | 0.20 | 7.81 | | 0.014 | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.050 | 0.000050 | 0.0010 | 0.00025 | 0.00010 | | 0.0040 |
| | July | 18 | 14 | 128 | 125 | 5.7 | 179 | 0.025 | 0.025 | 0.30 | 7.78 | | 0.011 | 0.00050 | 0.0000050 | 0.0010 | 0.0020 | 0.040 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | | 0.0060 |
| | August | 24 | | | 124 | 4.7 | 192 | 0.025 | 0.025 | 0.20 | 8.04 | | | | | | | | | | | | | |
| | September | 18 | 11 | 110 | 93 | 14 | 177 | 0.025 | 0.010 | 0.030 | 7.98 | | 0.0070 | 0.00040 | 0.0000050 | 0.0016 | 0.0010 | 0.080 | 0.000050 | 0.0020 | 0.00080 | 0.00010 | | 0.0020 |
| | October | 30 | | | 129 | 6.5 | 174 | 0.025 | 0.14 | 0.010 | 7.73 | | | | | | | | | | | | | |
| 2008 | April | 22 | | 187 | | 1.0 | 268 | 0.025 | 0.055 | 0.010 | 8.40 | | 0.010 | 0.00027 | 0.000040 | 0.00097 | 0.0012 | 0.030 | 0.000067 | 0.0017 | 0.0010 | 0.00030 | | 0.0017 |
| | June | 3 | | 92 | 98 | 15 | 137 | 0.025 | 0.040 | 0.037 | 8.02 | | 0.0050 | 0.00010 | 0.000040 | 0.0013 | 0.00050 | 0.050 | 0.000050 | 0.0012 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | | 17 | | | 86 | 14 | 138 | 0.025 | 0.060 | 0.075 | 7.89 | | 0.020 | 0.00010 | 0.000040 | 0.0013 | 0.0010 | 0.070 | 0.000050 | 0.0015 | 0.0010 | 0.0022 | 0.0000050 | 0.0020 |
| | August | 6 | 9.0 | 123 | 124 | 105 | 167 | 0.025 | 0.0050 | 0.14 | 7.92 | | 0.014 | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.070 | 0.000050 | 0.0010 | 0.0010 | 0.00010 | 0.000060 | 0.0060 |
| | September | 18 | 18 | | | 16 | 160 | 0.025 | 0.0050 | 0.018 | 7.85 | | 0.041 | 0.00035 | 0.0000050 | 0.0015 | 0.0030 | 0.15 | 0.00088 | 0.00050 | 0.0015 | 0.00075 | 0.0000050 | 0.0030 |
| | October | 28 | 11 | 123 | | 5.7 | 183 | 0.025 | | | 7.84 | | 0.0090 | 0.00050 | 0.0000050 | 0.00050 | 0.0010 | 0.078 | 0.000050 | 0.0011 | 0.0010 | 0.00030 | 0.0000050 | 0.0010 |
| 2009 | April | 30 | 18 | 20 | | 1.0 | 52 | | | | 6.84 | 7.60 | 0.053 | 0.00010 | 0.000080 | 0.00060 | 0.0050 | 0.070 | 0.00010 | 0.00013 | 0.00050 | 0.00030 | 0.0000050 | 0.0090 |
| | June | 8 | 9.2 | 93 | | 32 | 156 | | | | 7.90 | 7.74 | 0.013 | 0.00030 | 0.0000050 | 0.00020 | 0.0020 | 0.050 | 0.000050 | 0.0013 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | July | 27 | | 137 | | 4.0 | 184 | | | | 8.07 | | | | | | | | | | | | | |
| | August | 6 | | 121 | | 2.0 | 202 | | | 0.18 | 8.35 | 7.50 | | | | | | | | | | | | |
| | | 25 | 8.2 | | | | | | | | | 8.04 | | | | | | | | | | | | |
| | | 31 | | 110 | | | | | | | | | 0.010 | 0.00040 | 0.0000050 | 0.0012 | 0.0040 | 0.10 | 0.00040 | 0.0011 | 0.0010 | 0.00030 | 0.0000050 | 0.0010 |
| | October | 7 | 7.8 | 125 | 141 | 3.7 | 140 | 0.010 | 0.0025 | 0.14 | 7.99 | 8.24 | 0.0070 | 0.00030 | 0.000040 | 0.00050 | 0.0012 | 0.046 | 0.00010 | 0.0010 | 0.00050 | 0.00020 | 0.000010 | 0.0025 |
| | | 25 | 8.7 | 126 | 141 | 2.0 | 120 | 0.010 | 0.0025 | 0.15 | 8.05 | 8.23 | 0.0070 | 0.00030 | 0.000040 | 0.00050 | 0.0012 | 0.046 | 0.00010 | 0.0010 | 0.00050 | 0.00020 | 0.000010 | 0.0025 |

**Table D.3: Background data for Option 2 with median and 95th Percentile values.**

| Year | Month | Day | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010 | April | 19 | | | 80 | 3.5 | 142 | | | | 7.81 | 7.31 | 0.019 | 0.00030 | 0.000020 | 0.00040 | 0.0060 | 0.090 | 0.00030 | 0.00080 | 0.00050 | 0.00030 | 0.0000050 | 0.0050 |
| | | 27/29 | 21 | 36 | 36 | 2.0 | 62 | 0.016 | 0.0038 | 0.015 | 7.55 | 7.69 | 0.070 | 0.00030 | 0.0000050 | 0.00050 | 0.0038 | 0.17 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0025 |
| | May | 1-7 | 17 | 48 | 50 | 14 | 73 | 0.026 | 0.0050 | 0.048 | 7.75 | 7.61 | 0.042 | 0.00043 | 0.000010 | 0.00050 | 0.0028 | 0.39 | 0.00010 | 0.00050 | 0.0013 | 0.000050 | 0.000010 | 0.0025 |
| | | 9-14 | 11 | 79 | 79 | 5.3 | 123 | 0.019 | 0.0034 | 0.060 | 8.05 | 7.78 | 0.039 | 0.00040 | 0.000010 | 0.00050 | 0.0022 | 0.27 | 0.00010 | 0.00063 | 0.0013 | 0.00010 | 0.000010 | 0.0025 |
| | | 16-21 | 8.1 | 89 | 88 | 12 | 123 | 0.036 | 0.0025 | 0.038 | 8.20 | 7.62 | 0.015 | 0.00030 | 0.000016 | 0.00050 | 0.0013 | 0.069 | 0.00010 | 0.0010 | 0.00063 | 0.00023 | 0.000010 | 0.0031 |
| | | 23-29 | 7.7 | 112 | 126 | 181 | 148 | 0.059 | 0.011 | 0.12 | 8.05 | 7.53 | 0.022 | 0.00043 | 0.000050 | | 0.0023 | 0.063 | 0.00010 | 0.0018 | 0.0013 | 0.00045 | | 0.0050 |
| | May/June | 31-6 | 6.2 | 115 | 131 | 118 | 153 | 0.12 | 0.018 | 0.15 | 8.20 | 7.52 | 0.013 | 0.00030 | 0.000050 | | 0.0013 | 0.034 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| | June | 14-20 | 6.5 | 119 | 124 | 30 | 145 | 0.016 | 0.0039 | 0.15 | 8.24 | 6.97 | 0.0088 | 0.00020 | 0.000050 | | 0.00063 | 0.026 | 0.00010 | 0.0020 | 0.00050 | 0.00040 | | 0.0050 |
| | | 22-28 | 10 | 104 | 111 | 99 | 135 | 0.014 | 0.0036 | 0.11 | 8.09 | 7.95 | 0.017 | 0.00033 | 0.000050 | | 0.0013 | 0.051 | 0.00010 | 0.0010 | 0.0016 | 0.00040 | | 0.0050 |
| | July | 5 | 16 | 93 | 106 | 53 | 150 | 0.027 | 0.0025 | 0.070 | 8.06 | 8.02 | 0.019 | 0.00020 | 0.000050 | | 0.0020 | 0.10 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| | August | 5 | 13 | 118 | 116 | | 170 | | | | | 7.91 | 0.011 | 0.00040 | 0.000050 | | 0.0020 | 0.11 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| | September | 12 | 17 | 107 | 104 | 11 | 210 | 0.039 | 0.0025 | 0.030 | 7.98 | 8.02 | 0.016 | 0.00050 | 0.000050 | | 0.0010 | 0.23 | 0.00010 | 0.0010 | 0.0020 | 0.00040 | | 0.0050 |
| | October | 8 | 13 | 111 | 126 | 3.0 | 150 | 0.069 | 0.0025 | 0.070 | 8.10 | 7.85 | 0.011 | 0.00040 | 0.0000050 | 0.00050 | 0.0012 | 0.13 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| 2011 | April | 27 | 23 | 43 | 43 | 0.50 | 72 | 0.010 | 0.0025 | 0.010 | 7.41 | | 0.057 | 0.00030 | 0.000030 | 0.00050 | 0.0077 | 0.15 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.0050 |
| | May | 2 | 22 | 32 | 33 | 7.0 | 40 | | 0.0025 | 0.010 | 7.11 | | 0.076 | 0.00020 | 0.000040 | 0.00050 | 0.0070 | 0.17 | 0.00010 | 0.00050 | 0.0010 | 0.000050 | 0.000010 | 0.010 |
| | June | 1 | 11 | 92 | 94 | 23 | 120 | 0.012 | | | 8.09 | | 0.013 | 0.00030 | 0.0000050 | 0.00050 | 0.0016 | 0.10 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| | | 16 | 13 | 97 | 108 | 85 | 130 | 0.013 | 0.0025 | 0.10 | 8.00 | | 0.022 | 0.00040 | 0.0000050 | 0.00050 | 0.0019 | 0.21 | 0.00010 | 0.0010 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | July | 1 | 21 | 77 | 88 | 150 | 120 | 0.016 | 0.0070 | 0.050 | 7.76 | | 0.034 | 0.00070 | 0.000010 | 0.00050 | 0.0031 | 0.44 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | August | 2 | 24 | 59 | 86 | 400 | 110 | | 0.0025 | 0.060 | 7.67 | | 0.051 | 0.00070 | 0.000020 | 0.00050 | 0.0041 | 0.61 | 0.00010 | 0.00050 | 0.0030 | 0.00010 | 0.000010 | 0.0025 |
| | | 16/19 | 19 | 95 | 95 | 22 | 145 | 0.011 | 0.0025 | 0.050 | 8.01 | | 0.035 | 0.00075 | 0.0000075 | 0.00050 | 0.0020 | 0.57 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | September | 12 | 13 | 118 | 119 | 1.0 | 170 | 0.025 | 0.0025 | 0.050 | 8.03 | 7.92 | 0.024 | 0.00070 | 0.000010 | 0.00050 | 0.0016 | 0.62 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | October | 6 | 12 | 110 | 113 | 2.0 | 150 | 0.019 | 0.0025 | 0.11 | 8.07 | 7.65 | 0.013 | 0.00060 | 0.000030 | 0.00050 | 0.0012 | 0.35 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| | November | 22 | 7.7 | 148 | 144 | 27 | 156 | 0.021 | 0.0025 | 0.14 | 7.96 | | 0.0076 | 0.00040 | 0.0000050 | 0.00050 | 0.0011 | 0.17 | 0.00010 | 0.0013 | 0.0012 | 0.00016 | 0.000010 | 0.0025 |
| 2012 | January | 24 | 5.3 | 169 | 158 | 2.0 | 226 | 0.0050 | 0.0025 | 0.32 | 8.13 | | 0.0053 | 0.00041 | 0.000035 | 0.00050 | 0.0011 | 0.094 | 0.00010 | 0.0015 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| | February | 25 | 6.1 | 165 | 160 | 2.0 | 216 | 0.0060 | 0.0025 | 0.29 | 7.99 | 7.16 | 0.021 | 0.00033 | 0.000064 | 0.00050 | 0.015 | 0.049 | 0.00024 | 0.0014 | 0.00050 | 0.00034 | 0.000010 | 0.0083 |
| | March | 5 | 5.2 | 161 | 159 | 3.2 | 176 | 0.0067 | 0.0025 | 0.20 | 8.17 | 6.72 | 0.0031 | 0.00039 | 0.0000050 | 0.00050 | 0.0012 | 0.012 | 0.00010 | 0.0011 | 0.00050 | 0.00031 | 0.000010 | 0.0025 |
| | April | 24 | 14 | 39 | 37 | 11 | 100 | 0.0025 | 0.010 | 0.010 | 7.63 | 7.43 | 0.050 | 0.00048 | 0.000023 | 0.00050 | 0.0052 | 0.48 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| | May | 6/12 | 14 | 52 | 126 | 1158 | 100 | 0.093 | 0.0055 | 0.029 | 7.07 | 7.50 | 0.053 | 0.00089 | 0.000021 | 0.00050 | 0.0027 | 1.0 | 0.00015 | 0.00050 | 0.0018 | 0.000067 | 0.000010 | 0.0025 |
| | June | 19 | 16 | 92 | 105 | 165 | 128 | 0.18 | 0.015 | 0.083 | 8.12 | 7.59 | 0.027 | 0.00070 | 0.0000050 | 0.00050 | 0.0016 | 0.56 | 0.00010 | 0.0013 | 0.00200 | 0.00015 | 0.000010 | 0.0025 |
| | July | 17 | 11 | 116 | 144 | 582 | 143 | 0.10 | 0.0025 | 0.058 | 8.07 | 7.84 | 0.018 | 0.00070 | 0.0000085 | 0.00050 | 0.0012 | 0.52 | 0.00010 | 0.0010 | 0.0013 | 0.00013 | 0.000010 | 0.0025 |
| | | 30 | 13 | 122 | 160 | 539 | 161 | 0.13 | 0.011 | 0.12 | 8.17 | 7.88 | 0.031 | 0.00099 | 0.0000050 | 0.00050 | 0.0014 | 0.73 | 0.00029 | 0.0011 | 0.0014 | 0.00012 | 0.000010 | 0.0025 |
| | August | 1 | 16 | 117 | 133 | 246 | 166 | 0.089 | 0.018 | 0.074 | 8.04 | 7.75 | 0.059 | 0.0018 | 0.0000050 | 0.00050 | 0.0018 | 1.5 | 0.00010 | 0.0011 | 0.0031 | 0.00011 | 0.000010 | 0.0025 |
| | | 8-10 | 13 | 128 | 166 | 536 | 181 | 0.062 | 0.0081 | 0.11 | 8.17 | 8.26 | 0.032 | 0.0013 | 0.0000050 | 0.00050 | 0.0013 | 0.91 | 0.00010 | 0.0013 | 0.0019 | 0.00011 | 0.000010 | 0.0025 |
| | | 23-27 | 9.0 | 129 | 187 | 917 | 179 | 0.020 | 0.010 | 0.090 | 8.14 | 7.92 | 0.024 | 0.0013 | 0.0000050 | 0.00050 | 0.0015 | 0.93 | 0.00010 | 0.0011 | 0.0020 | 0.000093 | 0.000010 | 0.0025 |
| | September | 13 | 15 | 102 | 107 | 33 | 136 | 0.010 | 0.0025 | 0.056 | 8.09 | 7.97 | 0.020 | 0.00061 | 0.0000050 | 0.00050 | 0.0019 | 0.42 | 0.00010 | 0.00050 | 0.0025 | 0.000095 | 0.000010 | 0.0025 |
| | October | 13/16 | 11 | 129 | 130 | 27 | 158 | 0.022 | 0.0025 | 0.084 | 8.05 | 8.10 | 0.011 | 0.00060 | 0.0000050 | 0.00050 | 0.00094 | 0.60 | 0.00010 | 0.0011 | 0.0015 | 0.00014 | 0.000010 | 0.0025 |
| | November | 2 | 8.2 | 158 | 153 | 2.2 | 214 | 0.026 | 0.0025 | 0.22 | 7.93 | | 0.0095 | 0.00053 | 0.000031 | 0.00050 | 0.0024 | 0.18 | 0.00021 | 0.0013 | 0.0012 | 0.00018 | 0.000010 | 0.0025 |
| | | 12 | 8.7 | 153 | 155 | 2.2 | 162 | 0.025 | 0.0025 | 0.010 | 7.93 | 6.69 | 0.0062 | 0.00039 | 0.0000050 | 0.00050 | 0.0014 | 0.024 | 0.00010 | 0.00050 | 0.0014 | 0.00010 | 0.000010 | 0.0025 |
| | December | 29 | 10 | 223 | 206 | 0.50 | 262 | 0.025 | 0.0025 | 0.063 | 8.13 | 7.97 | 0.0061 | 0.00051 | 0.0000050 | 0.00050 | 0.0023 | 0.030 | 0.00010 | 0.0012 | 0.0011 | 0.00045 | 0.000010 | 0.0025 |
| 2013 | April | 30 | 4.6 | 192 | 198 | 5.8 | 246 | 0.0082 | 0.0025 | 0.13 | 8.27 | 8.18 | 0.0031 | 0.00025 | 0.0000050 | 0.00050 | 0.0011 | 0.014 | 0.00010 | 0.0013 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| | May | 14 | 19 | 32 | 35 | 34 | 77 | 0.10 | 0.0025 | 0.010 | 7.53 | 7.90 | 0.051 | 0.00033 | 0.000011 | 0.00050 | 0.0036 | 0.245 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| | June | 19/22 | 13 | 121 | 151 | 278 | 168 | 0.16 | 0.011 | 0.17 | 8.09 | 8.05 | 0.034 | 0.0011 | 0.0000085 | 0.00050 | 0.0017 | 0.590 | 0.00010 | 0.0013 | 0.0019 | 0.00011 | 0.000010 | 0.0045 |
| | July | 12/13 | 9.1 | 110 | 116 | 15 | 146 | 0.018 | 0.0025 | 0.090 | 8.00 | 7.72 | 0.010 | 0.00050 | 0.0000050 | 0.00050 | 0.0011 | 0.26 | 0.00010 | 0.0010 | 0.0012 | 0.00010 | 0.000010 | 0.0025 |
| | | 19/23 | | 127 | 178 | 343 | 179 | 0.20 | 0.016 | 0.091 | 8.16 | 8.26 | 0.028 | 0.0016 | 0.0000050 | 0.00050 | 0.0014 | 1.1 | 0.00010 | 0.0014 | 0.0024 | 0.000085 | 0.000010 | 0.0025 |
| | August | 21/22 | 13 | 131 | 154 | 218 | 179 | 0.080 | 0.0052 | 0.10 | 8.12 | 7.92 | 0.021 | 0.0011 | 0.0000050 | 0.00050 | 0.0012 | 0.71 | 0.00010 | 0.0012 | 0.0018 | 0.000093 | 0.000010 | 0.0025 |
| | September | 6/8 | 12 | 129 | 149 | 53 | 196 | 0.048 | 0.0037 | 0.10 | 7.98 | 7.80 | 0.022 | 0.0012 | 0.0000056 | 0.00065 | 0.0012 | 0.96 | 0.00010 | 0.00083 | 0.0020 | 0.000080 | 0.000010 | 0.0025 |
| | October | 7 | 8.2 | 107 | 106 | 74 | 176 | 0.044 | 0.0025 | 0.042 | 8.08 | 7.66 | 0.013 | 0.00051 | 0.0000050 | 0.00050 | 0.00097 | 0.15 | 0.00010 | 0.00050 | 0.0013 | 0.000050 | 0.000010 | 0.0025 |
| | | 18/21 | 13 | 137 | 142 | 28 | 199 | 0.078 | 0.0025 | 0.13 | 8.21 | 7.51 | 0.015 | 0.00088 | 0.0000050 | 0.00050 | 0.0011 | 0.82 | 0.00010 | 0.00085 | 0.0018 | 0.000090 | 0.000010 | 0.0025 |
| | November | 16/17 | 16 | 177 | 184 | 19 | 185 | 0.11 | 0.010 | 0.12 | 8.08 | 7.61 | 0.015 | 0.0022 | 0.000011 | 0.00077 | 0.00086 | 4.8 | 0.00010 | 0.0011 | 0.0025 | 0.00018 | 0.000010 | 0.0025 |
| | December | 7 | 8.0 | 164 | 186 | 2.1 | 207 | 0.016 | 0.0025 | 0.11 | 8.18 | 6.90 | 0.0038 | 0.00057 | 0.0000080 | 0.00050 | 0.0012 | 0.06 | 0.00010 | 0.00080 | 0.00080 | 0.00015 | 0.000010 | 0.0025 |
| **Median:** | | | **12** | **120** | **121** | **11** | **158** | **0.025** | **0.0025** | **0.090** | **7.97** | **7.77** | **0.014** | **0.00041** | **0.0000053** | **0.00050** | **0.0015** | **0.11** | **0.00010** | **0.0010** | **0.0011** | **0.00011** | **0.000010** | **0.0025** |
| **95th Percentile:** | | | **21** | **169** | **185** | **485** | **216** | **0.12** | **0.038** | **0.22** | **8.20** | **8.24** | **0.056** | **0.0013** | **0.000050** | **0.0013** | **0.0051** | **0.95** | **0.00028** | **0.0017** | **0.0024** | **0.00050** | **0.000010** | **0.0060** |

**Table D.4: Background data for Option 3 with median and 95th Percentile values.**

| Year | Month | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | May | | | 74 | 19 | 118 | 0.017 | 0.0011 | 0.034 | 7.85 | | 0.043 |
| | June | | | | 5.4 | 160 | 0.015 | 0.00067 | 0.052 | 7.83 | | 0.026 |
| | July | | | 138 | 11 | 173 | 0.010 | 0.00050 | 0.042 | 7.73 | | 0.020 |
| | August | | | 110 | 4.9 | 157 | 0.029 | 0.00066 | 0.010 | 8.10 | | 0.022 |
| | September | | | 111 | 58 | 151 | 0.012 | 0.00057 | 0.025 | 7.83 | | 0.024 |
| | October | | | 111 | 5.5 | 151 | 0.015 | 0.00050 | 0.060 | 7.64 | | 0.033 |
| 2006 | June | | 110 | | 206 | 112 | 0.026 | 0.0010 | 0.083 | 7.71 | | 0.075 |
| | July | | 120 | | 3.8 | 184 | 0.014 | | 0.19 | 7.86 | | 0.0056 |
| | August | | 124 | | 2.0 | 175 | 0.017 | | 0.075 | 7.92 | | 0.011 |
| | September | | 120 | | 4.0 | 182 | 0.010 | | 0.053 | 7.78 | | 0.0079 |
| | October | | 129 | | 3.0 | 164 | 0.052 | | 0.11 | 7.67 | | 0.0048 |
| 2007 | June | 8.2 | 110 | 97 | 28 | 147 | 0.025 | 0.027 | 0.14 | 7.84 | | 0.014 |
| | July | 14 | 128 | 125 | 5.7 | 179 | 0.025 | 0.025 | 0.30 | 7.78 | | 0.011 |
| | August | | | 124 | 4.7 | 192 | 0.025 | 0.025 | 0.20 | 8.04 | | |
| | September | 11 | 110 | 93 | 14 | 177 | 0.025 | 0.010 | 0.030 | 7.98 | | 0.0070 |
| | October | | | 129 | 6.5 | 174 | 0.025 | 0.14 | 0.010 | 7.73 | | |
| 2008 | April | | 187 | | 1.0 | 268 | 0.025 | 0.055 | 0.010 | 8.40 | | 0.010 |
| | June | | 92 | 92 | 15 | 133 | 0.025 | 0.058 | 0.049 | 7.90 | | 0.013 |
| | August | 9.0 | 123 | 124 | 105 | 167 | 0.025 | 0.005 | 0.143 | 7.92 | | 0.014 |
| | September | 18 | | | 16 | 160 | 0.025 | 0.005 | 0.018 | 7.85 | | 0.041 |
| | October | 11 | 123 | | 5.7 | 183 | 0.025 | | | 7.84 | | 0.0090 |
| 2009 | April | 18 | 20 | | 1.0 | 52 | | | | 6.84 | 7.60 | 0.053 |
| | June | 9.2 | 93 | | 32 | 156 | | | | 7.90 | 7.74 | 0.013 |
| | July | | 137 | | 4.0 | 184 | | | | 8.07 | | |
| | August | 12 | 96 | | 9.8 | 149 | | | 0.18 | 7.79 | 7.72 | 0.025 |
| | October | 8.3 | 125 | 141 | 2.8 | 130 | 0.010 | 0.0025 | 0.14 | 8.02 | 8.24 | 0.007 |
| 2010 | April | 21 | 36 | 50 | 2.5 | 89 | 0.016 | 0.0038 | 0.015 | 7.64 | 7.56 | 0.053 |
| | May | 11 | 83 | 88 | 67 | 119 | 0.034 | 0.0065 | 0.070 | 8.02 | 7.64 | 0.029 |
| | June | 7.6 | 113 | 121 | 63 | 143 | 0.059 | 0.0073 | 0.14 | 8.17 | 7.49 | 0.012 |
| | July | 16 | 93 | 106 | 53 | 150 | 0.027 | 0.0025 | 0.070 | 8.06 | 8.02 | 0.019 |
| | August | 13 | 118 | 116 | | 170 | | | | | 7.91 | 0.011 |
| | September | 17 | 107 | 104 | 11 | 210 | 0.039 | 0.0025 | 0.030 | 7.98 | 8.02 | 0.016 |
| | October | 13 | 111 | 126 | 3.0 | 150 | 0.069 | 0.0025 | 0.070 | 8.10 | 7.85 | 0.011 |
| 2011 | April | 23 | 43 | 43 | 0.50 | 72 | 0.010 | 0.0025 | 0.010 | 7.41 | | 0.057 |
| | May | 22 | 32 | 33 | 7.0 | 40 | | 0.0025 | 0.010 | 7.11 | | 0.076 |
| | June | 17 | 66 | 69 | 29 | 91 | 0.012 | 0.0025 | 0.040 | 7.65 | | 0.042 |
| | July | 21 | 77 | 88 | 150 | 120 | 0.016 | 0.0070 | 0.050 | 7.76 | | 0.034 |
| | August | 21 | 82 | 91 | 149 | 130 | 0.012 | 0.0036 | 0.053 | 7.86 | | 0.039 |
| | September | 13 | 118 | 119 | 1.0 | 170 | 0.025 | 0.0025 | 0.050 | 8.03 | 7.92 | 0.024 |
| | October | 12 | 110 | 113 | 2.0 | 150 | 0.019 | 0.0025 | 0.11 | 8.07 | 7.65 | 0.013 |
| | November | 7.7 | 148 | 144 | 27 | 156 | 0.021 | 0.0025 | 0.14 | 7.96 | | 0.0076 |
| 2012 | January | 5.3 | 169 | 158 | 2.0 | 226 | 0.0050 | 0.0025 | 0.32 | 8.13 | | 0.0053 |
| | February | 6.1 | 165 | 160 | 2.0 | 216 | 0.0060 | 0.0025 | 0.29 | 7.99 | 7.16 | 0.021 |
| | March | 5.2 | 161 | 159 | 3.2 | 176 | 0.0067 | 0.0025 | 0.20 | 8.17 | 6.72 | 0.0031 |
| | April | 14 | 39 | 37 | 11.2 | 100 | 0.0025 | 0.010 | 0.010 | 7.63 | 7.43 | 0.050 |
| | May | 14 | 52 | 126 | 1158 | 100 | 0.093 | 0.0055 | 0.029 | 7.07 | 7.50 | 0.053 |
| | June | 16 | 92 | 105 | 165 | 128 | 0.18 | 0.015 | 0.083 | 8.12 | 7.59 | 0.027 |
| | July | 13 | 121 | 162 | 630 | 158 | 0.134 | 0.010 | 0.11 | 8.15 | 7.86 | 0.031 |
| | August | 11 | 128 | 175 | 700 | 178 | 0.045 | 0.0097 | 0.10 | 8.16 | 8.08 | 0.030 |
| | September | 15 | 102 | 107 | 33 | 136 | 0.0099 | 0.0025 | 0.056 | 8.09 | 7.97 | 0.020 |
| | October | 11 | 129 | 130 | 27 | 158 | 0.022 | 0.0025 | 0.084 | 8.05 | 8.10 | 0.011 |
| | November | 8.5 | 156 | 154 | 2.2 | 188 | 0.026 | 0.0025 | 0.11 | 7.93 | 6.69 | 0.0079 |
| | December | 10 | 223 | 206 | 0.50 | 262 | 0.025 | 0.0025 | 0.063 | 8.13 | 7.97 | 0.0061 |
| 2013 | April | 4.6 | 192 | 198 | 5.8 | 246 | 0.0082 | 0.0025 | 0.13 | 8.27 | 8.18 | 0.0031 |
| | May | 19 | 32 | 35 | 34 | 77 | 0.098 | 0.0025 | 0.010 | 7.53 | 7.90 | 0.051 |
| | June | 13 | 121 | 151 | 278 | 168 | 0.16 | 0.011 | 0.17 | 8.09 | 8.05 | 0.034 |
| | July | 9.1 | 118 | 147 | 179 | 163 | 0.11 | 0.0092 | 0.091 | 8.08 | 7.99 | 0.019 |
| | August | 13 | 131 | 154 | 218 | 179 | 0.080 | 0.0052 | 0.097 | 8.12 | 7.92 | 0.021 |
| | September | 12 | 129 | 149 | 53 | 196 | 0.048 | 0.0037 | 0.10 | 7.98 | 7.80 | 0.022 |
| | October | 12 | 130 | 133 | 40 | 193 | 0.069 | 0.0025 | 0.11 | 8.18 | 7.55 | 0.014 |
| | November | 16 | 177 | 184 | 19 | 185 | 0.11 | 0.010 | 0.12 | 8.08 | 7.61 | 0.015 |
| | December | 8.0 | 164 | 186 | 2.1 | 207 | 0.016 | 0.0025 | 0.11 | 8.18 | 6.90 | 0.0038 |
| | **Median:** | **12** | **118** | **124** | **11** | **160** | **0.025** | **0.0025** | **0.075** | **7.96** | **7.80** | **0.019** |
| | **95th Percentile:** | **21** | **181** | **185** | **278** | **226** | **0.12** | **0.040** | **0.22** | **8.18** | **8.13** | **0.053** |

**Table D.4: Background data for Option 3 with median and 95th Percentile values.**

| Year | Month | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | May | 0.00029 | 0.000025 | 0.00050 | 0.0042 | 0.14 | 0.00025 | 0.00050 | 0.0014 | 0.00050 | 0.000010 | 0.0029 |
| | June | 0.00046 | 0.000025 | 0.00030 | 0.0023 | 0.16 | 0.000064 | 0.00085 | 0.0011 | 0.00050 | 0.0000050 | 0.0091 |
| | July | 0.00041 | 0.000025 | 0.00025 | 0.0033 | 0.16 | 0.000075 | 0.0011 | 0.0011 | 0.00050 | 0.0000050 | 0.0030 |
| | August | 0.00043 | 0.000010 | 0.00050 | 0.0026 | 0.27 | 0.00025 | 0.00083 | 0.0014 | 0.00050 | 0.000010 | 0.0029 |
| | September | 0.00039 | 0.0000085 | 0.00050 | 0.0027 | 0.31 | 0.00025 | 0.00059 | 0.0013 | 0.00050 | 0.000010 | 0.0025 |
| | October | 0.00044 | 0.000025 | 0.00025 | 0.0029 | 0.25 | 0.000025 | 0.00069 | 0.0012 | 0.00050 | 0.0000050 | 0.0013 |
| 2006 | June | 0.00051 | 0.000021 | 0.00050 | 0.0017 | 0.15 | 0.000094 | 0.00055 | 0.0019 | 0.00039 | 0.0000050 | 0.0025 |
| | July | 0.00048 | 0.0000050 | 0.00076 | 0.0011 | 0.083 | 0.000088 | 0.0011 | 0.0012 | 0.00013 | | 0.00063 |
| | August | 0.00035 | 0.0000050 | 0.00059 | 0.0013 | 0.083 | 0.000050 | 0.00088 | 0.00083 | 0.00010 | | 0.0024 |
| | September | 0.00046 | 0.000039 | 0.00070 | 0.0011 | 0.10 | 0.000050 | 0.00075 | 0.00067 | 0.00011 | | 0.0017 |
| | October | 0.00035 | 0.0000050 | 0.00025 | 0.00075 | 0.10 | 0.000050 | 0.0010 | 0.00065 | 0.00020 | | 0.0015 |
| 2007 | June | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.050 | 0.000050 | 0.0010 | 0.00025 | 0.00010 | | 0.0040 |
| | July | 0.00050 | 0.0000050 | 0.0010 | 0.0020 | 0.040 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | | 0.0060 |
| | August | | | | | | | | | | | |
| | September | 0.00040 | 0.0000050 | 0.0016 | 0.0010 | 0.080 | 0.000050 | 0.0020 | 0.00080 | 0.00010 | | 0.0020 |
| | October | | | | | | | | | | | |
| 2008 | April | 0.00027 | 0.000040 | 0.00097 | 0.0012 | 0.030 | 0.000067 | 0.0017 | 0.0010 | 0.00030 | | 0.0017 |
| | June | 0.00010 | 0.000040 | 0.0013 | 0.00075 | 0.060 | 0.000050 | 0.0014 | 0.0010 | 0.0013 | 0.0000050 | 0.0020 |
| | August | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.070 | 0.000050 | 0.0010 | 0.0010 | 0.00010 | 0.000060 | 0.0060 |
| | September | 0.00035 | 0.0000050 | 0.0015 | 0.0030 | 0.15 | 0.00088 | 0.00050 | 0.0015 | 0.00075 | 0.0000050 | 0.0030 |
| | October | 0.00050 | 0.0000050 | 0.00050 | 0.0010 | 0.078 | 0.000050 | 0.00108 | 0.0010 | 0.00030 | 0.0000050 | 0.0010 |
| 2009 | April | 0.00010 | 0.000080 | 0.00060 | 0.0050 | 0.070 | 0.00010 | 0.00013 | 0.00050 | 0.00030 | 0.0000050 | 0.0090 |
| | June | 0.00030 | 0.000005 | 0.00020 | 0.0020 | 0.050 | 0.000050 | 0.00127 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | July | | | | | | | | | | | |
| | August | 0.00027 | 0.000030 | 0.00067 | 0.0037 | 0.073 | 0.00018 | 0.00083 | 0.00083 | 0.00030 | 0.0000050 | 0.0040 |
| | October | 0.00030 | 0.000040 | 0.00050 | 0.0012 | 0.046 | 0.00010 | 0.0010 | 0.00050 | 0.00020 | 0.000010 | 0.0025 |
| 2010 | April | 0.00030 | 0.000010 | 0.00047 | 0.0045 | 0.14 | 0.00017 | 0.00060 | 0.00083 | 0.00013 | 0.0000083 | 0.0033 |
| | May | 0.00038 | 0.000023 | 0.00050 | 0.0021 | 0.19 | 0.00010 | 0.0010 | 0.0011 | 0.00022 | 0.000010 | 0.0034 |
| | June | 0.00028 | 0.000050 | | 0.00095 | 0.035 | 0.00010 | 0.0016 | 0.00091 | 0.00040 | | 0.0050 |
| | July | 0.00020 | 0.000050 | | 0.0020 | 0.10 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| | August | 0.00040 | 0.000050 | | 0.0020 | 0.11 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| | September | 0.00050 | 0.000050 | | 0.0010 | 0.23 | 0.00010 | 0.0010 | 0.0020 | 0.00040 | | 0.0050 |
| | October | 0.00040 | 0.0000050 | 0.00050 | 0.0012 | 0.13 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| 2011 | April | 0.00030 | 0.000030 | 0.00050 | 0.0077 | 0.15 | 0.00010 | 0.00050 | 0.0010 | 0.00005 | 0.000010 | 0.0050 |
| | May | 0.00020 | 0.000040 | 0.00050 | 0.0070 | 0.17 | 0.00010 | 0.00050 | 0.0010 | 0.00005 | 0.000010 | 0.010 |
| | June | 0.00030 | 0.000020 | 0.00050 | 0.0046 | 0.16 | 0.00010 | 0.00075 | 0.0013 | 0.000075 | 0.000010 | 0.005 |
| | July | 0.00070 | 0.000010 | 0.00050 | 0.0031 | 0.44 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | August | 0.00073 | 0.000011 | 0.00050 | 0.0028 | 0.55 | 0.00010 | 0.00050 | 0.0023 | 0.00010 | 0.000010 | 0.0025 |
| | September | 0.00070 | 0.000010 | 0.00050 | 0.0016 | 0.62 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | October | 0.00060 | 0.000030 | 0.00050 | 0.0012 | 0.35 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| | November | 0.00040 | 0.0000050 | 0.00050 | 0.0011 | 0.17 | 0.00010 | 0.0013 | 0.0012 | 0.00016 | 0.000010 | 0.0025 |
| 2012 | January | 0.00041 | 0.000035 | 0.00050 | 0.0011 | 0.094 | 0.00010 | 0.0015 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| | February | 0.00033 | 0.000064 | 0.00050 | 0.0154 | 0.049 | 0.00024 | 0.0014 | 0.00050 | 0.00034 | 0.000010 | 0.0083 |
| | March | 0.00039 | 0.0000050 | 0.00050 | 0.0012 | 0.012 | 0.00010 | 0.0011 | 0.00050 | 0.00031 | 0.000010 | 0.0025 |
| | April | 0.00048 | 0.000023 | 0.00050 | 0.0052 | 0.48 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| | May | 0.00089 | 0.000021 | 0.00050 | 0.0027 | 1.0 | 0.00015 | 0.00050 | 0.0018 | 0.000067 | 0.000010 | 0.0025 |
| | June | 0.00070 | 0.0000050 | 0.00050 | 0.0016 | 0.56 | 0.00010 | 0.0013 | 0.002 | 0.00015 | 0.000010 | 0.0025 |
| | July | 0.00096 | 0.0000062 | 0.00050 | 0.0014 | 0.73 | 0.00029 | 0.0011 | 0.0015 | 0.00012 | 0.000010 | 0.0025 |
| | August | 0.00128 | 0.0000050 | 0.00050 | 0.0014 | 0.91 | 0.00010 | 0.0012 | 0.0020 | 0.00011 | 0.000010 | 0.0025 |
| | September | 0.00061 | 0.0000050 | 0.00050 | 0.0019 | 0.42 | 0.00010 | 0.00050 | 0.0025 | 0.000095 | 0.000010 | 0.0025 |
| | October | 0.00060 | 0.0000050 | 0.00050 | 0.00094 | 0.60 | 0.00010 | 0.0011 | 0.0015 | 0.00014 | 0.000010 | 0.0025 |
| | November | 0.00046 | 0.000018 | 0.00050 | 0.0019 | 0.10 | 0.00016 | 0.00090 | 0.0013 | 0.00014 | 0.000010 | 0.0025 |
| | December | 0.00051 | 0.0000050 | 0.00050 | 0.0023 | 0.030 | 0.00010 | 0.0012 | 0.0011 | 0.00045 | 0.000010 | 0.0025 |
| 2013 | April | 0.00025 | 0.0000050 | 0.00050 | 0.0011 | 0.014 | 0.00010 | 0.0013 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| | May | 0.00033 | 0.000011 | 0.00050 | 0.0036 | 0.24 | 0.00010 | 0.00050 | 0.0012 | 0.00005 | 0.000010 | 0.0025 |
| | June | 0.0011 | 0.0000085 | 0.00050 | 0.0017 | 0.59 | 0.00010 | 0.0013 | 0.0019 | 0.00011 | 0.000010 | 0.0045 |
| | July | 0.0011 | 0.0000050 | 0.00050 | 0.0012 | 0.66 | 0.00010 | 0.0012 | 0.0018 | 0.000093 | 0.000010 | 0.0025 |
| | August | 0.0011 | 0.0000050 | 0.00050 | 0.0012 | 0.71 | 0.00010 | 0.0012 | 0.0018 | 0.000093 | 0.000010 | 0.0025 |
| | September | 0.0012 | 0.0000056 | 0.00065 | 0.0012 | 0.96 | 0.00010 | 0.00083 | 0.0020 | 0.000080 | 0.000010 | 0.0025 |
| | October | 0.00078 | 0.0000050 | 0.00050 | 0.0010 | 0.65 | 0.00010 | 0.00076 | 0.0017 | 0.000080 | 0.000010 | 0.0025 |
| | November | 0.0022 | 0.000011 | 0.00077 | 0.00086 | 4.8 | 0.00010 | 0.0011 | 0.0025 | 0.00018 | 0.000010 | 0.0025 |
| | December | 0.00057 | 0.0000080 | 0.00050 | 0.0012 | 0.062 | 0.00010 | 0.00080 | 0.00080 | 0.00015 | 0.000010 | 0.0025 |
| **Median:** | | **0.00041** | **0.000010** | **0.00050** | **0.0017** | **0.15** | **0.00010** | **0.0010** | **0.0011** | **0.00015** | **0.000010** | **0.0025** |
| **95th Percentile:** | | **0.0011** | **0.000050** | **0.0011** | **0.0054** | **0.91** | **0.00025** | **0.0015** | **0.0020** | **0.00050** | **0.000010** | **0.0084** |

**Table D.5: Annual Medians for Option 3.**

| Year | Month | DOC (mg/L) | Dissolved Hardness (mg/L) | Total Hardness (mg/L) | TSS (mg/L) | TDS (mg/L) | Ammonia (mg/L) | Nitrite (mg/L) | Nitrate (mg/L) | Lab pH (pH Units) | Field pH (pH Units) | Dissolved Aluminum (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | May | | | 74 | 19 | 118 | 0.017 | 0.0011 | 0.034 | 7.85 | | 0.043 |
| | June | | | | 5.4 | 160 | 0.015 | 0.00067 | 0.052 | 7.83 | | 0.026 |
| | July | | | 138 | 11 | 173 | 0.010 | 0.00050 | 0.042 | 7.73 | | 0.020 |
| | August | | | 110 | 4.9 | 157 | 0.029 | 0.00066 | 0.010 | 8.10 | | 0.022 |
| | September | | | 111 | 58 | 151 | 0.012 | 0.00057 | 0.025 | 7.83 | | 0.024 |
| | October | | | 111 | 5.5 | 151 | 0.015 | 0.00050 | 0.060 | 7.64 | | 0.033 |
| | **Annual Median** | | | **111** | **8.4** | **154** | **0.015** | **0.00061** | **0.038** | **7.83** | | **0.025** |
| 2006 | June | | 110 | | 206 | 112 | 0.026 | 0.0010 | 0.083 | 7.71 | | 0.075 |
| | July | | 120 | | 3.8 | 184 | 0.014 | | 0.19 | 7.86 | | 0.0056 |
| | August | | 124 | | 2.0 | 175 | 0.017 | | 0.075 | 7.92 | | 0.011 |
| | September | | 120 | | 4.0 | 182 | 0.010 | | 0.053 | 7.78 | | 0.0079 |
| | October | | 129 | | 3.0 | 164 | 0.052 | | 0.11 | 7.67 | | 0.0048 |
| | **Annual Median** | | **120** | | **3.8** | **175** | **0.017** | **0.0010** | **0.083** | **7.78** | | **0.0079** |
| 2007 | June | 8.2 | 110 | 97 | 28 | 147 | 0.025 | 0.027 | 0.14 | 7.84 | | 0.014 |
| | July | 14 | 128 | 125 | 5.7 | 179 | 0.025 | 0.025 | 0.30 | 7.78 | | 0.011 |
| | August | | | 124 | 4.7 | 192 | 0.025 | 0.025 | 0.20 | 8.04 | | |
| | September | 11 | 110 | 93 | 14 | 177 | 0.025 | 0.010 | 0.030 | 7.98 | | 0.0070 |
| | October | | | 129 | 6.5 | 174 | 0.025 | 0.14 | 0.010 | 7.73 | | |
| | **Annual Median** | **11** | **110** | **124** | **6.5** | **177** | **0.025** | **0.025** | **0.14** | **7.84** | | **0.011** |
| 2008 | April | | 187 | | 1.0 | 268 | 0.025 | 0.055 | 0.010 | 8.40 | | 0.010 |
| | June | | 92 | 92 | 15 | 133 | 0.025 | 0.058 | 0.049 | 7.90 | | 0.013 |
| | August | 9.0 | 123 | 124 | 105 | 167 | 0.025 | 0.005 | 0.143 | 7.92 | | 0.014 |
| | September | 18 | | | 16 | 160 | 0.025 | 0.005 | 0.018 | 7.85 | | 0.041 |
| | October | 11 | 123 | | 5.7 | 183 | 0.025 | | | 7.84 | | 0.0090 |
| | **Annual Median** | **11** | **123** | **108** | **15** | **167** | **0.025** | **0.030** | **0.033** | **7.90** | | **0.013** |
| 2009 | April | 18 | 20 | | 1.0 | 52 | | | | 6.84 | 7.60 | 0.053 |
| | June | 9.2 | 93 | | 32 | 156 | | | | 7.90 | 7.74 | 0.013 |
| | July | | 137 | | 4.0 | 184 | | | | 8.07 | | |
| | August | 12 | 96 | | 9.8 | 149 | | | 0.18 | 7.79 | 7.72 | 0.025 |
| | October | 8.3 | 125 | 141 | 2.8 | 130 | 0.010 | 0.0025 | 0.14 | 8.02 | 8.24 | 0.007 |
| | **Annual Median** | **10** | **96** | **141** | **4.0** | **149** | **0.010** | **0.0025** | **0.16** | **7.90** | **7.73** | **0.019** |
| 2010 | April | 21 | 36 | 50 | 2.5 | 89 | 0.016 | 0.0038 | 0.015 | 7.64 | 7.56 | 0.053 |
| | May | 11 | 83 | 88 | 67 | 119 | 0.034 | 0.0065 | 0.070 | 8.02 | 7.64 | 0.029 |
| | June | 7.6 | 113 | 121 | 63 | 143 | 0.059 | 0.0073 | 0.14 | 8.17 | 7.49 | 0.012 |
| | July | 16 | 93 | 106 | 53 | 150 | 0.027 | 0.0025 | 0.070 | 8.06 | 8.02 | 0.019 |
| | August | 13 | 118 | 116 | | 170 | | | | | 7.91 | 0.011 |
| | September | 17 | 107 | 104 | 11 | 210 | 0.039 | 0.0025 | 0.030 | 7.98 | 8.02 | 0.016 |
| | October | 13 | 111 | 126 | 3.0 | 150 | 0.069 | 0.0025 | 0.070 | 8.10 | 7.85 | 0.011 |
| | **Annual Median** | **13** | **107** | **106** | **32** | **150** | **0.037** | **0.0031** | **0.070** | **8.04** | **7.85** | **0.016** |
| 2011 | April | 23 | 43 | 43 | 0.50 | 72 | 0.010 | 0.0025 | 0.010 | 7.41 | | 0.057 |
| | May | 22 | 32 | 33 | 7.0 | 40 | | 0.0025 | 0.010 | 7.11 | | 0.076 |
| | June | 17 | 66 | 69 | 29 | 91 | 0.012 | 0.0025 | 0.040 | 7.65 | | 0.042 |
| | July | 21 | 77 | 88 | 150 | 120 | 0.016 | 0.0070 | 0.050 | 7.76 | | 0.034 |
| | August | 21 | 82 | 91 | 149 | 130 | 0.012 | 0.0036 | 0.053 | 7.86 | | 0.039 |
| | September | 13 | 118 | 119 | 1.0 | 170 | 0.025 | 0.0025 | 0.050 | 8.03 | 7.92 | 0.024 |
| | October | 12 | 110 | 113 | 2.0 | 150 | 0.019 | 0.0025 | 0.11 | 8.07 | 7.65 | 0.013 |
| | November | 7.7 | 148 | 144 | 27 | 156 | 0.021 | 0.0025 | 0.14 | 7.96 | | 0.0076 |
| | **Annual Median** | **19** | **79** | **89** | **17** | **125** | **0.016** | **0.0025** | **0.050** | **7.81** | **7.79** | **0.036** |
| 2012 | January | 5.3 | 169 | 158 | 2.0 | 226 | 0.0050 | 0.0025 | 0.32 | 8.13 | | 0.0053 |
| | February | 6.1 | 165 | 160 | 2.0 | 216 | 0.0060 | 0.0025 | 0.29 | 7.99 | 7.16 | 0.021 |
| | March | 5.2 | 161 | 159 | 3.2 | 176 | 0.0067 | 0.0025 | 0.20 | 8.17 | 6.72 | 0.0031 |
| | April | 14 | 39 | 37 | 11.2 | 100 | 0.0025 | 0.010 | 0.010 | 7.63 | 7.43 | 0.050 |
| | May | 14 | 52 | 126 | 1158 | 100 | 0.093 | 0.0055 | 0.029 | 7.07 | 7.50 | 0.053 |
| | June | 16 | 92 | 105 | 165 | 128 | 0.18 | 0.015 | 0.083 | 8.12 | 7.59 | 0.027 |
| | July | 13 | 121 | 162 | 630 | 158 | 0.134 | 0.010 | 0.11 | 8.15 | 7.86 | 0.031 |
| | August | 11 | 128 | 175 | 700 | 178 | 0.045 | 0.0097 | 0.10 | 8.16 | 8.08 | 0.030 |
| | September | 15 | 102 | 107 | 33 | 136 | 0.0099 | 0.0025 | 0.056 | 8.09 | 7.97 | 0.020 |
| | October | 11 | 129 | 130 | 27 | 158 | 0.022 | 0.0025 | 0.084 | 8.05 | 8.10 | 0.011 |
| | November | 8.5 | 156 | 154 | 2.2 | 188 | 0.026 | 0.0025 | 0.11 | 7.93 | 6.69 | 0.0079 |
| | December | 10 | 223 | 206 | 0.50 | 262 | 0.025 | 0.0025 | 0.063 | 8.13 | 7.97 | 0.0061 |
| | **Annual Median** | **11** | **128** | **156** | **19** | **167** | **0.024** | **0.0025** | **0.092** | **8.10** | **7.59** | **0.021** |
| 2013 | April | 4.6 | 192 | 198 | 5.8 | 246 | 0.0082 | 0.0025 | 0.13 | 8.27 | 8.18 | 0.0031 |
| | May | 19 | 32 | 35 | 34 | 77 | 0.098 | 0.0025 | 0.010 | 7.53 | 7.90 | 0.051 |
| | June | 13 | 121 | 151 | 278 | 168 | 0.16 | 0.011 | 0.17 | 8.09 | 8.05 | 0.034 |
| | July | 9.1 | 118 | 147 | 179 | 163 | 0.11 | 0.0092 | 0.091 | 8.08 | 7.99 | 0.019 |
| | August | 13 | 131 | 154 | 218 | 179 | 0.080 | 0.0052 | 0.097 | 8.12 | 7.92 | 0.021 |
| | September | 12 | 129 | 149 | 53 | 196 | 0.048 | 0.0037 | 0.10 | 7.98 | 7.80 | 0.022 |
| | October | 12 | 130 | 133 | 40 | 193 | 0.069 | 0.0025 | 0.11 | 8.18 | 7.55 | 0.014 |
| | November | 16 | 177 | 184 | 19 | 185 | 0.11 | 0.010 | 0.12 | 8.08 | 7.61 | 0.015 |
| | December | 8.0 | 164 | 186 | 2.1 | 207 | 0.016 | 0.0025 | 0.11 | 8.18 | 6.90 | 0.0038 |
| | **Annual Median** | **12** | **130** | **151** | **40** | **185** | **0.080** | **0.0037** | **0.11** | **8.09** | **7.90** | **0.019** |

**Table D.5: Annual Medians for Option 3.**

| Year | Month | Dissolved Arsenic (mg/L) | Dissolved Cadmium (mg/L) | Dissolved Chromium (mg/L) | Dissolved Copper (mg/L) | Dissolved Iron (mg/L) | Dissolved Lead (mg/L) | Dissolved Molybdenum (mg/L) | Dissolved Nickel (mg/L) | Dissolved Selenium (mg/L) | Dissolved Silver (mg/L) | Dissolved Zinc (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2005 | May | 0.00029 | 0.000025 | 0.00050 | 0.0042 | 0.14 | 0.00025 | 0.00050 | 0.0014 | 0.00050 | 0.000010 | 0.0029 |
| | June | 0.00046 | 0.000025 | 0.00030 | 0.0023 | 0.16 | 0.000064 | 0.00085 | 0.0011 | 0.00050 | 0.0000050 | 0.0091 |
| | July | 0.00041 | 0.000025 | 0.00025 | 0.0033 | 0.16 | 0.000075 | 0.0011 | 0.0011 | 0.00050 | 0.0000050 | 0.0030 |
| | August | 0.00043 | 0.000010 | 0.00050 | 0.0026 | 0.27 | 0.00025 | 0.00083 | 0.0014 | 0.00050 | 0.000010 | 0.0029 |
| | September | 0.00039 | 0.0000085 | 0.00050 | 0.0027 | 0.31 | 0.00025 | 0.00059 | 0.0013 | 0.00050 | 0.000010 | 0.0025 |
| | October | 0.00044 | 0.000025 | 0.00025 | 0.0029 | 0.25 | 0.000025 | 0.00069 | 0.0012 | 0.00050 | 0.0000050 | 0.0013 |
| | **Annual Median** | **0.00042** | **0.000025** | **0.00040** | **0.0028** | **0.21** | **0.00016** | **0.00076** | **0.0013** | **0.00050** | **0.0000075** | **0.0029** |
| 2006 | June | 0.00051 | 0.000021 | 0.00050 | 0.0017 | 0.15 | 0.000094 | 0.00055 | 0.0019 | 0.00039 | 0.0000050 | 0.0025 |
| | July | 0.00048 | 0.0000050 | 0.00076 | 0.0011 | 0.083 | 0.000088 | 0.0011 | 0.0012 | 0.00013 | | 0.00063 |
| | August | 0.00035 | 0.0000050 | 0.00059 | 0.0013 | 0.083 | 0.000050 | 0.00088 | 0.00083 | 0.00010 | | 0.0024 |
| | September | 0.00046 | 0.000039 | 0.00070 | 0.0011 | 0.10 | 0.000050 | 0.00075 | 0.00067 | 0.00011 | | 0.0017 |
| | October | 0.00035 | 0.0000050 | 0.00025 | 0.00075 | 0.10 | 0.000050 | 0.0010 | 0.00065 | 0.00020 | | 0.0015 |
| | **Annual Median** | **0.00046** | **0.0000050** | **0.00059** | **0.0011** | **0.10** | **0.000050** | **0.00088** | **0.00083** | **0.00013** | **0.0000050** | **0.0017** |
| 2007 | June | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.050 | 0.000050 | 0.0010 | 0.00025 | 0.00010 | | 0.0040 |
| | July | 0.00050 | 0.0000050 | 0.0010 | 0.0020 | 0.040 | 0.000050 | 0.0010 | 0.00070 | 0.00010 | | 0.0060 |
| | August | | | | | | | | | | | |
| | September | 0.00040 | 0.0000050 | 0.0016 | 0.0010 | 0.080 | 0.000050 | 0.0020 | 0.00080 | 0.00010 | | 0.0020 |
| | October | | | | | | | | | | | |
| | **Annual Median** | **0.00040** | **0.0000050** | **0.0010** | **0.0020** | **0.050** | **0.000050** | **0.0010** | **0.00070** | **0.00010** | | **0.0040** |
| 2008 | April | 0.00027 | 0.000040 | 0.00097 | 0.0012 | 0.030 | 0.000067 | 0.0017 | 0.0010 | 0.00030 | | 0.0017 |
| | June | 0.00010 | 0.000040 | 0.0013 | 0.00075 | 0.060 | 0.000050 | 0.0014 | 0.0010 | 0.0013 | 0.0000050 | 0.0020 |
| | August | 0.00040 | 0.0000050 | 0.00060 | 0.0020 | 0.070 | 0.000050 | 0.0010 | 0.0010 | 0.00010 | 0.000060 | 0.0060 |
| | September | 0.00035 | 0.0000050 | 0.0015 | 0.0030 | 0.15 | 0.00088 | 0.00050 | 0.0015 | 0.00075 | 0.0000050 | 0.0030 |
| | October | 0.00050 | 0.0000050 | 0.00050 | 0.0010 | 0.078 | 0.000050 | 0.00108 | 0.0010 | 0.00030 | 0.0000050 | 0.0010 |
| | **Annual Median** | **0.00035** | **0.0000050** | **0.0010** | **0.0012** | **0.070** | **0.000050** | **0.0011** | **0.0010** | **0.00030** | **0.0000050** | **0.0020** |
| 2009 | April | 0.00010 | 0.000080 | 0.00060 | 0.0050 | 0.070 | 0.00010 | 0.00013 | 0.00050 | 0.00030 | 0.0000050 | 0.0090 |
| | June | 0.00030 | 0.000005 | 0.00020 | 0.0020 | 0.050 | 0.000050 | 0.00127 | 0.0010 | 0.00030 | 0.0000050 | 0.0020 |
| | July | | | | | | | | | | | |
| | August | 0.00027 | 0.000030 | 0.00067 | 0.0037 | 0.073 | 0.00018 | 0.00083 | 0.00083 | 0.00030 | 0.0000050 | 0.0040 |
| | October | 0.00030 | 0.000040 | 0.00050 | 0.0012 | 0.046 | 0.00010 | 0.0010 | 0.00050 | 0.00020 | 0.000010 | 0.0025 |
| | **Annual Median** | **0.00028** | **0.000035** | **0.00055** | **0.0028** | **0.060** | **0.00010** | **0.00092** | **0.00067** | **0.00030** | **0.0000050** | **0.0033** |
| 2010 | April | 0.00030 | 0.000010 | 0.00047 | 0.0045 | 0.14 | 0.00017 | 0.00060 | 0.00083 | 0.00013 | 0.0000083 | 0.0033 |
| | May | 0.00038 | 0.000023 | 0.00050 | 0.0021 | 0.19 | 0.00010 | 0.0010 | 0.0011 | 0.00022 | 0.000010 | 0.0034 |
| | June | 0.00028 | 0.000050 | | 0.00095 | 0.035 | 0.00010 | 0.0016 | 0.00091 | 0.00040 | | 0.0050 |
| | July | 0.00020 | 0.000050 | | 0.0020 | 0.10 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| | August | 0.00040 | 0.000050 | | 0.0020 | 0.11 | 0.00010 | 0.0010 | 0.0010 | 0.00040 | | 0.0050 |
| | September | 0.00050 | 0.000050 | | 0.0010 | 0.23 | 0.00010 | 0.0010 | 0.0020 | 0.00040 | | 0.0050 |
| | October | 0.00040 | 0.0000050 | 0.00050 | 0.0012 | 0.13 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| | **Annual Median** | **0.00038** | **0.000050** | **0.00050** | **0.0020** | **0.13** | **0.00010** | **0.0010** | **0.0010** | **0.00040** | **0.000010** | **0.0050** |
| 2011 | April | 0.00030 | 0.000030 | 0.00050 | 0.0077 | 0.15 | 0.00010 | 0.00050 | 0.0010 | 0.00005 | 0.000010 | 0.0050 |
| | May | 0.00020 | 0.000040 | 0.00050 | 0.0070 | 0.17 | 0.00010 | 0.00050 | 0.0010 | 0.00005 | 0.000010 | 0.010 |
| | June | 0.00030 | 0.000020 | 0.00050 | 0.0046 | 0.16 | 0.00010 | 0.00075 | 0.0013 | 0.000075 | 0.000010 | 0.005 |
| | July | 0.00070 | 0.000010 | 0.00050 | 0.0031 | 0.44 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | August | 0.00073 | 0.000011 | 0.00050 | 0.0028 | 0.55 | 0.00010 | 0.00050 | 0.0023 | 0.00010 | 0.000010 | 0.0025 |
| | September | 0.00070 | 0.000010 | 0.00050 | 0.0016 | 0.62 | 0.00010 | 0.00050 | 0.0020 | 0.00010 | 0.000010 | 0.0025 |
| | October | 0.00060 | 0.000030 | 0.00050 | 0.0012 | 0.35 | 0.00010 | 0.0010 | 0.0010 | 0.00010 | 0.000010 | 0.0025 |
| | November | 0.00040 | 0.0000050 | 0.00050 | 0.0011 | 0.17 | 0.00010 | 0.0013 | 0.0012 | 0.00016 | 0.000010 | 0.0025 |
| | **Annual Median** | **0.00050** | **0.000016** | **0.00050** | **0.0029** | **0.26** | **0.00010** | **0.00050** | **0.0012** | **0.00010** | **0.000010** | **0.000010** |
| 2012 | January | 0.00041 | 0.000035 | 0.00050 | 0.0011 | 0.094 | 0.00010 | 0.0015 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| | February | 0.00033 | 0.000064 | 0.00050 | 0.0154 | 0.049 | 0.00024 | 0.0014 | 0.00050 | 0.00034 | 0.000010 | 0.0083 |
| | March | 0.00039 | 0.0000050 | 0.00050 | 0.0012 | 0.012 | 0.00010 | 0.0011 | 0.00050 | 0.00031 | 0.000010 | 0.0025 |
| | April | 0.00048 | 0.000023 | 0.00050 | 0.0052 | 0.48 | 0.00010 | 0.00050 | 0.0012 | 0.000050 | 0.000010 | 0.0025 |
| | May | 0.00089 | 0.000021 | 0.00050 | 0.0027 | 1.0 | 0.00015 | 0.00050 | 0.0018 | 0.000067 | 0.000010 | 0.0025 |
| | June | 0.00070 | 0.0000050 | 0.00050 | 0.0016 | 0.56 | 0.00010 | 0.0013 | 0.002 | 0.00015 | 0.000010 | 0.0025 |
| | July | 0.00096 | 0.0000062 | 0.00050 | 0.0014 | 0.73 | 0.00029 | 0.0011 | 0.0015 | 0.00012 | 0.000010 | 0.0025 |
| | August | 0.00128 | 0.0000050 | 0.00050 | 0.0014 | 0.91 | 0.00010 | 0.0012 | 0.0020 | 0.00011 | 0.000010 | 0.0025 |
| | September | 0.00061 | 0.0000050 | 0.00050 | 0.0019 | 0.42 | 0.00010 | 0.00050 | 0.0025 | 0.000095 | 0.000010 | 0.0025 |
| | October | 0.00060 | 0.0000050 | 0.00050 | 0.00094 | 0.60 | 0.00010 | 0.0011 | 0.0015 | 0.00014 | 0.000010 | 0.0025 |
| | November | 0.00046 | 0.000018 | 0.00050 | 0.0019 | 0.10 | 0.00016 | 0.00090 | 0.0013 | 0.00014 | 0.000010 | 0.0025 |
| | December | 0.00051 | 0.0000050 | 0.00050 | 0.0023 | 0.030 | 0.00010 | 0.0012 | 0.0011 | 0.00045 | 0.000010 | 0.0025 |
| | **Annual Median** | **0.00056** | **0.0000056** | **0.00050** | **0.0018** | **0.45** | **0.00010** | **0.0011** | **0.0014** | **0.00014** | **0.000010** | **0.0025** |
| 2013 | April | 0.00025 | 0.0000050 | 0.00050 | 0.0011 | 0.014 | 0.00010 | 0.0013 | 0.00050 | 0.00043 | 0.000010 | 0.0025 |
| | May | 0.00033 | 0.000011 | 0.00050 | 0.0036 | 0.24 | 0.00010 | 0.00050 | 0.0012 | 0.00005 | 0.000010 | 0.0025 |
| | June | 0.0011 | 0.0000085 | 0.00050 | 0.0017 | 0.59 | 0.00010 | 0.0013 | 0.0019 | 0.00011 | 0.000010 | 0.0045 |
| | July | 0.0011 | 0.0000050 | 0.00050 | 0.0012 | 0.66 | 0.00010 | 0.0012 | 0.0018 | 0.000093 | 0.000010 | 0.0025 |
| | August | 0.0011 | 0.0000050 | 0.00050 | 0.0012 | 0.71 | 0.00010 | 0.0012 | 0.0018 | 0.000093 | 0.000010 | 0.0025 |
| | September | 0.0012 | 0.0000056 | 0.00065 | 0.0012 | 0.96 | 0.00010 | 0.00083 | 0.0020 | 0.000080 | 0.000010 | 0.0025 |
| | October | 0.00078 | 0.0000050 | 0.00050 | 0.0010 | 0.65 | 0.00010 | 0.00076 | 0.0017 | 0.000080 | 0.000010 | 0.0025 |
| | November | 0.0022 | 0.000011 | 0.00077 | 0.00086 | 4.8 | 0.00010 | 0.0011 | 0.0025 | 0.00018 | 0.000010 | 0.0025 |
| | December | 0.00057 | 0.0000080 | 0.00050 | 0.0012 | 0.062 | 0.00010 | 0.00080 | 0.00080 | 0.00015 | 0.000010 | 0.0025 |
| | **Annual Median** | **0.0011** | **0.0000056** | **0.00050** | **0.0012** | **0.65** | **0.00010** | **0.0011** | **0.0018** | **0.000093** | **0.000010** | **0.0025** |

**Table D.6: Background water quality summary statistics for Option 2 (Grouped by Week) representing lower Minto Creek (Minnow 2016) [1]**

| Analytes | Background Concentrations | |
|---|---|---|
| | Individual Data Point Evaluator (95$^{th}$ percentile) | Central Tendency Evaluator (95$^{th}$ percentile of annual medians) |
| Ammonia (mg/L) | 0.12 | 0.058 |
| Nitrite (mg/L) | 0.038 | 0.034 |
| Nitrate (mg/L) | 0.22 | 0.14 |
| Dissolved Aluminum (mg/L) | 0.056 | 0.027 |
| Dissolved Arsenic (mg/L) | 0.0013 | 0.00077 |
| Dissolved Cadmium (mg/L) | 0.000050 | 0.000046 |
| Dissolved Chromium (mg/L) | 0.00130 | 0.00108 |
| Dissolved Copper (mg/L) | 0.0051 | 0.0025 |
| Dissolved Iron (mg/L) | 0.95 | 0.55 |
| Dissolved Lead (mg/L) | 0.000276 | 0.000138 |
| Dissolved Molybdenum (mg/L) | 0.00172 | 0.00114 |
| Dissolved Nickel (mg/L) | 0.0024 | 0.0017 |
| Dissolved Selenium (mg/L) | 0.00050 | 0.00046 |
| Dissolved Silver (mg/L) | 0.000010 | 0.000010 |
| Dissolved Zinc (mg/L) | 0.0060 | 0.0046 |

[1] For contaminants of potential concern (COPCs)

# Appendix G1
# Minto Mine Reclamation and Closure Plan – Preliminary Design Report for Treatment Wetland

Contango Strategies Ltd.

*Forward looking.* Lateral thinking.

# Minto Mine Reclamation and Closure Plan – Preliminary Design Report for Treatment Wetland

Document – 011_0716_04C

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**Executive Summary**
Passive water treatment is desired in closure at the Minto Mine, with a focus on the constituents of cadmium (Cd), copper (Cu), and selenium (Se). To address this goal, a constructed wetland treatment system (CWTS) is being designed in a site-specific manner, through a phased approach.

This document outlines foundational scientific information used to select the passive water treatment technology and develop conceptual designs for the Minto Mine. This document then proceeds through to the preliminary CWTS design which is based on findings from phases that included: information gathering, site assessment, off-site pilot-scale testing, and preliminary on-site demonstration-scale confirmation and optimization.

This report specifically considers water treatment by a CWTS within the footprint of the water storage pond at the Minto Mine. The preliminary CWTS design described herein is a surface flow wetland, designed to create and maintain anaerobic conditions in the sediment to sequester cadmium and copper in sulphide mineral form, and selenium in a low bioavailable elemental form. The phased plan for site-specific design and optimization has demonstrated that these elements can be successfully and sustainably treated at the Minto Mine through passive treatment such as a CWTS. A CWTS of this type can be brought online effectively by having more rigorous monitoring and adjustments during an initial commissioning period, followed by progressive decreases in monitoring and maintenance requirements through early- and long-term operation. Conceptual monitoring and maintenance schedules are also described herein.

# 1. Introduction

The Minto Mine, operated by Capstone Mining Corp., is located 240 km northwest of Whitehorse on the west side of the Yukon River. The Minto property lies within the eastern part of the Dawson Range, with elevations from 700 to 1,000 m; the landscape has rounded mountains intersected by broad valleys and drainages that are part of the Yukon River watershed.

The Minto Mine has been in commercial operation since October 2007 and the deposits being mined are copper sulphide mineralized zones. Surface and groundwater water quality is a key consideration in the evaluation of potential effects of mining and mineral development projects and changes to water quality parameters have the potential to affect aquatic and human use of water resources. A Reclamation and Closure Plan (RCP) is required under both the Water Licence and the Quartz Mining Licence. The RCP is intended to address the long-term physical and chemical stability of the site and closure of the proposed features and disturbances associated with the mine. As a part of the RCP, a Constructed Wetland Treatment System (CWTS) is being designed, evaluated, and optimized for water treatment at closure through a phased program (Minto Phase V/VI Expansion Project, YOR Project Number 2013-0100).

The purpose of this report is to describe the design considerations and conceptual monitoring and maintenance associated with a CWTS in the Water Storage Pond (WSP) area of the Minto Mine (Minto) in closure. The scope of this report resides with maintaining performance and treatment capacity, while engineering aspects to maintain hydrology (which in turn, is necessary for treatment) are addressed in Appendix A (SRK, 2016b).

# 2. Design

## 2.1. Treatment Technologies

Passive treatment systems are proposed as key mitigation measures for the achievement of acceptable water quality from the Minto site in the closure condition (Access, June 2013).

Passive treatment as a remediation method for mine-impacted water can be a sustainable method used during post-closure of a mine, as they generally involve significantly less direct capital costs, as well as lower operations and maintenance costs, when compared to traditional active treatment options (Kilbourn Inc., 1999).

A detailed review of the site-wide water balance confirmed that a significant portion of the mining impacted seepage, surface flow and contaminant load could be passively intercepted at a few specific areas which have sufficient space and topography for the incorporation of a wide variety of passive treatment systems (PTS) such as constructed wetland treatment systems (CWTS).

The various potential passive treatment technologies were evaluated and ranked in order to determine which passive treatment technologies held the greatest promise for incorporation in Minto water management and closure planning. A guidance document to help short list and then select an appropriate method for managing mine waste sites was created by The Interstate Technology and Regulatory Council (ITRC), a body of socio- economic and environmental regulators, industry, federal government, and stakeholders that work towards innovative environmental decision making (ITRC, 2010).

ITRC's "Mining Waste Treatment Technology Selection" guidance document (and associated literature reviews) is an interactive and iterative web-based decision tree which provides a systematic framework that can be used to identify a short list of appropriate technologies (ITRC, 2010). The ITRC decision tree framework was used for identifying the range of potential passive treatment technologies which may be applicable at the Minto Mine because it provides a straightforward and transparent method for selecting treatment technologies. It also provides legitimacy in the selection process by using an internationally recognized method that was created specifically for mining waste sites.

Following the identification of potential passive treatment technologies, a screening level evaluation and ranking of the potential passive treatment technologies was conducted. Some of the key considerations evaluating the various treatment technologies included:

- Work acceptably in cold weather;
- Sustainable in the long-term;
- Minimal/low intensity active maintenance scenario;
- Suitable for addressing Minto's specific constituents of potential concern (i.e., Cu, Cd, Se);
- Robust technology with adequate precedent of successful application;

- Amenable to collaboration with SFN and consistent with their aspirations for long-term employment and future land use;
- Cost effective; and
- Amenable to incorporation in an Adaptive Management Plan and modifying/expanding if initial design underperforms.

Based on key site-specific considerations, CWTS were deemed promising and were selected for further investigation at Minto. This report specifically considers water treatment by a CWTS within the footprint of the water storage pond.

## 2.2. Design Basis

PTS such as CWTS rely on transfers (e.g., sorption, filtration) and transformations (e.g., geochemical and biogeochemical reactions) to remove constituents from water (Haakensen et al., 2015; Rodgers and Castle, 2008). These processes require no or infrequent (periodic) electricity, amendment addition, substrate replacement, or flow management. Moreover, these processes can be targeted through specific design aspects, therefore identifying the desired processes and mechanisms to promote their activity and enhance their robustness promotion forms the foundation of the design basis of a CWTS.

Once CWTS have undergone commissioning, they can be relatively self-sustaining, operationally passive (or remotely operated), with minimal periodic maintenance or management required (e.g., addition of sources of carbon), and therefore can provide effective low-cost water treatment in remote environments. This, coupled with the ability to work in the absence of power or the need for active management, suggests that PTS are suitable as a component of a long-term solution to post-closure management of mine-influenced water quality.

The following sections discuss treatment mechanisms for constituents of concern at the Minto Mine.

### *2.2.1. Transfers*

Some of the simplest treatment mechanisms within a CWTS are transfers. These include sorption and filtration, which are not greatly affected by the temperature of the water. While facilitating treatment in colder temperatures, the transfer sites need to be renewed as they are only present in a finite abundance. Transfer sites are renewed by the vegetation, which aids filtration (by submerged vegetation and aquatic roots), and provides sorption sites (on live and decomposing vegetation). Transfer sites are particularly abundant in aquatic mosses. Aquatic plants were selected for the Minto CWTS based on being obligate wetland plants, with a high generation of organic matter, and ideally being peat forming. Such plants were identified at the Minto site during the 2013 CWTS site assessment, with *Carex aquatilis* (known as Aquatic Sedge or Water Sedge) and aquatic bryophytes (aquatic mosses, capable of growing fully submerged in water) being selected as the most promising candidates, (Contango, March 2014) and confirmed through off-site pilot-scale testing (Contango, November 2014).

However, once the constituents have been transferred from one location (water) to another (soils, vegetation) within the wetland, they still need to be transformed to a more stable and less bioavailable form, otherwise known as a coupled biogeochemical reaction. As the CWTS design aspects associated with transfers are fairly generic, the remainder of the design basis was formed around the biogeochemical transformations needed for long-term treatment and sequestration of constituents.

### *2.2.2. Transformations*

Transformations in a CWTS are largely governed by biogeochemical reactions are catalyzed by microbes. Specific microbes (and therefore biogeochemical pathways) can be encouraged through the environmental conditions created by the design of a CWTS. For example, metals can be removed from water by forming insoluble compounds with sulphides. These sulphides are generated by bacteria (sulphide-producing bacteria) that use organic carbon sources (e.g., wood chips, plant matter, methanol) to reduce sulphate in the water under specific oxidation-reduction conditions (Figure 1 and Table 1). This mechanism can be used to treat multiple metals, however, some metals and metalloids will be more readily removed than others as a sulphide mineral, while others can be directly treated through oxidation or reductive processes (Table 1). Therefore, the constituents targeted for treatment at the Minto mine (cadmium, copper, and selenium) are individually addressed in the sections below.

$$\text{Organic Carbon} + SO_4^{2-} \rightarrow HCO_3^- + HS^- + H_2O$$

$$HS^- + M^{2+} \leftrightarrow MS + 2H^+$$

M = divalent metals (e.g., Cd, Cu, Fe, Mo, Ni, Pb, Zn)

Figure 1 – Example equation of sulphate reduction and metals treatment.
The equation is not balanced and varies based on carbon source and pH. The equation shows the creation of alkalinity ($HCO_3^-$) and sulphides ($HS^-$), the latter which can then form insoluble metal sulphide complexes.

Table 1 – ORP values for various biochemical reactions.

| Biochemical Reaction | ORP (mV) |
|---|---|
| Nitrification | +100 to +350 |
| cBOD degradation with free molecular oxygen | +50 to +250 |
| Biological phosphorus removal | +25 to +250 |
| Denitrification | +50 to -50 |
| Selenium reduction | -50 to -200 |
| Sulphide formation | -50 to -250 |
| Biological phosphorus release | -100 to -250 |
| Acid formation (fermentation) | -100 to -225 |
| Methane production | -175 to -400 |
| Adapted from Gerardi, 2010. | |

### *2.2.3. Copper treatment mechanisms*

Copper treatment can be achieved in several ways, through oxidizing or reducing geochemical and biogeochemical reactions. When treated from water under appropriately designed reducing conditions, copper will form insoluble copper sulphides (Figure 1, Figure 2 and Figure 3). In contrast, in oxidizing conditions, copper can be removed from water as insoluble hydroxides, carbonates, or iron and manganese oxides (Figure 2).

Several copper treatment mechanisms can occur abiotically (i.e., geochemical reaction) given the right conditions and constituents in water (e.g., oxidizing and co-precipitation with iron). In contrast, formation of copper sulphides is generally biologically driven. It requires the production of sulphides by microbes under anaerobic (i.e., depleted dissolved oxygen) and reducing conditions (-50 to -250 mV; Table 1), with a carbon source to sustain the reaction. Although literature provides a range of -50 to -250mV for sulphate reduction, pilot-scale testing for the Minto CWTS, indicated the site-specific targeted soil redox is between -100 and -250 mV.

Within a CWTS, copper can be removed by both oxidizing and reducing conditions, oxidizing associated with actively growing aquatic mosses, and reduction associated with sediments and decaying mosses. These processes are often coupled, such that the long-term sequestration of the copper in the CWTS is as a copper sulphide. Some forms of mineralized copper are more stable and resistant to resolubilization, and the stability of these minerals is reflected by a $K_{sp}$ value (Table 2 and Table 3). Generally, the minerals that have been catalyzed by microbiological activity cannot spontaneously resolubilize under conditions periodically encountered in CWTS. Additionally, the CWTS forms other minerals, such as amorphous FeS which serves as a buffer to re-oxidation of minerals such as copper sulphides (Table 2). For these reasons, reductive mineralization of copper sulphides was chosen as the preferred treatment pathway for copper in this CWTS.

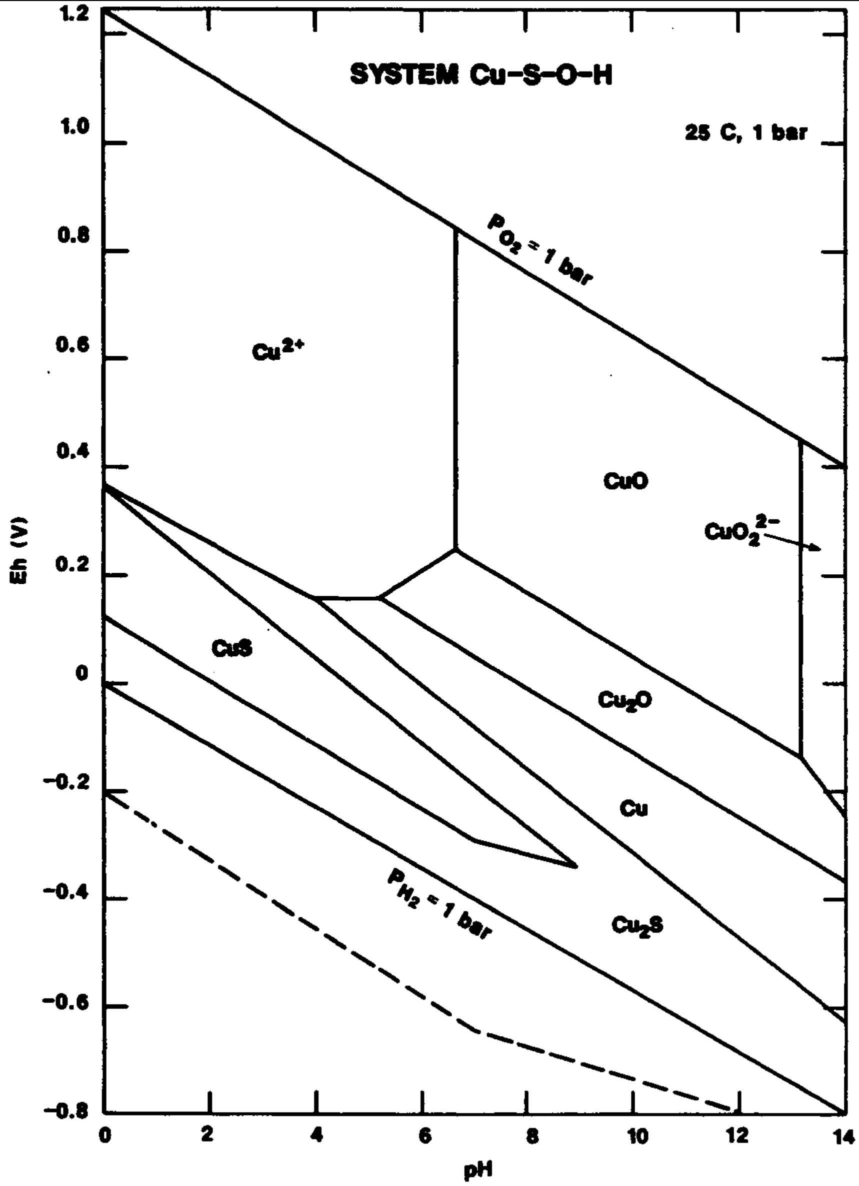


Figure 2 – Eh-pH diagram for part of the system Cu-S-O-H.
See Table 3 for thermodynamic data (Brookins 1988).

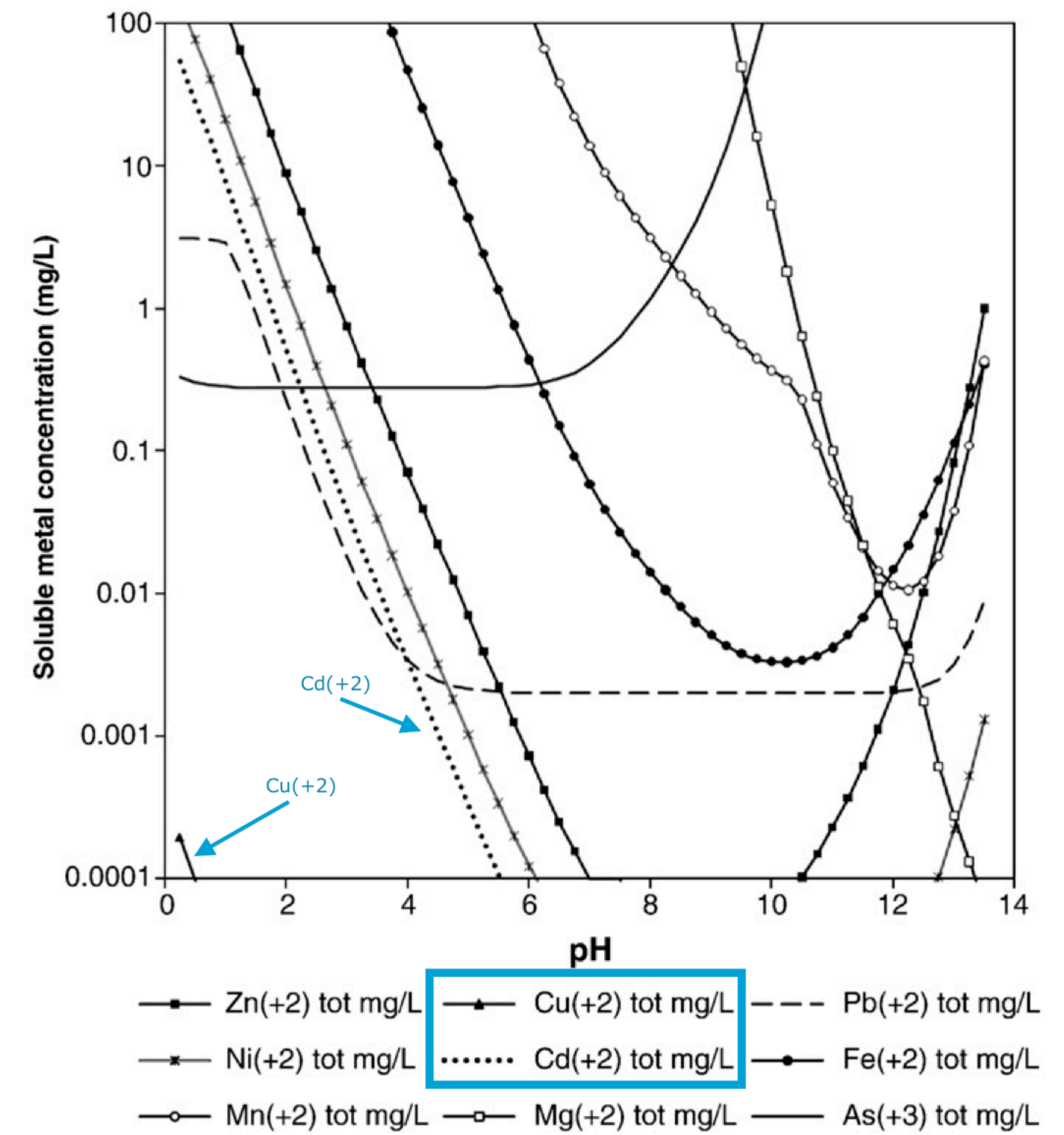


Figure 3 – pH dependence of metal sulphide solubility.
Copper- and cadmium-sulphide solubility indicated with blue arrows and box. Adapted from Lewis (2010).

Table 2 – Solubility of sulphide minerals.

| Metal Sulphide | Log $K_{sp}$ [1] |
|---|---|
| CdS | -25.8 |
| CuS | -36.1 |
| $Cu_2S$ | -47.7 |
| FeS | -18.1 |

[1] Solubility product ($K_{sp}$). Table adapted from Jackson (1986).

Table 3 – Thermodynamic data for copper.

| Species State | $\Delta G^0{}_f$(kcal/gfw) |
|---|---|
| $Cu_{(c)}$ | 0.00 |
| $Cu^+{}_{(aq)}$ | +11.94 |
| $Cu^{2+}{}_{(aq)}$ | +15.65 |
| $Cu_2S_{(c)}$ | -20.60 |
| $CuS_{(c)}$ | -12.81 |
| $Cu_2O_{(c)}$ | -34.98 |
| $CuO_{(c)}$ | -31.00 |
| $CuO_{2\,(aq)}^{2-}$ | -43.88 |
| $Cu_2(CO_3)(OH)_{2\ (c)}$ | -213.58 |
| $Cu_3(CO_3)_2(OH)_{2\ (c)}$ | -314.29 |

Adapted from Brookins, 1988; aq – aqueous (dissolved/soluble), c – crystalline (solid).

### *2.2.4. Cadmium treatment mechanisms*

Passive treatment mechanisms for cadmium are the same as copper, with precipitation as sulphides, hydroxides, carbonates, and iron and manganese oxides as means for removal depending on water chemistry and conditions (Figure 1, Figure 3, Figure 4, and Table 4). Both sulphides and iron and manganese oxides will achieve the ultralow concentrations desired for the Minto CWTS. Based on site-specific considerations and water chemistry at the Minto Mine, cadmium treatment is targeted to be removed in the most stable and low-bioavailable form, and therefore will be removed by the same mechanism as copper, by precipitation as a metal sulphide (cadmium sulphide, CdS; Table 2).

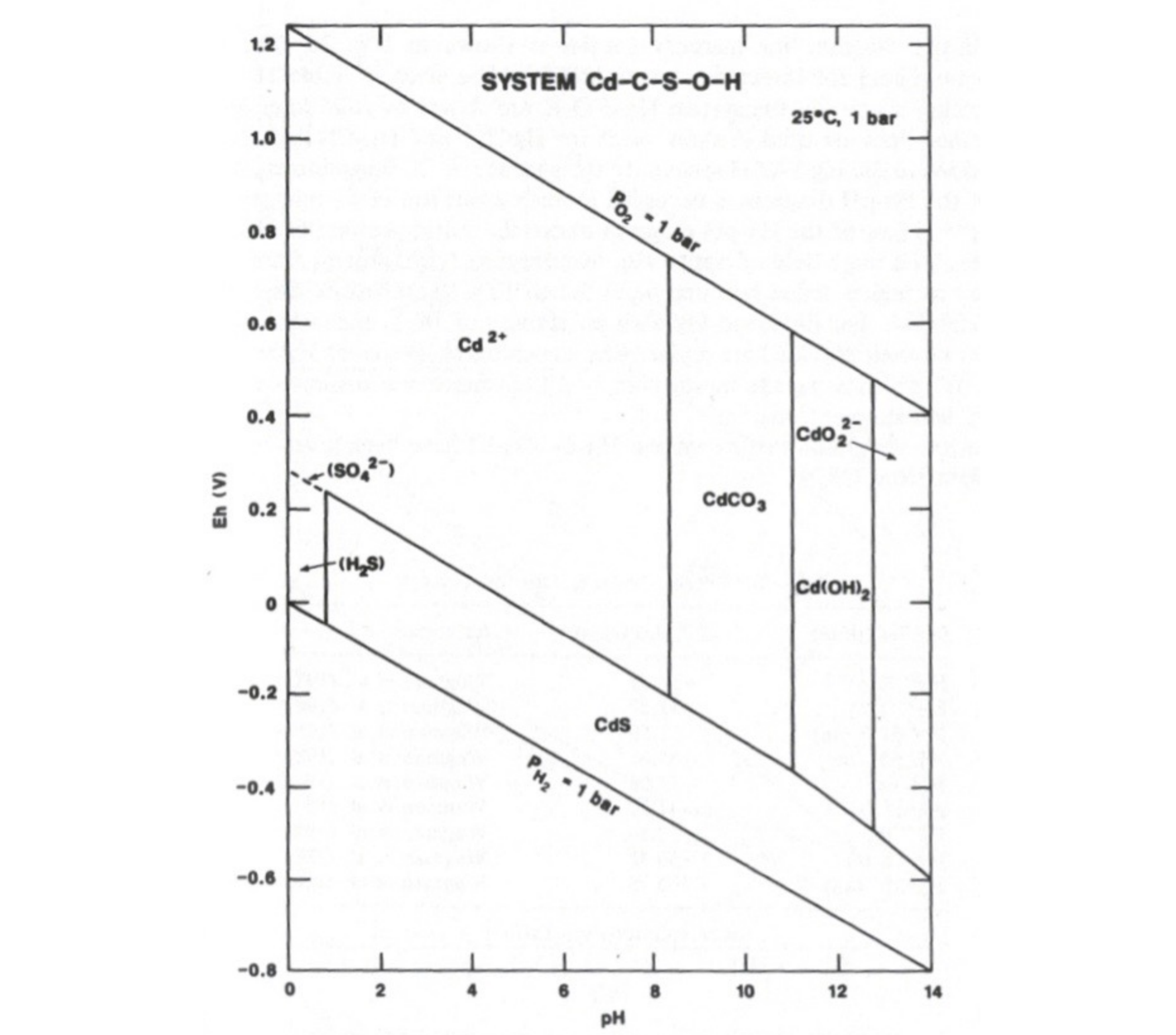


Figure 4 – Eh-pH diagram for cadmium.

Table 4 – Thermodynamic data for cadmium.

| Species State | $\Delta G^0_f$(kcal/gfw) |
|---|---|
| $Cd^{2+}{}_{(aq)}$ | -18.55 |
| $Cd(OH)_{2\ (c)}$ | -113.19 |
| $CdS_{\ (c)}$ | -37.40 |
| $CdO_{2\ (aq)}^{2-}$ | -67.97 |
| $CdCO_{3\ (c)}$ | -160.00 |
| $CdSO_{4\ (c)}$ | -196.33 |
| $CdO_{\ (c)}$ | -54.59 |

Adapted from Brookins (1988); aq – aqueous (dissolved/soluble), c – crystalline (solid).

### *2.2.5. Selenium treatment mechanisms*

The mechanism for selenium treatment is more direct, through microbially catalyzed dissimilatory selenium reduction. This is performed directly by bacteria acting on the selenium. The most common forms of aqueous Se are selenite and selenate, with valence states of Se(IV) and Se(VI), respectively. When these are reduced in a wetland to an insoluble state, Se precipitates as elemental Se(0) (Figure 5), which is the lowest bioavailability (Chapman et al., 2010).

While selenium can be directly treated through microbial reduction in a CWTS, there are constituents that can interfere with this process. Most notably, nitrate has a high affinity for available electrons and is preferentially reduced before other compounds including selenium and sulphate. Nitrate especially interferes with selenium reduction, as it may be performed by the same metabolic pathways in the same bacteria (Oremland et al., 1989 and Oremland et al., 1990). While it is known that over time through closure nitrate concentrations will decrease as the source (blasting residue) has ceased, during early closure nitrate may affect the CWTS treatment capacity for selenium. As such, the pilot-scale CWTSs were subjected to a 6-week trial of synthetic water that mimicked an early closure scenario, with nitrate concentrations based on predicted maximum worst-case ammonia and nitrate concentrations. This was followed by a second phase of testing with depleted nitrate concentrations to simulate the chemistry expected in long-term closure (Contango, November 2014).

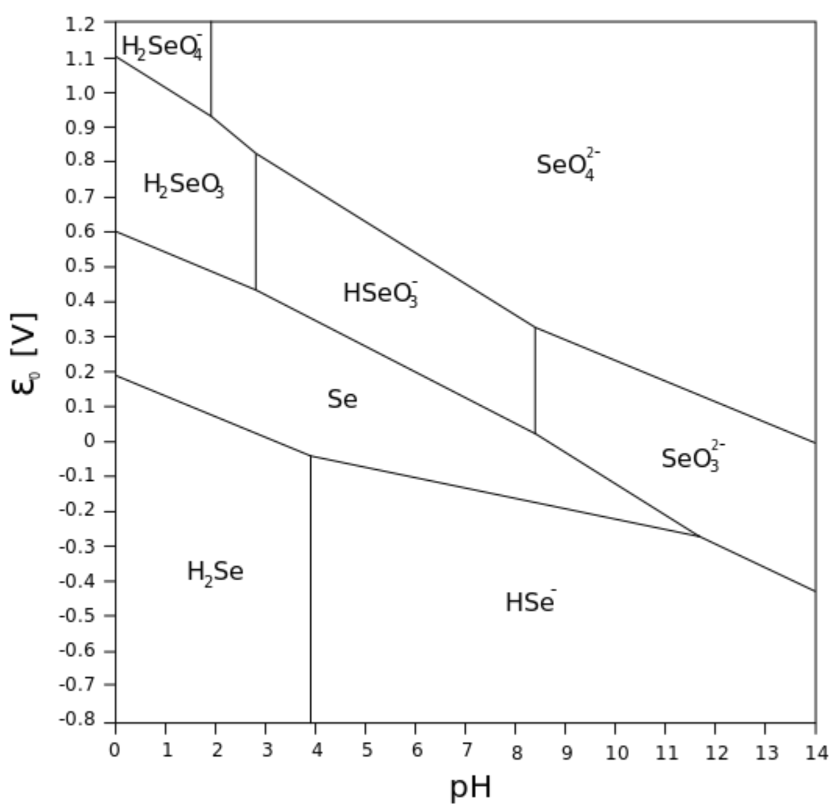


Figure 5 – Eh-pH diagram for selenium.

## 2.3. Design selection

There are numerous layouts and configurations that can be implemented for treatment wetlands, with varied hydrology, performance parameters, and operation and maintenance requirements. The most passive design was chosen as the goal of final mine site closure is to ensure long-term physical and geochemical stability and to minimize reliance on long-term active treatment. To meet the requirements for water treatment with minimal intervention, the selected passive treatment wetland design is one where there is no operational management necessary, and only minimal periodic maintenance is required, which could be performed by manpower (i.e., without machinery). Based on these guiding objectives, the selected configuration at the Minto Mine is a horizontal surface flow treatment wetland (Figure 6).

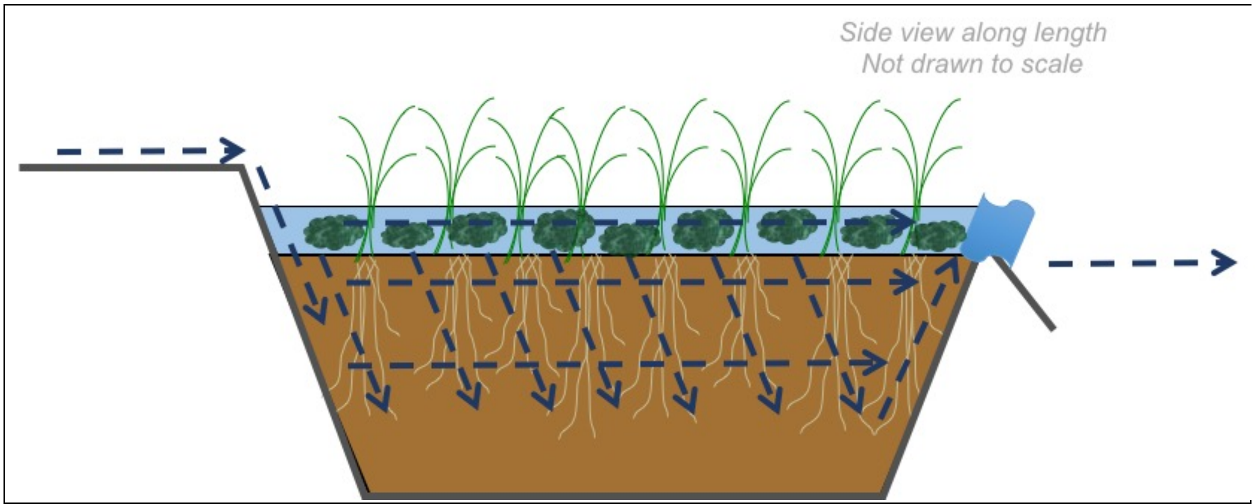


Figure 6 – Conceptual diagram of horizontal surface flow wetland.
Dotted arrows show flow path through wetland and into substrate and root zone. Vegetation in this example includes both emergent macrophytes (e.g., *Carex aquatilis* known as aquatic sedge), and bryophytes (aquatic mosses).

### *2.3.1. Plants*

For the CWTS, *Carex aquatilis* (aquatic sedge) was chosen, as it is readily available at the Minto site and was one of the first plants to colonize cleared areas, indicating that it may be a good candidate for quickly establishing the CWTS (Contango, March 2014). Moss was also used in pilot-scale CWTS designs, as locations at Minto with shallower water had *Carex* and Moss coexisting. The demonstration-scale CWTS was planted with *C. aquatilis* and mosses, as was determined by pilot-scale testing as being the best design for this site and application (Contango, November 2014).

### *2.3.2. Substrate*

The recommended soil for the CWTS is sand, with approximately 2-7% by volume as organic material (e.g., woodchips, straw). In the pilot-scale systems (Contango, November 2014), this resulted in a total organic carbon (TOC) content of 0.2-0.6% (the sand itself was at 0.1% TOC prior to adding amendment), and it was found that a higher concentration would likely decrease the duration of the commissioning period. In this composition, the sand allows for circulation of water through the root zone of the plants, while the organic matter initiates reductive microbial processes that in future years will be sustained by decaying plant matter. Additionally, sandy soil will support weight while wet for planting the CWTS.

#### *2.3.3. Water Depth*

The recommended water depth for the CWTS is based on plant selection. Once plants are well established and showing signs of colonizing through the wetland, the water depth may be increased to approximately 25-40 cm and the flow rate may also be increased.

A uniform water depth is necessary to prevent future issues such as channeling of water, open water spots due to plants being unable to grow because of excessive water depth, or conversely, drying out. The vegetation selected for the CWTS (*C. aquatilis* and aquatic mosses) are known to form peat, which will accrete in a generally uniform manner through the CWTS as long as it is initially planted uniformly and bare spots are addressed through commissioning.

#### *2.3.4. Flow Field*

A uniform flow field is necessary in the CWTS to avoid channeling, as the plants will avoid higher flows and preferentially establish in low flow areas. As such, to ensure a uniform flow field, a distribution mechanism at the inflow and outflow areas of the CWTS is needed and will be addressed in the final wetland engineering design.

#### *2.3.5. Water Velocity*

Linear flow velocity for the CWTS was selected to be no greater than 35 cm/s according to the Hjulstrom Curve (Figure 7) based on the selected substrate of coarse sand (grain diameter = 1mm). This maximum linear flow velocity is considered to be highly conservative, as it is based on resuspension of substrate to avoid scouring, and does not account for plant roots retaining the sediments in high flows. However, references specific for maximum flow velocity in CWTS recommend the ideal flow velocity for treatment should be less than 15 cm/s for effective treatment capacity (ITRC, 2003). Therefore, the flow through the CWTS should ideally be less than 15 cm/s under normal conditions, and not exceed 35 cm/s under high flow events. These flow rates should be tested in a site-specific manner through the reclamation research program, as actual tolerances will vary depending on plant species, substrates used, and targeted treatment processes.

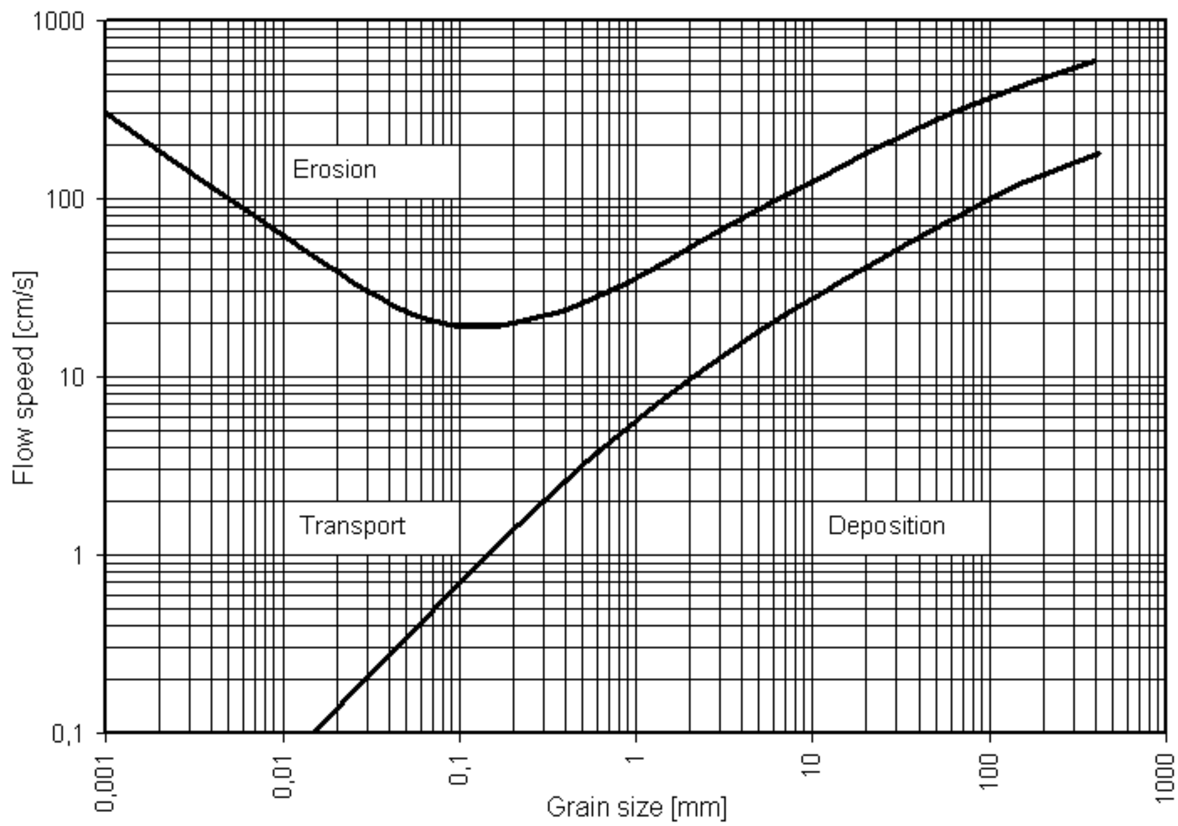


Figure 7 – Hjulstrom curve, demonstrating flow speed associated with resuspension of soils.

### 2.4. Removal Rate Coefficients and Calculations

An important factor for wetland design is the rate of treatment, also known as the treatment rate coefficient (*k*). The treatment rate coefficient is based on the treatability of a specific compound and the hydraulic retention time of the system, both of which are site-specific based on water chemistry, wetland designs, and characteristics of the system. The treatment rate coefficients in Table 5 are based on pilot-scale testing (Contango, November 2014) and are currently being refined with demonstration-scale (on site) testing (Contango March 2015, and Contango March 2016).

Based on pilot-scale testing for the Minto CWTS (Contango, November 2014), the treatment rate coefficient (k) applied for Se follows a zero-order reaction kinetic, while the rate coefficients for Cu and Cd follows first-order kinetics. In Equations 1-4, *Cf* is final concentration, *Ci* is initial concentration, V is volume of water in the system, and Q is flow rate. Using the removal rate coefficients (*k*) in Table 5 and Equations 1-4, parameters can be rearranged to solve for those of interest, such as the outflow concentration, given the available footprint in the WSP area.

Table 5 – Element treatment rate coefficient (*k*) values based on pilot-scale testing.

| Element | *k* [1] |
|---|---|
| Cd | 0.065 |
| Cu | 0.05 |
| Se | 0.0001 |

[1] All treatment rate coefficients are for first-order reaction kinetics except for selenium which is a zero-order reaction rate kinetic.

$$k = \frac{-\ln\left(\frac{Cf}{Ci}\right)}{V}\, x\, Q$$

Equation 1. Equation for calculation of first-order removal rate coefficient.

$$Cf = Ci \times e^{-k\, x\, \frac{V}{Q}}$$

Equation 2. Equation for calculation of first-order removal rate coefficient, rearranged to solve for outflow concentration.

$$k = \frac{(Ci - Cf)}{V}\, x\, Q$$

Equation 3. Equation for calculation of zero-order removal rate coefficient.

$$Cf = Ci - k\, x\, \frac{V}{Q}$$

Equation 4. Equation for calculation of zero-order removal rate coefficient, rearranged to solve for outflow concentration.

### 2.5. Thermodynamic minimum concentrations

Through all periods of pilot-scale testing, the outflow concentration of copper for any given system did not vary significantly, indicating that the thermodynamic minimum for copper removal has likely been approached within the system, with an average outflow concentration of 18 ± 5 µg/L. That is to say, making the wetland bigger using any of the tested designs would not result in a further significant decrease in outflow copper concentration, but rather, design alterations would need to be made in order to attempt to achieve lower outflow concentrations. It remains to be experimentally determined through the on-site demonstration-scale testing whether it is possible to achieve lower outflow concentrations of selenium and copper with this wetland design. Thermodynamic minimums developed through the site-specific testing for the Minto CWTS, have been applied to the conceptual performance modelling of a full-scale CWTS (SRK, 2016a), these are: cadmium, 0.000009 mg/L; copper, 0.015 mg/L; and selenium, 0.004 mg/L. This is not to say that lower concentrations may not periodically occur through the CWTS treatment, however these are values that should be consistently attainable if sufficient retention time is provided, and lower concentrations and not expected to be consistently achieved.

### 2.6. Evapotranspiration

Evapotranspiration is another plant-mediated CWTS characteristic that must be considered (Beebe et al., 2014; Haakensen et al., 2015). Evapotranspiration can be defined as the total sum of water removed from a CWTS by evaporation from surface water of the system and transpiration from plant leaves. The degree of evapotranspiration is dependent primarily on the plant species/ecotype and controlled by meteorological conditions such as air temperature, relative humidity, and wind. Evapotranspiration drives an important aspect of the hydrology of a CWTS by enhancing the effective treatment area of surface flow wetlands.

Evapotranspiration can also affect the perceived treatment in a CWTS because removing water from the system concentrates the constituents, but also results in an increase of the hydraulic retention time (Beebe et al., 2014). That is to say, when evaporation and transpiration levels are high, an increased CWTS footprint may actually result in a higher outflow concentration of elements than is seen partway through the system, even though the total load of an element is lower at the outflow based on treatment.

Trials are being undertaken through the reclamation research program with the demonstration-scale CWTS to determine and model the effects of evapotranspiration on load removal, and current estimates are that approximately 1cm of water will be lost per day (equal to ~10 L per square meter of CWTS).

## 3. CWTS Implementation Overview

### 3.1. Timeline overview

The conceptual schedule for implementation of the CWTS is currently being refined through the reclamation research plan as part of the RCP. Through the reclamation research plan the monitoring and maintenance requirements for closure will be refined (research is currently planned through 2018 with the on-site demonstration-scale CWTS). Table 6 therefore provides the best estimate of site-specific maintenance and monitoring requirements for the CWTS based on information at this time.

Table 6 – Conceptual timeline.

| Closure | | CWTS | Period | Comments |
|---|---|---|---|---|
| Period | Year | Year | | |
| Interim and Active Closure | 5 | 0 | Construction | Construction and planting of system. |
| Post Closure I | 6-7 | 1-2 | Commissioning | Water from outflow can be recycled through CWTS or be sent to active water treatment if additional treatment is necessary. |
| | 8-10 | 3-5 | Early operation | System meeting performance targets, with frequent monitoring ongoing to refine site-specific long-term monitoring and maintenance requirements of CWTS. Minor adjustments may still be needed. |
| Post Closure II | 11-20 | 6+ | Long-term operation | Performance monitoring at reduced frequency, for confirmatory purposes. Maintenance as needed. |

### 3.2. Construction

Physical construction of the CWTS is described in Appendix A (SRK, 2016b), and therefore only vegetation is covered here. Either before or after planting, a bed of straw and/or wood chips, approximately 5-10 cm deep, should be laid on top of the substrate to serve as an initial source of carbon for the beneficial microbes and to initiate reductive processes and contribute to accretion in early years while there is less plant matter being produced. If planted at the same density (5 plants per square meter) as the demonstration-scale CWTS (on site), *Carex aquatilis* would take approximately 2 years to fill in the CWTS, and based on results from the demonstration-scale CWTS, it is expected that a range of 3 – 5 *C. aquatilis* plants per square meter would be sufficient to fill the CWTS within 2 years. It is recommended that the aquatic mosses be added much more densely than originally distributed in the demonstration-scale CWTS, in order to avoid needing to add additional moss through the year. Approximately 3,000 $cm^3$ of moss (moist but compressed) is recommended per $m^2$ of area within the CWTS. It is expected that a team of 4 people can plant a hectare of wetland per day. It is expected that a sufficient quantity of plants for the full-scale wetland can be sourced from the demonstration-scale CWTS, and the W10 area (the original source of plants for the demonstration-scale CWTS), if required additional borrow sources will be utilized.

### 3.3. Commissioning

The time period between construction of the CWTS and achieving expected treatment performance is referred to as the commissioning period. This period is needed for operational adjustments (e.g., raising water depth, modifying outflow patterns), and for plant and microbial populations to establish and mature. Based on pilot-scale testing (Contango, November 2014), and preliminary results from on-site demonstration-scale operations (Contango, March 2016), the estimated commissioning period for the full-scale system is 4 – 8 months (of active growing season, or 1 – 2 calendar years). Progress through the commissioning period is assessed through a monitoring program, such as the conceptual schedule inTable 7.

The commissioning period involves guiding the CWTS from construction through to early operation. Commissioning activities can be divided into the categories of: flow management, vegetation establishment, and establishment of conditions for treatment. Flow management includes ensuring the flow field is as uniform as reasonably possible, with wide inflow and outflow berms. Flow management is addressed in Appendix A (SRK, 2016b). Establishment of vegetation will also aid in flow management, and based on observations from the on-site demonstration-scale CWTS (Contango, March 2016), is expected to take a period of approximately 2 years depending on seasonal variations and planting densities. During this time, it may be necessary to supplement vegetation in some areas of the CWTS depending upon transplantation success. The on-site demonstration-scale CWTS had >95% survival of planted vegetation, and a similar rate would be expected at full scale. Variable water depths can sometimes aid in vegetation establishment, and slow (or stagnant) water flows can aid in development of microbial populations. Therefore, during the first months of commissioning, water may be intermittently pumped to the CWTS and allowed to evaporate (but not allowed to dry out), rather than a constant flow. With an estimation of ~1 cm evapotranspiration per day (with *C. aquatilis* vegetation), water could be flowed through the CWTS for 1 week of every month, with the remaining time non-flowing.

## 4. Monitoring

Monitoring and maintenance schedules contained herein are conceptual, and are being refined with the guidance of the reclamation research plan. The monitoring parameters and schedules are selected to inform potential maintenance needs, and in turn, possible maintenance activities are designed to address performance considerations. The conceptual schedules outlined here are conservative, but not prescriptive. Monitoring includes testing for performance (i.e., decrease of cadmium, copper, and selenium concentrations), and during earlier periods (commissioning, early operations Table 1, Table 2). Explanatory parameters are quantifiable aspects of a CWTS environment that can explain the performance of a CWTS. The end goal of explanatory parameters is to develop a decision management tree to guide maintenance activities associated with treatment performance of the CWTS. This allows for prediction of potential performance issues so they can be addressed before they occur, or the ability to detect and appropriately respond to upsets. There are many parameters that can be included as explanatory parameters, and it is important to identify those which are informative to the constituents being treated, and the site-specific context. For the Minto Mine CWTS, the explanatory parameters are being developed through a phased reclamation research plan, and pilot-scale testing has thus far identified pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), conductivity, temperature, total organic carbon (TOC), nitrate, and soil redox potential as useful to understanding the performance of the CWTS. The explanatory parameters are continuing to be refined through the on-site demonstration-scale operation. Actual parameters and frequency of testing should be guided by the scientific analysis of the results from the previous operational period, therefore, the commissioning will be guided by the on-site demonstration, the early operations by the commissioning, and so forth. Maintenance of the system should be performed as necessary, and based on the results of monitoring activities.

### 4.1. Monitoring during commissioning (Years 1 – 2)

The commissioning period involves the most rigorous monitoring, to ensure the system is brought online effectively. Because biological systems are dynamic and could take several paths to maturation, rigorous monitoring during the commissioning phase is important to track progress and make corrections as necessary, allowing for the system to be guided through the desired maturation path. During the commissioning period, both performance and explanatory parameters are monitored in order to assess both the effectiveness and mechanisms of function of the CWTS. Some of these parameters would conceptually require weekly monitoring (e.g., visual inspections, water quality testing for total and dissolved metals, nitrate, pH, dissolved oxygen, oxidation reduction potential, and monitoring of plant health and establishment), while others would be tested less frequently. For example, water may be tested monthly for dissolved organic carbon and substrates for redox potential, while parameters such as substrate microbiology, nutrient and organic carbon content may be tested seasonally, and soils metals assays may occur on an annual basis. Parameter lists and testing schedules are being refined through the on-site demonstration-scale CWTS as part of the reclamation research plan.

Table 7 – Conceptual monitoring schedule.

| Closure Period | | Year 1 - 5 (Interim and Active Closure) | Year 6 - 10 (Post Closure I) | | | | | | | | Year 11 -20 (Post Closure II) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CWTS Stage | | Construction | Commissioning (Year 6-7) | | | | Early Operation (Year 8-10) | | | | Long-term Operation (Year 11-20) | | | |
| Site | Description | No Monitoring Required | Water | Substrate | Flow | Plants | Water | Substrate | Flow | Plants | Water | Substrate | Flow | Plants |
| CWTS IN | CWTS Inflow | NA | W,M | NA | W,M | NA | M | NA | M | NA | SSF | NA | SSF | NA |
| CWTS MID | Within CWTS | NA | W,M | M,SSF,A | W,M | W,M,A | M | M,A | NA | SSF,A | A | A | A | A |
| CWTS OUT | CWTS Outflow | NA | W,M | NA | W,M | NA | M | NA | M | NA | SSF | NA | SSF | NA |

W – weekly; M – monthly; SSF – spring, summer, fall; A – annually; NA – not applicable.
Where two frequencies are separated by a comma, multiple parameters are being tested, and on different schedules.

### 4.2. Monitoring during early operation (Years 3 – 5)

The CWTS will be transitioned from the commissioning monitoring schedule and considered to be operating in "Early Operations" once the explanatory parameter of targeted soil redox and outflow performance objectives for copper and cadmium are met. At this period targeted performance for selenium may or may not be met, depending on the depletion rate of residual nitrate concentrations. During Early Operations period, the CWTS is expected to be consistently meeting performance targets; however, frequent monitoring is continued to refine site-specific long-term monitoring and maintenance requirements of this system (Table 3). During early operations, the CWTS should be meeting performance targets, but with monitoring of performance and explanatory parameters ongoing to refine site-specific long-term monitoring and maintenance requirements of CWTS. Minor operational adjustments may still be needed during this period. Parameters that would conceptually continue on a monthly monitoring schedule include visual inspections, water quality testing for total and dissolved metals, nitrate, pH, dissolved oxygen, oxidation reduction potential, substrate redox potential, and general plant health. Parameters such as substrate microbiology, nutrient and organic carbon content, and metals assays may occur on an annual basis. Parameter lists and testing schedules are being refined through the on-site demonstration-scale CWTS as part of the reclamation research plan.

### 4.3. Monitoring during long-term operation (Years 6 – 10)

During long-term operation of the CWTS, monitoring is conducted mostly for performance, with a reduced frequency of monitoring for explanatory parameters (as defined from commissioning and early operations periods). The decision tree that was developed during demonstration-scale operation (and refined in full-scale commissioning and early operations) is applied to guide maintenance activities. During long-term operations, the CWTS should be meeting performance targets, with monitoring of performance and only those key explanatory parameters defined as leading indicators of performance (through the reclamation research plan and early operations of the full-scale CWTS). Conceptually, seasonal testing will be performed for performance (dissolved metals), and soil redox. Parameter lists and testing schedules are being refined through the on-site demonstration-scale CWTS as part of the reclamation research plan, and will be further refined through testing in commissioning and early operations of the full-scale CWTS.

## 5. Maintenance and operational adjustments

Maintenance of engineering and flow-management structures associated with the CWTS are covered in Appendix A (SRK, 2016b), and only performance related aspects are addressed here. Activities commonly associated with maintaining the performance of a CWTS are detailed in Table 8. The frequency of these activities should be guided by the monitoring activities, and is being refined through the on-site demonstration-scale CWTS as part of the reclamation research plan. A decision matrix based on the explanatory parameters is being developed through the reclamation research plan, and will be used to guide the operation of the full-scale CWTS. Additionally, periods of more intensive monitoring during commissioning and early operations will further guide the appropriate frequency of site-specific maintenance and refine the decision matrix. During early operations, minor adjustments may still be needed to the system, such as addition of solid phase organic materials (e.g., straw or wood chips), and corrections to non-uniform flows (e.g., adding sand bags at inflow and outflow of cells).

**Table 8 – Conceptual maintenance actions.**

| Observation | Monitoring | Item Addressed | Action | Follow up |
|---|---|---|---|---|
| **Soil redox drifting upwards** | Nutrients, TOC, microbiology | Decrease of treatment effectiveness due to low microbial activity or lack of food for microbes. | Add nutrients (fertilizer), and/or organic carbon. | Soil redox testing weekly until within stable range. Microbiology, TOC and/or nutrients testing bi-weekly until within desired range. |
| | Flow rates | Water volume to carbon ratio is too high. | Check inflow mechanism. | If ongoing issue (and not addressed by adding organic carbon), adjust inflow mechanism. |
| **Water depth decreasing** | Flow rates, accretion | System is designed to accrete (increase mass of soil), which causes soils to build within CWTS. Expected rate of 0.5-2mm/year (Robinson and Moore, 1999). | Increase height of outflow (and inflow) berms. | Record accretion rate to schedule for next depth increase event. |
| **Undesirable plants** | Vegetation monitoring | Channeling or decreased treatment effectiveness due to competing microbial habitats. | Remove undesirable plants. | Monitor to ensure undesirable plants have successfully been removed. |
| **Wildlife interferences** | Visual monitoring | Non-uniform flow field due to wildlife interferences (e.g., beaver dam) and decreased treatment performance. | Remove wildlife interferences. | Monitor to ensure interference is not re-established. |
| **Channeling** | Flow rates | Channeling can be due to undesirable plants, non-uniform flow fields, or flow rates beyond CWTS design. | Check inflow mechanism. | If ongoing issue, adjust inflow mechanism. |
| **Flow blockages** | Flow rates, visual monitoring | Blockages can be due to debris (fallen branches) and wildlife activity (beavers). | Remove blockages. | Adjust monitoring frequency accordingly. |
| **Poor plant health** | Nutrients | Decreased treatment effectiveness due to less active treatment zone if plants not actively transpiring and moving water through root zone. | Add nutrients (fertilizer). | Nutrients testing bi-weekly until within desired range. |

## 6. Closure

We trust the information herein satisfies your present requirements. Should you have any questions, please contact the persons listed below. We appreciate the opportunity to provide the services detailed in this report, and look forward to discussing any comments you may have.

Regards,
Contango Strategies Ltd.

Monique Haakensen, PhD, RPBio, PBiol, EP    Vanessa Friesen, PhD

## 7. References

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# Minto Creek Constructed Wetland: Physical Infrastructure Preliminary Design

**Prepared for**

Minto Explorations Ltd.

**Prepared by**

SRK Consulting (Canada) Inc.
1CM002.044
August 2016

# Minto Creek Constructed Wetland: Physical Infrastructure Preliminary Design

August 2016

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Project No: 1CM002.044

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# Table of Contents

# 1 Introduction

Minto Explorations Ltd. (Minto) asked SRK develop designs for the necessary physical infrastructure to support a Constructed Wetland Treatment System (CWTS) proposed to be constructed within the footprint currently occupied by the Water Storage Pond (WSP) as part of mine closure works at Minto Mine, central Yukon Territory. This report describes the design basis and the accompanying drawings provide the preliminary design details.

This physical infrastructure preliminary design report was developed to support Contango Strategies' design of the treatment wetland (Minto Mine Reclamation and Closure Plan – Preliminary Design Report for Treatment Wetland (Contango 2016)). Details related to wetland establishment, monitoring, and maintenance are provided in Contango's design report, along with a thorough discussion of treatment mechanisms, on-site wetland trials (completed, in-progress, and planned), and performance expectations.

# 2 Background

Water Licence QZ14-031 was issued to Minto in 2015. The licence included a condition requiring Minto to submit a revised reclamation and closure plan (RCP), and the submission date for the revised RCP was extended to August 5, 2016 via a December 2015 amendment to QZ14-031. Minto's 2016 Reclamation and Closure Plan will be the sixth major revision of the site closure plan, and will be referred to as 'RCP 2016-01' in this document.

The CWTS preliminary infrastructure design is one component of RCP 2016-01.

## 2.1 Current Layout of Site

The Water Storage Dam was constructed during initial mine construction in 2006. It was constructed across the Minto Creek valley at a narrow point near the eastern limit of Minto's quartz claims and represents the eastern-most major infrastructure facility at Minto Mine. The dam construction formed the WSP reservoir, which was initially used for mill water supply and later as a clean water reservoir for storing water prior to discharge to Minto Creek. The outline of the WSP and the Water Storage Dam are shown in Drawing WC-01.

## 2.2 Closure Phases

For the closure and post closure periods, planning and management of site activities are guided by the Minto RCP. This includes the identification of distinct closure phases with defined activities and performance expectations:

1. Active Closure;
2. Post Closure I (transition to passive treatment); and
3. Post Closure II (passive treatment only).

# 3 Design

## 3.1 Overview

During Active Closure, the Water Storage Dam will be decommissioned and the footprint of the WSP will receive fill and be graded to allow the subsequent construction of a Constructed Wetland Treatment System (CWTS), which is also referred to as the Minto Creek Constructed Wetland. The CWTS will receive water from E3 Conveyance Channel in the closure conveyance system, which receives surface water from nearly all of the disturbed areas of the mine site that lie within the Minto Creek catchment. Flows up to 3000 $m^3$/day[1] will route through the CWTS, with inflows controlled by inlet control structures. To protect the CWTS from high flows, the inlet control structures are designed to convey higher flows through a spillway system to discharge into a high flow bypass channel. Details are presented in Drawings CW-03 in Appendix A.

During Post-Closure 1, commissioning of the CWTS will take place and CWTS effluent will be managed by a combination of reservoir and pumping-and-piping system, with water that meets discharge standards discharged off site and water that does not meet discharge standards pumped to one of the open pits for storage. As discussed in the Section 7.7.1 of the RCP the water treatment plant used during operations will remain in operational until WUL criteria can be achieved consistently without its utilization. Transition from Post-closure 1 to Post-closure 2 will occur when the CWTS effluent adequately meets performance objectives, at which time the effluent reservoir will be connected to the high flow bypass channel and the system will transition to being passively managed

Drawings WC-01 through WC-04 provide the preliminary designs for the physical infrastructure of the CWTS and bring in relevant conveyance design details from other components of the Minto Mine RCP for reference, including details from Appendix G2, *Closure Water Conveyance System Design Update Report, Minto Mine, Yukon* (SRK 2016a).

The following sections generally are organized sequentially by order in which the various components will be constructed.

## 3.2 Design Objectives, Considerations and Criteria

Summarized in this section are the objectives, considerations, and criteria for the preliminary CWTS design. Physical design elements are illustrated in the appended preliminary drawing package. Design criteria that are critical to the biological efficiency of the wetland system to sequester soluble metals were developed by Contango. These design elements are included in the physical wetland design and the water conveyance dynamics.

### 3.2.1 Head Pond and Wetland Intake Structure:

- Design flow rate for the passive treatment wetland system is based on a typical average monthly summer flow experienced in June, July and August. The maximum targeted flow rate

[1] Range of flows received by CWTS is expected to range from zero (during summer dry periods) to a maximum of 3000 $m^3$/day (under extreme high runoff conditions).

to be diverted into the wetland system is 3000 $m^3$/day or approximately 0.035 $m^3$/s. 3000 $m^3$/day is the upper limit of the flow rate that the CWTS is intended to handle.

### 3.2.2 Wetland Cell and Conveyance Channel Geometry:

- A 3:1 aspect ratio (Length to Width) is used to site the location of the passive treatment wetland cells. The cells are typically 15 m wide and 45 m long. Due to the limited width of the valley, space was limited in some areas- the cells were designed as typical 15 m wide and in some cases it was necessary to shorten the length of the cells to fit the site configuration.
- Substrate depth within the cells is designed to be a minimum of 0.5 m, substrate depths are illustrated in the design drawings to be 1 m thick and submerged by 0.3 m for a total of 1.3 m of initial design height above liner to the water surface in each cell. The substrate material will consist of sand with 2 to 7% by volume as organic matter (e.g. wood chips, straw).

### 3.2.3 Seepage Management:

- Seepage losses from the wetland cells and groundwater ingress into the cells is managed by inclusion of a low hydraulic conductivity geomembrane liner. The liner will prevent both groundwater from entering and seepage from leaving the CWTS and will avoid the performance uncertainty that would accompany unquantified inputs and losses of both flow and geochemical load.

### 3.2.4 Erosion Management:

- Internal erosion protection of the wetland pond system is limited to rip-rap channel protection because the CWTS inlet control structure is to be designed to limit inflows to a maximum flow rate of 3000 $m^3$/day.
- Distinct from limits on daily volumes, considerations around wetland plant establishment and propagation patterns require limits on water velocity as follows: maximum velocity 0.35 m/s, and typical velocities of $<0.15$m/s (Contango 2016).

### 3.2.5 Restrict Dam Classification for Designed Infrastructure:

- Design intentions have been focused on precluding the classification of any design infrastructure as a dam as defined by the Canadian Dam Safety Guidelines (CDA 2007) and dam classification guidelines in the Yukon Territory. CDA defines a dam as a constructed barrier that is at least 2.5 m tall and retains at least 30,000 $m^3$ of water. The Yukon Territory's definition of a constructed dam without a licence for a Schedule 7 Quartz Mining Undertaking as having a height greater than 3 m and less than 10,000 $m^3$ of water storage (Yukon Government 2012).

### 3.2.6 Exclusions

The following elements are outside of the limits of the preliminary physical infrastructure design:

- Establishment and success of wetland vegetation in the CWTS,
- Treatment performance of the CWTS,

- Revegetation of disturbed surfaces associated with the construction of the CWTS, and
- Construction compaction specifications of fill materials are not specified for this preliminary level of design. An assessment of available material properties is required at future stages of design to determine compaction requirements.

## 3.3 Constructability and Sequencing

The overall wetland layout and the configuration of the cells and intake structures have considered a long-term closure of the Minto site and the future needs of this site beyond the Post Closure 1 timeline. Intake and conveyance structure designs to the wetland ponds have been considered for their ability to be adaptive (i.e. allowance for the modification of conveyance elevations and flow rates to allow vegetation to establish).

In future stages of closure design it is recommended that a staged construction and decommissioning plan be developed to optimize water management resource needs and material handling. Additionally, a phased commissioning plan for a constructed closure conveyance system and wetlands must be developed.

Decommissioning of the Water Storage Pond Dam is required to construct the wetland and diversion channels. Initial decommissioning efforts require that the reservoir be drawn down and incoming flows routed around the construction area to allow for the partial excavation of the dam. Flow routing is expected to include excavating a water retention sump and back pumping water to the Main Pit to manage sedimentation and through pumping water from the Main Pit to Minto Creek. Retention sump locations details are provided in Drawing CW-02 in Appendix A.

Final decommissioning of the WSP dam will include the construction of the High Flow Bypass Channel that will convey flow around the wetlands. Additionally, it will require the removal of the sump and pumping diversion systems to allow flows to enter the wetland pond system. The infrastructure design, alignments, and specifications are located in the drawings in Appendix A.

Access for post-closure monitoring and maintenance at the CWTS is to be maintained after construction. The pond system is designed with a wide berm access of 4 m around the perimeters of each wetland cell to accommodate a vehicle or small excavator.

## 3.4 Foundation Preparation and Base Construction

To construct the passive treatment wetlands and provide a graded profile to the wetland area the existing WSP Dam will be decommissioned. Decommissioning of the WSP dam is illustrated in Drawing CW-02 located in Appendix A. The Dam is constructed of coarse waste rock and fine grained materials as segregated zones. During the decommissioning of the dam the segregated materials are repurposed in the construction of the wetland system. Coarse rock will be used to build up the basal area of the pond system, fine grained materials are to be used as separation layering between geomembranes and coarse materials.

During the decommissioning of the WSP Dam an existing access road will potentially require upgrades for haul truck access within the former ponded area. Material stockpiles, load and haul routes within the wetland area should be constructed as dam decommissioning advances.

## 3.5 Wetland Intake Flow Control Structure

A Primary Head Pond is designed to buffer turbulent flows exiting the E3 conveyance channel stilling basin. The pond elevation (715 masl) will be controlled by two hydraulic control structures: High Flow Discharge Channel and the Wetland Intake Structure. The Secondary Head Pond Intake Structure will convey 1% of the total flow entering the Primary Head Pond into the Secondary Head Pond the remainder of flows enter the High Flow Bypass Channel. Water entering the Secondary Head Pond will then be moderated where the design flow for the wetland system is conveyed in the wetland intake structure and the remainder of flow is conveyed through a spillway into the High Flow Bypass Channel.

The Secondary Head Pond and Wetland Intake structure are designed to reduce the intake flows and convey the expected design flows from the Primary Head Pond to the wetland cells. Flows exceeding this rate will be diverted to the High Flow Bypass Channel. Discharge flow from the wetland system is discharged to the High Flow Bypass Channel down gradient of the wetland system. Surface water quality monitoring station W50 is located approximately 50 m downstream of the confluence of these two flows.

At this stage of design the wetland intake structure has not been designed in detail. Conceptually, hydraulic principles that govern open channel flow have been considered to confirm that the system of ponds, inlet structures, and high flow spillways can reduce peak flows adequately to limit CWTS inflows to the design peak flow rate. The wetland infrastructure design is capable of separating a maximum of 3000 $m^3$/day from the mine closure conveyance system and conveying the flow through the wetland cells. It should be noted that this design peak flow rate is based on treatment performance limitations, and not on limitations of the hydraulic system to pass substantially greater flow volumes.

Future stages of design should consider an options analysis for common hydraulic structures such as weirs, flumes, and orifice flow control structures. Options to consider include orienting the inlet structure to be south facing to maximize early spring thaw, and applying a coating to the inlet structure to maximize solar heat absorption to melt and shed ice buildup.

## 3.6 Passive Treatment Wetland Cells and Conveyance Channels

Water depth within the wetland cells is designed to a targeted 0.15-0.4 m depth. After vegetation planting and during the initial growing seasons the water level in the cells will be controlled to be 0.2 m. Once the vegetation is rooted and acclimatized the wetland cells, water depth will be increased to 0.3-0.4 m. Section and plan details illustrating the CWTS designs are provided in Drawing CW-02 and CW-04 in Appendix A.

Internal cell-to-cell conveyance channels are designed as an excavated 4 m wide swale with 2:1 side slopes and a 1% slope. The mild channel slope is designed to have a 350 mm layer of rock rip-rap with an average diameter of 200 mm. Flow velocities through the cell spillway sections are measured as 0.3 m/s and a water depth of 30 mm.

Underlying the passive treatment wetland cells and the cell-to-cell conveyance channels is a geomembrane to manage seepage loss and ingress. It is recommended that all exposed geomembranes be covered with a minimum of 0.3 m of fine grained material to reduce its exposure to radiation from the sun.

# 4 Physical Monitoring and Maintenance

The construction, commissioning, and operation of the passive treatment wetland is expected to have a variable management requirements for the physical monitoring and maintenance. This section discusses what physical attention is needed for the wetland infrastructure. Effective implementation of the *Closure Adaptive Management Plan* (SRK 2016b) will mitigate conditions beyond those expected during closure and post closure care and maintenance programs.

During construction and dam decommissioning water within the footprint of the CWTS construction will require ongoing and active monitoring and maintenance. The commissioning phase will require a site presence to monitor flow rates at the wetland intake structure to confirm that the wetland system is receiving the design flow rates. During this phase it may be required to make alterations to the flow regulating structure. After the commissioning phase it is expected that the frequency of inspection and maintenance decrease over time. However, long-term physical monitoring and maintenance will be required for this wetland system.

Monitoring frequency and maintenance requirements should be re-assessed and adapted based on the judgement of a qualified person as the site transitions through Active Closure, Post-Closure I and Post-Closure II periods. The proposed schedule for the monitoring programs is provided in Section 7.12 of the RCP. The following subsections suggest some of basic monitoring and maintenance needs for the structure of the wetland system.

## 4.1 Active Closure

Physical monitoring and maintenance requirements during the construction period include:

- Routine water quality sampling for sediment and metal composition at the intake and discharge of the pond system.
- Assessing the grading of the channels between ponds to assess the flow paths. Flow through the channels should be unobstructed and non-eroding.
- During initial rooting stages of pond vegetation commissioning the water depth in the ponds are expected to be lower than the final operational elevation. Once advised that the rooting is sufficient the elevation in the ponds can be increased to the final elevation.
- Routine removal of vegetation and debris that may block channels.

- Assessment of initial signs of settlement and erosion of surfaces adjacent to the wetland system. If settlement within the conveyance network is observed then remedial construction activities should be initiated as described in the closure adaptive management plan.
- Ground water seepage assessments of the surrounding area to determine if there will be exposed seeps in the former WSP area that may affect the pond system. If seepage volumes are considerable and are leading to erosion of soils then remedial construction activities should be initiated as described in the closure adaptive management plan.

## 4.2 Post-Closure I

The closure monitoring and maintenance requirements will be developed at the end of the active construction phase as the site transitions to passive treatment. Typically the monitoring will assess the following geotechnical and hydraulic conditions:

- Measure the flow rates into the wetland system and determine if the flow rates are appropriate and if there are meeting objectives. Field samples should be collected to determine the water quality at the intake and discharge of the pond system.
- Assess the flow profile through and in between each wetland cell to document the development or extent of erosion or blockages.
- The intake flow structures should be assessed for operation and integrity.
- Surface erosion and settlement deformations.

## 4.3 Post-Closure II

An assessment of the existing state of the wetland system is required to identify the needs of monitoring and maintenance as the site transitions to the Post Closure II phase.

# 5 Recommendations

This section summarizes design requirement to advance the design of the wetland system from preliminary to a feasibility level.

- Limnology study of sediments in WSP to quantify chemistry and thickness to determine if additional design and management allowance is needed for the wetland pond system.
- Geotechnical investigation of the wetland foundation area and the High Flow Bypass Channel for the existence of permafrost and other geotechnical considerations which may have a potential for thaw consolidation and settlement.
- Site wide definition of material sources including defining dam materials and potential opportunity to use local soils and local quarries near the existing WSP Dam. The site-wide materials assessment should define the volumes and material types that are needed for the wetland construction.

- Evaluation of merit of routing the High Flow Bypass Channel through a purpose built rock quarry located in south abutment of dam.
- Assessment of the suitability of rip-rap in the current WSP dam spillway for use as riprap in the long term. Evaluation of the existing spillway rip-rap covering is needed to determine if the condition of the armouring is suitable for reuse for closure activities as foundation fill material for the wetland area.
- Excavation optimization for the materials removed from the WSP Dam which can be reused as foundation fill material for the wetland area.
- Hydrologic assessment of the transition of the High Flow Bypass Channel from the former WSP Dam area downstream to the Minto Creek basin.
- Evaluation and design of the hydraulic intake structure that moderated flow from the head ponds into the wetland system at the specified rate of 3000 $m^3$/day or the rate required during the final engineering and design stages.
- Reassessment of the need for a geomembrane to line the ponds and conveyance channels between ponds.
- Future assessment to the efficiency of the wetland pond dynamics may redefine the cell geometry needs and peak flow rate requirements defined by Contango.
- Head Pond: design requires further optimization such that the final design (excessive storage water volume or height of impounded water) does not become defined as a dam.
- Tailings Diversion Ditch: energy dissipation area requires additional design consideration to transition flow exiting the Tailings Diversion Ditch into the High Flow Bypass Channel. Additional design should focus on managing flow hydraulics and erosion.

This report, Preliminary Design: Physical Infrastructure for the Water Storage Pond Constructed Wetland Treatment System, was prepared by

Stuart McPhee, EIT

PERMIT TO PRACTICE
Signature
Date 2016-08-12
PERMIT NUMBER: PP019
Association of Professional Engineers of Yukon

and reviewed by

PROFESSIONAL YUKON VICTOR ALEJANDRO MUNOZ SAAVEDRA TERRITORY ENGINEER 08/10/2016

Victor Muñoz S., MEng, PEng.

Dylan MacGregor, MASc, PGeo

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

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SRK Consulting (Canada) Inc. 2016a. Closure Water Conveyance System Design Update Report, Minto Mine, Yukon. August 2016.SRK Consulting (Canada) Inc. 2016a. Closure Adaptive Management Plan. August 2016.

# Appendix A: Drawings

# Engineering Drawings for the Minto Creek Constructed Wetlands Minto Mine, Yukon, Canada

## ACTIVE DRAWING STATUS

| DWG NUMBER | DRAWING TITLE | REVISION | DATE | STATUS |
|---|---|---|---|---|
| CW-00 | Engineering Drawings for the WSP Constructed Wetlands, Minto Mine, Yukon, Canada | A | July 29, 2016 | Issued For Review |
| CW-01 | General Arrangement | A | July 29, 2016 | Issued For Review |
| CW-02 | Wetland Cell Configuration | A | July 29, 2016 | Issued For Review |
| CW-03 | Primary Head Pond Area Layout | A | July 29, 2016 | Issued For Review |
| CW-04 | Typical Cell and Cell Spillway Layout | A | July 29, 2016 | Issued For Review |

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ENGINEER
08/12/2016

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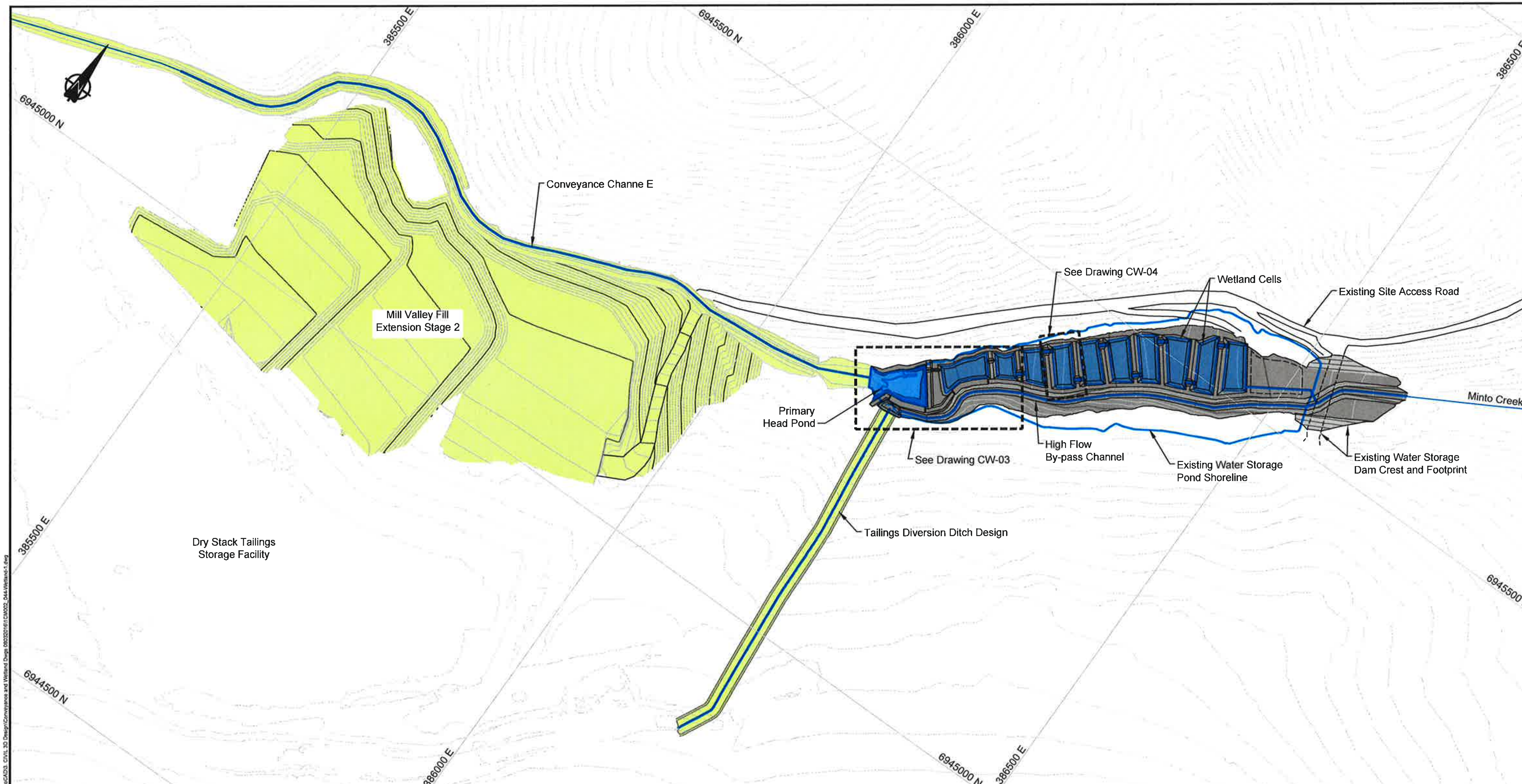
PROJECT NO: 1CM002.044
Revision A - Issued for Review
July 29, 2016
Drawing CC-00




## NOTES

1. Contour Interval 1m typical though drawing package.
2. Coordinate system is in NAD83 UTM Zone 8.
3. Digital topographic surface has been provided by Minto Exploration ltd.
4. Notes on this drawing apply to all other drawings within this drawing package unless otherwise advised.

## LEGEND

- Constructed Wetlands Design
- Designed Infrastructure (Not Constructed)
- Design Toes & Crests
- Flow Direction

**NOT FOR CONSTRUCTION**

0 40 80 120 160 200

Scale in Metres

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08/12/2016

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FILE NAME: 1CM002_044-Wetland-1.dwg

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SRK JOB NO.: 1CM002.042

Preliminary Infrastructure Minto Creek Constructed Wetlands

DRAWING TITLE: General Arrangement

| DRAWING NO. | SHEET | REVISION NO. |
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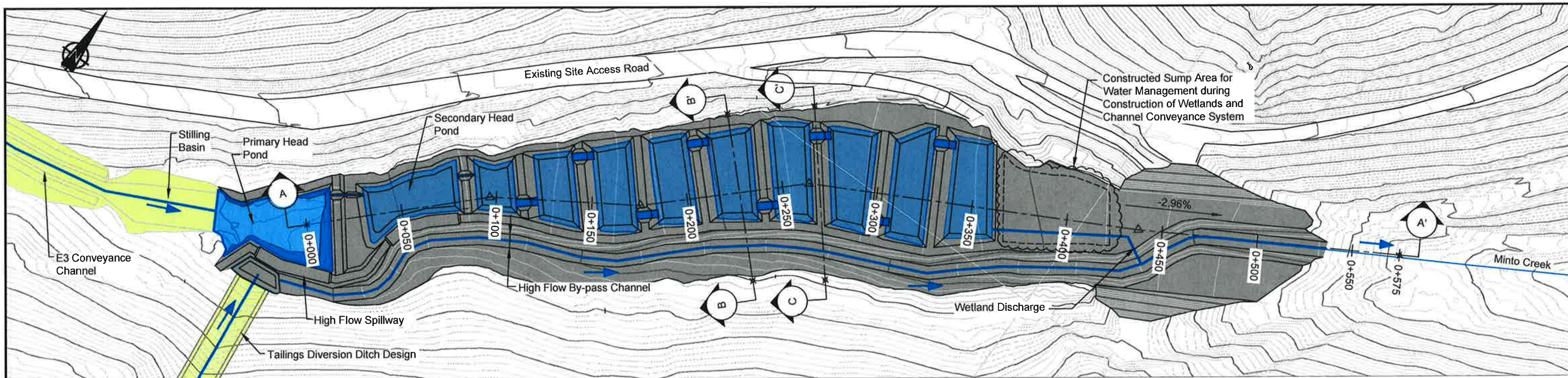
| CW-01 | 2 OF 5 | A |




## CONSTRUCTED WETLANDS PLAN VIEW

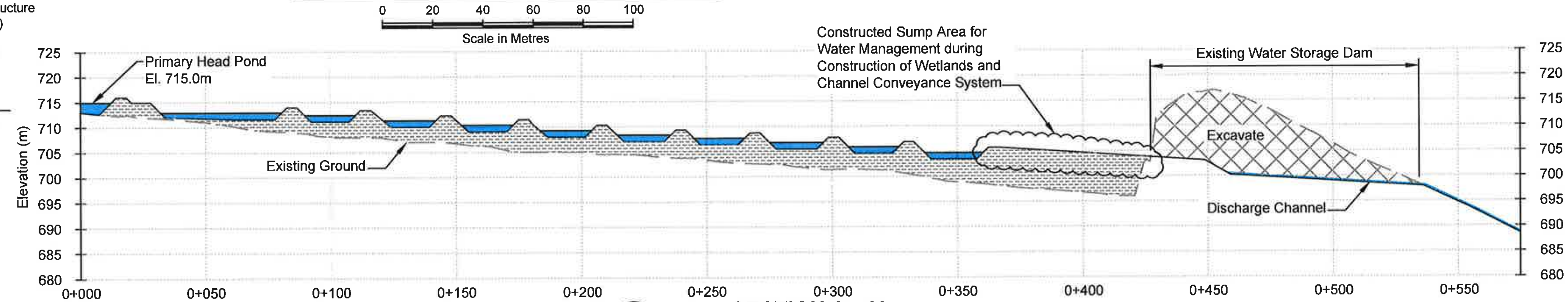
0 20 40 60 80 100
Scale in Metres

## LEGEND

- Wetland Foundation Fill Material
- Rip Rap
- Constructed Wetlands Design
- Designed Infrastructure (Not Constructed)
- Geomembrane
- Flow Direction

## NOTES

1. During the decommissioning of the dam the segregated materials are repurposed in the construction of the wetland system.
2. Road access within WSP footprint will be required for construction.
3. Material stockpiles, load and haul routes within the wetland area should be constructed as dam decommissioning advances.
4. Decommissioning of the WSP dam will include the construction of the High Flow By-pass Channel that will convey flow around the wetlands as per SRK Closure Conveyance Channel Design 2016.
5. Supporting features: E3 Stilling Basin, Energy dissipation pond, and the High Flow By-pass Channel are designed by SRK in the Closure Conveyance Design Report 2016.
6. Notes on this drawing apply to all other drawings within this drawing package unless otherwise advised.




## SECTION A - A'

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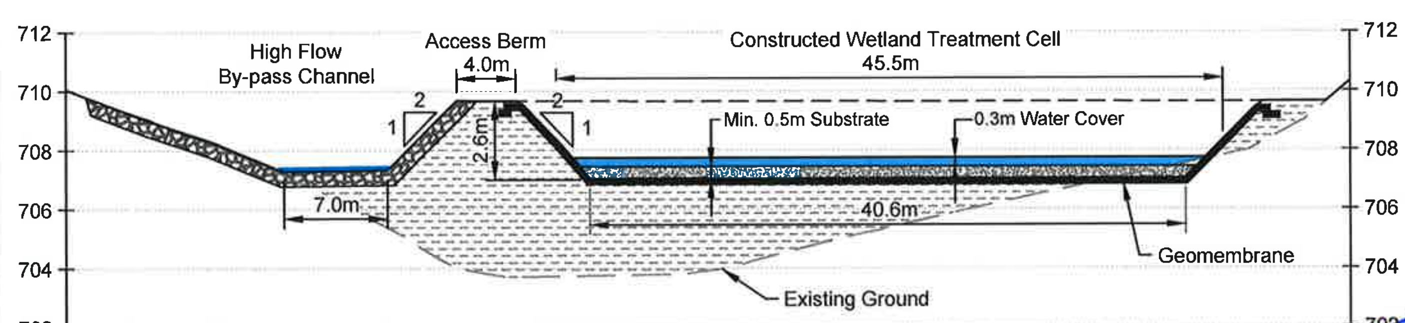
Horizontal Scale in Metres
Vertical Exaggeration 2X




## SECTION B - B'

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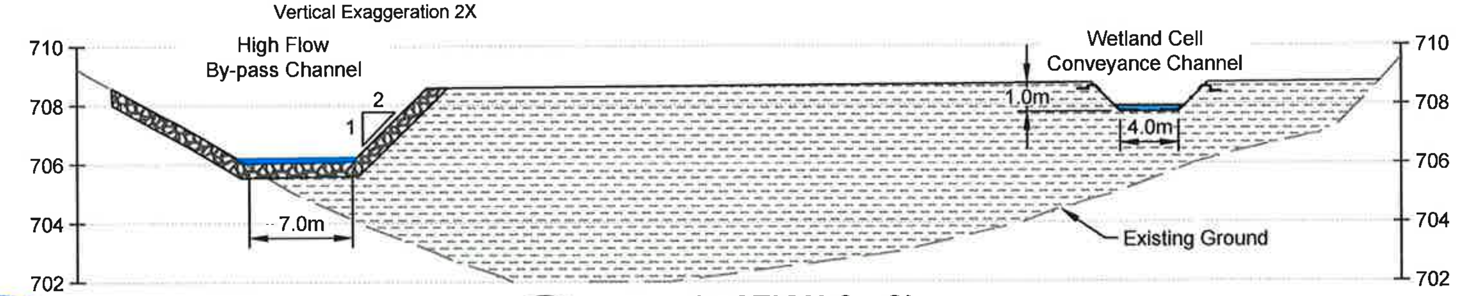
Horizontal Scale in Metres
Vertical Exaggeration 2X




## SECTION C - C'

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Exaggeration 2X

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FILE NAME: 1CM002_044-Wetland-1.dwg

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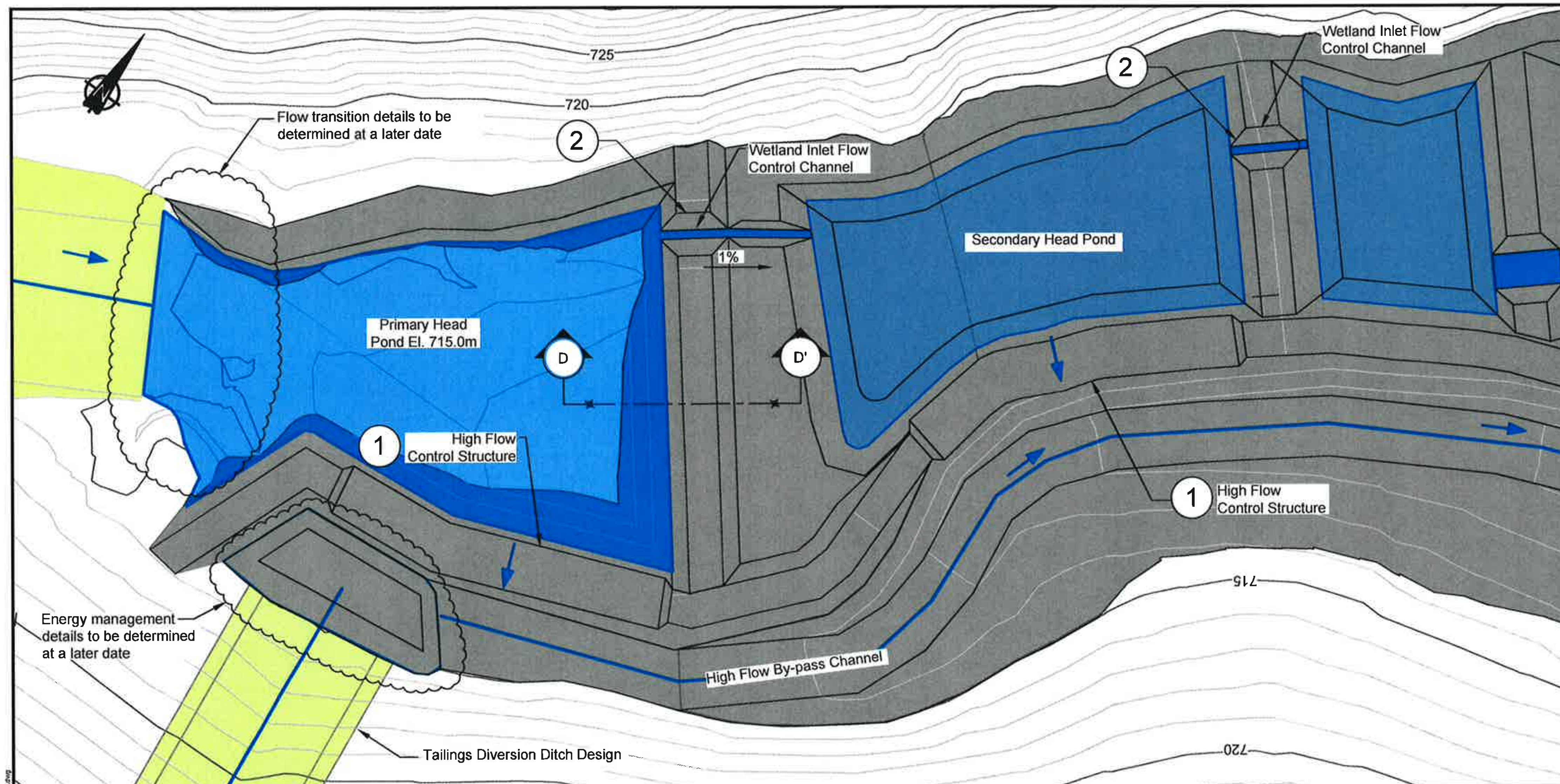
MINTO EXPLORATIONS Ltd.

SRK JOB NO.: 1CM002.042

Preliminary Infrastructure Minto Creek Constructed Wetlands

DRAWING TITLE: Wetland Cell Configuration

DRAWING NO. CW-02 | SHEET 3 OF 5 | REVISION NO. A




## LEGEND

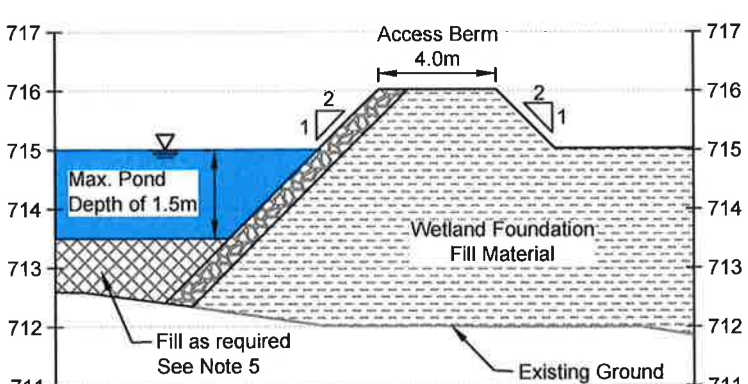
- Wetland Foundation Fill Material
- Rip Rap
- Constructed Wetlands Design
- Designed Infrastructure (Not Constructed)
- Geomembrane
- Flow Direction

## NOTES

1. The Wetland Intake structure is designed to convey the design flow rate from the Primary Head Pond to the Secondary Head Pond. Flows exceeding this rate enter the high-flow bypass channel.
2. Wetland intake structure to be designed at later stages of design to convey 3000 m3/day into the wetland.
3. High Flow By-Pass flow control structure to be designed at later stages of design.
4. High Flow By-Pass Channel and Stilling Basin designed by SRK Closure Conveyance Channel Design Report 2016.
5. Pond to be filled to avoid structures classified as dams.

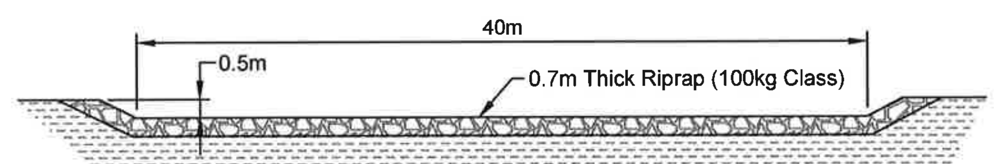
## PRIMARY AND SECONDARY HEAD POND PLAN VIEW

0 10 20 30
Scale in Metres



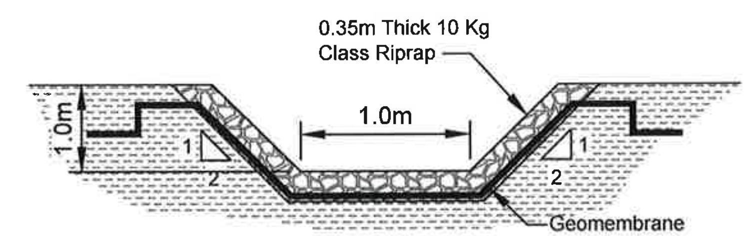

## D SECTION D - D'

0 2 4 6 8 10
Horizontal Scale in Metres
Vertical Exaggeration 2X




## 1 DETAIL 1 - TYPICAL HIGH FLOW CONTROL STRUCTURE

NTS




## 2 DETAIL 2 - TYPICAL WETLAND INLET FLOW CONTROL CHANNEL

NTS

PROFESSIONAL YUKON TERRITORY ENGINEER
ALEJANDRO MUNOZ SAAVEDRA
08/12/2016

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|---|---|---|---|
| REFERENCE DRAWINGS | | | |

| NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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| A | Issued for Review | SM | VM | 15Jul16 |
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FILE NAME: 1CM002_044-Wetland-1.dwg

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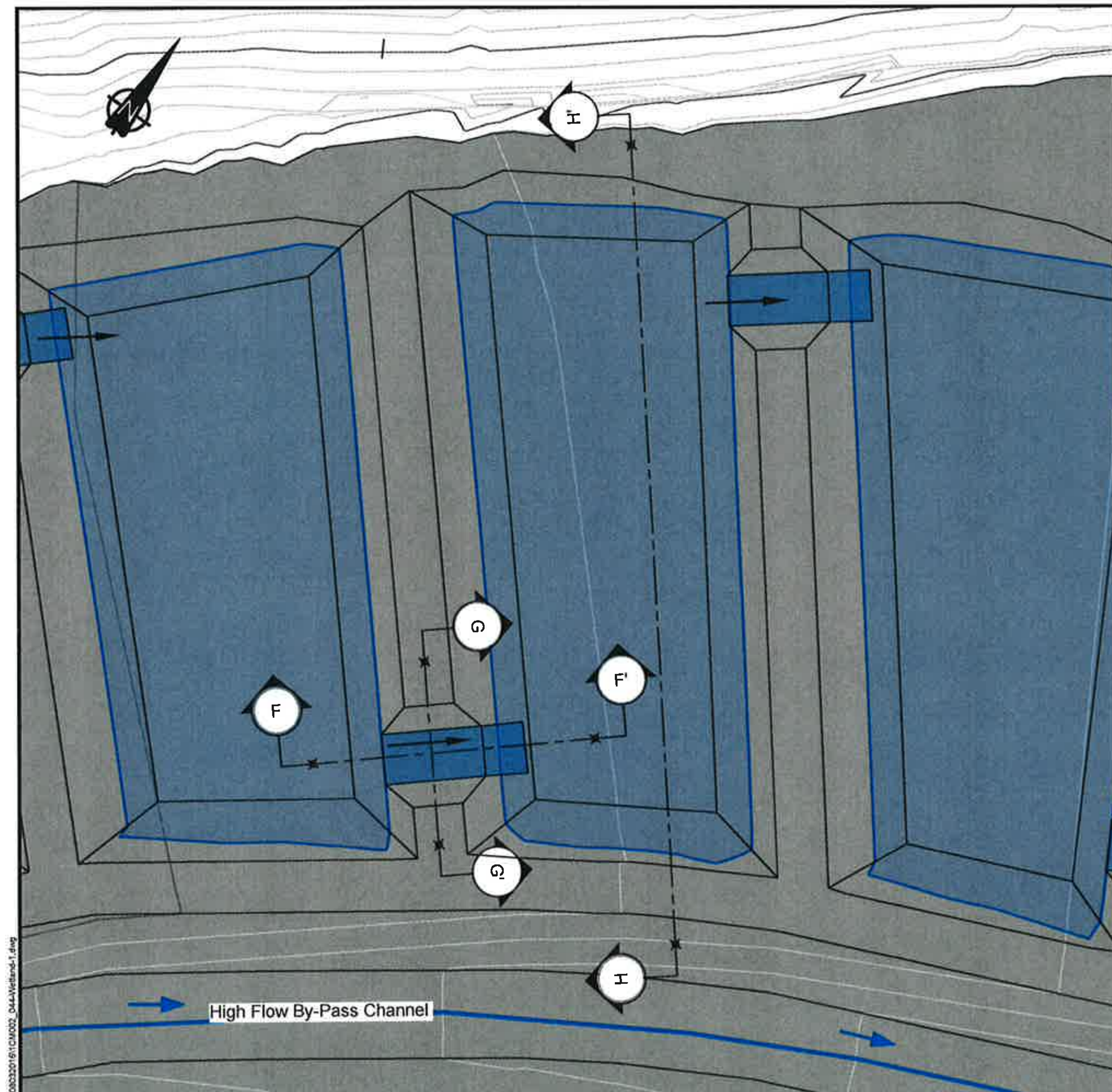
Preliminary Infrastructure Minto Creek Constructed Wetlands

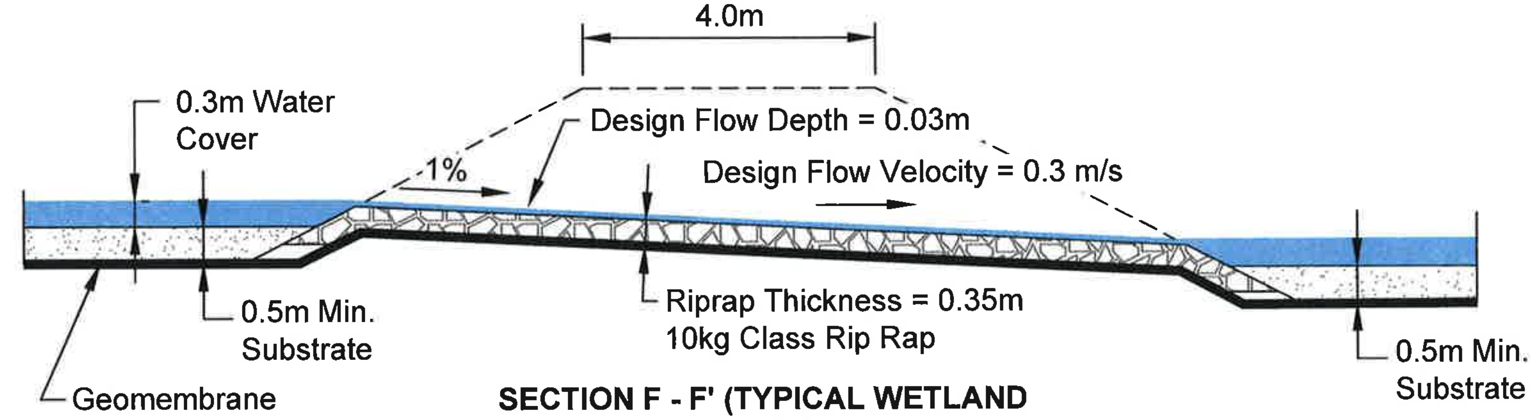
DRAWING TITLE: Head Pond Area Layout

| DRAWING NO. | SHEET | REVISION NO. |
|---|---|---|
| CW-03 | 4 OF 5 | A |




## TYPICAL CELL PLAN VIEW

0 5 10 15 20 25
Scale in Metres



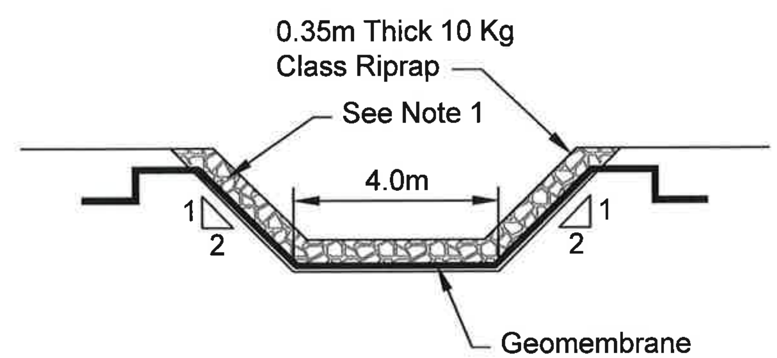

## SECTION F - F' (TYPICAL WETLAND CELL CONVEYANCE CHANNEL)

F

NTS

### 10kg CLASS - RIP RAP

| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 300 |
| $D_{85}$ | 280 |
| $D_{50}$ | 200 |
| $D_{15}$ | 90 |
| Layer Thickness | 350 |



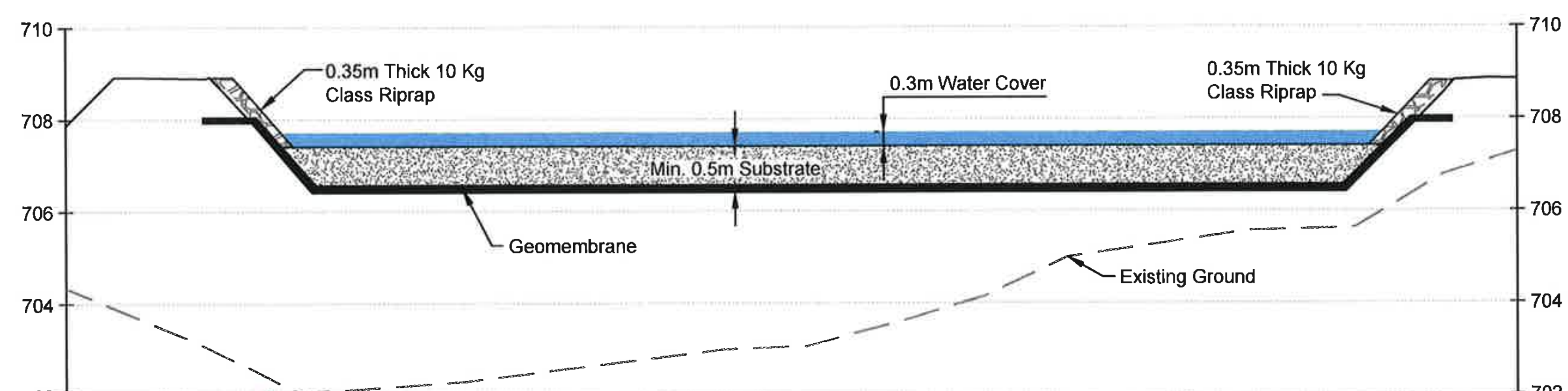

### 100 kg CLASS - RIP RAP

| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 680 |
| $D_{85}$ | 610 |
| $D_{50}$ | 450 |
| $D_{15}$ | 200 |
| Layer Thickness | 700 |

## SECTION G - G' (TYPICAL WETLAND CELL CONVEYANCE CHANNEL)

G

NTS




## SECTION H - H' (TYPICAL CONSTRUCTED WETLAND)

H

0 2 4 6 8 10
Horizontal Scale in Metres
Vertical Exaggeration 2X

### LEGEND

- Rip Rap
- Constructed Wetlands Design
- Geomembrane
- Flow Direction

### NOTES

1. Cell Conveyance Channel requires a minimum 350 mm layer of rock rip-rap having an average diameter of greater than 200 mm to mitigate erosion.
2. Typical 4.0 m wide berms to be constructed to provide access for Construction and monitoring and maintenance.

PROFESSIONAL ENGINEER
YUKON TERRITORY
VICTOR ALEJANDRO MUNOZ SAAVEDRA
08/12/2016

NOT FOR CONSTRUCTION

| DRAWING NO. | DRAWING TITLE | DRAWING NO. | DRAWING TITLE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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|---|---|---|
| CHECKED: SM | APPROVED: VM | DATE: July 2016 |

FILE NAME: 1CM002_044-Wetland-1.dwg

SRK JOB NO.: 1CM002.042

Preliminary Infrastructure Minto Creek Constructed Wetlands

DRAWING TITLE: Typical Cell and Cell Spillway Layout

DRAWING NO. CW-04 | SHEET 5 OF 5 | REVISION NO. A

# Appendix G2
# Closure Water Conveyance System Design 2018 Update Report, Minto Mine

# Closure Water Conveyance System Design Update Report, Minto Mine

**Prepared for**

Minto Explorations Ltd.

**Prepared by**

SRK Consulting (Canada) Inc.
1CM002.042
February 2018

# Closure Water Conveyance System Design Update Report, Minto Mine

February 2018


**Prepared for**

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**Prepared by**

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Project No: 1CM002.042

File Name: Minto_ClosureConveyanceDesign_1CM002-042_20180201_spb_VM_dbm

# Table of Contents

# List of Tables



# Appendices

# 1 Introduction

SRK Consulting (Canada) Inc. has prepared this updated post-closure water conveyance system design report for the Minto Mine located in Yukon, Canada, and operated by Minto Explorations Ltd. The updated designs are intended to form a part of Minto's January 2018 update of the mine's Reclamation and Closure Plan (RCP 2018-01).

The designs of the post-closure water conveyance system described herein are updates to those developed for the previous version of the RCP (RCP 2016-01). The updated designs account for the following:

- Updated as-built details of the current ground surface;
- Updated as-built and design details for the Main Pit Dump;
- Redesign of the ultimate Area 2 Stage 3 Pit; and
- Refinements based on outcomes of the 2017 Failure Modes and Effects Assessment (AEG 2018).

Because of the above revisions, the existing post-closure designs for the water conveyance network and related infrastructure required updates. Included in this report is the preliminary design level of the post-closure water network. Secondary and tertiary drainage features are not included in the preliminary engineering design for the conveyance network; however, the accompanying cover designs address local drainage networks as part of managing surface runoff and limiting erosion for covered facilities (SRK 2018).

The post-closure conveyance system is a network of channels, erosion protection features, and energy dissipation structures that convey surface water from and through the mine site to Minto Creek, which itself discharges into the Yukon River. This design report focuses on the primary arterial network of conveyance channels within the mine footprint. The network of channels is designed to collect, intercept, and convey water through the mine in its closed state. To support the conveyance system designs and methodology summarized in this report, the following technical memos are provided in the appendices:

- Appendix A – Conveyance System Drawings,
- Appendix B – Site-Specific Hydrology Review,
- Appendix C – Climate Change Analysis,
- Appendix D – Routing Flow Closure Evaluation, and
- Appendix E – Integrating Vegetation Erosion Protection.

# 2 Water Management Review

To support the water conveyance designs, SRK has reviewed and updated the site-wide hydrology analysis to reflect climate change, modified watershed catchment areas and assessed options of alignments for conveyance channels. The results of this review are summarized below. Further details are provided in the technical memos (Appendices B, C and D).

## 2.1 Hydrology Review

This section summarizes the background and results of the site wide hydrology review which is included with this report in Appendix B.

The hydrology analysis was updated to estimate the summer probable maximum precipitation (PMP), the probable maximum flood (PMF), and 1:200-year peak flows for the design of the conveyance channels and erosion protection required for the Reclamation and Closure Plan (RCP).

The maximum instantaneous 200-year peak flow and PMF were calculated using a rainfall-runoff methodology where maximum average daily snowmelt was modelled as baseflow. The Soil Conservation Service method was used to determine runoff based on catchment area characteristics such as: lag time, area, and curve number coefficients. The Soil Conservation Service Type I rainfall distribution was selected for use in the HEC-HMS (2013) model. The Type I distribution approximates an intense, short-duration storm event typical of storms in the Yukon and nearby Alaskan interior. A HEC-HMS model was developed for the post-closure conveyance network, to determine the 1:200 year return-period peak flows and the PMF along the post-closure conveyance channels.

The PMP for a 24-hour duration event was evaluated to be 159 mm of precipitation based on observed data from 20 regional meteorological stations. Additional details of the hydrology and evaluation of the PMP are presented in Appendix B.

## 2.2 Climate Change Analysis

This section summarizes the background and results of the climate change study which is included in Appendix D of this report.

The International Panel on Climate Change (IPCC) projects a 5°C to 6°C increase in the ambient temperature in Northern Canada for year 2100 relative to the 1980 to 1999 temperatures (IPCC 2007). Evaluating the climate change models relative to Minto Mine, the mean annual air temperature has the potential to increase 3.3°C over the next century. Trending forward in time, the mean annual air temperatures may reach −0.8°C, 0.2°C, and 1.1°C in the 2020s, 2050s, and 2080s, respectively.

According to the climate change model, the total precipitation at Minto is forecasted to increase 67.9 mm (15%) during the closure and post-closure periods (2011 to 2040) and 199.3 mm (44%) by 2100. Heavy rainfall, which is the fraction of annual precipitation greater than the 95th percentile, is predicted to increase by 96% over the next century at Minto. Similarly, the number of days with more than 10 mm of rainfall is forecasted to increase by 140%. This trending increase in annual precipitation was accounted for in the sizing and specifications of conveyance structures (Section 3).

The monthly average snow depth at Minto is expected to increase over the next century. Forecasts suggest that freshet will occur in April, and maximum daily snowmelt will increase over the next century.

### 2.3 Channel Routing Options Evaluation

This section summarizes the results of an alternative assessment for the channel alignment around the Main Pit and Area 2 Stage 3 Pit. Channel alignments and flood routing through the pits were evaluated for a range of design storms including the PMF.

Two flood routing alternatives for the Area 2 Stage 3 Pit were considered:

- Option 1 – Area 2 Stage 3 Pit upstream flow is routed into the pit through Channel B. From the pit, flows are discharged to Channel D.
- Option 2 – Area 2 Stage 3 Pit upstream flow is routed around the pit through Channel B. Channel B and Channel C both report to Channel E.

The results of the two routing options illustrate a minimal difference in the magnitude of the PMF in downstream channels for Options 1 and 2. Furthermore, the Option 2 of diverting flows around the Area 2 Stage 3 Pit does not result in any measurable difference in the timing of the peak flow into lower Minto Creek.

A total of three geometric channel configurations were evaluated for the pit outlet channels to assess hydraulic design requirements (i.e. channel depth and erosion protection):

- Case 1 – Minimum spillway width (2 m).
- Case 2 – Constructible spillway width, based on dozer sizing (7 m).
- Case 3 – Maximum spillway width, based on topography (22 m for Main Pit, 15 m for Area 2 Pit).

Based on the routing alternatives and channel geometry assessment, it is recommended that channel alignments flow into the Main Pit and Area 2 Stage 3 Pit.

Based on the constructability methods and costs of using a dozer, it is recommended that channel widths be sized to a minimum of a dozer blade (i.e. Case 2). Given that there is no benefit to route flows around the pits, it is recommended that channel alignments flow into the pits and should be sized to have a minimum bottom width of a dozer blade (i.e. 7 m). More detail of this analysis is included in Appendix D.

# 3 Design Basis

The design basis of the closure water conveyance system is to collect upstream surface runoff and convey flows through the mine site to downstream Minto Creek.

The conveyance system should be designed in a manner that constructed water management features are robust and durable post-closure. Key design criteria considered in the design include:

- Rip rap erosion protection and integration of vegetation,
- Robust geometry that reduces the risk of overtopping and erosion,
- Allowance for future climate change conditions and discharge requirements, and
- Utilization of pit lakes for mixing, energy dissipation, and sediment deposition.

## 3.1 Summary of the Channel Alignments

The conveyance channel system is composed of seven primary conveyance channels, the Stilling Basin, and the Primary Head Pond (Drawing CC-01; Appendix A). These channel alignments were selected based on four design considerations:

- Ability to convey surface runoff generated from upstream catchment areas,
- Minimization of channel slopes and excavation volumes (while maintaining alignments that are robust against excess flows and negative effects of long term thaw consolidation of foundation materials),
- Utilization of pit lakes established in the Main Pit and Area 2 Stage 3 Pit to dissipate energy and settle sediments, and
- Convey flows generated on site to the Minto Creek channel upstream of the W3 monitoring station downstream of all mine disturbances.

The following section provides a summary of the function of each conveyance structure at closure.

- **Conveyance Channel A:** Located southwest of the Main Pit, downgradient of the Main Waste Dump (MWD) and the Southwest Waste Dump (SWD). This channel will convey surface water from the W15 tributary across the South Wall Buttress into the Main Pit lake. The channel alignment will incorporate a light vehicle swale crossing at its inlet to maintain access to the upgradient catchment areas.
- **Conveyance Channel B:** Located east of the Area 2 Stage 3 Pit. This channel collects flow from the Airport Road Ditch and from the W35A tributary and conveys into the Area 2 Stage 3 Pit. The channel is cut into the pit wall and incorporates erosion protection. The upstream channel alignment incorporates a light vehicle swale crossing to maintain access to the underground portal to the west of the channel (South Portal).
- **Conveyance Channel C:** Channel C conveys discharge water from the Main Pit to a downstream confluence with Channel D, where the two combine to form the upstream segment of Channel E. Additionally, a constructed access road is required to maintain access to Channel C and to the Main Pit for post-closure monitoring and maintenance.

- **Conveyance Channel D:** Channel D conveys the discharge water from the Area 2 Stage 3 Pit to the confluence with Channel C. The confluence of flows from Channel C and D requires additional design attention to ensure flow transitions don't result in channel erosion. Similar to Channel C, the channel design also includes a parallel access road for post-closure monitoring and maintenance.
- **Conveyance Channel E:** Channel E has been subdivided into a system of three sequential channels: E1, E2, and E3. Channel E ultimately conveys water from the Main and Area 2 Stage 3 open pits into the Constructed Wetland Treatment System (CWTS). Flows in excess of the design of the CWTS flow rate are directed into a high-flow bypass channel (Channel G).

  Channel E1 commences at the confluence between channels C and D and conveys water in a constructed channel at a slope grade of 1% to the existing alignment of the site access road. Channel E2 and E3 is constructed on the alignment of the existing access road with grades ranging from 1.5% to 20%. Downstream of Channel E3, high velocity flows are transitioned into the Stilling Basin located upstream of the Primary Head Pond.
- **Conveyance Channel F:** Conveyance Channel F has been subdivided into two channels. Channel F1 represents the existing Tailings Diversion Ditch and Channel F2 represents the downstream segment of the diversion to convey flows upstream of the Dry Stack Tailings Storage Facility to Channel G (High Flow Bypass Channel).
- **Conveyance Channel G:** The High Flow Bypass Channel conveys flows from the Primary and Secondary Head Ponds through the High Flow Control Structures around the CWTS to lower Minto Creek. Flows that are diverted around the wetland are those that are in excess of the design flow rate for the CWTS or which enter the channel via Channel F (SRK 2016 and Contango 2016).
- **Stilling Basin:** Downslope of Channel E3, high velocity water is received by a Stilling Basin which is designed to dissipate energy and contain the development of a hydraulic jump within the protected stilling basin surface. Water passes from the Stilling Basin into the Primary Head Pond.
- **Primary Head Pond:** The Primary Head Pond moderates turbulent flows that exit the Stilling Basin before water is directed into the CWTS or the High Flow Bypass Channel by flow control structures on the south side of each head pond. The dual head pond system is designed to step down the flow rate discharging the Channel E3 to essentially separate the wetland design flow from the remainder of the water discharging the site. A design layout for the Primary and Secondary head ponds are illustrated in the Minto Creek Constructed Wetland: Physical Infrastructure Preliminary Design report (SRK 2016).

## 3.2 Design Criteria

### 3.2.1 Channel Design Criteria

All closure conveyance channels are designed to be lined with riprap for erosion protection for flows up to a 24-hour, 200-year return period. Evaluation of the suitability of using vegetation as a stand-alone protection will be considered at a later stage of design. Further details on the selection of vegetation species and biotechnical techniques are included in Appendix E. Given that over time, vegetation will naturally establish within the conveyance system, channels were sized to convey the 200-year peak flow with vegetation growth.

For channels with cross-slope alignments that have a risk of overtopping during a return period greater than the 200-year event and causing significant downstream effect (i.e. Channel B), channels were designed to convey the PMF. Table 3-1 provides a summary of the design criteria applied for the erosion and conveyance (i.e. channel sizing).

**Table 3-1: Channel Design Criteria Summary**

| Channel | Design Criteria | | Description |
|---|---|---|---|
| | Erosion Protection | Conveyance | |
| A | 200-year | PMF | Risk of overtopping onto Main Pit Dump and causing erosion. Channel sized to contain PMF. |
| B | | PMF | Risk of overtopping onto Dry Stack Tailings Storage Facility and causing erosion. Channel sized to contain PMF. |
| C | | 200-year + freeboard | Surrounding topography provides adequate relief to convey PMF. |
| D | | 200-year + freeboard | Surrounding topography provides adequate relief to convey PMF. |
| E1 | | 200-year + freeboard | Surrounding area graded to form valley-bottom to convey PMF to Channel E2. |
| E2 | | 200-year + freeboard | Surrounding area graded to form valley-bottom to convey PMF to Channel E3. |
| E3 | | 200-year + freeboard | Surrounding area graded to form valley-bottom to convey PMF to Stilling Basin. |
| F1 | | PMF | Risk of overtopping onto Dry Stack Tailings Storage Facility and causing erosion. Channel sized to contain PMF. |
| F2 | | 200-year + freeboard | Surrounding topography provides adequate relief to convey PMF (PMF contained within natural gulley). |
| G | | 200-year + freeboard | PMF contained in the valley-bottom to downstream Minto Creek. Overtopping of wetland infrastructure will occur under flows that exceed channel capacity. |

All closure conveyance channels are designed with a typical geometry that reflects the size and capability of the heavy equipment used on site. All channels were designed to have a minimum base width of 7 m (D11 dozer blade width), side slopes of 2:1 and a minimum freeboard of 0.3 m.

The base of the channel will be graded to create a thalweg in the center of the channel instead of incorporating a pilot channel as a design element. During low flow events, flows will be conveyed along the thalweg.

Excavated depths are variable due to channel grade and riprap sizes and each channel is divided into segments that relate to a typical riprap classification. A summary of required channel depths and rip rap specifications are provided in the drawing package (Appendix A).

The closure conveyance channels are designed to be lined with riprap for erosion protection and geotextile to prevent sediment migration and erosion of the channel side slopes. Sediment migration and erosion of the base material beneath the riprap protection may not warrant any geotextile along the proposed alignments, however geotextile has been incorporated at this stage of design. A geotextile element may not ultimately be necessary because the excavated material from which the channel alignments are constructed consists of either heavily compacted fills from existing haul roads or coarse rock fills generated during mine development. The need for geotextile will be considered further during later design.

Seepage losses from Channel E2 would ultimately report to the Stilling Basin, and are therefore expected to not represent a risk to closure performance. Seepage volumes are expected to be low, in part due to the highly compacted nature of the mine access road that forms the base of the post-closure channel. As such, no additional low permeability element has been incorporated into the design.

### 3.2.2 Stilling Basin Design Criteria

This structure is designed and protected to convey up to the PMF. Channel E3 enters the Stilling Basin at the western (upstream) end; Channel E2 has a maximum slope of 20% followed by a slope of 0.5% in the Stilling Basin itself. This abrupt slope change is anticipated to produce a hydraulic jump under design flows, and that hydraulic jump will provide energy dissipation. To improve the energy reduction, the channel width is increased from 7 to 20 m.

### 3.2.3 Primary Head Pond

The design criteria developed for the management of the passive treatment wetlands is to portion 3000 $m^3$/day of water from the discharge of E3 and the Stilling Basin and convey it into the wetlands (Contango 2016). To moderate the flows entering the CWTS and to direct excess flows to the High Flow Bypass Channel, a sequence of inlet flow control structures and outlet overflow structures are required.

The second component to the CWTS flow conveyance system is required to bypass the flows that exceed the design flow capacity of the CWTS. The High Flow Bypass Channel is designed to convey excess flow from the two head ponds around the wetland system, as well as to keep the discharge from the Tailings Diversion Ditch separate from the wetlands and route that water to lower Minto Creek. Downstream, wetland passive treatment discharge flows will join with the bypass flow and enter Minto Creek.

# 4 Methodology

## 4.1 Design Flow Estimates

Conveyance channel design flows were determined based on the site-wide hydrology and climate change reviews that were prepared by SRK (see Appendix B and C).

A rainfall-runoff approach was used to model peak flows. Rainfall was applied to a 24-hour distribution curve and was then converted to runoff based on catchment characteristics, including curve number, lag time, and total area, using the Soil Conservation Service (SCS) Method. A HEC-HMS model was developed to evaluate the peak 200-year and PMF to design the riprap protection and channel size of each conveyance channel.

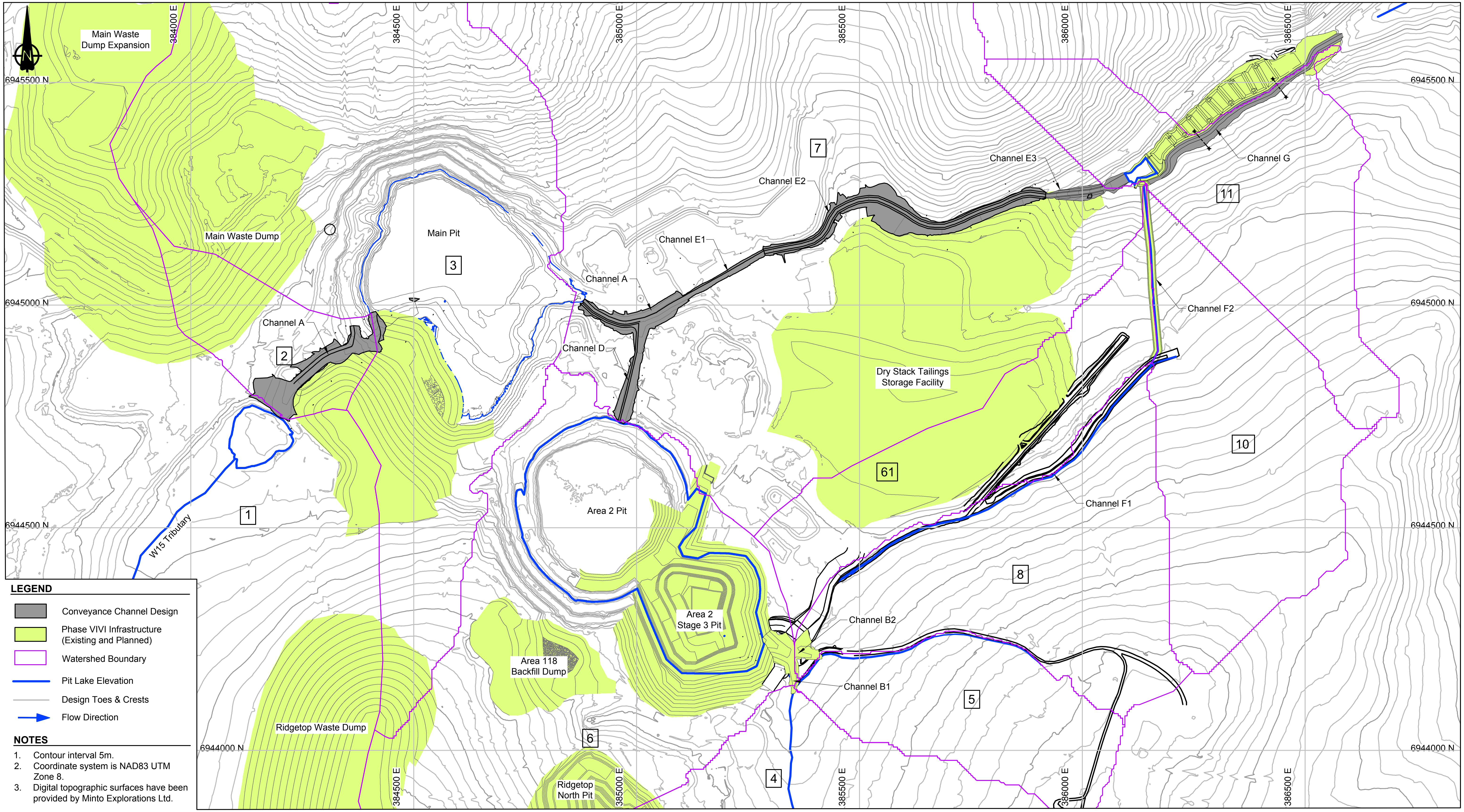
Figure 4-1 illustrates the catchment delineation for each channel and Table 4-1 summarizes the model inputs and Table 4-2 presents the 200-year and PMF flows for each channel. Appendix B provides additional details of the model inputs and validation.

**Table 4-1: Summary of Hydrology Model Inputs**

| Catchment | Area ($km^2$) | Lag Time (min) | Baseflow ($m^3/s$) |
|---|---|---|---|
| 1 | 3.46 | 27 | 0.92 |
| 2 | 0.10 | 6 | 0.03 |
| 3 | 0.86 | 6 | 0.23 |
| 4 | 1.87 | 21 | 0.50 |
| 5 | 0.17 | 9 | 0.05 |
| 6 | 0.64 | 7 | 0.17 |
| 7 | 1.81 | 17 | 0.33 |
| 8 | 0.32 | 18 | 0.09 |
| 9 | 0.21 | 19 | 0.06 |
| 10 | 0.32 | 12 | 0.09 |
| 11 | 0.29 | 12 | 0.08 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

Note: CN number applied to upstream watershed = 83




**NOTES**

1. Contour interval 5m.
2. Coordinate system is NAD83 UTM Zone 8.
3. Digital topographic surfaces have been provided by Minto Explorations Ltd.

**NOT FOR CONSTRUCTION**

srk consulting | capstone MINTO MINE (OPERATED BY MINTO EXPLORATIONS LTD.) | Closure Conveyance Design

| | | | | |
|---|---|---|---|---|
| DESIGN: | DRAWN: TH | REVIEWED: | MINTO EXPLORATIONS Ltd. | DRAWING TITLE: Watershed Delineation |
| CHECKED: | APPROVED: | DATE: 2018/01/12 | | |
| FILE NAME: 1CM002_042-WS.dwg | | | SRK JOB NO.: 1CM002.042 | DRAWING NO. 4.1 |

**Table 4-2: Summary of Peak Flows**

| Channel | 200-year ($m^3/s$) | Probable Maximum Flood ($m^3/s$) |
|---|---|---|
| A | 11.5 | 42.6 |
| B | 7.6 | 28.2 |
| C | 13.1 | 47.7 |
| D | 9.7 | 36.6 |
| E1 | 28.9 | 110.1 |
| E2 | 28.9 | 110.1 |
| E3 | 28.9 | 110.1 |
| F1 | 1.3 | 4.8 |
| F2 | 2.3 | 8.6 |
| G | 31.5 | 121.3 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\CatchmentSummary_Minto_Closure_2018_spb_rev01.xlsm

## 4.2 Hydraulic Analysis (Channel Dimension and Erosion Protection)

The hydraulic analysis and sizing of channels were determined using Manning's Equation under a steady state normal depth condition. As described in Section 3.2.1, rip rap was sized for the 200-year peak flow and channels were sized for either the 200-year peak flow or PMF depending on the downstream risk (see Table 3-1) and the assumption that post-closure vegetation will be established. The Manning's roughness coefficient for a channel with vegetation in literature is determined to be 0.1 (Bedient et al, 2008). Studies of willows in channel have also been completed where it was found that the Manning's roughness coefficient for Sandbar Willows ranged from 0.04 to 0.08 depending of the channel depth (Chen et al. 2009). For the sizing of the conveyance channels at Minto a roughness coefficient of 0.1 was applied for channels with vegetation. The procedure to evaluate the Manning's coefficient for the rip rap is an iterative process between water depth, Manning's roughness and rip rap size.

Riprap sizing and Manning's roughness values were derived through model iterations. The Manning's equation was evaluated using initial roughness values, and the results were extracted at each channel segment of different longitudinal slope. For each interval, the $D_{50}$ of the riprap was calculated based on the velocity in the channel, and the corresponding Manning's roughness value was calculated based on the riprap sizing. This process was repeated until similar *n* values were obtained between model iterations.

### 4.2.1 Riprap Calculations

#### Closure Conveyance Channels

Riprap sizing for the closure conveyance channels was estimated using three expressions: Isbash (USACE 1991), Robinson et al. (1998), and Khan and Ahmad (2011). To be conservative, the maximum of the three estimates was used in the conveyance channel design.

Equation 2 presents the Isbash expression.

$$D_{50} = \frac{V^2}{C^2 2g(\frac{\gamma s - \gamma w}{\gamma w})} \qquad \text{Eq. [2]}$$

Where $V$ is the average velocity (ft/s), $g$ is gravitational acceleration (ft/s$^2$), $\gamma_s$ is the unit weight of riprap (lb/ft$^3$), $\gamma_w$ is the unit weight of water (lb/ft$^3$), $D_{50}$ is the median riprap size (ft), and C is the Isbach coefficient. The Isbach coefficient was set to 1.2 for low turbulence or bank protection.

Equations 3 and 4 present the Robinson et al (1998) expressions, which are based on the channel slope.

$$D_{50} = (\frac{Q}{9.76x10^{-7} * S^{-1.50}})^{\frac{1}{1.89}} \qquad S < 0.10 \qquad \text{Eq. [3]}$$

$$D_{50} = (\frac{Q}{8.07x10^{-6} * S^{-0.58}})^{\frac{1}{1.89}} \qquad 0.10 \leq S \leq 0.40 \qquad \text{Eq. [4]}$$

Where $Q$ is the unit peak flow rate (m$^3$/s/m), $D_{50}$ is the median riprap size (m), and $S$ is the slope (m/m).

Equation 5 presents the Khan and Ahmad (2011) expression.

$$D_{50} = 0.66\ x\ t^{0.58}\ x\ S^{0.22}\ x\ {C_u}^{-0.45}\ x\ {Q_f}^{0.22} \qquad \text{Eq. [5]}$$

Where $t$ is the riprap thickness (m), $S$ is the channel slope (m/m), $C_u$ is the coefficient of uniformity, and $Q_f$ is the critical unit discharge (m$^3$/s/m).

**Stilling Basin and Head Pond**

The erosion protection of the Stilling Basin and Head Pond were designed to be protected to convey the PMF resulting in large peak flows. The above three rip rap sizing expressions were complemented with Wittler and Abt, Mishra, and LaGasse et al. (Abt et al. 2013), which are expressions that are more suitable for evaluating larger sized riprap.

Because of the variability of the rip rap results, the riprap selected for the Stilling Basin and Head Pond was based on the average of these all six expressions (i.e. Isbash, Robinson et al., Khan and Ahmad, Wittler and Abt, Mishra, and LaGasse et al.), where the minimum and maximum values were removed from the average.

### 4.2.2 Manning's Roughness Estimation

Given a riprap size estimate, a Manning's roughness value (n) was then calculated based on three relationships by Strickler, Anderson, and Abt et al. (1988). The average *n* value obtained from the three expressions was selected. A smaller *n* value corresponds to a higher velocity and lower flow depth and vice versa; the average provides a conservative velocity and depth for the design.

Equation 6 presents the Strickler expression.

$$n = 0.0385{K_s}^{1/6} \qquad \text{Eq. [6]}$$

Where *n* is the Manning's roughness value, and $K_s$ is the particle diameter of the largest 15% of the riprap grain size distribution (ft).

Equation 7 presents the Abt et al. (1988) expression.

$$n = 0.0456(D_{50}\ x\ S)^{0.159} \qquad \text{Eq. [7]}$$

Where *n* is the Manning's roughness value, S is the channel slope (ft/ft), and $D_{50}$ is the average riprap diameter (inches).

Equation 8 presents the Anderson expression.

$$n = 0.0395{D_{50}}^{1/6} \qquad \text{Eq. [8]}$$

Where *n* is the Manning's roughness value, and $D_{50}$ is the average riprap diameter (ft).

### 4.2.3 Riprap Classification and Gradation for Conveyance Channels

The riprap classifications (Table 4-3) were developed based on MOT BC (2006) to follow the design rationale described in this section for the closure channel segments. As stated before, the conveyance channels are composed of channel segments that have a typical profile, slope, and velocity profile. Each segment was assigned a riprap class and a layer thickness. The layer thickness is an aggregate of rock diameter types. Details pertaining to the riprap specifications for each segment are provided in the drawing package (Appendix A).

**Table 4-3: Riprap Class Gradation**

| Class of Riprap [kg] | Riprap Thickness [mm] | Rock Gradation Percentage Larger than Given Rock Mass [kg] | | | Rock Gradation Percentage Smaller than Given Rock Diameter [mm] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 85% | 50% | 15% | $D_{15}$ | $D_{30}$ | $D_{50}$ | $D_{85}$ | $D_{100}$ |
| 10 | 400 | 1 | 10 | 30 | 90 | 140 | 200 | 280 | 300 |
| 25 | 600 | 2.5 | 25 | 75 | 130 | 200 | 300 | 380 | 450 |
| 100 | 900 | 10 | 100 | 300 | 200 | 300 | 450 | 610 | 680 |
| 250 | 1200 | 25 | 250 | 750 | 270 | 400 | 600 | 820 | 900 |
| 500 | 1600 | 50 | 500 | 1500 | 340 | 540 | 800 | 1030 | 1200 |
| 1000 | 2000 | 100 | 1000 | 3000 | 420 | 670 | 1000 | 1300 | 1500 |

# 5 Closure Conveyance Channel Design

This section summarizes the closure conveyance channel design parameters. Channel depths are variable and related to the depth of water being conveyed. Specification tables for the channel geometry, flow depths and riprap are provided in Appendix A. All conveyance channel alignments are selected to avoid sharp bends to minimize the risk of scour and erosion and ultimately long-term maintenance requirements. Additional design elements that are specific to each channel are provided in the following sections and in the drawing package included in Appendix A. Drawing CC-01 (Appendix A) illustrates the general post-closure arrangement of the primary water conveyance network.

The following designs are prepared as an interim surface water conveyance design for closure which is based on the as-built configuration of the August 2017 surface. The closure design will need to be reviewed and updated based on future changes to mining and closure concepts.

## 5.1 Channel A

The closure design concept of Channel A is to collect and convey surface water from the W15 tributary to the Main Pit lake. Surface water from the W15 tributary is designed to enter Channel A through an intake transition section. This section will be designed to a detail level upon the completion mining, using the final surface as-built details.

The alignment, profile and typical cross-sections for Channel A are illustrated in Drawing CC-02. Table 5-1 summarizes the hydraulic design for Channel A where the maximum slope is 35%. The channel was sized to convey the PMF (42 $m^3$/s) and rip rap protection was sized for the 200-year peak flow (11 $m^3$/s).

**Table 5-1: Design Summary for Closure Conveyance Channel A**

| Segment ID | Length [m] | Slope [%] | Channel Base Width (m) | Minimum Channel Depth [m] | 1:200 year Water Depth[1] [m] | Riprap | |
|---|---|---|---|---|---|---|---|
| | | | | | | D50 (mm) | Class (kg) |
| 1 | 83 | 0.091 | 10 | 1.50 | 0.55 | 300 | 25 |
| 2 | 159 | 0.040 | 10 | 1.50 | 0.70 | 200 | 10 |
| 3 | 107 | 0.353 | 10 | 1.00 | 0.37 | 450 | 100 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.2 Channel B

Currently routine flows from the W35A Tributary and Airport Diversion Ditch flow through a pipe crossing to the Tailings Diversion Ditch (Channel F). Flows in excess are routed through a spillway into the Area 2 Stage 3 Pit. The proposed closure concept for Channel B is to reroute all flows from W35A tributary and Airport Diversion Ditch to the Area 2 Stage 3 pit through a new alignment cut into the pit wall and sloped back at a 16% grade. The channel will be protected against erosion with rip rap and provide a thermal layer to reduce permafrost degradation.

The closure conveyance channel design will plug and backfill the entrance to the existing pipe crossing and regrade the current spillway to convey flows to the Channel B at closure. Surface water from the W35A tributary and the Airport Diversion Ditch is designed to enter Channel B through an intake transition section. These sections will be designed to a detail level upon the completion of final closure mine plan and will include rock riprap erosion protection and compacted earth berms that direct flows from the W35A tributary and the Airport Diversion Ditch into Channel B.

Drawings CC-03 illustrate the alignment, profile and typical cross-sections. The Table 5-2 summarizes the closure conveyance hydraulic design Channel B. The channel was sized to convey the PMF (28 $m^3/s$) and rip rap protection was sized for the 200-year peak flow (8 $m^3/s$).

**Table 5-2: Design Summary for Closure Conveyance Channel B**

| Segment ID | Length [m] | Slope [%] | Channel Base Width (m) | Minimum Channel Depth [m] | 1:200 year Water Depth[1] [m] | Riprap | |
|---|---|---|---|---|---|---|---|
| | | | | | | D50 (mm) | Class (kg) |
| 1 | 72 | 0.046 | 7 | 1.35 | 0.64 | 200 | 10 |
| 2 | 52 | 0.064 | 7 | 1.23 | 0.59 | 300 | 25 |
| 3 | 83 | 0.162 | 7 | 1.00 | 0.45 | 450 | 100 |
| 4 | 56 | 0.162 | 7 | 1.00 | 0.45 | 450 | 100 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.3 Channel C

The closure design concept for Channel C is to convey discharge water from the Main Pit water cover at elevation 786 m to the downstream confluence of Channel C (Area 2 Stage 3 Pit outlet channel). The intake structure in the Main Pit of Channel C will be designed to a detail level upon the completion of final closure plan.

Parallel to Channel C, a 4-m wide light vehicle access road will be designed. This road will provide post-closure access for monitoring and maintenance of the conveyance channel. The traffic surface of the access road is sloped towards the conveyance channel for drainage and to minimize excavation.

Drawings CC-04 illustrate the alignment, profile and typical cross-section for Channel C. Table 5-3 summarizes the closure conveyance hydraulic design for Channel C where a minimum channel slope of 1% was applied. The riprap erosion protection and channel was sized to convey the 200-year peak flow (13 $m^3/s$). Given the large cut, and parallel access road, it is also able to convey the PMF (48 $m^3/s$).

**Table 5-3: Design Summary for Closure Conveyance Channel C**

| Segment ID | Length [m] | Slope [%] | Channel Base Width (m) | Minimum Channel Depth [m] | 1:200 year Water Depth[1] [m] | Riprap | |
|---|---|---|---|---|---|---|---|
| | | | | | | D50 (mm) | Class (kg) |
| 1 | 182 | 0.010 | 7 | 1.70 | 1.35 | 200 | 10 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.4 Channel D

The closure design concept for Channel D is to convey discharge water from the Area 2 Stage 3 Pit at an elevation of 799 m to the downstream confluence of Channel C. The intake structure in from the Area 2 Stage 3 Pit to Channel D will be designed to a detail level upon the completion of final closure plan. A flow contraction transition structure constructed from overburden backfill and coarse oversize rock riprap is recommended for consideration to reduce permafrost degradation and direct the pit discharge into Channel D.

Drawings CC-05 illustrate the alignment, profile and typical cross-section for Channel D. Table 5-4 summarizes the closure conveyance hydraulic design. The riprap erosion protection and channel was sized to convey the 200-year peak flow (10 $m^3/s$). Given the large cut, and parallel access road, it is also able to convey the PMF (37 $m^3/s$).

**Table 5-4: Design Summary for Closure Conveyance Channel D**

| Segment ID | Length [m] | Slope [%] | Channel Base Width (m) | Minimum Channel Depth [m] | 1:200 year Water Depth[1] [m] | Riprap | |
|---|---|---|---|---|---|---|---|
| | | | | | | D50 (mm) | Class (kg) |
| 1 | 160 | 0.023 | 7 | 2.10 | 1.80 | 200 | 10 |
| 2 | 78 | 0.137 | 7 | 1.40 | 1.10 | 450 | 100 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.5 Channel E

Channel C and D converge to form Channel E. This confluence location was selected based on existing topography and the chosen channel grades for Channel C and D. The confluence will be designed to a detail level upon the completion of the final closure plan and will require an apron sufficiently large enough to protect against an increase in water depth and high velocities due to the development of a hydraulic jump. Channel E is composed of three sequential subsections E1, E2, and E3 and conveys flows from the mine site (i.e. Main Pit, Area 2 Stage 3 Pit and Dry Stack Tailings Storage Facility to the CWTS).

Channel E1 starts at the confluence of channels C and D and conveys flows originating from the Main Pit and from the Area 2 Stage 3 Pit and transitions into Channel E2 and E3 along the existing access and discharges into a stilling basin prior to flowing into the CWTS.

The Channel E alignment is designed to overlay the current mine access road. A light vehicle access road is designed parallel to the alignment. The existing road surface was chosen for construction of a channel because the roadway has undergone traffic compaction over the life of mine and is expected to experience minimal long-term settlement and minimal seepage interception from the Dry Stack Tailings Storage Facility. At future stages of closure design, the need for seepage management along Channel E2 should be evaluated and, if found necessary, may require additional design details to address the need to further limit seepage interception into the channel. This potential additional design requirement could be addressed through lining the channel or components of the channel with low conductivity geomembranes. At this stage of the design, the compacted road material of the existing site access road is accepted to have sufficient low permeability.

Drawings CC-06, CC-07 and CC-08 illustrate the alignment, profile and typical cross-sections for Channel E1, E2 and E3 respectively. Channel E1 and E1 have segments with slopes ranging from 1% to 8%. Channel E3 is designed as a high velocity conveyance channel with a slope of 20% into the Stilling Basin.

Table 5-5 summarizes the hydraulic design for Channel E. The riprap erosion protection and channel was sized to convey the 200-year peak flow (29 $m^3$/s). The mine site will be graded to create a valley bottom to direct all flows from the site into Channel E and ultimately the Stilling Basin. As such, the Channel E valley-bottom can convey the PMF (110 $m^3$/s).

**Table 5-5: Design Summary for Closure Conveyance Channel E**

| Segment ID | Length [m] | Slope [m/m] | Channel Base Width (m) | Minimum Channel Depth [m] | 1:200 year Water Depth[1] [m] | Riprap | |
|---|---|---|---|---|---|---|---|
| | | | | | | D50 (mm) | Class (kg) |
| 1 | 278 | 0.011 | 7 | 2.00 | 1.82 | 200 | 10 |
| 2 | 260 | 0.062 | 7 | 2.00 | 1.26 | 450 | 100 |
| 3 | 98 | 0.014 | 7 | 2.00 | 1.89 | 450 | 100 |
| 4 | 92 | 0.058 | 7 | 2.00 | 1.28 | 450 | 100 |
| 5 | 92 | 0.063 | 7 | 2.00 | 1.26 | 450 | 100 |
| 6 | 105 | 0.041 | 7 | 2.00 | 1.41 | 450 | 100 |
| 7 | 33 | 0.076 | 7 | 2.00 | 1.19 | 600 | 250 |
| 8 | 46 | 0.051 | 7 | 2.00 | 1.33 | 450 | 100 |
| 9 | 150 | 0.207 | 7 | 2.00 | 0.90 | 1000 | 1000 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.6 Stilling Basin

Downslope of the E3 channel is the Stilling Basin which is designed to contain the development of a hydraulic jump within the protected stilling basin surface. The Stilling Basin geometry consists of a 20 m wide basin channel with 2H:1V side slopes constructed from riprap. Outflow from the Stilling Basin transitions into the Primary Head Pond which has a surface elevation of 715 m.

Table 5-6 summarizes the hydraulic design for the Stilling Basin.

**Table 5-6: Design Summary for the Stilling Basin**

| Segment ID | Length [m] | Slope [m/m] | Channel Base Width (m) | Minimum Channel Depth [m] | 1:200 year Water Depth[1] [m] | Riprap | |
|---|---|---|---|---|---|---|---|
| | | | | | | D50 (mm) | Class (kg) |
| 10 | 40 | 0.005 | 20 | 3.30 | 1.50 | 450 | 100 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.7 Channel F (Tailings Diversion Ditch)

Channel F is composed of two sequential subsections. Channel F1 illustrates the existing Tailings Diversion Ditch (TDD) constructed to divert flows around the Dry Stack Tailings Storage Facility and transitions to Channel F2 down an existing natural gulley down to the High Flow Bypass Channel (Channel G).

The grade along the existing TDD (Channel F1) range from 0.8% to 7% and the channel dimensions fluctuate along the alignment. Drawings CC-09 illustrates the alignment, profile and a cross-section of Channel F1. This cross-section was chosen to illustrate the most critical section (i.e. flattest slope and shallow channel depth) along the alignment. Channel F1 has sufficient capacity to convey the post-closure 200-year peak flow (1.3 $m^3/s$) with a Manning's coefficient of 0.1 assuming vegetation will be established within the channel section. The flattest segment of Channel F1 (0.8%) has the capacity to convey the PMF (4.8 $m^3/s$) at a maximum channel depth of 1.4 m.

Channel F2 is aligned in an existing natural gulley with grades ranging from 8% to 30% near the outlet into Channel G. Drawing CC-10 illustrates the alignment, profile and a typical cross-section of the Channel F2 design. Channel F2 has a v-shaped cross-section with a 12% side-slope and a minimum channel depth of 0.8 m to convey the 200-year peak flow under post-closure conditions (i.e. with vegetation established within the channel). The riprap protection was designed for the 200-year peak flow. Table 5-7 summarizes the hydraulic design for Channel F2. Given that the alignment follows natural topography, the PMF (8.6 $m^3/s$) will not create a new flow path. Some long-term settlement along the channel is expected due to thawing of the underlying permafrost; however, as the channel follows an existing natural channel with a steep gradient, any differential settlement is not likely to result in a change in flow path.

**Table 5-7: Design Summary for Closure Conveyance Channel F2**

| Segment ID | Slope [m/m] | Minimum Channel Depth [m] | 1:200 year Water Depth[1] [m] | Riprap | |
|---|---|---|---|---|---|
| | | | | D50 (mm) | Class (kg) |
| 1 | 0.078 | 0.8 | 0.50 | 800 | 500 |
| 2 | 0.121 | 0.8 | 0.46 | 800 | 500 |
| 3 | 0.159 | 0.8 | 0.44 | 800 | 500 |
| 4 | 0.092 | 0.8 | 0.49 | 800 | 500 |
| 5 | 0.163 | 0.8 | 0.44 | 800 | 500 |
| 6 | 0.168 | 0.8 | 0.43 | 800 | 500 |
| 7 | 0.174 | 0.8 | 0.43 | 800 | 500 |
| 8 | 0.284 | 0.8 | 0.39 | 800 | 500 |
| 9 | 0.270 | 0.8 | 0.40 | 800 | 500 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.8 Channel G (High Flow Bypass Channel)

The High Flow Bypass Channel conveys flows from Channel F and excess flows the Head Pond of the CWTS. Excess flows from the head pond flow through a 40 m wide and 0.5 m deep spillway. Flows that are diverted around the CWTS are those that are in excess of the design flow rate that can be managed by the wetlands (SRK 2016 and Contango 2016).

Drawing CC-11 illustrates the alignment, profile and typical cross-sections for Channel F. Table 5-8 summarizes the hydraulic design for Channel G. The channel slope ranges from 1% to 5%. The riprap protection and channel was sized to convey the 200-year peak flow (32 $m^3/s$). The 200-year water depth post closure with vegetation established in the channel will vary along the alignment depending on topography. During the PMF event, water levels will rise and flow into the CWTS and ultimately downstream to Minto Creek.

**Table 5-8: Design Summary for Closure Conveyance Channel G**

| Segment ID | Length [m] | Slope [m/m] | Channel Base Width (m) | Minimum Channel Depth [m] | Riprap | |
|---|---|---|---|---|---|---|
| | | | | | D50 (mm) | Class (kg) |
| 1 | 28 | 0.01 | 7 | 2.5 | 300 | 25 |
| 2 | 62 | 0.05 | 7 | 2.0 | 300 | 25 |
| 3 | 61 | 0.02 | 7 | 2.0 | 300 | 25 |
| 4 | 84 | 0.03 | 7 | 2.0 | 300 | 25 |
| 5 | 334 | 0.03 | 7 | 2.0 | 300 | 25 |

Source: \\VAN-SVR0\Projects\01_SITES\Minto\1CM002.042_ClosureConveyance\FMEA_2017\Minto - Channel_SPB.xlsm

**Notes:**

[1] Water depths represent the water depth for the 200-year peak flow with vegetation established post-closure in the channel.

## 5.9 Primary Head Pond

The Primary Head Pond moderates turbulent flows that exit the Stilling Basin before water is directed into a secondary head pond of the CWTS or Channel G by two flow control structures (CC-11).

The dual head pond system is designed to step down the flow rate discharging from the E Conveyance Channel to protect the constructed wetland treatment system from excess flows.

Design details for the CWTS and the head pond flow control structures can be found in *Minto Creek Constructed Wetland: Physical Infrastructure Preliminary Design* (SRK 2016).

# 6 Information Required to Advance the Channel Design

To further develop the closure conveyance channel design towards a final closure design plan, the following data requirements and project developments are required:

- The final post-mining as-built surfaces (such as as-built waste rock, pit, and general mine area surfaces) will be required to update and optimize the conveyance channel design.
- Review site wide closure progress and closure designs for other site components. This will allow determination of design gaps or redundancies in the closure conveyance channel design and will permit identification of opportunities for optimization and integration.
- In conjunction with review of site-wide closure designs, surficial drainage features from adjacent areas will need to be incorporated into the conveyance system. Designed drainage features include elements in the final cover designs, landform grading on waste rock dumps and tailings covers, and mine elements (e.g. haul roads, pit shells, and the underground portal).
- Design elements for the planned constructed wetland treatment system within the current WSP footprint will need to be integrated.
- Include an as-built design of the Tailings Diversion Ditch upon its completion to finalize the design of the High Flow Bypass Channel and related wetland infrastructure.
- Final post closure road layout design will be required to ensure integration of the road and channel networks.
- It is expected that the channels will have limited seepage losses and that there is no requirement for incorporation of low permeability elements in the channel designs. This should be confirmed during final design.
- At future stages of closure design, details of the specific hydraulic design of the Main and Area 2 Stage 3 open pit outlets and the energy dissipation aprons will need to be developed.

This report, "Closure Water Conveyance System Design Update Report, Minto Mine", was prepared by

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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# Appendix A – Conveyance System Drawings

# Engineering Drawings for the Closure Conveyance Design, Minto Mine, Yukon, Canada

## ACTIVE DRAWING STATUS

| DWG NUMBER | DRAWING TITLE | REVISION | DATE | STATUS | REPLACED REVISIONS |
|---|---|---|---|---|---|
| CC-00 | Engineering Drawings for the Closure Conveyance Design, Minto Mine, Yukon, Canada | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-01 | Post-Closure General Arrangement | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-02 | Channel A | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-03 | Channel B | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-04 | Channel C | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-05 | Channel D | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-06 | Channel E1 | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-07 | Channel E2 | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-08 | Channel E3 AND STILLING BASIN | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |
| CC-09 | Channel F1 Existing Tailings Diversion Ditch | F | Jan. 16, 2018 | Issued For Review | |
| CC-10 | Channel F2 | F | Jan. 16, 2018 | Issued For Review | |
| CC-11 | Channel G High Flow By-Pass | B | Jan. 16, 2018 | Issued For Review | July 27, 2016; Rev A IFR |

PERMIT TO PRACTICE
Signature [signature]
Date 2/06/2018
PERMIT NUMBER: PP019
Association of Professional Engineers of Yukon

PROFESSIONAL ENGINEER
YUKON TERRITORY
VICTOR ALEJANDRO MUÑOZ SAAVEDRA
[signature] 2/05/2018

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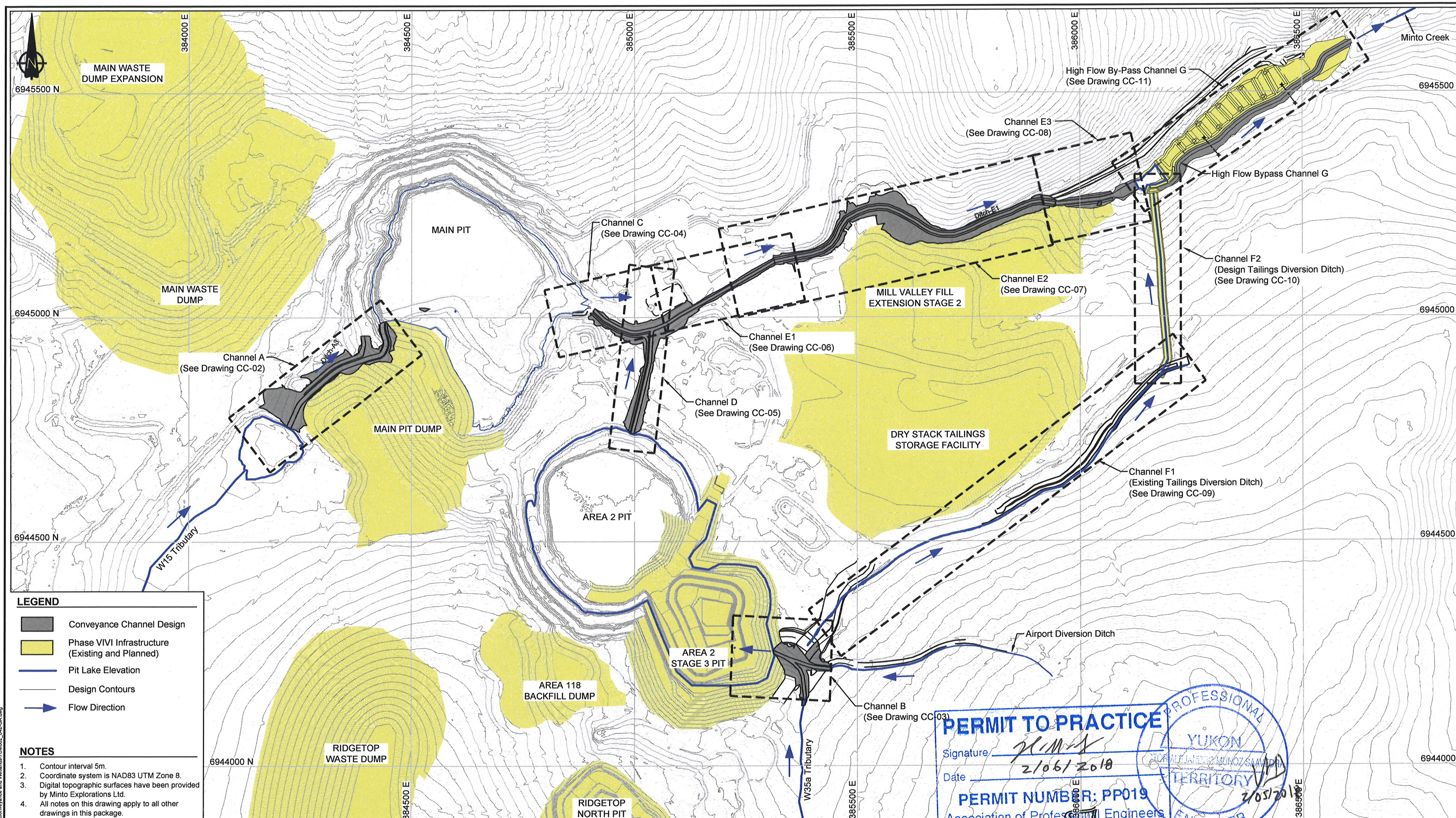
PROJECT NO: 1CM002.042
Revision B - Issued for Review
January 16, 2018
Drawing CC-00




## LEGEND

- Conveyance Channel Design
- Phase VIVI Infrastructure (Existing and Planned)
- Pit Lake Elevation
- Design Contours
- Flow Direction

## NOTES

1. Contour interval 5m.
2. Coordinate system is NAD83 UTM Zone 8.
3. Digital topographic surfaces have been provided by Minto Explorations Ltd.
4. All notes on this drawing apply to all other drawings in this package.

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Date 2/06/2018
PERMIT NUMBER: PP019
Association of Professional Engineers of Yukon

PROFESSIONAL ENGINEER
YUKON TERRITORY
JORGE ... MUNOZ SAAVEDRA
2/05/2018

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P:\01_SITES\Minto Mine YK Capstone\1040.CAD\IFR - Conveyance and Wetlands\1CM002_042-GA.dwg

| NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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| B | Issued for Review | SP | VM | 16Jan18 |
| A | Issued for Review | SM | VM | 15Jul16 |

REVISIONS

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| FILE NAME: 1CM002_042-GA.dwg | | |

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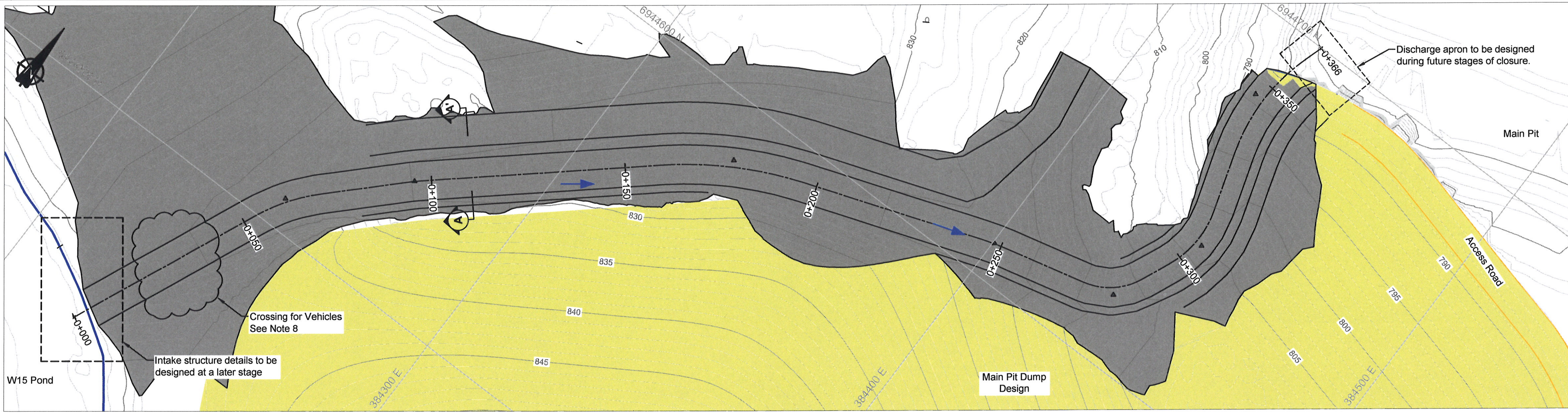
SRK JOB NO.: 1CM002.042

Closure Conveyance Design

DRAWING TITLE:

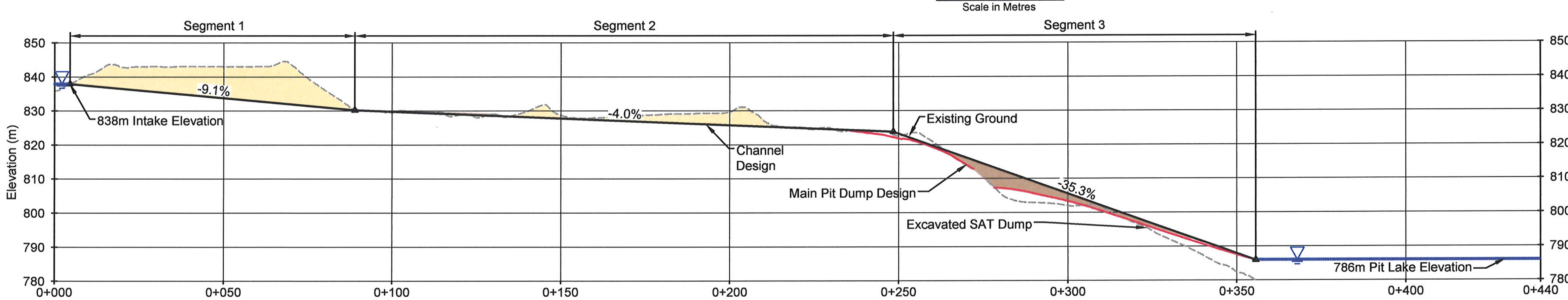
Post-Closure General Arrangement

| DRAWING NO. | SHEET | REVISION NO. |
|---|---|---|
| CC-01 | 1 OF 12 | B |



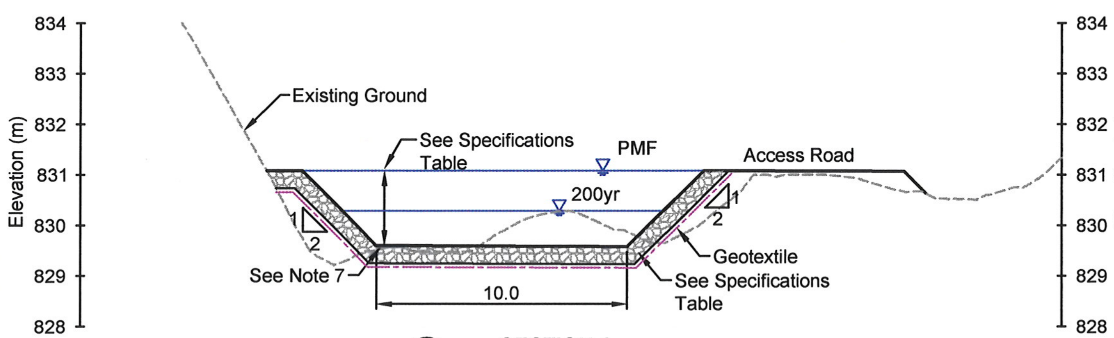

## PLAN VIEW
## A CONVEYANCE CHANNEL

0 5 10 15 20 25
Scale in Metres




## PROFILE
## A CONVEYANCE CHANNEL

0 5 10 15 20 25
Scale in Metres




A SECTION A

0 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration 2X

### LEGEND

- Conveyance Channel Design
- Channel Fill
- Channel Excavation
- Phase VI/VII Infrastructure (Existing and Planned)
- Pit Lake Elevation
- Design Toes and Crests
- Flow Direction

### NOTES

1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. Topographic surfaces shown are comprised of existing and designed surfaces.
4. Constructed channel specifications are provided in the specifications table as per each channel segment.
5. Rip Rap classification gradation tables are provided in Drawing CC-06.
6. Future mining activities may alter the topography of the channel alignment. SRK recommends that at future stages of closure design channel alignment and grades be re-assessed.
7. The base of the channel will be graded to create a thalweg in the centerline.
8. A light vehicle crossing is to be designed into the closure conveyance channel upon the completion of the channel construction. A swale crossing with 5:1 side slopes should be considered during detailed design and alignment selection.

### CHANNEL A SPECIFICATIONS:

| Segment | Length (m) | Slope (%) | Minimum Channel Depth (m) | Channel Bottom Width (m) | Water Depth for 1:200 yrs (m) | Rip-rap Class (kg) | Rip-rap Thickness (mm) | $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 83 | -9.1 | 1.5 | 10.0 | 0.55 | 25 | 600 | 300 |
| 2 | 159 | -4.0 | 1.5 | 10.0 | 0.70 | 10 | 400 | 200 |
| 3 | 107 | -35.3 | 1.0 | 10.0 | 0.37 | 100 | 900 | 450 |

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2/05/2018

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Closure Conveyance Design
DRAWING TITLE:
Channel A
DRAWING NO. CC-02 | SHEET 3 OF 12 | REVISION NO. B

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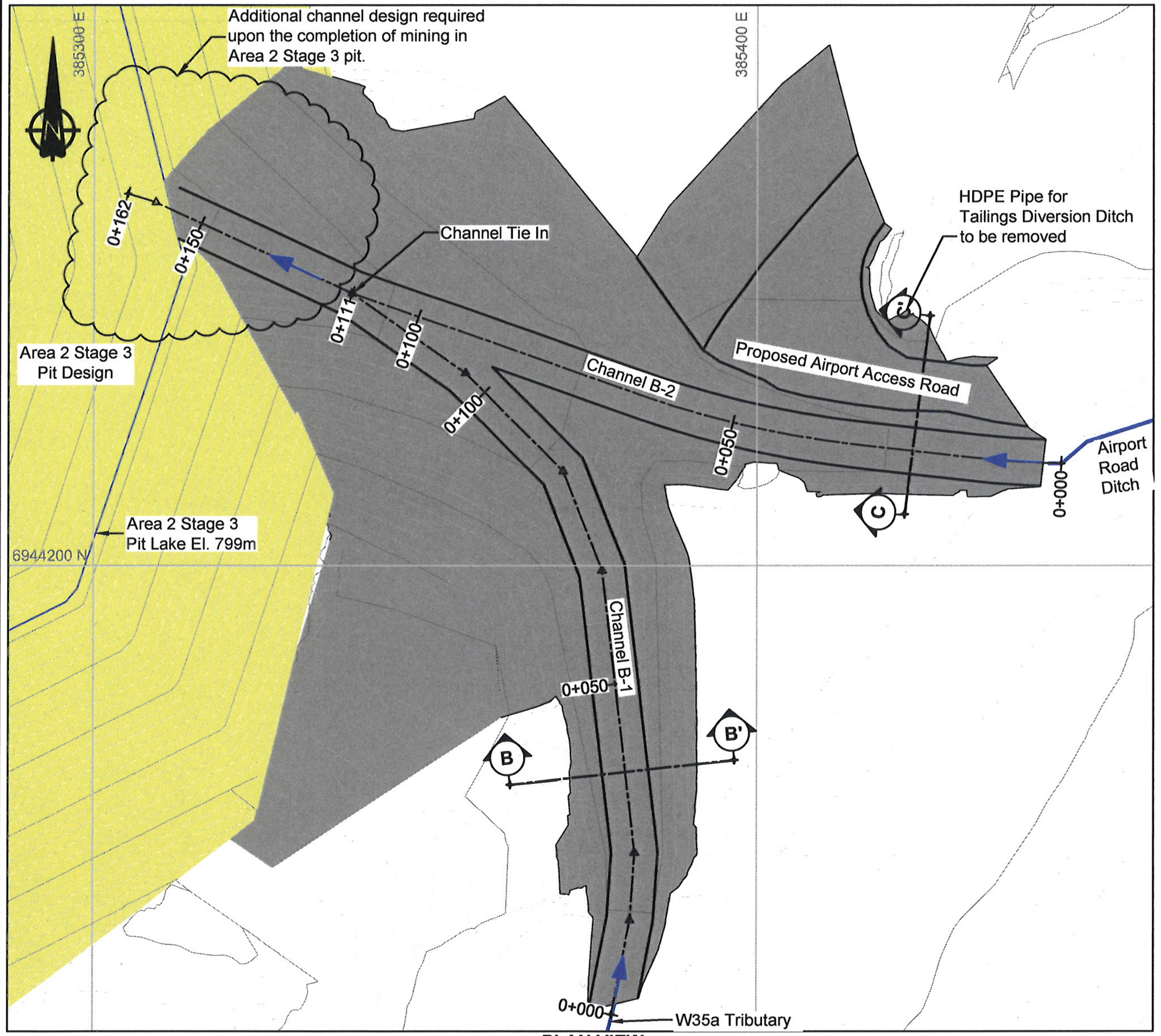



**PLAN VIEW**
**B CONVEYANCE CHANNEL**
0 5 10 15 20 25
Scale in Metres

## LEGEND

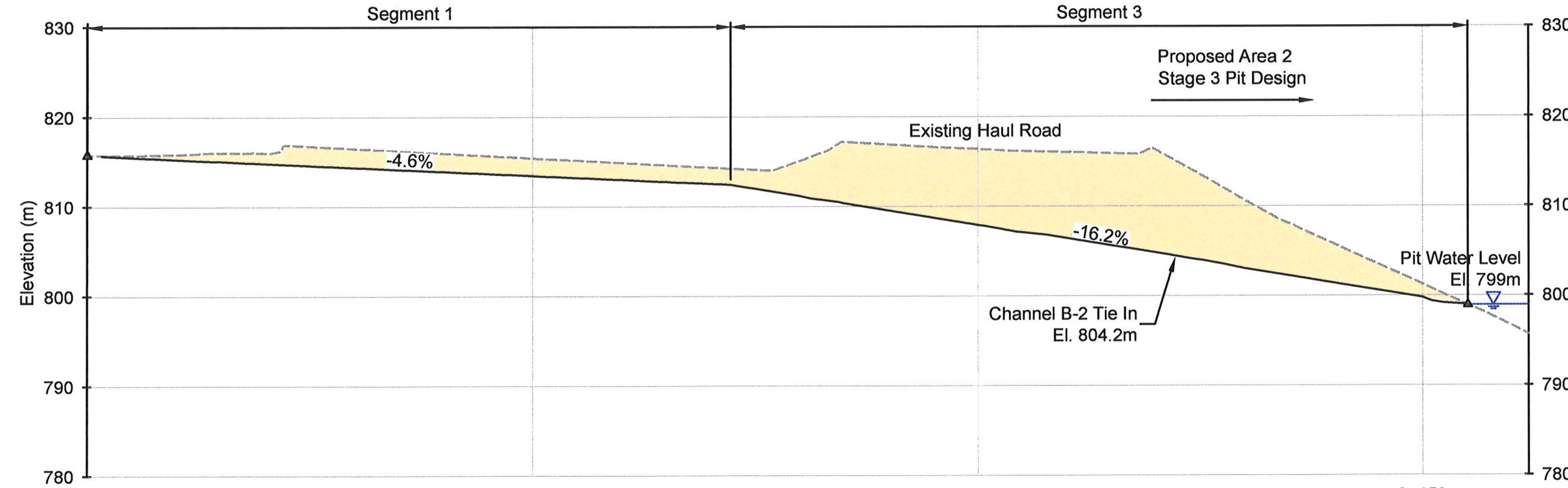
- Conveyance Channel Design
- Channel Fill
- Channel Excavation
- Phase VIVI Infrastructure (Existing and Planned)
- Pit Lake Elevation
- Access Roads, Design Toes & Crests
- Flow Direction

## NOTES

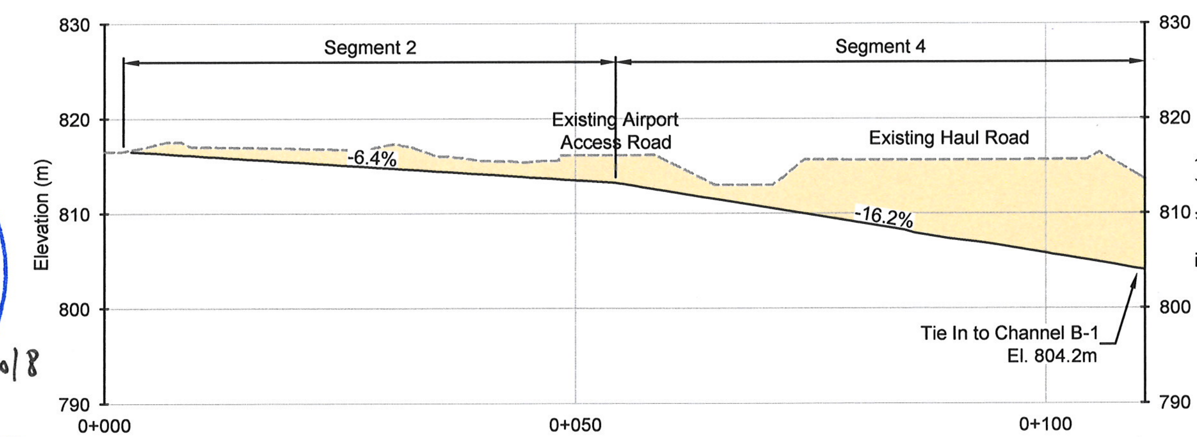
1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. Topographic surfaces are comprised of existing and designed surfaces.
4. Swale crossing design for light vehicle access to be designed later.
5. Rip Rap classification gradation tables are provided in Drawing CC-06.
6. The base of the channel will be graded to create a thalweg in the centerline.

## CHANNEL B SPECIFICATIONS:

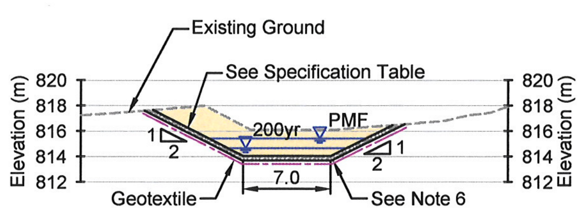
| Segment | Length (m) | Slope (%) | Minimum Channel Depth (m) | Channel Bottom Width (m) | Water Depth for 1:200 yrs (m) | Rip-rap Class (kg) | Rip-rap Thickness (mm) | $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 72 | -4.6 | 1.35 | 7.00 | 0.64 | 10 | 400 | 200 |
| 2 | 52 | -6.4 | 1.23 | 7.00 | 0.59 | 25 | 600 | 300 |
| 3 | 83 | -16.2 | 1.00 | 7.00 | 0.45 | 100 | 900 | 450 |
| 4 | 56 | -16.2 | 1.00 | 7.00 | 0.45 | 100 | 900 | 450 |



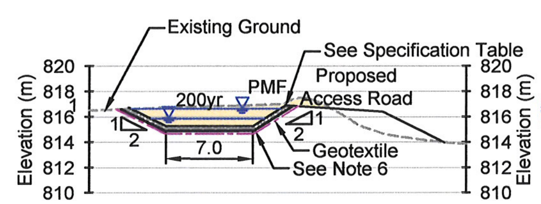

**PROFILE**
**B-1 CONVEYANCE CHANNEL**
0 4 8 12 16 20
Scale in Metres




**PROFILE**
**B-2 CONVEYANCE CHANNEL**
0 4 8 12 16 20
Scale in Metres




**SECTION B**
**TYPICAL SECTION**
0 2 4 6 8 10
Horizontal Scale in Metres




**SECTION C**
**TYPICAL SECTION**
0 2 4 6 8 10
Horizontal Scale in Metres

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YUKON TERRITORY
MUNOZ SAAVEDRA
2/05/2018

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FILE NAME: 1CM002_042-A&B.dwg
SRK JOB NO.: 1CM002.042

Closure Conveyance Design
DRAWING TITLE: Channel B
DRAWING NO. CC-03
SHEET 4 OF 12
REVISION NO. B

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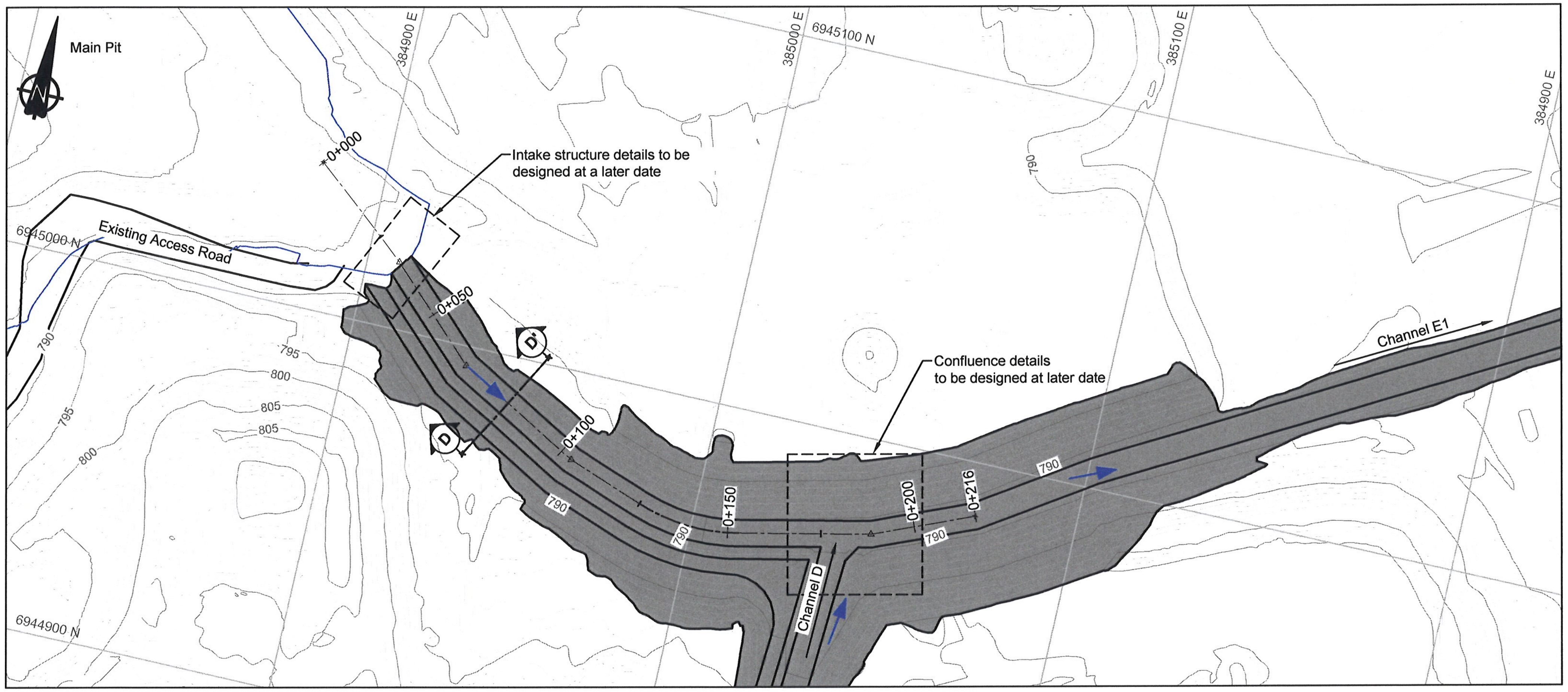



## LEGEND

- Conveyance Channel Design
- Channel Fill
- Channel Excavation
- Water Elevation
- Design Toes & Crests
- Flow Direction

## NOTES

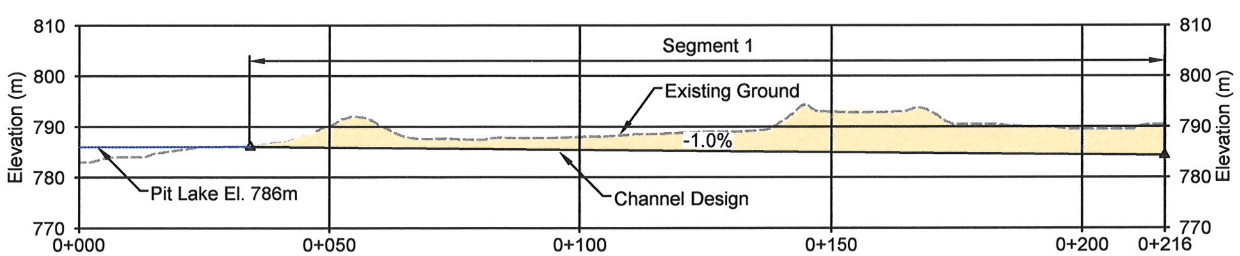
1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. The base of the channel will be graded to create a thalweg in the centerline.

**PLAN VIEW CHANNEL C**

0 5 10 15 20 25
Scale in Metres

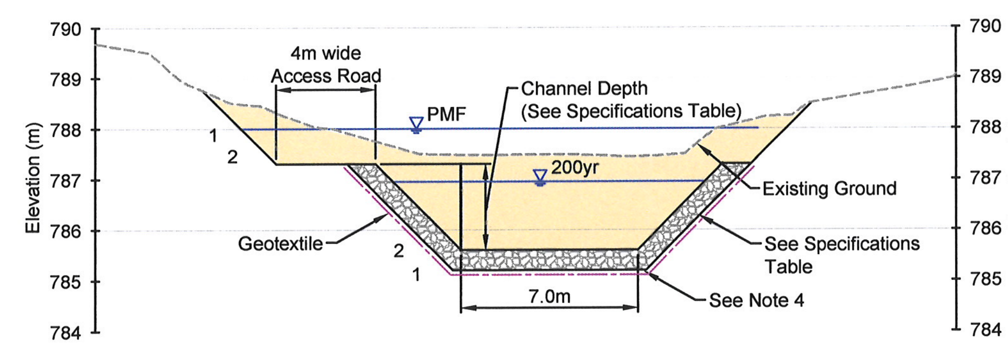
**CHANNEL C SPECIFICATIONS:**

| Segment | Length (m) | Slope (%) | Minimum Channel Depth (m) | Channel Bottom Width (m) | Water Depth for 1:200 yrs (m) | Rip-rap Class (kg) | Rip-rap Thickness (mm) | $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 182 | -1.0 | 1.70 | 7.00 | 1.35 | 10 | 400 | 200 |




**PROFILE CHANNEL C**

0 5 10 15 20 25
Scale in Metres




**SECTION D**
**TYPICAL SECTION**

0 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration 2X

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Signature
Date 2/06/2018
PERMIT NUMBER: PP019
Association of Professional Engineers of Yukon

PROFESSIONAL YUKON TERRITORY ENGINEER
VICTOR ALEJANDRO MUNOZ SAAVEDRA
2/05/2018

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Closure Conveyance Design

DRAWING TITLE:
Channel C

| DRAWING NO. | SHEET | REVISION NO. |
|---|---|---|
| CC-04 | 5 OF 12 | B |

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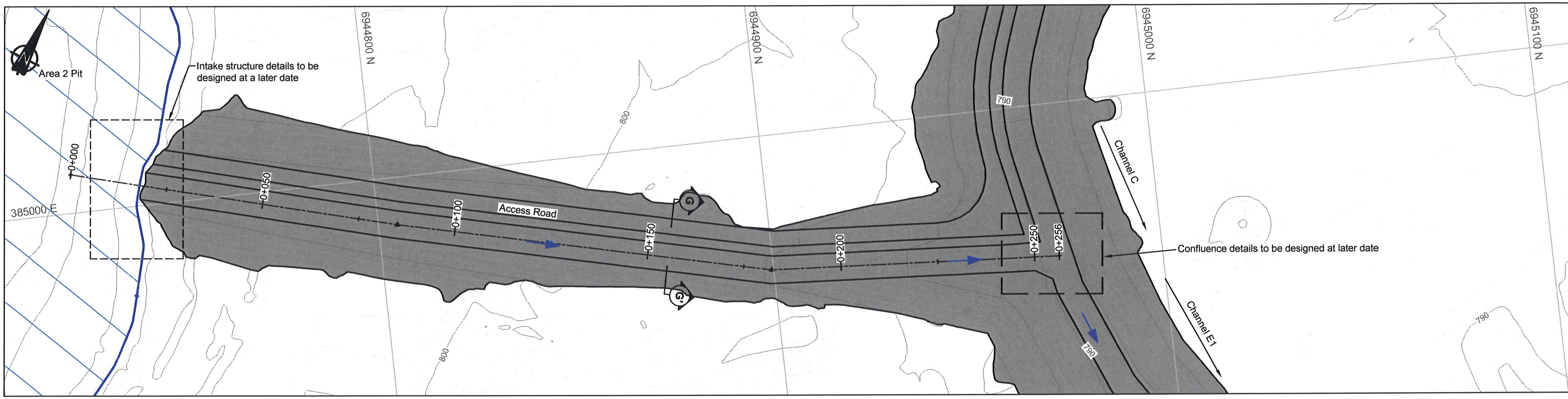
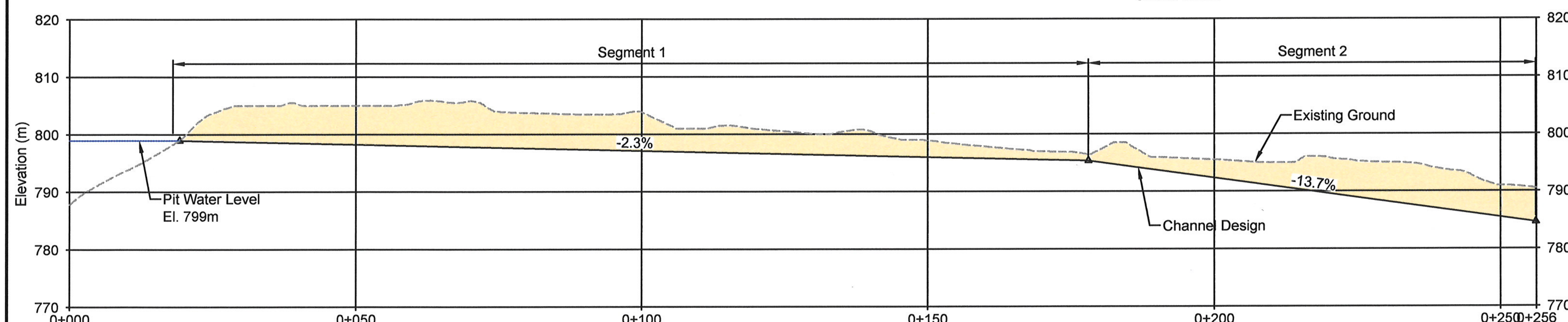



**PLAN VIEW CHANNEL D**

0 5 10 15 20 25
Scale in Metres




**PROFILE CHANNEL D**

0 5 10 15 20 25
Scale in Metres

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Date 2/06/2018
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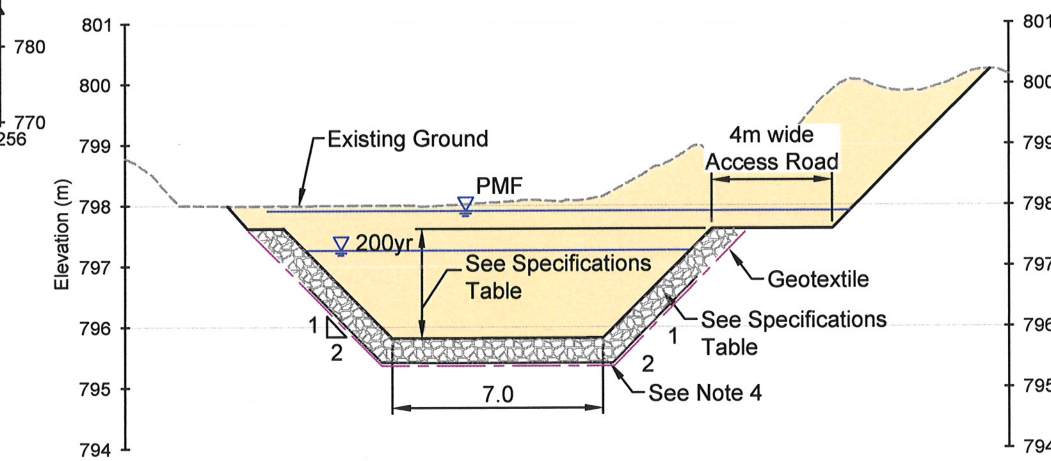
YUKON TERRITORY
VICTOR ALEJANDRO MUNOZ SAAVEDRA
2/05/2018

## LEGEND

- Conveyance Channel Design
- Channel Fill
- Channel Excavation
- Pit Lake Elevation
- Design Toes & Crests
- Flow Direction

## NOTES

1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. Access road paralleling channel to be connected with the site wide access roads for mine closure.
4. Rip Rap classification gradation tables are provided in Drawing CC-06.
5. The base of the channel will be graded to create a thalweg in the centerline.




**SECTION G**

0m 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration 2X

**CHANNEL D SPECIFICATIONS:**

| Segment | Length (m) | Slope (%) | Minimum Channel Depth (m) | Channel Bottom Width (m) | Water Depth for 1:200 yrs (m) | Rip-rap Class (kg) | Rip-rap Thickness (mm) | $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 160 | -2.3 | 2.10 | 7.00 | 1.80 | 10 | 400 | 200 |
| 2 | 78 | -13.70 | 1.40 | 7.00 | 1.10 | 100 | 900 | 450 |

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Closure Conveyance Design
DRAWING TITLE:
Channel D
DRAWING NO. CC-05 | SHEET 6 OF 12 | REVISION NO. B

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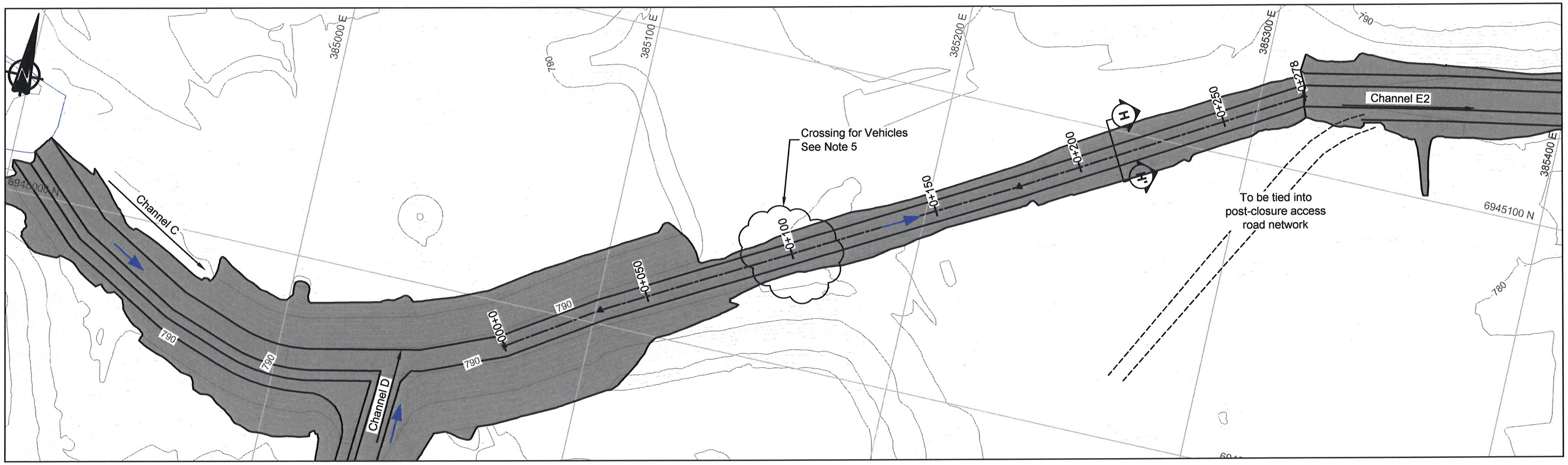



## LEGEND

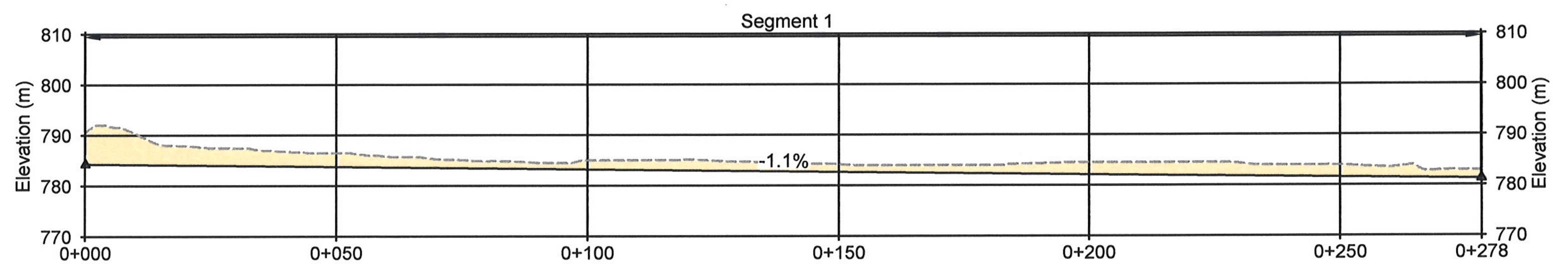
- Conveyance Channel Design
- Channel Excavation
- Design Toes & Crests
- Flow Direction

## NOTES

1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. Channel E is constructed as a typical channel. The base of the channel will be graded to create a thalweg in the centerline.
4. A light vehicle crossing is to be designed into the closure conveyance channel upon the completion of the channel construction. A swale crossing with 5:1 side slopes should be considered during design and alignment selection.
5. Surrounding area along Channel E1 graded to create a valley bottom. PMF will be conveyed downstream to Channel E2.
6. Segment 1 and Segment 3 set to a minimum freeboard of 10cm because of topographical constraint.

### PLAN VIEW CHANNEL E1

0 5 10 15 20 25
Scale in Metres




### PROFILE CHANNEL E1

0 5 10 15 20 25
Scale in Metres

**10 kg CLASS - RIP RAP**

| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 300 |
| $D_{85}$ | 280 |
| $D_{50}$ | 200 |
| $D_{15}$ | 90 |
| Layer Thickness | 400 |

**25kg CLASS - RIP RAP**

| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 450 |
| $D_{85}$ | 380 |
| $D_{50}$ | 300 |
| $D_{15}$ | 130 |
| Layer Thickness | 600 |

**100 kg CLASS - RIP RAP**

| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 680 |
| $D_{85}$ | 610 |
| $D_{50}$ | 450 |
| $D_{15}$ | 200 |
| Layer Thickness | 900 |

**250kg CLASS - RIP RAP**

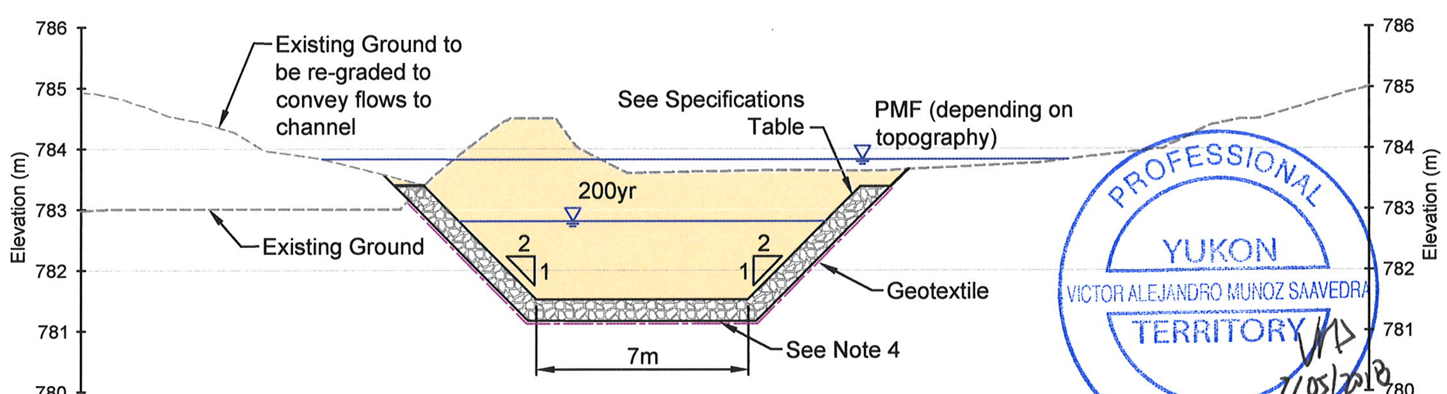
| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 900 |
| $D_{85}$ | 820 |
| $D_{50}$ | 600 |
| $D_{15}$ | 270 |
| Layer Thickness | 1200 |

**500kg CLASS - RIP RAP**

| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 1200 |
| $D_{85}$ | 1030 |
| $D_{50}$ | 800 |
| $D_{15}$ | 340 |
| Layer Thickness | 1600 |

**1000kg CLASS - RIP RAP**

| Material Type | Rip Rap Dia. (mm) |
|---|---|
| $D_{100}$ | 1500 |
| $D_{85}$ | 1300 |
| $D_{50}$ | 1000 |
| $D_{15}$ | 420 |
| Layer Thickness | 2000 |




### SECTION H TYPICAL SECTION

0m 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration 2X

**CHANNEL E SPECIFICATIONS:**

| Segment | Length (m) | Slope (%) | Minimum Channel Depth (m) | Channel Bottom Width (m) | Water Depth for 1:200 yrs (m) | Rip-rap Class (kg) | Rip-rap Thickness (mm) | $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|---|
| 1 | 278 | -1.1 | 2.0 | 7.0 | 1.82 | 10 | 400 | 450 |
| 2 | 260 | -6.2 | 2.0 | 7.0 | 1.26 | 100 | 900 | 450 |
| 3 | 98 | -1.4 | 2.0 | 7.0 | 1.89 | 100 | 900 | 450 |
| 4 | 92 | -5.8 | 2.0 | 7.0 | 1.28 | 100 | 900 | 450 |
| 5 | 92 | -6.3 | 2.0 | 7.0 | 1.26 | 100 | 900 | 450 |
| 6 | 105 | -4.1 | 2.0 | 7.0 | 1.41 | 100 | 900 | 450 |
| 7 | 33 | -7.6 | 2.0 | 7.0 | 1.19 | 250 | 1200 | 600 |
| 8 | 46 | -5.1 | 2.0 | 7.0 | 1.33 | 100 | 900 | 450 |
| 9 | 150 | -20.7 | 2.0 | 7.0 | 0.90 | 1000 | 2000 | 1000 |
| 10 | 40 | -0.05 | 3.3 | 20.0 | 1.50 | 100 | 900 | 300 |

PROFESSIONAL ENGINEER – YUKON TERRITORY – VICTOR ALEJANDRO MUNOZ SAAVEDRA – 2/05/2018

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Signature
Date 2/06/2018
PERMIT NUMBER: PP019
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FILE NAME: 1CM002_042-1.dwg | SRK JOB NO.: 1CM002.042

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Closure Conveyance Design
DRAWING TITLE: Channel E1
DRAWING NO.: CC-06 | SHEET: 7 OF 12 | REVISION NO.: B

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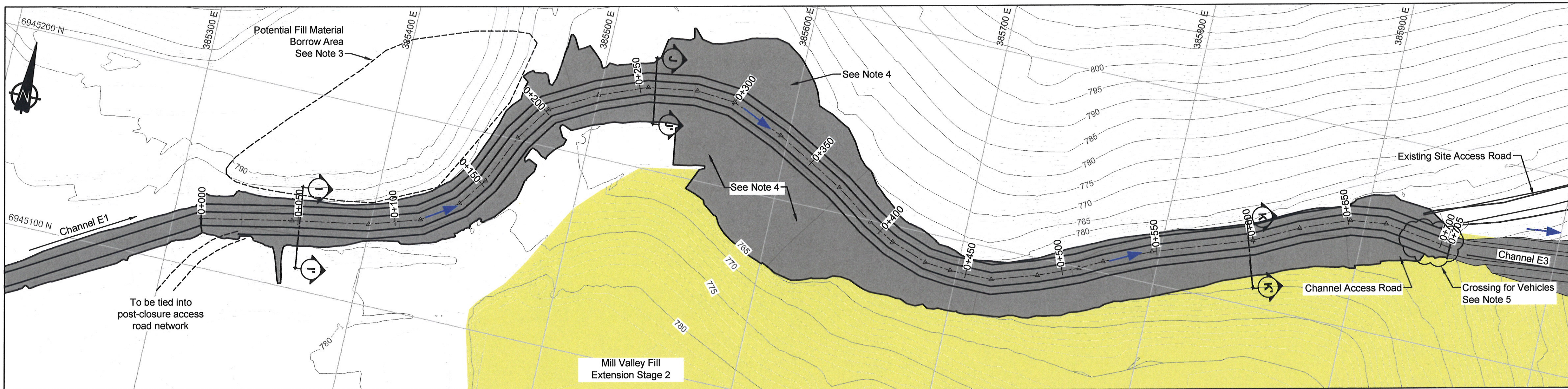



**PLAN VIEW CHANNEL E2**

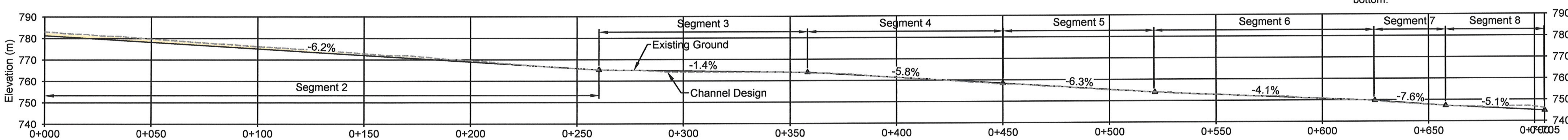
0 10 20 30 40 50
Scale in Metres

## LEGEND

- Conveyance Channel Design
- Phase VIVI Infrastructure (Existing and Planned)
- Channel Excavation
- Design Toes & Crests
- Flow Direction

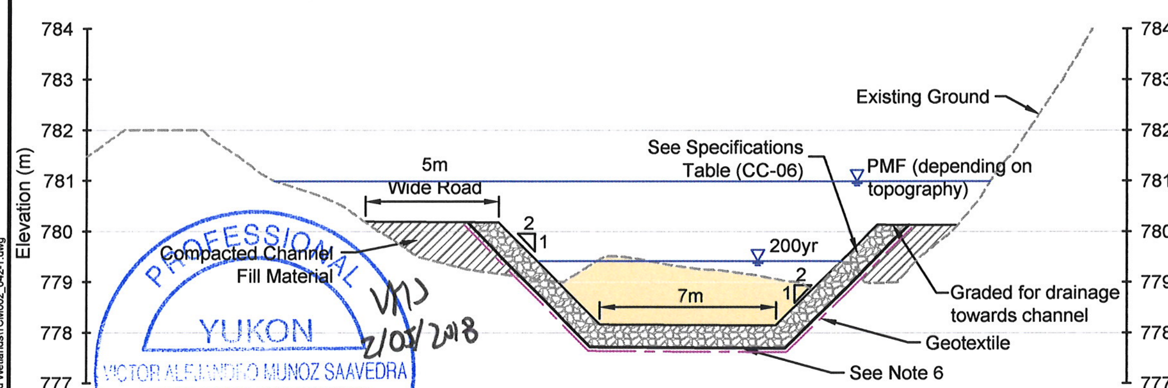
## NOTES

1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. Extents and depth of the potential fill material borrow area has not be defined for this stage of design. Area identified as a potential source due to overburden / fill thickness.
4. Backfill and regrade required to convey surface water to conveyance channel
5. A light vehicle crossing is to be designed into the closure conveyance channel upon the completion of channel construction. A swale crossing with 5:1 side slopes should be considered during design and alignment selection.
6. The base of the channel will be graded to create a thalweg in the centerline
7. Surrounding area along Channel E2 to be graded to create a valley bottom.



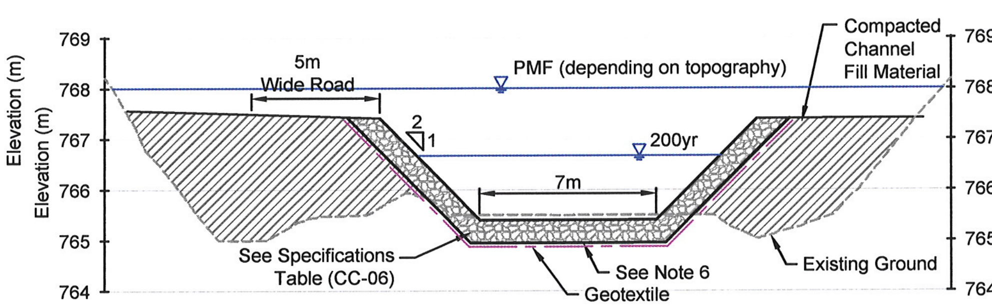

**PROFILE CHANNEL E2**

0 10 20 30 40 50
Scale in Metres



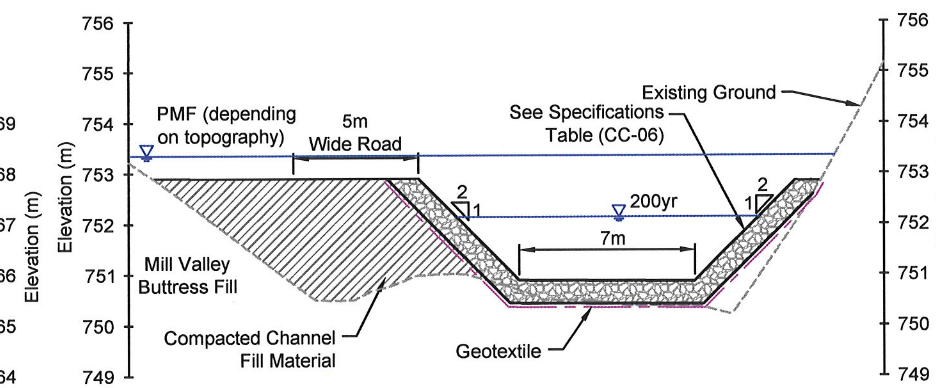

**SECTION I**

0 2 4 6 8 10
Horizontal Scale in Metres
Vertical Exaggeration 2X




**SECTION J**

0 2 4 6 8 10
Horizontal Scale in Metres
Vertical Exaggeration 2X




**SECTION K**

0 2 4 6 8 10
Horizontal Scale in Metres
Vertical Exaggeration 2X

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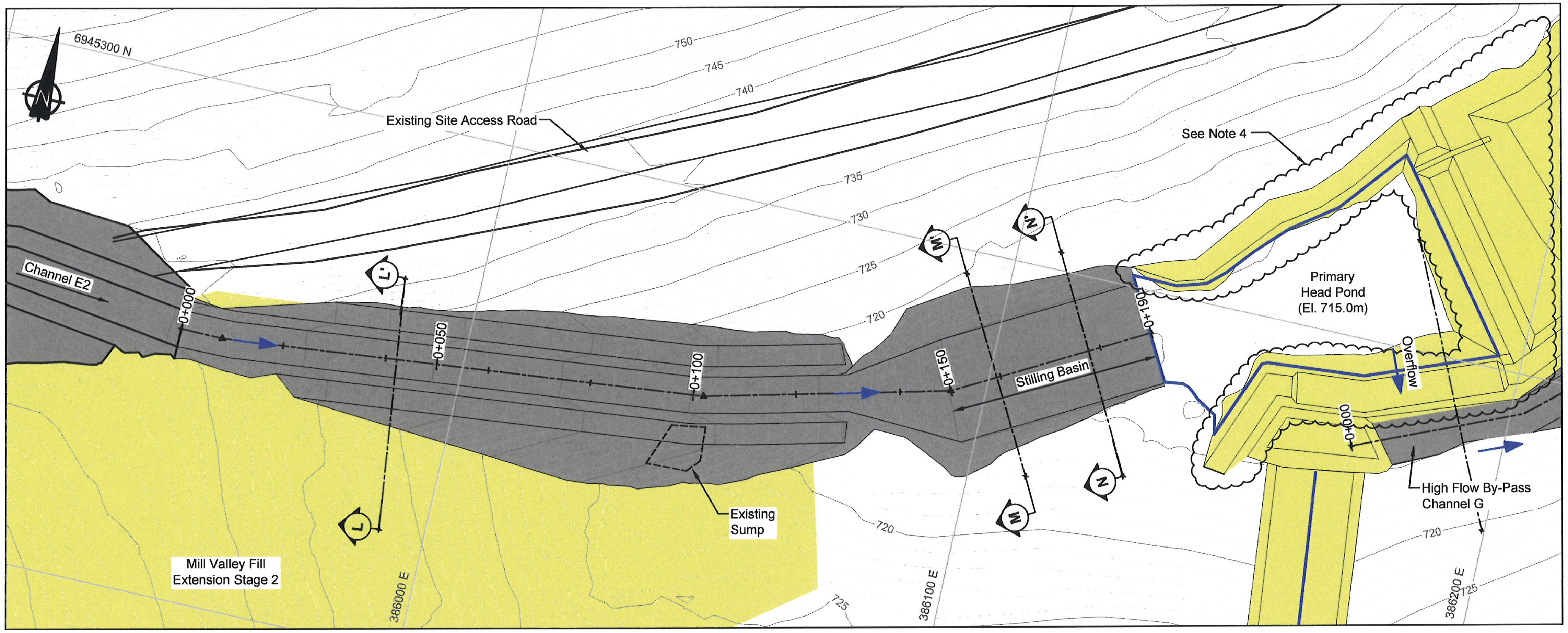
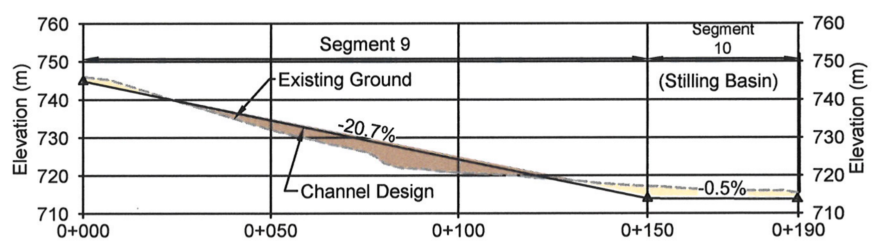
Channel E2

DRAWING NO.: CC-07 | SHEET 8 OF 12 | REVISION NO. B



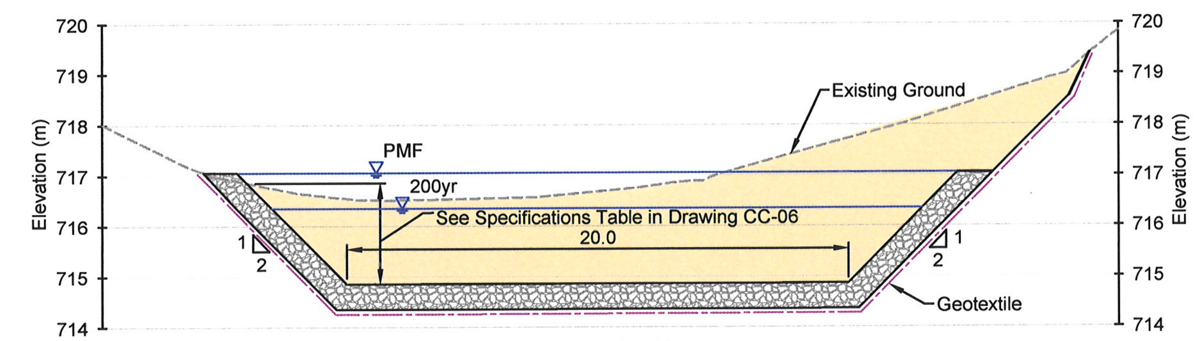

PLAN VIEW CHANNEL E3

0 5 10 15 20 25 Scale in Metres



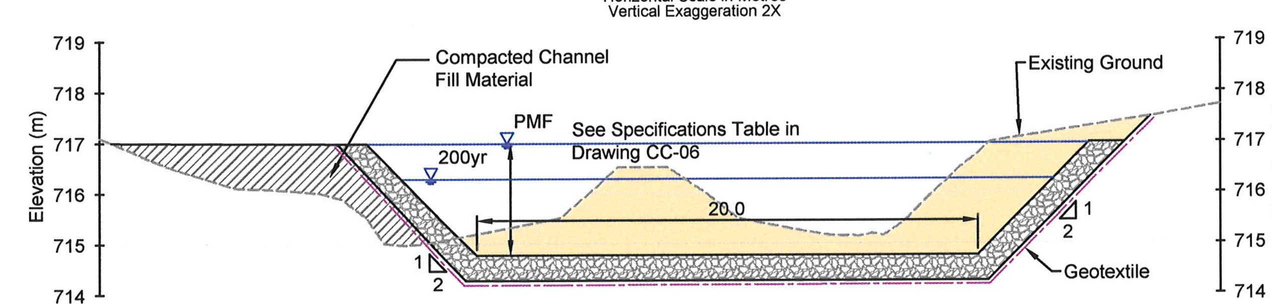

PROFILE CHANNEL E3

0 10 20 30 40 50 Scale in Metres



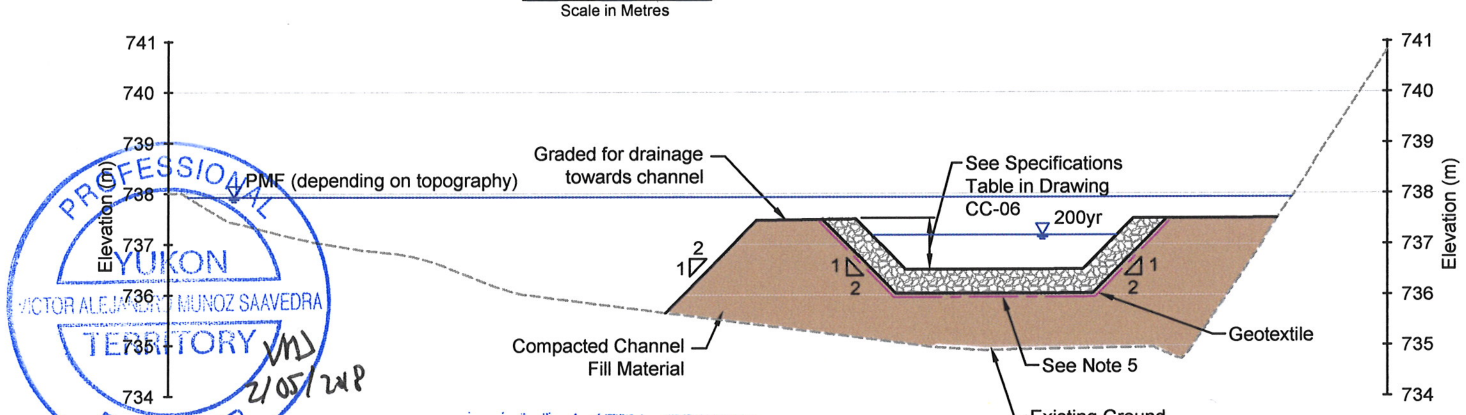

SECTION M

0 1 2 3 4 5 Horizontal Scale in Metres Vertical Exaggeration 2X




SECTION N

0 1 2 3 4 5 Horizontal Scale in Metres Vertical Exaggeration 2X




SECTION L

0 1 2 3 4 5 Horizontal Scale in Metres Vertical Exaggeration 2X

## LEGEND

- Conveyance Channel Design
- Channel Foundation Fill
- Channel Excavation
- Phase VIVI Infrastructure (Existing and Planned)
- Design Toes & Crests
- Flow Direction

## NOTES

1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. Stilling basin design rip rap specifications are located in the specifications tables in Drawing CC-06.
4. Wetland Infrastructure Design prepared by SRK. Refer to Wetland Infrastructure Design Report (SRK 2016).
5. The base of the channel will be graded to create a thalweg in the centerline
6. Surrounding area along Channel E3 graded to create a valley bottom. PMF will be conveyed downstream to the stilling basin.

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DRAWING TITLE: Channel E3 and Stilling Basin

DRAWING NO.: CC-08 | SHEET: 9 OF 12 | REVISION NO.: B

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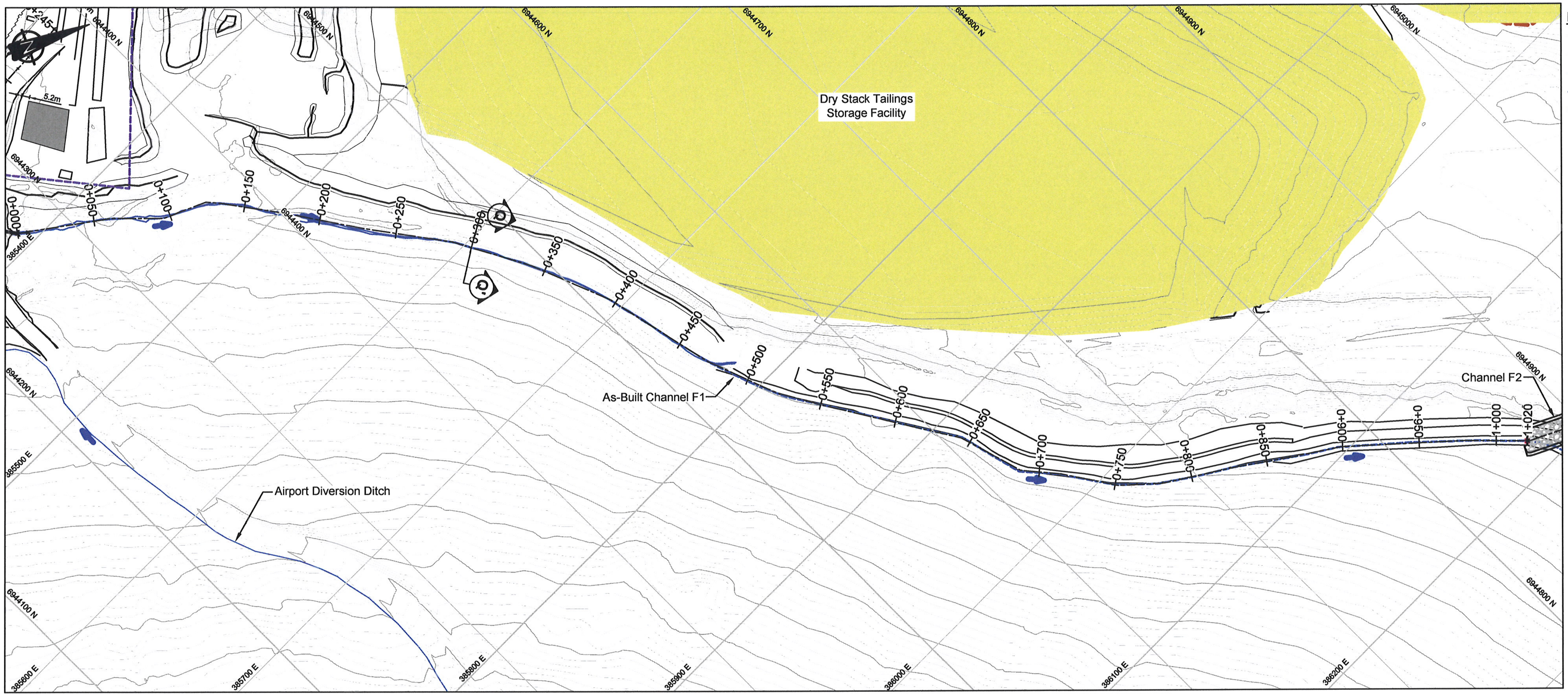



**LEGEND**

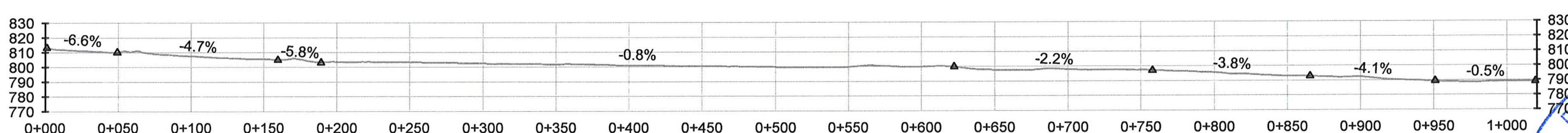
- Existing Major Contour
- Existing Minor Contour
- Diversion Channel (existing)
- Diversion Channel (design by others)
- Excavation Limits
- Water Flow Direction
- Phase VIVI Infrastructure (Existing and Planned)

**NOTES**

1. Existing topographic contours provided by Minto dated August 2017.
2. Contour interval is 1m.

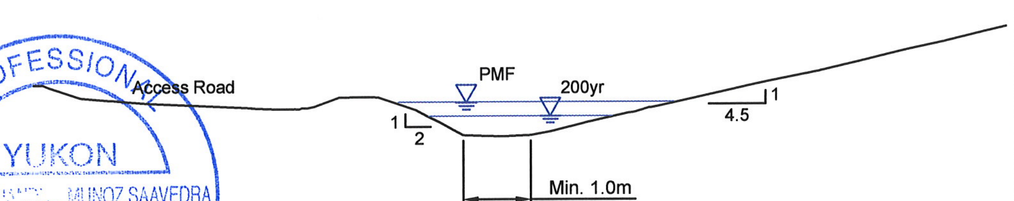
**PLAN VIEW CHANNEL F1**

0m 10 20 30 40 50 60




**AS-BUILT PROFILE CHANNEL F1**

0m 20 40 60 80




**SECTION Q**

0m 20 40 60 80

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| D | Issued for Discussion | - | - | 28Jul14 |
| C | Issued for Discussion | - | - | 1Nov13 |
| B | Issued for Discussion | - | - | 7Aug13 |
| A | Issued for Review | - | - | 6Jun13 |

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Channel F1
Existing Tailings Diversion Ditch

DRAWING NO. CC-09
SHEET 10 of 12
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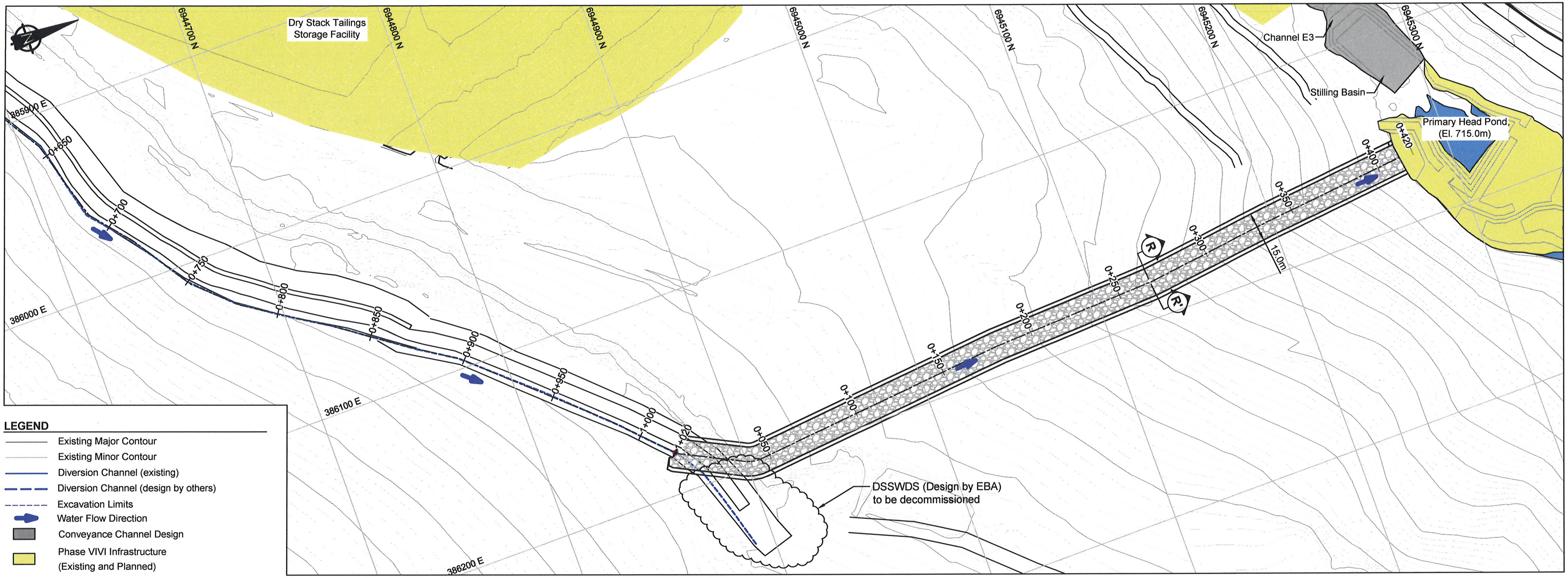
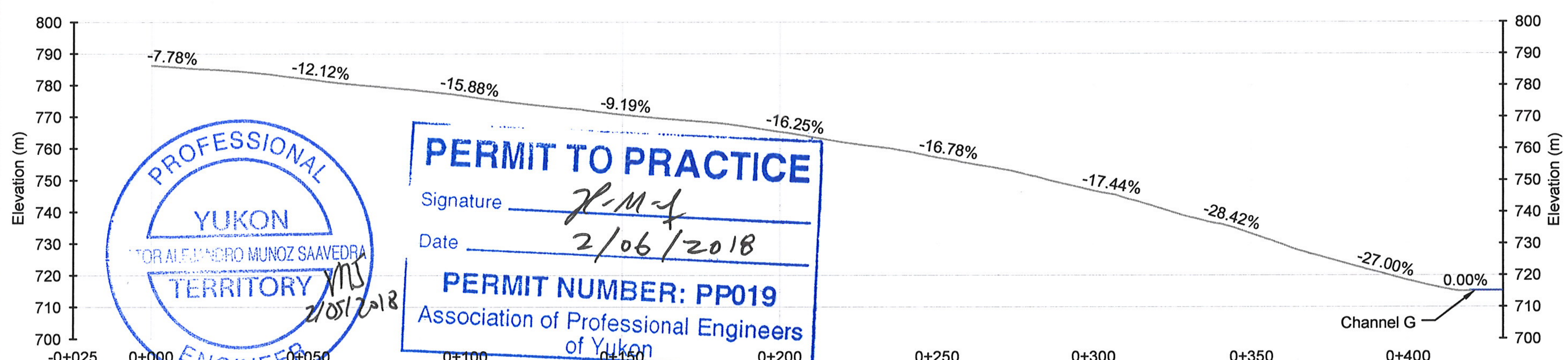



**PLAN VIEW CHANNEL F2**

0 10 20 30 40 50
Scale in Metres

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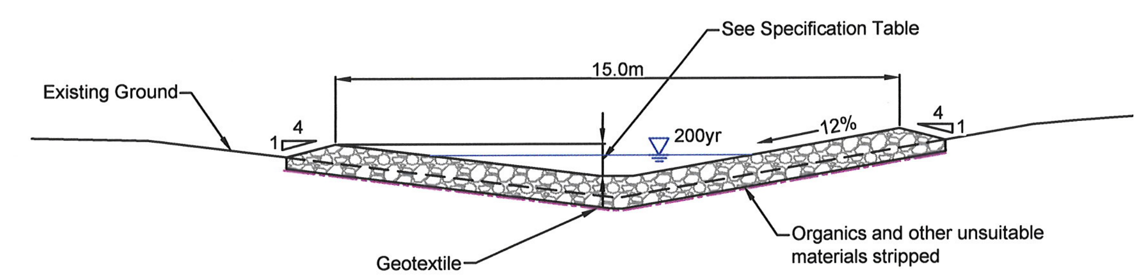
**PROFILE CHANNEL F2**

0 10 20 30 40 50
Scale in Metres




R **SECTION R**

0 10 20 30 40 50
Scale in Metres

**CHANNEL F SPECIFICATIONS:**

| Length (m) | Minimum Channel Depth (m) | Rip-rap Class (kg) | Rip-rap Thickness (mm) | $D_{50}$ (mm) |
|---|---|---|---|---|
| 420 | 0.8 | 500 | 1600 | 800 |

**NOTES**

1. Existing topographic contours provided by Minto dated January 2014.
2. Contour interval is 1m.
3. Rip-rap sized for steepest grade (28.42%).

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DRAWING TITLE: Channel F2
DRAWING NO.: CC-10 | SHEET: 11 of 12 | REVISION NO.: F

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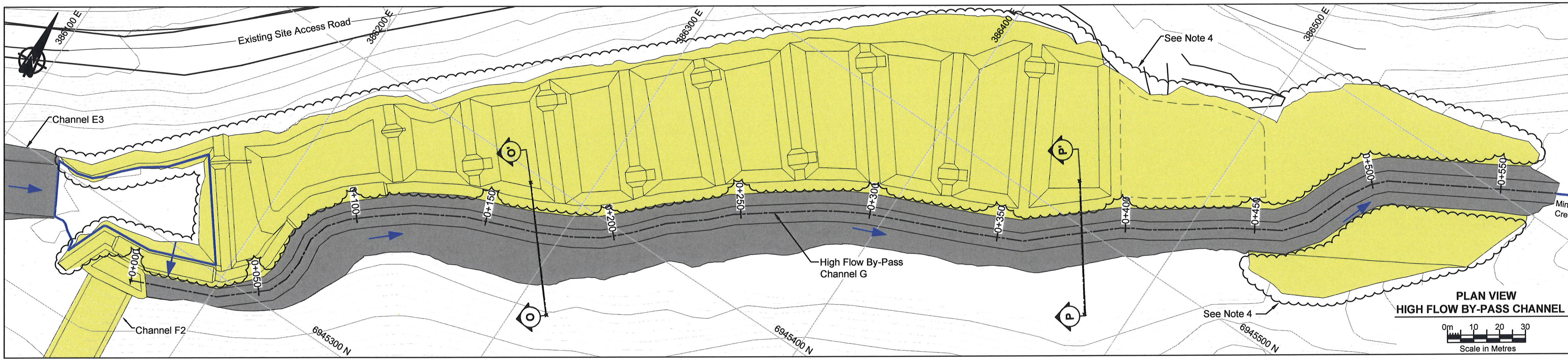
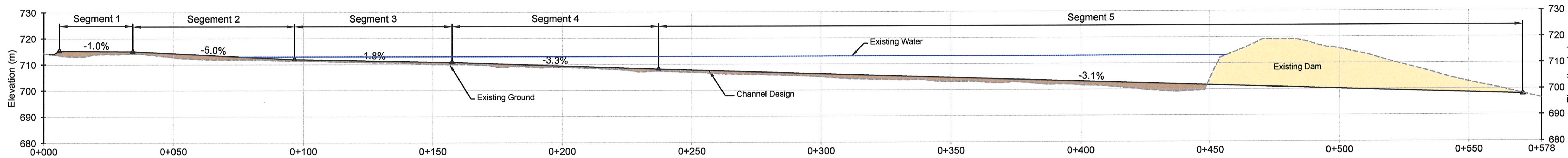



PLAN VIEW
HIGH FLOW BY-PASS CHANNEL G
0m 10 20 30
Scale in Metres



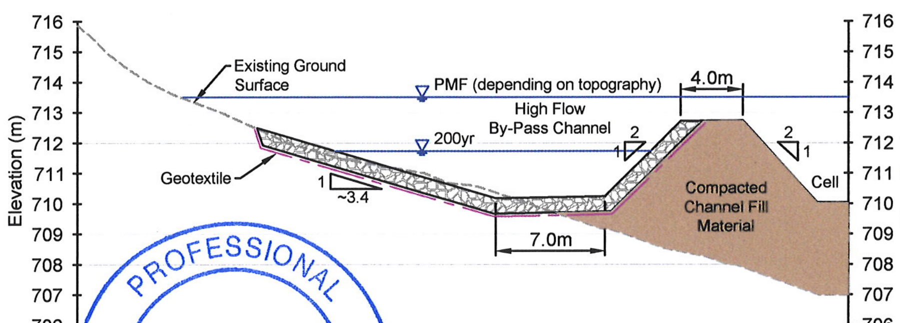

CENTRELINE PROFILE
HIGH FLOW BY-PASS CHANNEL G
0m 10 20 30
Scale in Metres

## LEGEND

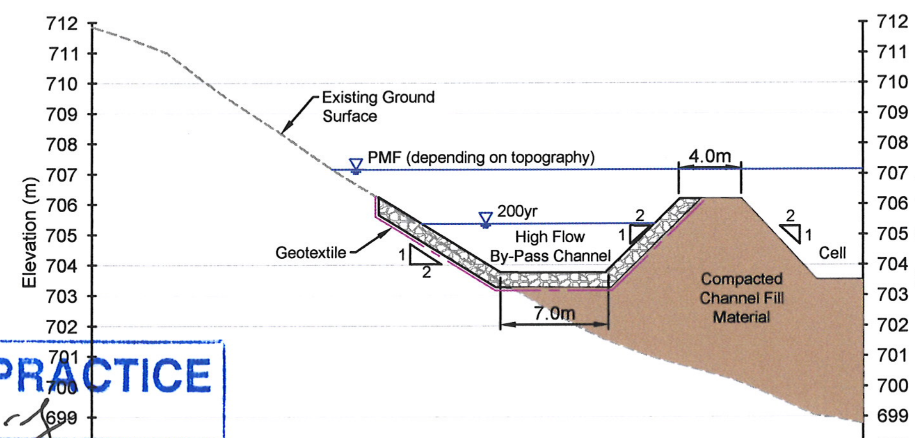
- Conveyance Channel Design
- Channel Foundation Fill
- Channel Excavation
- Designed Infrastructure (Not Constructed)
- Design Toes & Crests

## NOTES

1. Contour interval 1m.
2. Digital topographic surfaces have been provided by Minto Explorations Ltd.
3. Wetland Infrastructure Design prepared by SRK. Refer to Wetland Infrastructure Design Report (SRK 2016).
4. 200 year channel depth along channel varies depending on topography.




SECTION O
0 2 4 6 8 10
Scale in Metres




SECTION P
0 2 4 6 8 10
Scale in Metres
Horizontal Scale in Metres
Vertical Exaggeration 2X

CHANNEL HIGH FLOW BY-PASS CHANNEL SPECIFICATIONS:

| Segment | Length (m) | Slope (%) | Minimum Channel Depth (m) | Channel Bottom Width (m) | Rip-rap Class (kg) | Rip-rap Thickness (mm) | $D_{50}$ (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 28 | -1.0 | 2.5 | 7.0 | 25 | 600 | 300 |
| 2 | 62 | -5.0 | 2.0 | 7.0 | 25 | 600 | 300 |
| 3 | 61 | -1.8 | 2.0 | 7.0 | 25 | 600 | 300 |
| 4 | 84 | -3.3 | 2.0 | 7.0 | 25 | 600 | 300 |
| 5 | 334 | -3.1 | 2.0 | 7.0 | 25 | 600 | 300 |

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High Flow By-Pass Channel G
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# Appendix B – Site-Specific Hydrology Review

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**F: +1.604.687.5532**

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www.srk.com

# Memo

| | | | |
|---|---|---|---|
| **To:** | Ryan Herbert, Minto Explorations Ltd. | **Client:** | Minto Explorations Ltd. |
| **From:** | Samantha Barnes<br>Victor Muñoz S.<br>Francis Smith | **Project No:** | 1CM002.042 |
| **Cc:** | Dylan MacGregor, SRK | **Date:** | August 3, 2016 |
| **Subject:** | Site-Specific Hydrology Review, Minto Mine, Yukon | | |

# 1 Introduction

SRK Consulting (Canada) Inc. has prepared an updated closure water conveyance plan design report for Minto Mine (Minto) located in Yukon, Canada, and operated by Minto Explorations Ltd. In support of the updates to the conveyance designs, SRK reviewed and updated site-wide hydrology models to include potential influences resulting from future climate change and alterations to watershed catchment areas. Inputs to the modelling are listed as follows:

- Rainfall depths for short duration storms for return periods ranging from the 1:2 through the 1:200 year precipitation event
- Maximum snowmelt depth expected over a 24-hour period
- Probable maximum precipitation (PMP) over a 24-hour period
- Hydrological curve number calibrated for regional catchment
- Hydrologic modelling approach to estimate peak flows for each structure

This memorandum outlines the formulation of inputs required for the closure conveyance designs.

# 2 Supporting Information from Public Databases

Regional historic precipitation data was obtained from the Meteorological Service of Canada (MSC) division of Environment Canada (EC 2015a). Regional stations were included in the studies for short duration rainfall, mean annual precipitation (MAP) and probable maximum precipitation (PMP).

Regional daily hydrometric data was obtained from the Water Survey of Canada (WSC) within an approximate 300 km radius surrounding the site for the unit peak flow analysis (EC 2015b).

Precipitation intensity–duration-frequency (IDF) estimation was derived utilizing short-duration rainfall IDF statistics obtained from the Government of Canada's Engineering Climate Dataset (Government of Canada 2016).

# 3 Precipitation

## 3.1 Mean Annual Precipitation

Regional regression analyses were performed using the 20 nearest MSC meteorological stations. RStudio® software (version 3.2.3; i386 - w64) was used to calculate mean annual precipitation for each station. Table 3-1 presents the station locations, distance relative to the site and their respective MAP estimates.

**Table 3-1: Regional Meteorological Stations and MAP**

| Station Name | Longitude | Latitude | MAP [mm] | Elevation | Distance |
|---|---|---|---|---|---|
| PELLY RANCH | −137.4 | 62.8 | 309 | 454 | 23 |
| CARMACKS | −136.3 | 62.1 | 282 | 525 | 75 |
| STEWART CROSSING | −136.7 | 63.4 | 332 | 480 | 89 |
| MCQUESTEN | −137.5 | 63.6 | 349 | 458 | 109 |
| MAYO A | −135.9 | 63.6 | 304 | 504 | 131 |
| STEWART RIVER | −139.4 | 63.3 | 294 | 358 | 136 |
| DRURY CREEK | −134.4 | 62.2 | 373 | 609 | 154 |
| SNAG A | −140.4 | 62.4 | 366 | 587 | 165 |
| ELSA | −135.5 | 63.9 | 430 | 814 | 170 |
| KENO HILL | −135.2 | 63.9 | 585 | 1473 | 178 |
| DAWSON A | −139.1 | 64.0 | 323 | 370 | 184 |
| BEAVER CREEK A | −140.9 | 62.4 | 413 | 649 | 188 |
| BEAVER CREEK YTG | −140.9 | 62.4 | 414 | 663 | 189 |
| ANVIL | −133.4 | 62.4 | 389 | 1158 | 200 |
| FARO A | −133.4 | 62.2 | 318 | 716 | 205 |
| KLONDIKE | −138.2 | 64.5 | 468 | 973 | 210 |
| CLINTON CREEK | −140.7 | 64.5 | 344 | 576 | 269 |
| OGILVIE RIVER | −138.3 | 65.4 | 340 | 597 | 310 |

Figure 3-1 includes a location map of the stations used in the MAP analysis. It also presents the subsequent regression analysis for MAP against elevation and the monthly precipitation distributions.

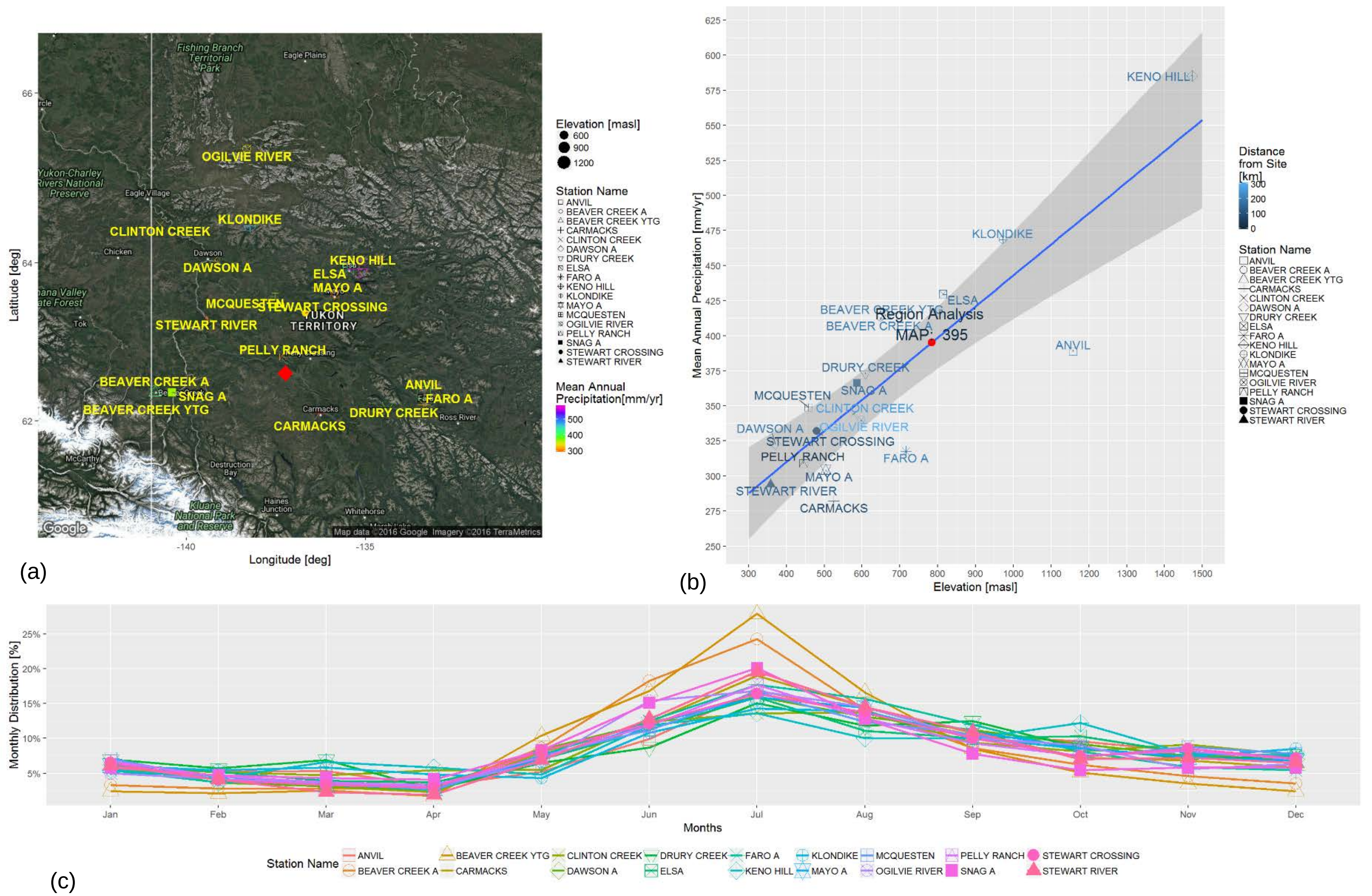


**Figure 3-1: MAP Analysis Station Locations (a), Regional Regression Analysis (b), and Monthly Precipitation Distributions (c)**

Based on the MAP versus elevation regression analysis and an average site elevation of 784 meters above sea level (masl), the MAP for Minto is estimated to be 395 mm.

## 3.2 Precipitation-Duration-Frequency Analysis

Short-duration storm analyses provide an estimation of the amount of precipitation expected for a storm return period ranging from 2 to 200 years with durations ranging from 5 minutes to 24 hours. A regional analysis was performed in order to understand the relationships between return period, duration, and rainfall for stations within close proximity to the site.

Using the results of the regional analysis, the precipitation-duration-frequency (PDF) data for the site was established using the following equation:

Equation 1: $$Pp_{Duration\ hrs.}^{Frequency\ years} = Pp_{24hrs.}^{10yrs} \cdot FF_{(Frequency)} \cdot DF_{(Duration)}$$

Where,

$Pp$ is the precipitation as a function of storm frequency and duration;

$Pp_{24hrs.}^{10yrs}$ is the precipitation in 24 hours with a return period of 10 years;

$FF$ are frequency factors, which correspond to the rate between precipitation associated with a defined frequency and the return period of 10 years; and

$DF$ are duration factors, which correspond to the rate between the defined storm duration and a storm duration of 24 hours.

Duration and frequency factors for a 1:10 year, 24-hour precipitation event were established from the regional analysis. The following sections discuss how the design precipitation event was developed using the frequency factors.

### 3.2.1 One-in-Ten Year 24-hour Precipitation Event

This analysis was performed using the RStudio software, and was conducted using data obtained from the Environment Canada meteorological stations (Environment Canada 2015a) located throughout the Yukon (Figure 3-1). Frequency analyses were performed for each station to estimate the 1:10 year, 24-hour–duration precipitation depth. These values were then correlated with elevation, latitude, and longitude. The strongest correlation was with longitude, which was used to establish the 1:10 year precipitation for the site (Figure 3-2).

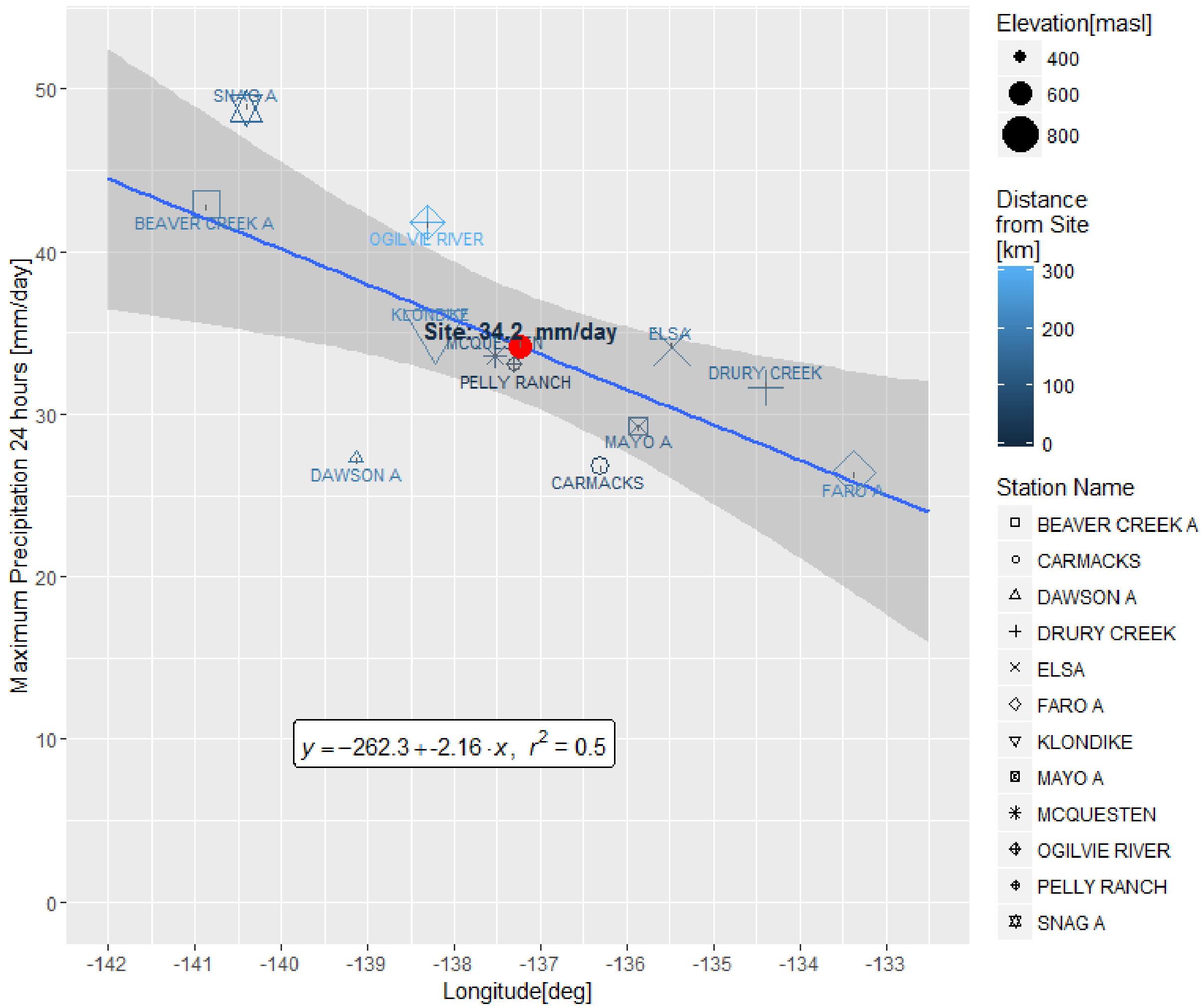


**Figure 3-2: Regional Analysis for the 1:10 Year 24-hour Duration Rainfall Event**

Based on the site longitude of −137.2 degrees, the 1:10 year 24-hour rainfall event is 34.2 mm.

### 3.2.2 Regional Intensity-Duration-Frequency Relationships

Five meteorological stations with IDF statistics all within 185 km of the site were located and are summarized in Table 3-2.

**Table 3-2: Summary of Meteorological Stations Used for Short Duration Storm Event Analysis**

| Station Name | Latitude | Longitude | Elevation | Years of Data |
|---|---|---|---|---|
| Mayo A | −135.9 | 63.6 | 503.8 | 22 |
| Pelly Ranch | −137.4 | 62.8 | 454.2 | 32 |
| Dawson A | −139.1 | 64.0 | 370.3 | 26 |
| Carmacks | −136.3 | 62.1 | 524.9 | 15 |
| Burwash A | −139.1 | 61.4 | 806.2 | 13 |

The frequency analyses were prepared considering the following probabilistic distributions: Normal, Log Normal, GEV, Gumbel, Pearson III, and Log Pearson III. The selection of the distribution parameters was prepared with the L-moments methodology.

The L-moments approach provides a more robust estimation to outliers when compared with typical estimations. The selection of the best-fit distribution was prepared based on four criteria: Akaike Information Criterion, Corrected Akaike Information Criterion, Anderson-Darling Criterion, and Bayesian Information Criterion, as described by (Laio, Di Baldassarre, and Montanari 2009). These best-fit distributions were implemented using RStudio.

The results from the frequency analyses were compiled into an IDF table for each station. Duration and frequency factors for each regional station were calculated using an iterative optimization process, such that the product of the two factors and the 1:10 year, 24-hour precipitation depth would equal the rainfall depth for a given duration and frequency, based on Equation 1. The results were then compared regionally to determine the appropriate factors to be applied to the site.

### Regional Trends in Duration Factors

The duration factors for each station were plotted against return period (Figure 3-3). The Burwash A station was found to behave differently from the other four stations, as shown in Figure 3-3. The Pearson distribution was used to determine whether the duration factors for each duration were related to the elevation, latitude, or longitude of the meteorological station. Regional analysis suggests this is likely due to the stations high elevation and geographic position within a valley immediately on the leeward side of the Saint Elias Mountains, with a greater orographic influence than the other stations and the project area, which are located further east within the lower elevation interior of Yukon. Consequently, the longitude of the site, −137.2 degrees, was used to establish the duration factors for each return period at site. Table 3-3 and Figure 3-3 present the duration factors established for each regional station and for the site.

**Table 3-3: Regional Analysis of Duration Factors**

| Station ID | Long. | Lat. | Elev. masl | Dist, km | Storm Duration | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 6 min | 10 min | 30 min | 1 hr | 2 hr | 3 hr | 6 hr | 12 hr | 24 hr |
| Mayo A | -135.87 | 63.62 | 503.80 | 131.10 | 0.20 | 0.26 | 0.29 | 0.34 | 0.37 | 0.45 | 0.61 | 0.78 | 1.00 |
| Pelly Ranch | -137.37 | 62.82 | 454.20 | 23.45 | 0.23 | 0.32 | 0.40 | 0.48 | 0.58 | 0.66 | 0.75 | 0.85 | 1.00 |
| Dawson A | -139.13 | 64.04 | 370.30 | 184.33 | 0.30 | 0.38 | 0.42 | 0.51 | 0.57 | 0.65 | 0.72 | 0.87 | 1.00 |
| Carmacks | -136.30 | 62.10 | 524.90 | 75.35 | 0.24 | 0.34 | 0.40 | 0.47 | 0.52 | 0.60 | 0.72 | 0.89 | 1.00 |
| Burwash A | -139.05 | 61.37 | 806.20 | 168.10 | 0.09 | 0.13 | 0.16 | 0.21 | 0.28 | 0.34 | 0.65 | 0.77 | 1.00 |
| Site Estimated | -137.22 | 62.62 | 784.45 | n/a | 0.24 | 0.32 | 0.38 | 0.45 | 0.52 | 0.59 | 0.70 | 0.85 | 1.00 |

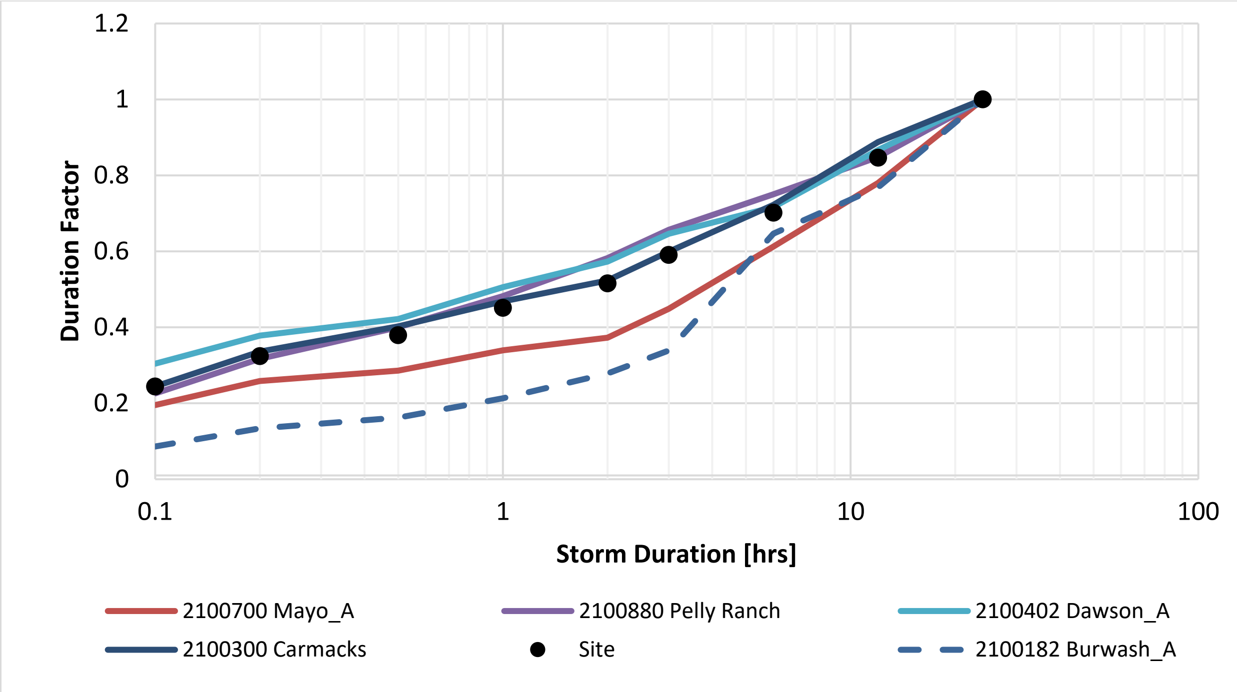


**Figure 3-3: Regional and Site-Specific Duration Factors**

### Regional Trends in Frequency Factors

Similarly to the duration factors, the Pearson distribution was used to determine whether the frequency factors for each return period were related to the elevation, latitude, or longitude of the meteorological station. The best relationship was found to be with elevation; however, the difference in frequency factors across the region was minimal, and the site elevation was within the range of the stations analyzed. Therefore, the average from the regional frequency factors was applied to the site. Table 3-4 and Figure 3-4 present the duration factors established for each regional station and for the site.

**Table 3-4: Regional Analysis of Frequency Factors**

| Station ID | Long. [degrees] | Lat. [degrees] | Elevation [masl] | Distance [km] | Return Period [years] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 2 | 5 | 10 | 25 | 50 | 100 |
| Mayo A | −135.87 | 63.62 | 503.80 | 131.10 | 0.70 | 0.88 | 1.00 | 1.15 | 1.26 | 1.37 |
| Pelly Ranch | −137.37 | 62.82 | 454.20 | 23.45 | 0.58 | 0.83 | 1.00 | 1.19 | 1.34 | 1.49 |
| Dawson A | −139.13 | 64.04 | 370.30 | 184.33 | 0.65 | 0.85 | 1.00 | 1.15 | 1.28 | 1.40 |
| Carmacks | −136.30 | 62.10 | 524.90 | 75.35 | 0.64 | 0.85 | 1.00 | 1.17 | 1.30 | 1.43 |
| Burwash A | −139.05 | 61.37 | 806.20 | 168.10 | 0.71 | 0.89 | 1.00 | 1.15 | 1.26 | 1.36 |
| Site (Estimated) | −137.22 | 62.62 | 784.45 | n/a | 0.66 | 0.86 | 1.00 | 1.16 | 1.29 | 1.41 |

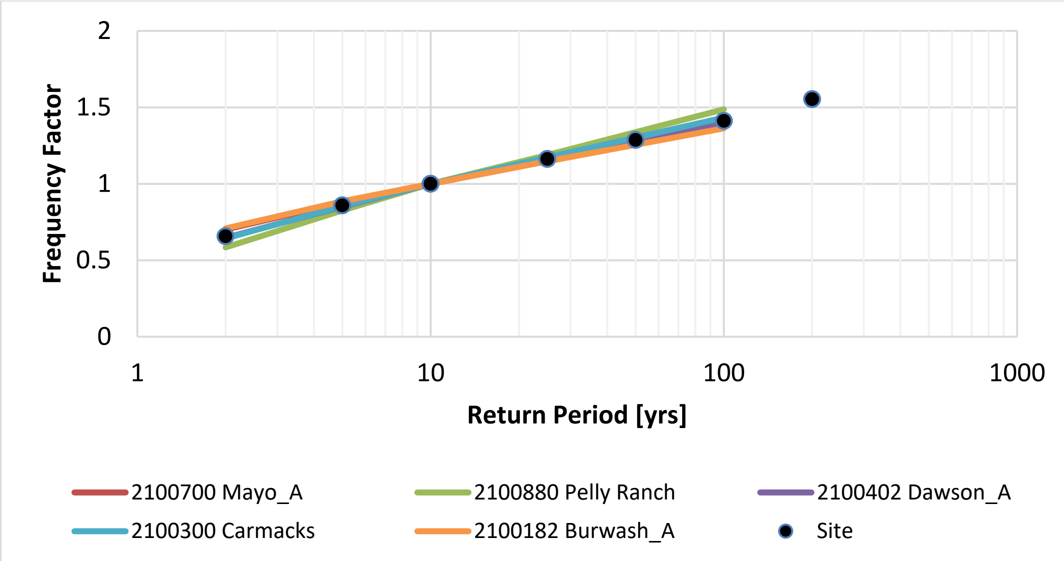


**Figure 3-4: Regional and Site-Specific Frequency Factors**

### 3.2.3 Site-Specific Intensity-Duration-Frequency Table

The results of site-specific frequency and duration factors and the 1:10 year, 24-hour duration rainfall of 34.2 mm were converted to an IDF table using Equation 1. In addition, the 1:200 year rainfall depth was extrapolated for each duration using a linear extrapolation of the duration factors and frequency factors. Results are presented in Table 3-5.

**Table 3-5: Site-Specific IDF Table**

| Storm Duration | | Return Period [years] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Minutes** | **Hours** | **2** | **5** | **10** | **25** | **50** | **100** | **200** |
| 5 | 0.08 | 5.5 | 7.2 | 8.3 | 9.7 | 10.7 | 11.8 | 13.0 |
| 10 | 0.17 | 7.3 | 9.5 | 11.1 | 12.9 | 14.3 | 15.6 | 17.2 |
| 15 | 0.25 | 8.5 | 11.2 | 13.0 | 15.1 | 16.7 | 18.3 | 20.2 |
| 30 | 0.5 | 10.1 | 13.3 | 15.4 | 17.9 | 19.9 | 21.8 | 24.0 |
| 60 | 1 | 11.6 | 15.2 | 17.6 | 20.5 | 22.7 | 24.9 | 27.4 |
| 120 | 2 | 13.3 | 17.4 | 20.2 | 23.5 | 26.0 | 28.5 | 31.4 |
| 360 | 6 | 15.8 | 20.6 | 24.0 | 27.9 | 30.9 | 33.9 | 37.3 |
| 720 | 12 | 19.0 | 24.9 | 29.0 | 33.6 | 37.3 | 40.9 | 45.0 |
| 1440 | 24 | 23.5 | 30.0 | 34.2 | 39.3 | 42.9 | 46.6 | 47.6 |

### 3.2.4 Climate Change and IDF Results

The values for the respective return periods and durations were increased by 44% to reflect the forecasted increase resulting from the effects of future climate change (SRK 2016). Adjusted IDF values are presented in Table 3-6.

**Table 3-6: Site-Specific IDF Table Adjusted for Total Precipitation Increase by 2100**

| Storm Duration | | Return Periods [years] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Minutes** | **Hours** | **2** | **5** | **10** | **25** | **50** | **100** | **200** |
| 5 | 0.08 | 7.9 | 10.3 | 12.0 | 14.0 | 15.5 | 17.0 | 18.7 |
| 10 | 0.17 | 10.5 | 13.7 | 16.0 | 18.5 | 20.5 | 22.5 | 24.8 |
| 15 | 0.25 | 12.3 | 16.1 | 18.7 | 21.7 | 24.0 | 26.4 | 29.0 |
| 30 | 0.5 | 14.6 | 19.1 | 22.2 | 25.8 | 28.6 | 31.4 | 34.5 |
| 60 | 1 | 16.7 | 21.8 | 25.4 | 29.5 | 32.7 | 35.8 | 39.5 |
| 120 | 2 | 19.1 | 25.0 | 29.1 | 33.8 | 37.4 | 41.1 | 45.2 |
| 360 | 6 | 22.7 | 29.7 | 34.6 | 40.2 | 44.5 | 48.8 | 53.7 |
| 720 | 12 | 27.4 | 35.8 | 41.7 | 48.5 | 53.7 | 58.9 | 64.8 |
| 1440 | 24 | 33.8 | 43.2 | 49.2 | 56.6 | 61.8 | 67.1 | 68.5 |

## 3.3 Snowmelt

Snowmelt estimation was performed in RStudio software using a daily snowmelt-energy model. This model incorporates daily meteorological parameters including daily maximum and minimum temperatures, wind speed, and total precipitation. Daily values for each parameter were obtained using the ERA-Interim reanalysis tool with daily information from 1979 to 2015 (ECMWF 2015).

Using the energy-based model (Walter 2005), the snow-water equivalent, potential snowmelt, and snowpack depth were calculated at each time step. The maximum daily snowmelt for each month of the simulated record from ERA-Interim was calculated, and the 50$^{th}$ percentile of maximum daily snowmelt was determined to be 23 mm/day (SRK 2016). This value can be applied as a baseflow on top of the design storm to estimate true peak flows for each catchment.

## 3.4 Probable Maximum Precipitation

The PMP for a 24-hour duration event was evaluated using the Hershfield method (World Meteorological Organization (WMO), 2009), for the same 20 regional meteorological stations used in the analysis for MAP. The Hershfield methodology requires the daily maximum 24 hour precipitation for at least 10 years of record. The analysis was performed in RStudio software, generating a PMP estimate for each of the 20 regional stations. A regression analysis was performed against longitude, which was found to have a better correlation than latitude or elevation. The results are presented in Figure 3-5, which presents a 24-hour PMP for the site of 159 mm.

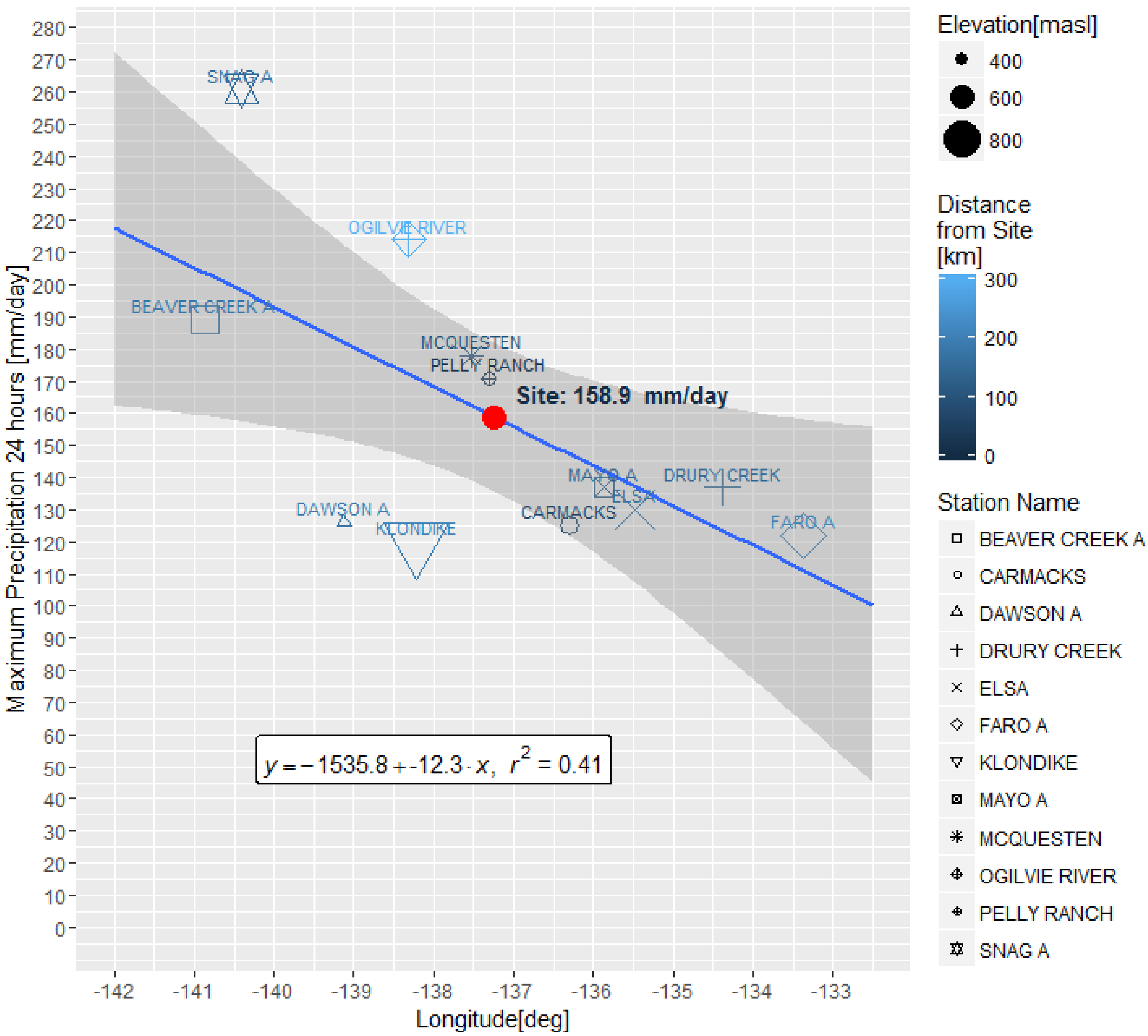


**Figure 3-5: Regional Analysis for PMP**

# 4 Peak Flows

A rainfall-runoff approach can be used to model peak flows at the site. Rainfall is applied to 24-hour distribution curve and is then converted to runoff based on catchment characteristics, including curve number, lag time, and total area, using the Soil Conservation Service (SCS) Method.

The following section summarizes the methodology to evaluate peak flows for the mine site.

## 4.1 Frequency-based Hypothetical Storm

The depth and temporal distribution of the storm hyetograph are defined using synthetic 24-hour rainfall distributions developed by National Resource Conservation Service (NRCS) (Chow et al. 1988), with a Type 1 rainfall distribution. This was selected due to the Pacific maritime climate with wet winters and dry summers observed in the Yukon, which closely mirrors the climate within Alaska for which a Type 1 distribution is typical (Chow et al. 1988). This distribution approximates an intense, short-duration storm event.

## 4.2 Initial loss

The SCS curve number model is used to estimate precipitation excess as a function of cumulative precipitation, soil cover, land use and antecedent moisture using the following equation:

$$P_e = \frac{(P - I_a)}{P - I_a + S}$$

Where,

$P_e$ = accumulated precipitation excess at time *t*,

$P$ = accumulated rainfall depth at time *t*,

$I_a$ = the initial abstraction (initial loss), and

$S$= potential maximum retention, a measure of the ability of a watershed to abstract and retain storm precipitation.

An empirical relationship between $I_a$ and $S$ was developed by the SCS as:

$$I_a = 0.2S$$

The maximum retention, $S$, and watershed characteristics related through an intermediate parameter, the curve number was developed as:

$$S = \frac{25400 - 254\,CN}{CN}$$

Incremental excess for a time interval is computed as the difference between the accumulated excess at the end of and beginning of the period.

## 4.3 Hydrological Transformations

The SCS Unit Hydrograph method is used to transform precipitation excess into an outflow hydrograph for each sub-area. A HEC-HMS (2013) model can be used to evaluate peak flows. HEC-HMS uses a single input parameter, the lag time ($T_{lag}$), defined as the time between the centroid of precipitation mass to the peak for the resulting hydrograph. The lag time for each catchment was calculated using the NRCS transformation from time of concentration. The NRCS transformation is $T_{lag}$ = 0.6*Tc. Time of concentration and resulting lag times are relatively short (<15 minutes), resulting in a flashy response with peak discharge timing almost coincident with the timing of the precipitation peak. The time of concentration was estimated with the methods cited in (Li *et al*. 2008) where a minimum time of concentration of 10 minutes was applied.

## 4.4 Curve Number

The SCS curve number is utilized for the calculation of precipitation excess and the transformation of runoff within the watershed (NRCS 1986). The curve number for a watershed can be estimated as a function of land use, soil type, and antecedent watershed moisture, using tables published by the SCS and refined using calibration methods.

Once the closure period begins, the active mining areas will be decommissioned, and the land use is assumed to return to natural conditions. Based on this assumption, the curve number for the site can be validated using a regional catchment with known peak flows, a rainfall depth, and catchment characteristics including lag time and area.

A suitable regional catchment was selected using a regional analysis, comparing unit peak flows for eight nearby WSC hydrometric stations (EC 2015b). The stations are summarized in Table 4-1 (EC 2015b) and were compiled in RStudio software.

**Table 4-1: Summary of Water Survey of Canada Stations used in Regional Analysis of Peak Flows**

| Station Name | Lat. [degrees] | Long [degrees] | Area [km$^2$] | Distance from Site [km] | Years with Info. |
|---|---|---|---|---|---|
| DRURY CREEK AT KM 469 ROBERT CAMPBELL HIGHWAY | 62.2 | -134.4 | 552 | 154 | 15 |
| LITTLE SOUTH KLONDIKE RIVER BELOW ROSS CREEK | 64.0 | -137.6 | 860 | 154 | 13 |
| GILTANA CREEK NEAR THE MOUTH | 61.2 | -137.0 | 190 | 159 | 27 |
| SOUTH BIG SALMON RIVER BELOW LIVINGSTONE CREEK | 61.4 | -134.4 | 515 | 203 | 14 |
| IBEX RIVER NEAR WHITEHORSE | 60.7 | -135.5 | 648 | 230 | 23 |
| SIDNEY CREEK AT KILOMETRE 46 SOUTH CANOL ROAD | 60.8 | -133.1 | 372 | 301 | 12 |
| WHEATON RIVER NEAR CARCROSS | 60.1 | -134.9 | 864 | 304 | 48 |
| SOUTH MACMILLAN RIVER AT KILOMETRE 407 CANOL ROAD | 62.9 | -130.5 | 997 | 343 | 22 |
| PINE CREEK NEAR ATLIN | 59.6 | -133.7 | 697 | 391 | 11 |

Peak and unit peak flows were calculated for return periods between the 1:2 year and 1:200 year events, where the unit peak flow is equal to the peak flow divided by the catchment area. Relationships were developed for unit peak flows of each return period and longitude, elevation and latitude. The best correlation was found to be with latitude, and the results of the regression analyses are presented in Figure 4-3.

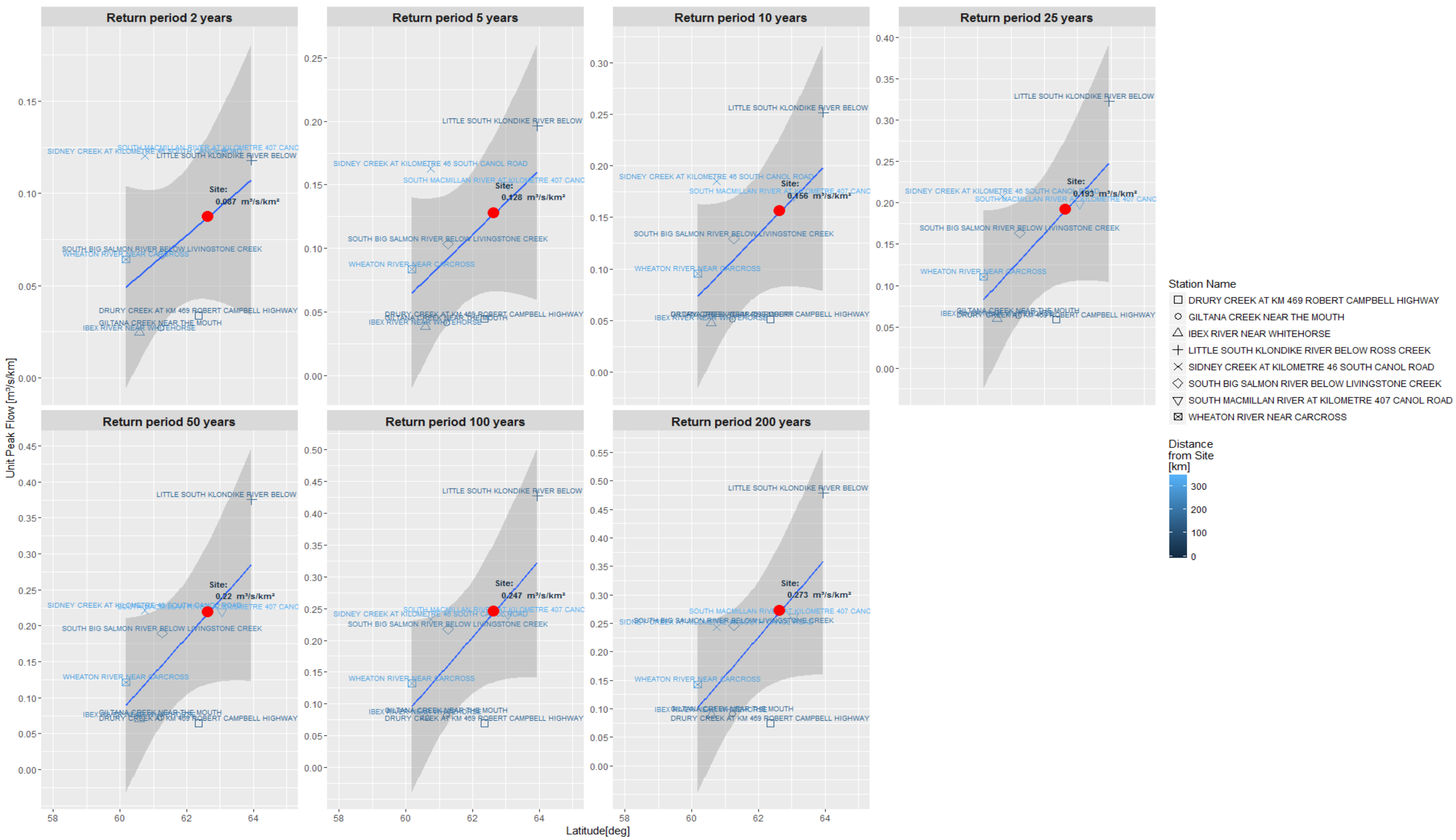


**Figure 4-1: Regional Unit Peak Flows**

For return periods greater than the 1:5 year event, the Little South Klondike River below Ross Creek presents the highest unit peak. For this reason, the Little South Klondike River below Ross Creek hydrometric station was selected for curve number calibration purposes to generate a conservatively high estimate.

The lag time for Little South Klondike River below Ross Creek was calculated to be 137 minutes, using the methodology described in Section 4.3 and was modelled in HEC-HMS (2013) along with the catchment area. Rainfall depths from the IDF results in Table 3-5 prior to climate change impacts were modelled for the 1:200 year event and the 1:10 year event, which form the design criteria for the closure conveyance structures. The curve number value was adjusted until the modelled peak flows matched the historically estimated peak flows. The results of the calibration are presented in Table 4-2, and include varying the curve number value from 70 to 84.

**Table 4-2: Curve Number Calibration Results**

| Return Period [years] | Historic Rainfall Depth [mm] | Historic Peak Flow [$m^3/s$] | Curve Number | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 70 | 75 | 80 | 82 | 83 | 84 |
| 200 | 47.6 | 411.7 | 91.4 | 172.1 | 311.3 | 385.2 | 425.6 | 468.6 |
| 10 | 34.2 | 216.3 | 27.8 | 53 | 111.4 | 151 | 175.1 | 201.6 |

The 1:200 year return period was best matched using a curve number value of 83. The peak flow for the 1:10 year event using this curve number value is underestimated. However this return period is only used for the sizing of pilot channels within larger floodplain channels, ensuring that any overtopping of the pilot channel as a result of slightly underestimated flows will be captured. The curve number value of 83 was applied to all site catchments for closure conditions.

# 5 Summary

For the purpose of the post-closure water conveyance analysis, a hydrologic study was completed. The study used regional meteorological stations to generate expected precipitation estimates for the site that can be used for the design of the required conveyance infrastructure.

The following is a summary of the hydrology analysis for conveyance channels:

- Mean annual precipitation of 395 mm;
- The intensity-duration-frequency results are adjusted for potential impacts due to climate change, for a range of storm durations and frequencies (Table 3-6)
  - 1:200 year 24-hour rainfall depth of 68.5 mm,
  - 1:10 year 24-hour rainfall depth of 49.2 mm;
- Maximum expected 24-hour snowmelt depth of 23 mm including the impacts of climate change;

- 24-hour probable maximum precipitation (PMP) of 159 mm;
- Calibrated regional curve number for natural catchments is a value of 83.

SRK Consulting (Canada) Inc.

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# Appendix C – Climate Change Analysis

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# Memo

| | | | |
|---|---|---|---|
| **To:** | Ryan Herbert, Minto Explorations Ltd. | **Client:** | Minto Explorations Ltd. |
| **From:** | Victor Munoz Saavedra<br>Tia Shapka-Fels | **Project No:** | 1CM002.042 |
| **Cc:** | Dylan McGregor, SRK | **Date:** | August 3, 2016 |
| **Subject:** | Climate Change Analysis, Minto Mine, Yukon | | |

# 1 Introduction

SRK Consulting (Canada) Inc. has prepared an updated closure water conveyance plan design report for Minto Mine (Minto) located in the Yukon, Canada, and operated by Minto Exploration Ltd.

There is agreement within the engineering community that climate change is occurring and that climate change needs to be integrated into engineering designs. Engineers Canada (2013) encourages its members to keep themselves informed about the changing climate and consider potential impacts on their professional activities. Design integration of climate change analysis results looks to the long term performance of mine closure designs such as conveyance channels and waste rock cover systems. Mine closure infrastructure designed using average daily temperatures and precipitation values during mines operation may not be adequate for infrastructures that support the mine site in the future when the climate has changed.

This memo presents climate change projections of key climatic and hydrological parameters which may be experienced at the mine site in the future. Parameters include, but are not limited to, projections for changes in temperature, rain and snowfall precipitation. This memo further discusses how the climate change projections for the Minto site are then integrated into the closure conveyance channel design.

# 2 Method

Climate change analysis includes collating and evaluating baseline climate data, querying available climate change prediction models, and making forecasting climate trends. This analysis produced a graphical summary of results (Section 5). The summaries presented in Section 5 are a probabilistic expected change in the climatic with respect to baseline conditions at the Minto mine site.

The analysis required three steps as outlined in Section 2.1 to 2.3.

## 2.1 Step 1: Data Retrieval

The first step of the analysis was to identify the availability of the climate change models for each required climate parameter. Environment Canada provides access to monthly climate change modeling predictions for any location in the World from the following climate change assessment reports:

- Canadian Regional Climate Model (CRCM), also called First Assessment Report (AR1) (EC 2015)
- Second Assessment Report (AR2) (IPCC 1995)
- Third Assessment Report (AR3) (IPCC 2001)
- Fourth Assessment Report (AR4) (IPCC 2007)
- Fifth Assessment Report (AR5) (IPCC 2014)

Information for the first four assessment reports is available from 1960, with predictions out to 2100 for the meteorological variables listed in Table 2.1; however, there are significant gaps depending on the assessment report, scenario evaluated, and variable assessed. Information for the fifth assessment report is available for 1900 to 2100, but only includes mean temperature and total precipitation.

As part of the procedure, data from the five assessment reports are downloaded from Environment Canada for the site being evaluated based on latitude and longitude. This process is automated through a purpose built script developed using R programming language (CRAN 2015).

The meteorological parameters covered in the assessment reports are used, though application of empirical models, to calculate climate change design parameters for other parameters such as intensity-duration–frequency (IDF) curves (i.e. extreme storm events), snowpack thickness, evaporation, etc.

**Table 2.1: Metrological Parameters Listed in AR1 through AR4**

| Parameter | Base Parameter | Details |
|---|---|---|
| Air Temperature | Temperature | Mean ($T_{mean}$), Mean Max ($T_{max}$), Mean Minimum ($T_{min}$), and Extreme Range at 2 m above ground surface |
| Heat Wave Duration Index | Temperature | Maximum period >5 consecutive days with $T_{max}$ >5°C above the baseline $T_{max}$ normal |
| Frost Days | Temperature | Total number of frost days (days with absolute minimum temperature <0°C) |
| Growing Season Length (GSL) | Temperature | Growing season length is defined as the time period each year between when $T_{mean}$ >5°C for more than 5 days and when $T_{mean}$ <5°C for more than 5 days |
| Air Temp. Extreme Range | Temperature | Intra-annual extreme temperature range is the difference between the highest temperature and lowest temperature of the same calendar year |

| Parameter | Base Parameter | Details |
|---|---|---|
| Total Precipitation | Precipitation | Total precipitation including rainfall and snowfall as snow water equivalent |
| Days with rain >10 mm | Precipitation | Days with rain greater than or equal to 10 mm/day |
| Simple Daily Intensity Index | Precipitation | Annual total precipitation divided by the number of precipitation days greater than or equal to 1 mm/day |
| Dry Days | Precipitation | Max amount of consecutives dry days (precipitation <1 mm) |
| Fraction of total annual precipitation >95$^{th}$ percentile | Precipitation | Annual precipitation >95th percentile |
| Wind Speed | Wind Speed | Mean, Meridional, and Zonal wind speed at 10 m above ground surface |
| Solar Radiation | Radiation | Shortwave surface down-welling |
| Humidity | Humidity | Relative and specific humidity at 2 m above ground surface |
| Sea Level Pressure | Air Pressure | Mean sea level pressure |

## 2.2 Step 2: Baseline Analysis (Outcome 1)

Climate change models presented in the assessment reports assume application of radiative forces (energy flux) through different anthropogenic sources that results in discharge of varying concentrations of atmospheric greenhouse gases. These radiative forces are not constant through time, as they are based on global anthropogenic behavior such as environmental policies, population growth, economic growth, energy sources, land use, hydrocarbon usage, etc. Each individual climate change model presented in the assessment reports represent these non-linear radiative forces differently and thus present a different climate change scenario, underscored by its own model assumptions and boundary conditions.

None of these individual models are inherently superior or inferior to others, and likewise, the newer generation of assessment reports are not necessarily more reliable than older versions, but rather represent more detailed consideration of global anthropogenic forces. Therefore, the user is forced to make a judgement call on which individual model or generation of models are the most suitable to use in design, which invariably leads to bias. This method of analysis is specifically aimed at eliminating this bias by analysing all the available climate change models with equal weight and presenting a single climate change design parameter based on a rational statistical evaluation of the overall cumulative results.

Using each and every climate change model available in the five assessment reports, the projected change with respect to a set baseline condition can be calculated using Equation 2.1.

**Equation 2.1**

$$Change\ with\ respect\ to\ set\ baseline\ condition\ [\%] = \frac{Projection - Baseline}{Baseline}$$

In Equation 2.1, the *Baseline* and *Projection* periods have a minimum timeframe of 30 years, which is generally recognized as being the minimum acceptable period length of record that is statistically significant (WMO 2007). These periods can be defined as follows:

- *Baseline* is the time frame associated with the past (i.e. estimation of the climate data based on the climate change models). For the purpose of this analysis, this period is fixed from 1975 to 2005, which coincides with the baseline adopted for AR5.
- *Projection* is the future time frame where climate change models are applied, reflecting climate change predictions. Three *Projection* periods are applied from 2011 to 2040, 2041 to 2070, and 2071 to 2100. These 30-year periods are based on convention as stipulated in WMO (2007).

Climate change model predictions are currently presented up to the year 2100 (IPCC 2014), which is deemed that maximum reasonable timeframe to extend predictions to. As a result, this is the maximum timeframe for which this analysis method applies.

Equation 2.1 is automatically processed using a script developed in R. An example result is presented in Figure 2.1, which represents the outcome at a hypothetical site for the meteorological parameter mean air temperature. For this example, the *Projection* period is representative of 2041 to 2070.

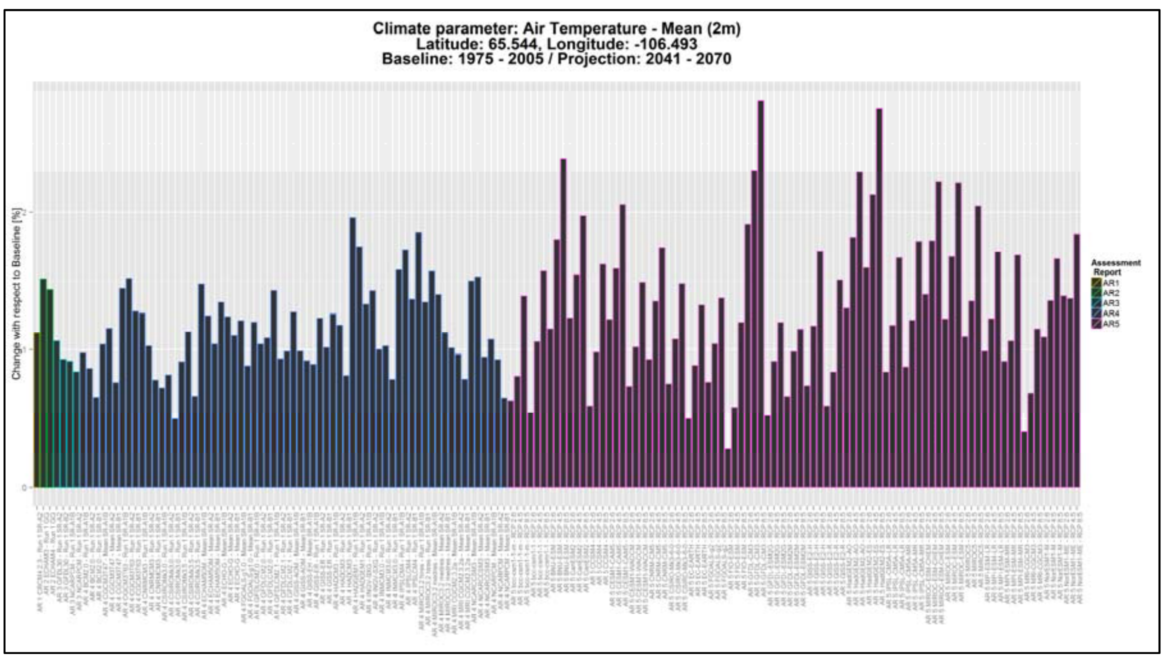


**Figure 2.1: Example outcome for hypothetical site showing results of change to baseline conditions for individual climate change models associated with each of the five assessment reports for a projection period from 2041 to 2070**

The analysis presented in Figure 2.1 can be presented as a box-whisker plot as illustrated in Figure 2.2. The change with respect to baseline conditions for each individual Assessment Report is summarized, together with an overall summary representing all the assessment reports combined. The centerline of the box represents the median value, while the upper and lower box borders represent the first and third quartile values, respectively. The limits whiskers will extend to the maximum and minimum of 1.5 times the total range of the box (i.e. the third quartile minus first quartile). If values exist outside the whisker limits (i.e. outliers), then they are presented as dots.

The results in Figure 2.2 can also be presented as a cumulative probabilistic curve as illustrated in Figure 2.3. To weigh all climate change models equally, only the cumulative probabilistic curve associated with combined data from all assessment reports was considered in this analysis. The overall spread of results as presented by the collection of box-whisker plots in Figure 2.2 illustrates why this is deemed appropriate.

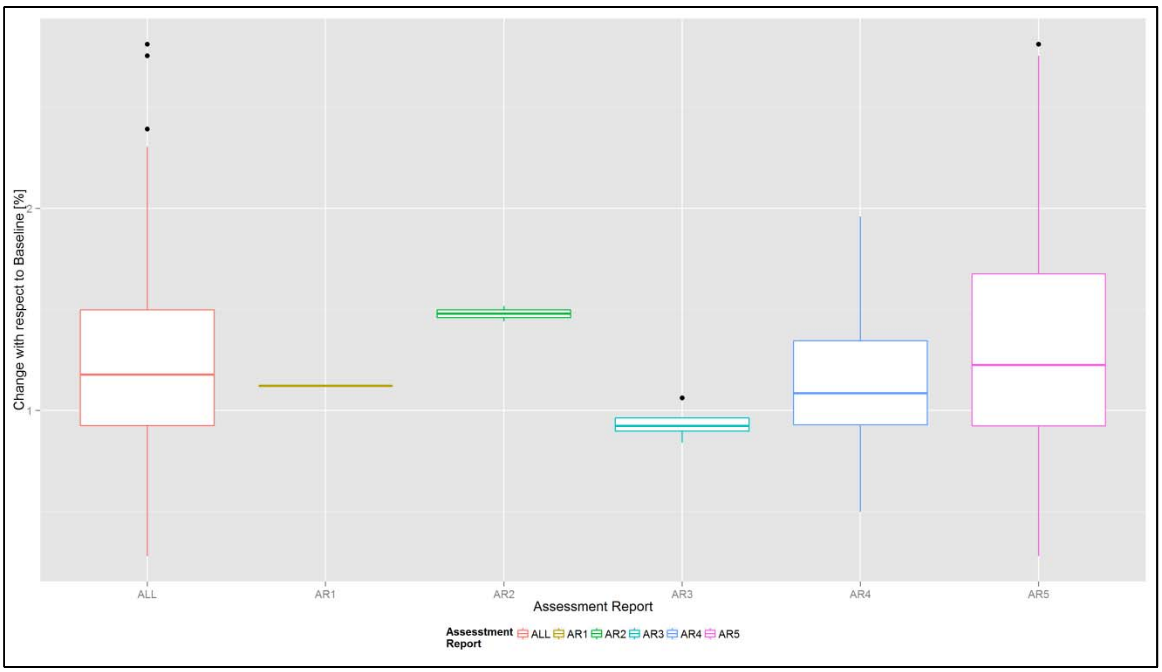


**Figure 2.2: Combined box-whisker plot of change to baseline conditions for the individual climate change models presented in the Figure 2.1 example**

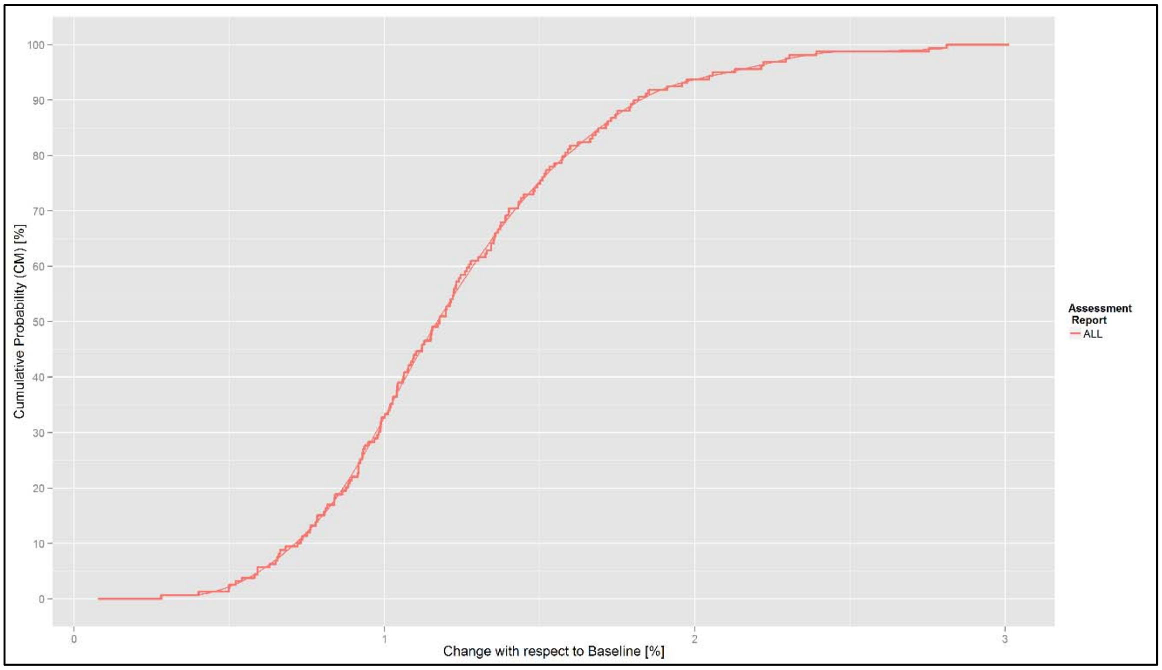


**Figure 2.3: Cumulative probability curve of climate change prediction models from all assessment reports expressed as a percentage of change against baseline conditions**

## 2.3 Step 3: Trend Analysis (Outcome 2)

As discussed in Section 2.2, climate change models consider global anthropogenic forces that are not constant in time. Irrespective of such forces, the science of hydrology estimates and predicts future meteorological conditions through consideration of historic trends. Therefore, to facilitate selection of climate change parameters for design, a trend analysis approach is used as a reality check.

To best represent the historical trend, a global climatic model reanalysis approach is used, rather than relying on regional meteorological stations for historic data, since the availability and timespan of records vary greatly. Reanalysis combines satellite information, land records, and numerical models that simulate the earth's climatic conditions. Typically, reanalysis extends for several decades and covers the entire planet. State-of-the-art publically available reanalysis data from ERA-Interim produced by the European Center for Medium-Range Weather Forecast (ECMWF 2015) was used in this analysis. ERA-Interim includes twice daily data from 1979 to 2015 for the entire world, based on a 0.75 degree latitude by 0.75 degree longitude grid.

The ERA-Interim data trend analysis entailed two parts: first, identification of the trend, and second, estimation of the statistical significance of the trend. Five different trend analysis methodologies were considered:

- Ordinary least square (Maidment 1993)
- Quantile regression (Koenker and Bassett 1978)

- Mann-Kendall and Theil Sen (Mann 1945 and Sen 1968)
- Zhang (Zhang 2000)
- Yue and Pilon (Yue et al 2002)

Figure 2.4 presents the outcome of the reanalysis for the hypothetical example site presented in Figure 2.1 through Figure 2.3. Each regression method has a statistical significance value over 95%; however, this may not always be the case and the meaning of that is described further in next section.

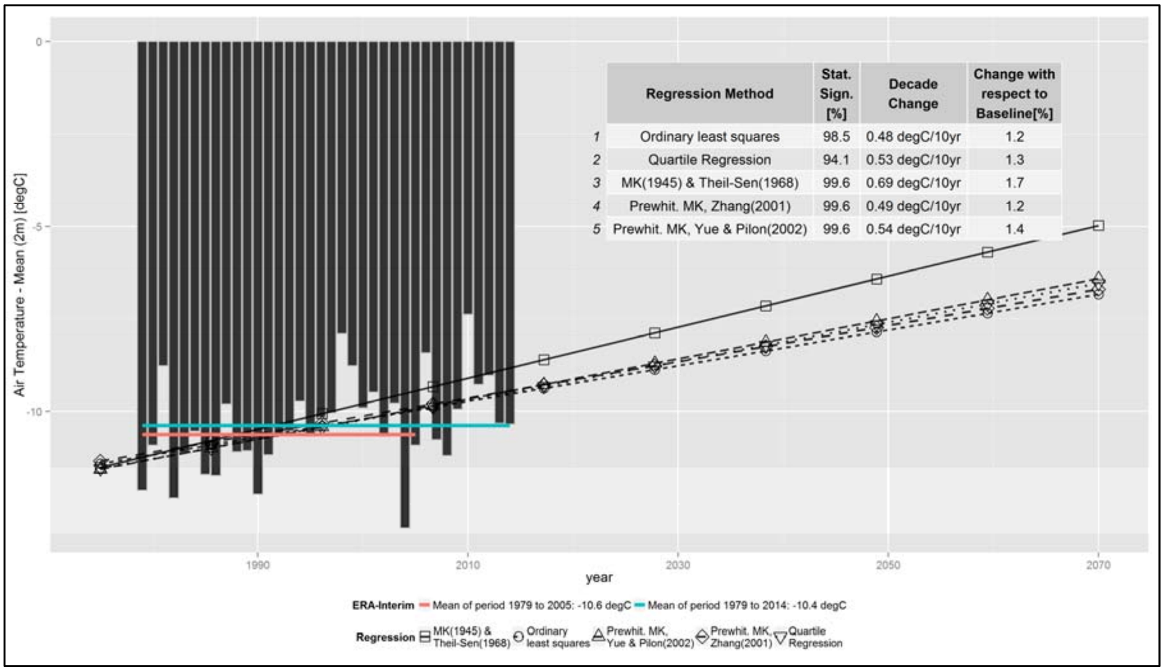


**Figure 2.4: Trend analysis outcome based on reanalysis evaluation for hypothetical site presented in Figure 2.1**

## 2.4 Recommended Climate Change Design Parameter

Following completion of the previously described procedure, a design recommendation for each identified climate change parameter is presented. The previous procedure produces two outcomes as follows:

- Outcome 1 is a cumulative probability curve representing change relative to baseline conditions based on the Step 2 analysis; this is also represented by Figure 2.3.
- Outcome 2 is the five separate regression analysis results from the Step 3 trend analysis, again representing change relative to baseline conditions represented by Figure 2.4. The statistical significance of each regression analysis is calculated during this step and must yield a value greater than 95% to be deemed statistically significant.

If the trend analysis shows no regression of statistical significance (i.e. greater than 95%), the climate change design parameter is the 50% cumulative probability value based on the Step 2 baseline analysis. If on the other hand, one or more of the trend analyses suggest trends of statistical significance, the climate change parameter is the maximum of either the 50% cumulative probability value based on the Step 2 baseline analysis, or the mean of all the trend analysis values with statistical significance. Equation 2.2 provides an expression for this criteria.

**Equation 2.2**

$$\begin{aligned}&\mathit{Recommended\ Climate\ Change\ Design\ Parameter}\\&\quad = \mathrm{Maximum}(50\%\ \mathit{Cumulative\ Probability},\ \mathit{Mean}\ \{\mathit{Regression}_{Stat.\ Sign \geq 95\%}\})\end{aligned}$$

# 3 Climate Change Projections

## 3.1 Long Term Temperature Trends

The mean annual air temperature at Minto is expected to increase by about 3.3°C over the next century (Table 3.1), with mean annual air temperatures of −0.8°C, 0.2°C, and 1.1°C in the 2020s, 2050s and 2080s, respectively. These predictions compare well with those presented by other studies. The International Panel on Climate Change (IPCC) projects a 5°C to 6°C increase in the temperature in Northern Canada for 2100 relative to the 1980 to 1999 temperatures (IPCC 2007).

Table 3.1 though Table 3.8 present additional temperature related climate forecasts for the Minto area. These tables predict longer periods with high temperatures and consequently shorter periods with lower temperatures and less inter-annual temperature variation.

**Table 3.1: Mean Annual Air Temperature at Minto**

| Timeline | Context | Value (°C) | Change Over Baseline (°C) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | -2.12 | - | - |
| 1979-2014 | Current Reality | -2.29 | -0.17 | -0.06% |
| 2011-2040 | 2020s | -0.82 | 1.30 | 0.48% |
| 2041-2070 | 2050s | 0.24 | 2.36 | 0.87% |
| 2071-2100 | 2080s | 1.13 | 3.25 | 1.20% |

**Table 3.2: Mean Maximum Air Temperature at Minto**

| Timeline | Context | Value (°C) | Change Over Baseline (°C) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 1.39 | - | - |
| 1979-2014 | Current Reality | 1.26 | -0.13 | -0.05% |
| 2011-2040 | 2020s | 1.40 | 0.01 | 0.36% |
| 2041-2070 | 2050s | 1.40 | 0.01 | 0.69% |
| 2071-2100 | 2080s | 1.41 | 0.02 | 1.10% |

**Table 3.3: Mean Minimum Air Temperature at Minto**

| Timeline | Context | Value (°C) | Change Over Baseline (°C) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | -5.46 | - | - |
| 1979-2014 | Current Reality | -5.68 | -0.22 | -0.08% |
| 2011-2040 | 2020s | -5.49 | -0.03 | 0.48% |
| 2041-2070 | 2050s | -5.51 | -0.05 | 0.93% |
| 2071-2100 | 2080s | -5.54 | -0.08 | 1.40% |

**Table 3.4: Intra-Annual Temperature Range at Minto(1)**

| Timeline | Context | Value (°C) | Change Over Baseline (°C) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 61.3 | - | - |
| 1979-2014 | Current Reality | 62.2 | 0.9 | 0.27% |
| 2011-2040 | 2020s | 59.8 | -1.5 | -0.45% |
| 2041-2070 | 2050s | 58.6 | -2.7 | -0.81% |
| 2071-2100 | 2080s | 57.6 | -3.7 | -1.10% |

**Note(s):**

(1) The difference between the highest temperature of the year and the lowest temperature of the year.

**Table 3.5: Daily Minimum Air Temperature, 90th Percentile at Minto**

| Timeline | Context | Value (%) | Change Over Baseline (%) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 10.0 | - | - |
| 1979-2014 | Current Reality | 10.2 | 0.2 | 2.0% |
| 2011-2040 | 2020s | 14.6 | 4.6 | 46.0% |
| 2041-2070 | 2050s | 21.0 | 11.0 | 110.0% |
| 2071-2100 | 2080s | 31.0 | 21.0 | 210.0% |

**Table 3.6: Growing Season Length(1) at Minto**

| Timeline | Context | Value (days) | Change Over Baseline (days) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 93 | - | - |
| 1979-2014 | Current Reality | 95.9 | 2.9 | 3% |
| 2011-2040 | 2020s | 115.3 | 22.3 | 24% |
| 2041-2070 | 2050s | 136.7 | 43.7 | 47% |
| 2071-2100 | 2080s | 147.9 | 54.9 | 59% |

**Note(s):**

(1) Growing season length is the number of days between the first five consecutive days of the year with a mean air temperature above 5°C, and the last five such days of the year.

**Table 3.7: Heat Wave Duration Index[(1)] at Minto**

| Timeline | Context | Value (days) | Change Over Baseline (days) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 108 | - | - |
| 1979-2014 | Current Reality | 110 | 2.0 | 2% |
| 2011-2040 | 2020s | 143 | 34.6 | 32% |
| 2041-2070 | 2050s | 185 | 76.7 | 71% |
| 2071-2100 | 2080s | 270 | 162.0 | 150% |

**Note(s):**

(1) The maximum period for the year of at least five consecutive days with the maximum air temperature at least 5°C warmer than the daily climatology baseline.

**Table 3.8: Frost Days[(1)] at Minto**

| Timeline | Context | Value (days) | Change Over Baseline (days) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 225 | - | - |
| 1979-2014 | Current Reality | 225 | 0.0 | 0.0% |
| 2011-2040 | 2020s | 216 | -9.5 | -4.2% |
| 2041-2070 | 2050s | 207 | -18.5 | -8.2% |
| 2071-2100 | 2080s | 196 | -29.3 | -13.0% |

**Note(s):**

(1) Total number of days with an absolute minimum temperature less than 0°C.

## 3.2 Long Term Precipitation Trends

The total precipitation at Minto is forecasted to increase 67.9 mm (15%) during the mine life (2011 to 2040) and 199.3 mm (44%) by 2100 (Table 3.9).

**Table 3.9: Total Precipitation at Minto**

| Timeline | Context | Value (mm) | Change Over Baseline (mm) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 453 | - | - |
| 1979-2014 | Current Reality | 469 | 16.0 | 4% |
| 2011-2040 | 2020s | 521 | 67.9 | 15% |
| 2041-2070 | 2050s | 584 | 131.4 | 29% |
| 2071-2100 | 2080s | 652 | 199.3 | 44% |

## 3.3 Frequency of Drought

Climate change model suggests that consecutive dry days will decrease by up to 13% by 2100 (Table 3.10).The clear mean annual temperature increase trend (Table 3.1) along with the increasing precipitation trend (Table 3.9) and decreasing consecutive dry day trend (Table 3.10) suggest that the frequency of drought should be decreasing.

**Table 3.10: Consecutive Dry Days[1] at Minto**

| Timeline | Context | Value (days) | Change Over Baseline (days) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 17.1 | - | - |
| 1979-2014 | Current Reality | 17.8 | 0.7 | 4.1% |
| 2011-2040 | 2020s | 16.0 | -1.1 | -6.4% |
| 2041-2070 | 2050s | 15.2 | -1.9 | -11.0% |
| 2071-2100 | 2080s | 14.9 | -2.2 | -13.0% |

**Note(s):**

(1) Maximum number of consecutive dry day is a year. Days with less than 1 mm of precipitation are considered dry days.

## 3.4 Frequency of Rainfall

The simple daily precipitation intensity index is the mean annual precipitation divided by the total number of wet days. Therefore, the total number of wet days can be estimated from the simple daily precipitation intensity index values and the total precipitation.

The simple daily precipitation intensity index at Minto is forecasted to increase by 6.6% during the mine life and by 25% in the next century (Table 3.11).

Table 3.12 presents the estimated number of wet days. The total estimated number of wet days is forecasted to increase by a similar amount with a 7.9% increase during the mine life and a 15.2% increase during the next century.

**Table 3.11: Simple Daily Precipitation Intensity Index[1] at Minto**

| Timeline | Context | Value (mm/year) | Change Over Baseline (mm/year) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 3.9 | - | - |
| 1979-2014 | Current Reality | 3.95 | 0.05 | 1.28% |
| 2011-2040 | 2020s | 4.16 | 0.26 | 6.60% |
| 2041-2070 | 2050s | 4.41 | 0.51 | 13.00% |
| 2071-2100 | 2080s | 4.88 | 0.98 | 25.00% |

**Note(s):**

(1) The total annual precipitation divided by the total number of wet days in a year

**Table 3.12: Estimated Total Number of Wet Days(1) at Minto**

| Timeline | Context | Value (days) | Change Over Baseline (days) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 116.2 | - | - |
| 1979-2014 | Current Reality | 118.7 | 2.6 | 2.2% |
| 2011-2040 | 2020s | 125.3 | 9.2 | 7.9% |
| 2041-2070 | 2050s | 132.6 | 16.4 | 14.2% |
| 2071-2100 | 2080s | 133.8 | 17.7 | 15.2% |

**Note(s):**

(1) The total number of wet days is not directly developed from the R analysis, but rather calculated based on the values in Table 3.9 and Table 3.11.

## 3.5 Long Duration Rainfall

Long duration rainfall, fraction of annual precipitation greater than 95th percentile, is predicted to increase by 96% over the next century at Minto (Table 3.13). The number of days with more than 10 mm of rainfall is forecasted to increase by 140% (Table 3.14).

The change in days with more than 10 mm of rain is forecasted to be 58% respectively during mine life (2011 to 2040). Similarly the maximum total precipitation for a five day period will increase by 20% over the next century and 7.8% over the mine life (2011 to 2040) as shown in

Table 3.15. Therefore, the volume and frequency of high precipitation events will tend to increase over the century.

**Table 3.13: Fraction of Annual Precipitation >95th Percentile(1) at Minto**

| Timeline | Context | Value (%) | Change Over Baseline (%) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 5.01 | - | - |
| 1979-2014 | Current Reality | 5.29 | 0.28 | 5.59% |
| 2011-2040 | 2020s | 7.01 | 2.00 | 40.00% |
| 2041-2070 | 2050s | 7.52 | 2.51 | 50.00% |
| 2071-2100 | 2080s | 9.82 | 4.81 | 96.00% |

**Note(s):**

(1) Percentage of days with precipitation greater than the 95th percentile calculated for wet days from the baseline period.

**Table 3.14: Days with Precipitation Greater Than or Equal to 10 mm at Minto**

| Timeline | Context | Value (days) | Change Over Baseline (days) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 3.88 | - | - |
| 1979-2014 | Current Reality | 4.3 | 0.38 | 9.79% |
| 2011-2040 | 2020s | 6.1 | 2.25 | 58.00% |
| 2041-2070 | 2050s | 7.7 | 3.84 | 99.00% |
| 2071-2100 | 2080s | 9.3 | 5.43 | 140.00% |

**Table 3.15: Greatest Five Days Total Rainfall at Minto**

| Timeline | Context | Value (mm) | Change Over Baseline (mm) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 38.9 | - | - |
| 1979-2014 | Current Reality | 40.2 | 1.3 | 3.3% |
| 2011-2040 | 2020s | 41.9 | 3.0 | 7.8% |
| 2041-2070 | 2050s | 43.6 | 4.7 | 12.0% |
| 2071-2100 | 2080s | 46.7 | 7.8 | 20.0% |

## 3.6 Short Duration Rainfall

Based on an evaluation of the predicted values for greatest five-day total precipitation, consecutive dry days, simple daily intensity index, days with rain greater than 10 mm, and fraction of total annual precipitation greater than the 95th percentile, the IDF for Minto was adjusted, where the total precipitation increase is forecasted to increase by 44% in 2100. Using the current reality, the values for the respective return periods and durations were increased by 44% to reflect the forecasted increase

**Table 3.16: IDF Adjusted for Total Precipitation Increase by 2100**

| Duration | | Return Periods [years] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Minutes** | **Hours** | **2** | **5** | **10** | **25** | **50** | **100** | **200** |
| 5 | 0.08 | 7.9 | 10.3 | 12.0 | 14.0 | 15.5 | 17.0 | 18.7 |
| 10 | 0.17 | 10.5 | 13.7 | 16.0 | 18.5 | 20.5 | 22.5 | 24.8 |
| 15 | 0.25 | 12.3 | 16.1 | 18.7 | 21.7 | 24.0 | 26.4 | 29.0 |
| 30 | 0.5 | 14.6 | 19.1 | 22.2 | 25.8 | 28.6 | 31.4 | 34.5 |
| 60 | 1 | 16.7 | 21.8 | 25.4 | 29.5 | 32.7 | 35.8 | 39.5 |
| 120 | 2 | 19.1 | 25.0 | 29.1 | 33.8 | 37.4 | 41.1 | 45.2 |
| 360 | 6 | 22.7 | 29.7 | 34.6 | 40.2 | 44.5 | 48.8 | 53.7 |
| 720 | 12 | 27.4 | 35.8 | 41.7 | 48.5 | 53.7 | 58.9 | 64.8 |
| 1440 | 24 | 33.8 | 43.2 | 49.2 | 56.6 | 61.8 | 67.1 | 68.5 |

## 3.7 Snow Accumulation

Estimations of snow accumulation were developed by coupling the climate change model predictions for precipitation, temperature, and wind speed with the energy snowmelt model by Walter et al. (2005).

To estimate snowmelt, a subroutine from the EcoHydRolody library in R, called SnowMelt was used to analyze snow melt from an energy-based model. This program function forecasts the future daily snowmelt using energy--based model posed by Walter et al. (2005). This hydrological model is based on typical meteorological parameters (e.g. daily maximum, minimum temperature, wind speed, and total precipitation).

These inputs were obtained on a sub-daily and daily scale from the reanalysis source ERA-Interim from 1979 to 2015. As a terrain source, the model required latitude and longitude of the site, topographical slope, and aspect of the terrain. These last two parameters were obtained from the topographical information GTopo30. This source provides a worldwide topographical information with a spacing of 30 arc-sec which is approximately equal to 1 km.

The result of the model is a daily snowmelt model including parameters such as snowfall water equivalent, snowmelt, snowpack depth, and snow water equivalent of snowpack.

The monthly average snow depth at Minto is expected to increase from over the next century (Table 3.17). In the time periods 1979 to 2005 and 1979 to 2014, the snowpack depth will tend to increase with the time to a maximum in the 2100s. These snowpack values should be taken as a reference as snowmelt model should be calibrated with site information.

**Table 3.17: Monthly Average Snowpack at Minto**

| Timeline | Snow Depth (mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1979-2005 | 230 | 260 | 240 | 220 | 30 | 0 | 0 | 10 | 30 | 100 | 160 | 180 |
| 1979-2014 | 240 | 260 | 260 | 230 | 40 | 0 | 0 | 10 | 30 | 110 | 170 | 210 |
| 2011-2040 | 270 | 280 | 280 | 230 | 30 | 0 | 0 | 0 | 20 | 100 | 180 | 230 |
| 2041-2070 | 290 | 300 | 280 | 210 | 20 | 0 | 0 | 0 | 10 | 90 | 190 | 240 |
| 2071-2100 | 330 | 330 | 300 | 200 | 10 | 0 | 0 | 0 | 10 | 90 | 210 | 280 |

## 3.8 Snowmelt

The daily maximum snowmelt in an average year at Minto can be seen in Table 3.18, the month in which these maximum values are obtained from can be seen in Table 3.19. These predictions forecast freshet in April, and slightly increasing maximum daily snowmelt over the next century. The predicted maximum daily snowmelt in 2071 to 2100 is similar that of the snowmelt 1979 to 2005 (Table 3.18).

**Table 3.18: Maximum Daily Snowmelt in Average Year at Minto**

| Timeline | Daily Maximum Snowmelt (mm/day) |
|---|---|
| 1979-2005 | 20 |
| 1979-2014 | 20 |
| 2011-2040 | 22 |
| 2041-2070 | 23 |
| 2071-2100 | 22 |

**Table 3.19: Daily Maximum Snowmelt per Month at Minto**

| Timeline | Snow Melt (mm/day) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
| 1979-2005 | 4 | 4 | 6 | 20 | 0 | 0 | 0 | 0 | 1 | 6 | 4 | 4 |
| 1979-2014 | 3 | 4 | 6 | 20 | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 4 |
| 2011-2040 | 4 | 6 | 9 | 22 | 0 | 0 | 0 | 0 | 0 | 5 | 4 | 4 |
| 2041-2070 | 5 | 7 | 13 | 23 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 5 |
| 2071-2100 | 5 | 9 | 16 | 22 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 6 |

## 3.9 Wind Speed

The mean annual wind speed at Minto is predicted to increase by 2.4% over the next century (Table 3.20).

**Table 3.20: Mean Wind Speed at Minto**

| Timeline | Context | Value (m/s) | Change Over Baseline (m/s) | Change [%] |
|---|---|---|---|---|
| 1979-2005 | Baseline | 2.56 | - | - |
| 1979-2014 | Current Reality | 2.55 | -0.01 | -0.39% |
| 2011-2040 | 2020s | 2.56 | 0.00 | 0.01% |
| 2041-2070 | 2050s | 2.58 | 0.02 | 0.87% |
| 2071-2100 | 2080s | 2.62 | 0.06 | 2.40% |

# 4 Benchmarking

The climate change projections were benchmarked against the following reports with climate projections:

- **Yukon Climate Change Indicators and Key Findings 2015** (NCEC 2015). The report is designed to provide an overview of the trends in temperature, precipitation, fire severity, and sea ice extent/volume for decision makers in the province. The temperature and precipitation trends can be used as a comparative for the climate change value evaluated in this report.

- **Coffee Gold Project, Climate Change Projection for Coffee Creek Region, Yukon** (Lorax 2015). The report is designed to address climate projections and their potential impacts on the project. They address temperature, precipitation and freeze and thaw dates, which can be used as a comparative for the climate change projections evaluated in this report.

Projected mean annual temperature, precipitation and freezing days all exhibit similar values. The NCEC report uses historical trends to predict the future outcomes. Coffee Gold's report uses global climate models, while this report uses both. Lorax (2015) in the Coffee Gold report uses five downscaled model averages climate change models. SRK's methodology does not use downscaled climatic model models, instead considered gridded information for all the available climate change models and compared those results applied to the site with historical trends from Reanalysis ERA-Interim.

The expected mean annual temperature presents similar trend in all of three reports. Freezing-day estimations are also quite similar in Coffee Gold's report and to SRK's. MAP shows an increasing trend in all reports; SRK's report presents a greater increase than either of the two benchmark reports. However, the magnitude seems reasonable compared with the benchmarked reports. Table 4.1 presents an overall synthesis of the climate change results in the area.

**Table 4.1: Climate Change Benchmarks – Meteorological Parameters**

| Projected Parameter | Period [years] | NCEC Yukon, 2015 | Lorax -Coffee Gold, 2015 | SRK – Minto, 2016 |
|---|---|---|---|---|
| Mean Annual Temperature | 2060's | >+2 ˚C | | +2.4 ˚C[1] |
| | 2100's | | +3-5 ˚C | +3.3 ˚C |
| Mean Annual Precipitation | 2060's | +10-20% | | + 29% [1] |
| | 2100's | | +20% | +44% |
| Freezing Days | 2060's | N/A | | -18.5 Days[1] |
| | 2100's | | -30 Days | -29 Days |

**Note(s):**

(1) Value defined for 2050s.

For IDF benchmarking the site IDF was compared with Simonovic et al's (Western University – London, ON) IDF CC tool (2016). They provide a web evaluation of all the IDF curves in Canada under different time frames and for a wide variety of climate change scenarios. The IDF information from the closest EC meteorological station of Pelly Ranch located 25 km north of the site was used from this web page as a comparison to the site IDF.

The climate change timeframe used in all of the scenarios is 2071 to 2100. Simonovic et al. (2016) provide IDF values for three representative concentration pathway (RCP) scenarios: RCP 2.6, RCP 4.5 and RCP 8.5. Table 4.2 provides a summary of the IDF changes for the Site (SRK) versus Pelly Ranch (Simonovic et. al., 2016) based on baseline conditions. The table shows that the SRK value falls within the higher range of the values presented by Simonovic et al. However, the value is within a reasonable range considering the uncertainty associated to these climate change models.

**Table 4.2: Climate Change Benchmarks – Intensity Duration Frequency Curves**

| Source | RCP 2.6 (2071-2100) | RCP 4.5 (2071-2100) | RCP 8.5 (2071-2100) | Compiled (2071-2100) |
|---|---|---|---|---|
| IDF CC Tool – Pelly Ranch, 2016 | +20% | +26% | +47% | |
| SRK – Minto, 2016 | | | | +44% |

# 5 Summary of Overall Climate Change Trends

Climate change effects develop over very long timescales relative to the project life. As such the trends listed in Table 5.1 will manifest as minimal increases and decrease over the length of the Project.

**Table 5.1: Overall Climate Change Trends**

| Climate Factor | Trend | Justification |
|---|---|---|
| Mean Annual Temperature | Increasing | The mean annual temperature should increase in total 3.3 degrees Celsius for the period 2100's. |
| Frequency of Extreme Temperatures | Reduction of variability | The intra-annual temperature range will decrease with the time, range between extreme maximum and minimum temperatures. |
| Frequency of Rainfall | Increasing | The IDF will increase in 44% for the period 2100s. This is also complemented with an increase in the amount of wet days in a year. |
| Total Rainfall | Increasing | Increase in total precipitation of 199.3 mm (44%) by 2100's. |
| Snow Accumulation | Increasing | Snow depth appears to be increasing between December and March mainly by years 2100s. |
| Snowmelt | Unknown | There is a predicted increase in the daily maximum snowmelt, however the values are not monotonically increasing with the time; and the variation magnitude is close to 10%, which suggest some uncertainty. |
| Floods and Storms | Unknown, likely Increasing | Increasing temperature, precipitation, long duration rainfall and storm intensities in the trends to 2100 suggest that storms and freshet are increasing. Therefore it is likely reasonable to assume that storms and floods will increase by the period of 2100's. |

# 6 Effects of Climate Change on Closure Design Criteria

The climate change projections discussed in this memo and specifically summarized in Section 5 contribute to develop a long-term design criteria for engineered closure designs and infrastructure. For closure conveyance channel designs the predicted increase in precipitation and in the frequency of storms play a considerable role in engineering channel geometries and riprap specifications. According to the climate change study, channels which are designed on the present day discharges are projected to more water in the form of a greater peak flow, greater and more frequent storm runoffs, and even freshets flow.

SRK Consulting (Canada) Inc.

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Victor Muñoz S., MEng, PEng

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# Appendix D – Channel Routing Options Evaluation

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# Memo

| | | | |
|---|---|---|---|
| **To:** | Ryan Herbert, Minto Explorations Ltd | **Client:** | Minto Explorations Ltd. |
| **From:** | Samantha Barnes, SRK | **Project No:** | 1CM002.042 |
| **Cc:** | Dylan McGregor, SRK | **Date:** | August 3, 2016 |
| **Subject:** | Minto Channel Routing Options Evaluation | | |

## 1 Introduction

This memo summarizes the impacts of routing runoff through the pit versus diverting it around the pit. The Minto routing flow closure evaluation assessed channel design options for surface water flow received by the Main and Area 2 open pits.

Flow routing alternatives include two options for the Area 2 Pit:

- Option 1 – Area 2 Pit upstream flow are routed into Area 2 Pit through Channel B (Ditch B Phase V/VI Design). From the pit, the flows are discharged through channel width, which becomes Channel D.
- Option 2 – Area 2 Pit catchment is diverted into Channel B (Ditch B), which by-passes the Area 2 Pit.

Three 24 hours precipitation return period models were applied to three geometric channel configurations for the Main Pit and options 1 and 2 for the Area 2 Pit.

## 2 Hydraulic – Hydrologic Model

Three 24 hours precipitation return period events were modelled to test the change in resultant peak flow and flow depth in the discharge channel design: a 2-year peak flow, a 200-year peak flow, and a probable maximum flood (PMF). Three geometries were assessed for discharge channels from both open pits as follows:

- Case 1 – Minimum channel width (2 m)
- Case 2 – Constructible channel width, based on dozer sizing (7 m)
- Case 3 – Maximum channel width, based on topography (22 m for Main Pit, 15 m for Area 2 Pit)

Geometric models of each routing alternative and each channel width alternative were compared using HEC-HMS developed by US Army Corps of Engineers (2000).

# 3 Results

## 3.1 Routing Options – Hydrologic Results

Figure 1 shows the complete hydrograph for Option 1 and Option 2. The blue solid line is the routing and channel width alternative (Option 1). The red dashed line is the diversion alternative (Option 2). Figure 2 shows a close-up of this variation in peak flow under both scenarios. The difference between the two routing options is approximately 30 m³/s for the PMF event.

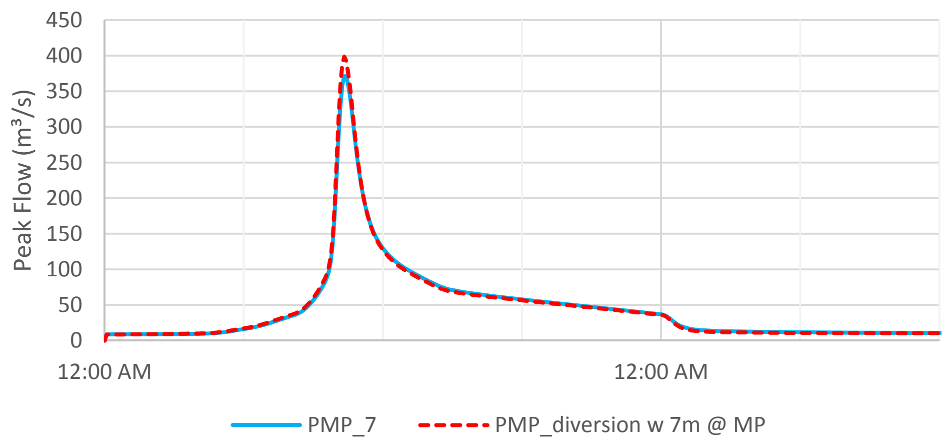


**Figure 1: Routing Option Comparison for the PMF**

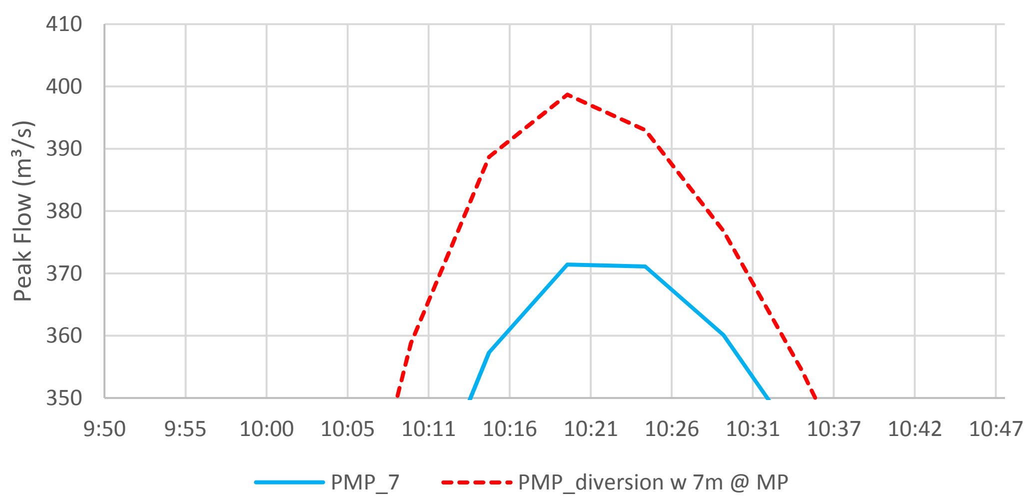


**Figure 2: Routing Option Comparison for the PMF (Flow Peak Close-up)**

### 3.2 Geometric Cases – Hydraulic Results

The results for the three channel width cases are presented in Table 1 where the design peak flow events are assumed to be the PMP. The riprap was sized based on the Isbash method (Garcia 2007).

**Table 1: Probable Maximum Flood Results**

| Channel Width Scenario | Area 2 Pit | | | Main Pit | | |
|---|---|---|---|---|---|---|
| | Peak Flow ($m^3/s$) | Flow Depth (m) | Riprap D50 (m) | Peak Flow ($m^3/s$) | Flow Depth (m) | Riprap D50 (m) |
| Case 1 (2m) | 5.8 | 0.99 | 0.08 | 17.4 | 1.71 | 0.30 |
| Case 2 (7m) | 9.7 | 0.79 | 0.09 | 23 | 1.31 | 0.32 |
| Case 3 (max) | 14 | 0.64 | 0.07 | 31.9 | 0.86 | 0.17 |

# 4 Discussion and Recommendations

The results of the two routing options illustrate a minimal difference in impact from diverting runoff around the Area 2 Pit as opposed to through the pit. Furthermore, the diversion Option 2 does not result in a difference in the magnitude of peak flow or the period of time when the peak is presented when compared to routing flows through the pit. For the channel width options to minimize the size of riprap required, Case 2 is recommended for both open pit channel widths.

Based on the analyses presented and considering future construction riprap needs, it is recommended that the Option 1 channel alignment and the Case 2 channel width option be implemented. Option 1 represents the routine option with the lowest flows and it is paired with the channel geometry that requires the most conservative riprap sizing.

SRK Consulting (Canada) Inc.

*Original Signed By*

Samantha Barnes, EIT
Consultant

# 5 References

Garcia M. 2007. Sedimentation Engineering - Processes, measurements, ,modeling and practice. ASCE Manuals and reports on engineering practice No 110. Virginia: ASCE.

US Army Corps of Engineers. 2000. "Hydrologic Modeling System - HEC-HMS - Technical Reference Manual."

# Appendix E – Integrating Vegetation Erosion Protection

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# Memo

| | | | |
|---|---|---|---|
| **To:** | Ryan Herbert, Minto Explorations Ltd. | **Client:** | Minto Explorations Ltd. |
| **From:** | Stuart McPhee, EIT | **Project No:** | 1CM002.042 |
| **Cc:** | Dylan MacGregor, SRK | **Date:** | August 3, 2016 |
| **Subject:** | Integrating Vegetation Erosion Protection | | |

This memo discusses the use of vegetation to assist channel stabilization and erosion reinforcement of disturbed soils for the Minto Project. Best management practices (BMPs) are provided in the Yukon Revegetation Manual for Practical Approaches and Methods (Matheus 2013) and the Government of Alberta's Transportation Erosion and Sediment Control Manual (2011). These BMP's provide guidelines for analysis, design selection, construction, and maintenance of erosion, and sediment control structures and site-specific selection of vegetation and establishing plant communities.

A commonly employed reclamation practice is to use live vegetation for channel protection and erosion control of disturbed soils. The use of biotechnical techniques do not replace the need for rock riprap, but can complement and improve channel stabilization designs during construction (e.g. regraded slopes and rock riprap). These techniques also improve soil reinforcement on disturbed slopes and regraded areas and ultimately assist in establishing vegetation, riparian zones, and develop soils.

The vegetation proposed for channel stabilization and erosion control focus on the use of coarse woody, grass and legume, and wetland species of vegetation. These species are widely used in industrial site reclamation design, construction, and maintenance to mitigate erosion, and sedimentation. The Yukon Revegetation Manual summarizes common plant species that are established by seeding. Common seeding practices for reclamation include hydroseeding and broadcast seeding. Appended to this memo are the summary tables prepared in the Yukon Revegetation Manual *Chapter 5: Revegetation Scenarios and Seed Recommendations*. Included in the appended tables are both Non-Native (Agronomical) and Locally-Collected (Native) seeds and the reclamation scenario's that they are suited for.

Methods to improve existing and proposed infrastructure (e.g. conveyance channels, covers and disturbed erodible slopes) include:

- establish vegetation and restorative self-sustaining plant communities;
- increase slope and channel stability due to root reinforcement, interlock, and soil draining;
- provide protection against wind, water, and surface erosion and rock fall;

- provide shade to regulate temperature and humidity close to surface that promotes further vegetation growth of volunteer species;
- provide improvement to the soil water regime through interception, evapotranspiration, and storage;
- improve soil development and the formation of organic soils;
- improve habitat provisions for animals;
- may reduce construction and maintenance costs (compared to other designs); and
- establish post closure landscapes that are often more appealing due to their more natural features.

At this stage of closure design, a preliminary assessment of common biotechnical reclamation practices has identified that there is a future opportunity to integrate vegetation erosion protection into the closure conveyance channel design and the disturbed soils adjacent to the channels.

There are three main components to the design and construction of the closure conveyance channels that would benefit from biotechnical stabilization BMPs:

- Disturbed and excavated slopes
- Establishing riparian vegetation
- Channel erosion and protection

Closure designs for conveyance channels will require sections of channels to have excavated alignments through erodible materials. The excavated slopes within these materials will typically have slopes graded towards the channel. It is expected that if these disturbed slopes are left, they will erode and even transport sediment into the channels. If the slopes contain weak fine grained erodible soils, then the slopes may be subject to sloughing and larger scale transportation of materials, which may block the conveyance channels.

Immediately after construction the closure conveyance channels will lack riparian vegetation. Biotechnical techniques can assist with slope stabilization and establishing riparian vegetation. Techniques for stabilizing these slopes are recommended to be a combination of BMPs provided in the Government of Alberta's Transportation Erosion and Sediment Control Manual (2011) as listed in Table 1. The BMP figure for live staking method is attached to this memo as an example.

**Table 1: Selected Closure BMPs from Alberta Transportation Erosion and Sediment Control Manual**

| BMP ID | BMP Name | Disturbed and Excavated Slopes | Riparian Vegetation Development | Channel Erosion Protection |
|---|---|---|---|---|
| 13b | Rolled Erosion Control Products | ✓ | | |
| 14a,b | Riprap Armouring | ✓ | | ✓ |
| 19a,b | Slope Drains | ✓ | ✓ | |
| 24a | Hydroseeding | ✓ | ✓ | |

| BMP ID | BMP Name | Disturbed and Excavated Slopes | Riparian Vegetation Development | Channel Erosion Protection |
|---|---|---|---|---|
| 27a | Live Staking | ✓ | ✓ | ✓ |
| 27b1,2,3 | Brush Layering | ✓ | ✓ | ✓ |
| 28 | Wattle (Live Fascine) | ✓ | ✓ | |
| 34a | Surface Roughening | ✓ | ✓ | |
| 34c | Slope Benching | ✓ | | |
| 38a,b,c | Coir/Straw Rolls with Brush Layers | ✓ | ✓ | |
| 39 | Brush Mattress | ✓ | ✓ | |
| 40 | Live Siltation | | ✓ | ✓ |
| 41 | Willow Post and Pole | ✓ | ✓ | ✓ |
| 44 | Vegetated MSE | ✓ | ✓ | ✓ |
| 45a,b,c,d | Vegetated Riprap | ✓ | ✓ | ✓ |

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*Original Signed By*

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

# 1 References

Government of Alberta. 2011. Erosion and Sediment Control Manual. AB. Recovered July 28, 2016 from http://www.transportation.alberta.ca/Content/docType372/Production/ErosionControlManual.pdf

Matheus P, and Omtzigt T. 2013. Yukon Revegetation Manual – Practical Approaches and Methods. Recovered July 28, 2016 from: http://www.yukonrevegetationmanual.ca/.

# Attachment 1: Revegetation Scenarios and Seed Recommendations

## Summary of Recommended Species

Table 5.27

### NON-NATIVE HERBACEOUS SPECIES (COMMERCIAL SEEDS) AND APPLICABLE SCENARIOS

| | SCENARIO | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| **SPECIES** (cultivar) | **# OF SEEDS/KG** | **LOW SLOPE, LOW-MID ELEVATION SITES** | **STEEP SLOPES** | **WET SITES** | **HIGHWAY RIGHT-OF-WAYS** | **DISTURBED PERMAFROST SITES** | **ARCTIC TUNDRA AND STABLE PERMAFROST SITES** | **ALPINE AND SUBALPINE SITES** |
| **Rocky Mountain fescue** *Festuca saximontana* (common) | 1,430,000 | x | x | | x | x | | x |
| **Violet wheatgrass** *Elymus alaskanus* (common) | 330,000 | x | x | | x | | x | x |
| **Glaucous bluegrass** *Poa glauca* (Tundra or common) | 2,904,000 | x | x | | x | | x | x |
| **Slender wheatgrass** *Elymus trachycaulus* (Revenue, Adanac, Highlander or common) | 349,800 | x | x | | x | | | |
| **Ticklegrass** *Agrostis scabra* (common) | 11,000,000 | x | | | | x | | x |
| **Tufted hairgrass** *Deschampsia caespitosa* (Nortran or common) | 3,300,000 | x | | x | x | x | x | x |
| **Fowl bluegrass** *Poa palustris* (common) | 4,840,000 | x | | x | x | x | | |
| **Spike trisetum** *Trisetum spicatum* (common) | 5,500,000 | | | | | | x | x |
| **Bluejoint reedgrass** *Calamagrostis Canadensis* (Sourdough or common) | 8,442,438 | x | | x | | x | | |
| **Polargrass** *Arctagrostis latifolia* (Alyeska or common) | 3,960,000 | | | x | | x | x | |
| **American sloughgrass** *Beckmannia syzigachne* (Egan or common) | 2,723,600 | | | x | | x | | |
| **Alpine bluegrass** *Poa alpina* (Gruening or common) | 2,353,826 | | | | | | x | x |

## Summary of Recommended Species

Table 5.28

### NON-NATIVE HERBACEOUS SPECIES (COMMERCIAL SEEDS) AND APPLICABLE SCENARIOS

| | SCENARIO | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| **SPECIES** (cultivar) | **# OF SEEDS/KG** | **LOW SLOPE, LOW-MID ELEVATION SITES** | **STEEP SLOPES** | **WET SITES** | **HIGHWAY RIGHT-OF-WAYS** | **DISTURBED LOWLAND PERMAFROST SITES** | **ARCTIC TUNDRA AND STABLE PERMAFROST SITES** | **ALPINE AND SUBALPINE SITES** |
| **Kentucky bluegrass** *Poa pratensis* (Nugget) | 3,057,648 | | | x | | | x | |
| **Creeping red fescue** *Festuca rubra* (Arctared for northern Yukon, Boreal for southern Yukon) | 539,407 | x | x | | x | x | x | x |
| **Canada bluegrass** *Poa compressa* (Reubens or common) | 5,264,204 | x | x | x | x | x | | |
| **Streambank wheatgrass** *Elymus lanceolatus* (Sodar) | 336,600 | x | x | x | x | x | x | |
| **Meadow foxtail** *Alopecurus pratensis* (common) | 895,136 | x | x | x | x | x | x | |
| **Red top** *Agrostis gigantea* (common) | 10,672,640 | x | | x | | | | |
| **Timothy** *Phleum pratense* (Climax, Engmo) | 2,559,400 | | | x | | x | x | |
| **Alfalfa** *Medicago sativa* (Rangelander, Rambler or Peace) | 498,960 | | x | | | | | |
| **Sheep fescue** *Festuca ovina* (common) | 1,100,000 | x | | | x | x | x | x |
| **Annual rye** *Lolium multiflorum* | 477,400 | | x | | | x | | |
| **Barley** *Hordeum vulgare* | 29,920 | | x | | | x | x | x |

## Summary of Recommended Species

Table 5.29

### LOCALLY-COLLECTED NATIVE HERBACEOUS SPECIES (SEEDS) AND APPLICABLE SCENARIO

| | SCENARIO | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| SPECIES | # OF SEEDS/KG | LOW SLOPE, LOW-MID ELEVATION SITES | STEEP SLOPES | WET SITES | HIGHWAY RIGHT-OF-WAYS | DISTURBED LOWLAND PERMAFROST SITES | ARCTIC TUNDRA AND STABLE PERMAFROST SITES | ALPINE AND SUBALPINE SITES |
| **Northern rough fescue** *Festuca altaica* | 451,854 | x | x | x | x | x | x | |
| **Yukon wheatgrass** *Elymus calderi* | — | x | | | | | | |
| **Macrourum's wheatgrass** *Elymus macrourus* | 374,782 | x | x | | | | | |
| **Northern brome** *Bromus pumpellianus* | 202,400 | x | x | | x | | | |
| **Sweetgrass** *Hierochloë hirta* (formerly *H. odorata*) | 242,000 | x | x | | x | | | |
| **Alpine sweetgrass** *Hierochloë alpina* | — | | | | | | x | x |
| **Mountain timothy** *Phleum alpinum* (formerly *P. commutatum*) | — | | | | | x | | x |
| **Northern bluegrass** *Poa alpigena/Poa pratensis* | 3,057,648 | | | x | | x | x | x |
| **Arctic bluegrass** *Poa arctica* | 3,250,553 | | | | | | x | |
| **Nuttall's alkaligrass** *Puccinellia nuttalliana* | 4,648,140 | x | x | x | x | x | x | x |
| **Yellow locoweed** *Oxytropis campestris* | 521,400 | x | | | x | | | |
| **Showy locoweed** *Oxytropis splendens* | 1,548,800 | x | | | x | | | |
| **Bear root** *Hedysarum alpinum* | 154,000 | x | | | | | | |
| **Mackenzie's hedysarum** *Hedysarum Mackenzii* | 101,889 | x | | | | | | |
| **Yarrow** *Achillea millefolium* and *Achillea sibirica* | 6,274,426 | x | | | x | | | |
| **Mountain avens** *Dryas* spp. | — | x | | | x | x | x | x |
| **Arctic lupine** *Lupinus arcticus* | 22,733 | x | | x | x | x | x | x |
| **Wormwood/sage** *Artemesia* spp. | — | x | x | | x | | x | x |

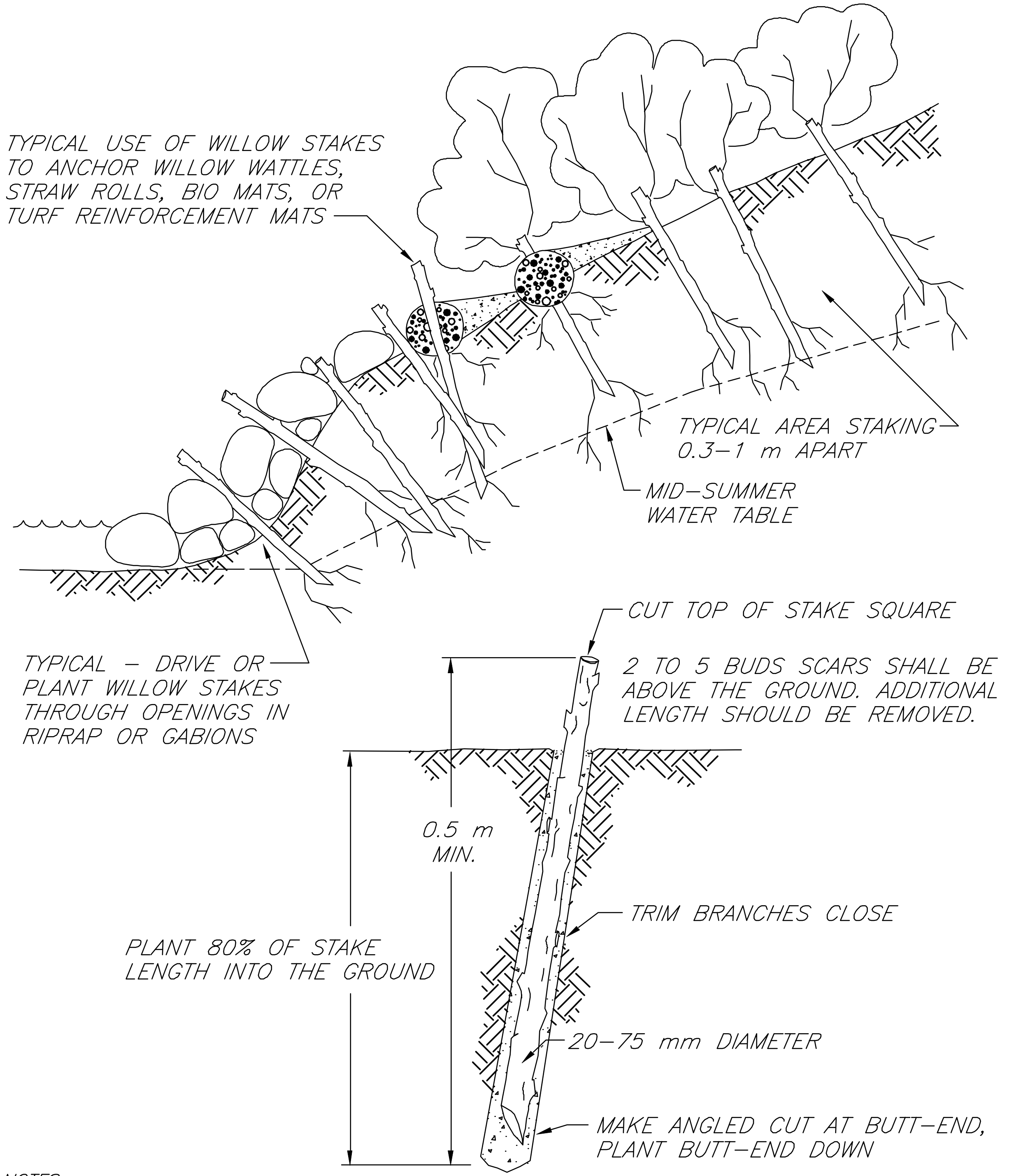
## Summary of Recommended Species

Table 5.30

### LOCALLY-COLLECTED WOODY SPECIES AND APPLICABLE SCENARIOS

| SCENARIO | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| LOCAL WOODY SPECIES | LOW SLOPE, LOW-MID ELEVATION SITES | STEEP SLOPES | WET SITES | HIGHWAY RIGHT-OF-WAYS | DISTURBED LOWLAND PERMAFROST SITES | ARCTIC TUNDRA AND STABLE PERMAFROST SITES | ALPINE AND SUBALPINE SITES |
| **Willow**<br>*Salix alaxensis, S. pulchra*, *S. planifolia*, *S. richardsonii, S. hastate*, *S. arbusuloides*, *S. lucida*, *S. pseudomyrsinites* (the two best species are *S. alaxensis* and *S. pulchra*) | x | | x | | x | x | x |
| **Poplar**<br>*Populus balsamifera* | x | | x | | | | |
| **Shrub birch**<br>*Betula glandulosa* | x | | x | | | x | x |
| **Dwarf birch**<br>*Betula nana* | | | | | | x | |
| **Green alder**<br>*Alnus crispa* | x | | x | | | x | x |
| **Grey alder**<br>*Alnus tenuifolia* | x | | x | | | | |

# Attachment 2: Live Staking BMP Technique




NOTES:

1. HARVEST AND PLANT STAKES DURING THE DORMANT SEASON.
2. USE HEALTHY, STRAIGHT AND LIVE WOOD AT LEAST 1 YEAR OLD.
3. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION, USE A PILOT BAR IN FIRM SOILS.
4. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
5. TAMP THE SOIL AROUND THE STAKE.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

FILE: LIVESTK

NOT TO SCALE

# LIVE STAKING

# Appendix H
# Minto Site Characterization Plan 2018-01

# Appendix I
# Water and Load Balance Model Report 2018

# Appendix J1
# Minto Mine - Operations Adaptive Management Plan 2020-01

# Appendix J2
# Closure Adaptive Management Plan 2020-01

# Appendix K
# Minto Mine Closure Cost Estimates – RCP Revision 2020-01