APPENDIX D:
HYDROLOGICAL BASELINE DATA REPORT
PALMER ENVIRONMENTAL

Prepared for:
Canadian Environmental Assessment Agency

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AMBERSHAW PROJECT SITE

HYDROLOGICAL BASELINE DATA REPORT
ADVANCED EXPLORATION PERMIT

PREPARED FOR:
AMBERSHAW METALLICS INC.

PREPARED BY:
PALMER ENVIRONMENTAL CONSULTING GROUP INC.

MARCH 20, 2019

Revision History

REV. NO.	DATE	AUTHOR	DESCRIPTION
1	March 19, 2019	SF, JC	Updated to most recent mine plan layout and minor revisions from PB

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1 INTRODUCTION

1.1 Background

Ambershaw Metallics Inc. ("AMI") is a Canadian DR-grade magnetite pellet developer company with interests in the Bending Lake Property ("Property" or "site") located approximately 35 km southwest of Ignace, Ontario and 80 km north of Atikokan, Ontario and accessed via a secondary access road from Highway 622 (**Figure 1-1**). This document is one of a series of environmental baseline reports prepared by Palmer Environmental Consulting Group Inc. (PECG) to describe the existing environmental conditions at the property to support an application to the Ministry of Energy, Northern Development and Mines (ENDM) to support the Bending Lake Advanced Exploration Project ("Project").

The Project consists of an open pit with the extraction of approximately up to 100,000 tonnes of iron mineralized rock to allow for an examination of potential development options with respect to the mineralized rocks present and process options to assess the potential of a commercially viable mine. To support this project PECG initiated an integrated baseline environmental program in May 2017 to expand upon the limited environmental information available near the site to provide a comprehensive understanding of the existing environmental conditions.

This introduction section is included in each environmental baseline document prepared by PECG such that each report can be read independently. This report presents the Baseline Hydrological Conditions for the Project. The other baseline reports in the series are those prepared for the following environmental disciplines:

- Hydrogeology;
- Fish and Aquatic Resources;
- Water Quality; and,
- Terrestrial Ecology.

While each baseline document has been prepared separately, it is recognized that all physical, chemical and biological systems are interconnected. As such, PECG has focused on taking an ecosystem and watershed-based approach to understanding the integrated nature of the existing environmental conditions for the Project.

1.2 Project Setting

The Bending Lake property is situated at the southeasterly end of a 30 km long northwest-southeast trending belt of Achaean metamorphosed volcanic and sedimentary rocks which is part of a 70 km long belt of supracrustal rocks referred to as the Manitou-Stormy Lakes greenstone belt. The Project site is located at UTM Zone 15 N 5463800 m, E 559600 m.

Presently, the area is characterized by a wilderness, forestry and mineral exploration land use. Access to the site is along a series of historical mining and logging roads, accessed from Highway 622 (**Figure 1-2**). The Advanced Exploration site is located on a local topographic high between the Wabigoon Lake Subwateshed and the Bending Lake Subwatershed, with extraction activities focus in the Bending Lake Subwatershed (**Figure 1-3**). Page Lake is located south of the site and Bending Lake is located to the east. Page Lake drains into Bending Lake along a small first order stream located in the southern portion of the Project Development Area. Surface water flow at the site is towards the north towards a wetland and drainage features that ultimately discharges onto Bending Lake.

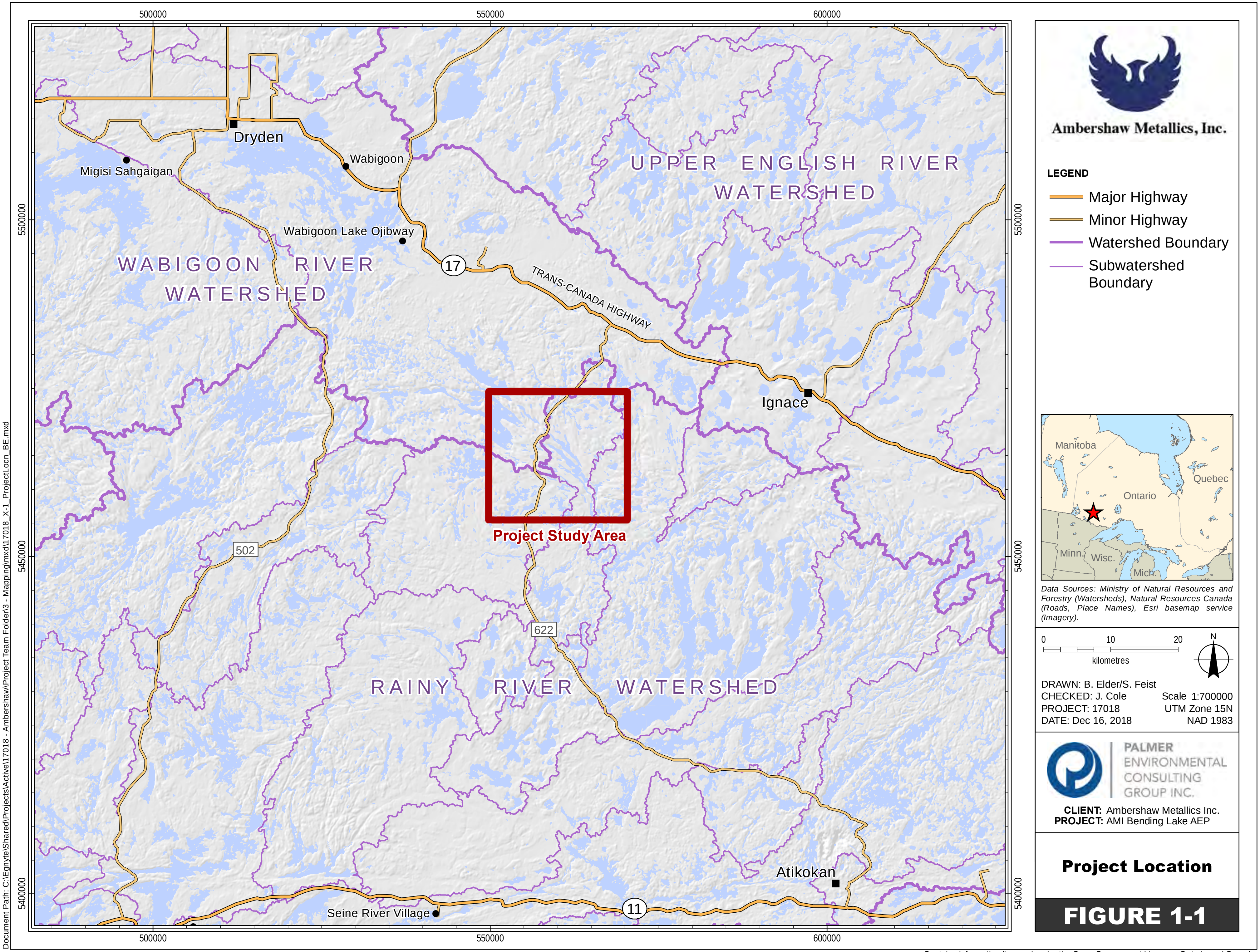
1.3 Overview of the Project

AMI proposes to complete a bulk sampling program as part of an Advanced Exploration Project for the Bending Lake Property. As part of this program, AMI proposes to complete earthworks and bedrock extraction from a small open pit for an up to 100,000 tonne bulk sampling program, with crushing and sampling completed on-site. The bulk sample will be trucked off-site for processing at an approved facility to test metallurgical recoveries to assess the commercial viability of a mine. The Project Description prepared by AMI (October 2018) provides additional details on the proposed Project

The proposed Project site facilities layout is presented within the Project Development Area on **Figure 1-3**. Preference has been given to utilizing previously disturbed areas and existing access roads to complete the Project. The major proposed Project components are expected to include:

- Open Pit (104 m by 71 m by 10 m deep);
- Stockpiles;
- Portable Crusher;
- Administration and Parking Facilities;
- On-Site Power and Waste Facilities; and
- Project Access Roads.

The Project is proposed to be completed in three phases, with an overall project duration of 4 months. A monitoring and mitigation plan will be implemented based on the recommendations from each of the technical environmental disciplines.



UPPER ENGLISH RIVER WATERSHED
WABIGOON RIVER WATERSHED
RAINY RIVER WATERSHED
Dryden
Wabigoon
Migisi Sahgaigan
Wabigoon Lake Ojibway
TRANS-CANADA HIGHWAY
17
Ignace
Project Study Area
502
622
11
Atikokan
Seine River Village
500000
550000
600000
5500000
5450000
5400000
Ambershaw Metallics, Inc.
LEGEND
Major Highway
Minor Highway
Watershed Boundary
Subwatershed Boundary
Manitoba
Quebec
Ontario
Minn.
Wisc.
Mich.
Data Sources: Ministry of Natural Resources and Forestry (Watersheds), Natural Resources Canada (Roads, Place Names), Esri basemap service (Imagery).
0 10 20
kilometres
N
DRAWN: B. Elder/S. Feist
CHECKED: J. Cole
PROJECT: 17018
DATE: Dec 16, 2018
Scale 1:700000
UTM Zone 15N
NAD 1983
PALMER ENVIRONMENTAL CONSULTING GROUP INC.
CLIENT: Ambershaw Metallics Inc.
PROJECT: AMI Bending Lake AEP
Project Location
FIGURE 1-1
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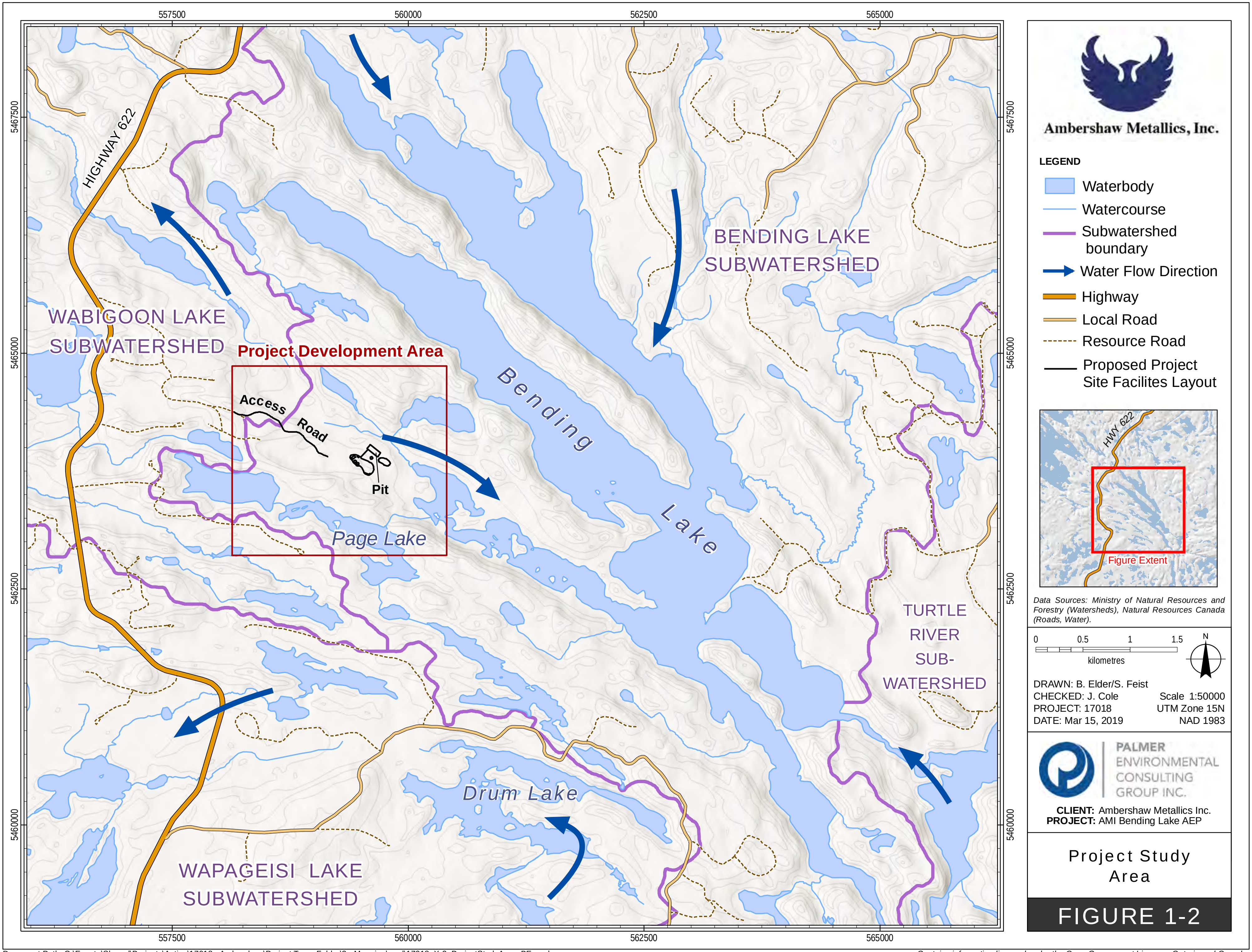

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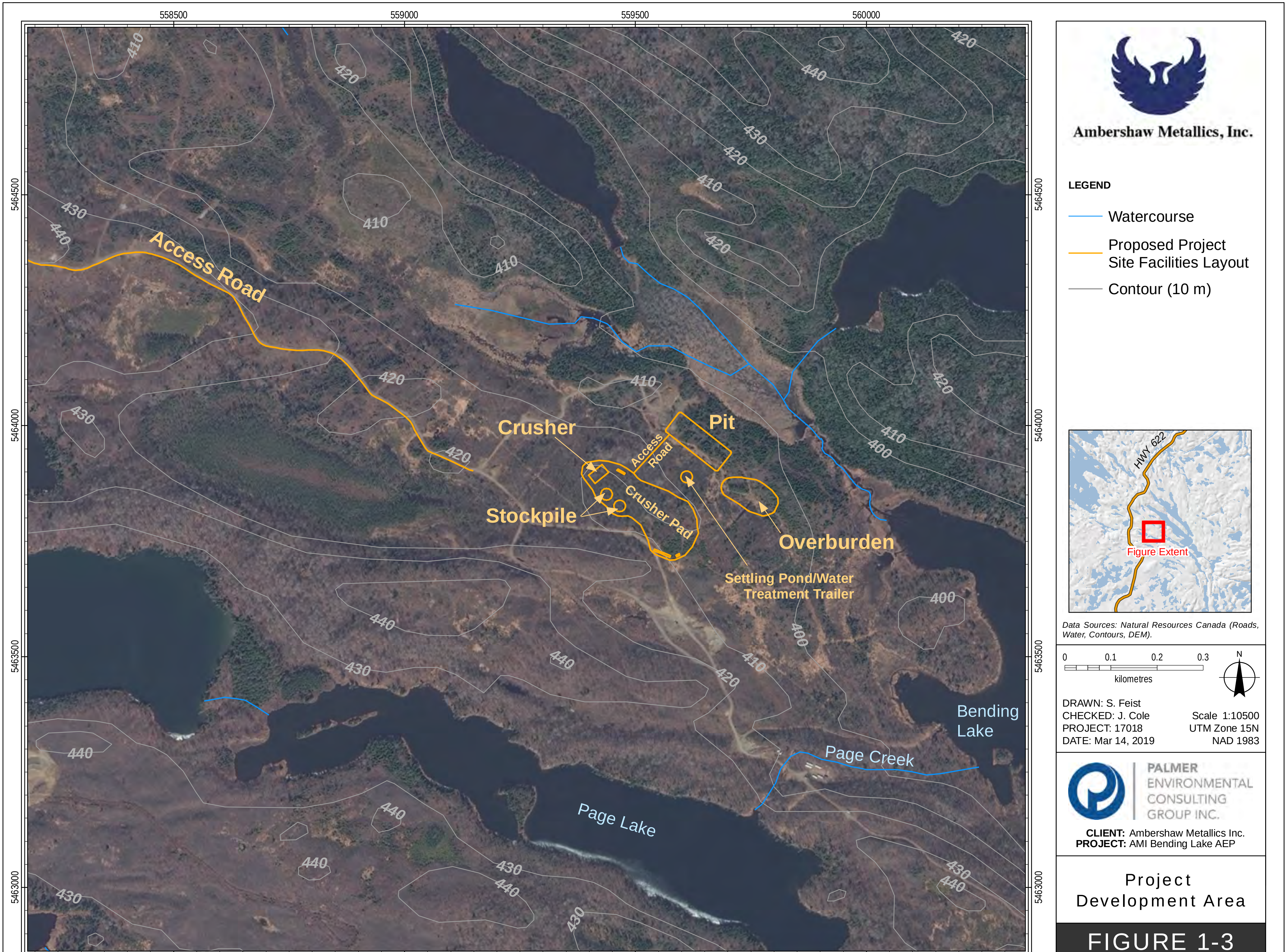

Project Development Area

FIGURE 1-3

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2 HYDROLOGY BASELINE PROGRAM OVERVIEW

2.1 Project Objective

This report presents methods and results of baseline hydrology studies in support of the Advanced Exploration (AE) permit for the Project. PECG and TBE Engineering were responsible for all the recent sampling activities and establishment of the new hydrology monitoring stations discussed in this report. The primary objective of the baseline hydrology study was to establish a monitoring network to characterize the hydrological conditions of the vicinity of the Bending Lake Advanced Exploration Project. The network and study design focused on the Bending Lake Watershed and the small watercourses within the Project Development Area.

The baseline information gathered will be used to provide hydrology inputs for use in a future predictive water balance model used to estimate potential changes to water quantity and quality resulting from mining activities. Given the stage of the project, this level of detail is not required for this submission, but establishment of the existing hydrological conditions and the capture of a long-term surface water dataset will provide valuable input for later permitting and design stages of the Project.

2.2 Scope of Work

This report focuses on summarizing the results of the 2017-2018 hydrometric monitoring program completed by PECG. This work was conducted in May 2017, November 2017 and May 2018 and included identifying and installing five (5) continuous hydrometric monitoring stations that include 3 standard monitoring stations and 2 lake level gauges. All stations were selected following a review of the latest available project footprint, historical data collection locations, regional data availability, and in collaboration with water quality sampling stations.

The report includes the following information on the hydrology baseline program:

- Instrumentation of hydrology stations within the Bending Land and surrounding subwatersheds;
- Hydrology station descriptions and monitoring data;
- Manual streamflow and stage measurements;
- Discharge rating curves;
- 2017-18 water level hydrographs; and
- Unit yield analysis for the identified subcatchments.

2.3 Temporal Boundaries

The Bending Lake watershed has been studied in the past, with various monitoring programs taking place within the Project area in 1978 and 2011. These works include the 1977 Environmental Assessment completed by Beak Consultants Limited for the Bending Lake Project, prepared for Steep Rock Iron Mines Limited in Atikokan, Ontario (Capper, 1978), and the 2011 preliminary technical report prepared by

Fladgate Exploration Consulting Corporation for Bending Lake Iron Group Limited (Fladgate Exploration, 2011).

Hydrometric data specific to the development proposed by AMI and used in this baseline assessment were collected between 2011 to 2012 by DST Consulting Engineers Ltd (DST) and in 2017 to 2018 by PECG.

2.4 Spatial Boundaries

The extent of the spatial boundaries for the Hydrology Baseline Study for the Project include the following areas:

> Project Study Area – The Project Study Area boundaries have been delineated to coincide with mapped watershed boundaries of the Bending Lake, Wabigoon Lake, Wapageisi Lake and Turtle River subwatersheds as shown on **Figure 1-2**. Discipline specific investigations may extend outside of the area shown on **Figure 1-2**, but are fully contained with the mapped subwatershed boundaries.
>
> Project Development Area – The Project Development Area boundary encompasses the area immediately affected by the proposed Advanced Exploration Project site facilities as shown on **Figure 1-3**.

2.5 Description of Project Study Area

The topography of the project area is consistent between the Bending Lake, Wabigoon Lake, Wapageisi Lake and Turtle River subwatersheds within the Project Study Area and the physical hydrological and climatic properties of each are expected to be generally similar, even though the drainage areas for the subwatersheds varies significantly. An overview of subwatershed elevations and drainage areas is included in **Table 2-1.**

The Wabigoon Lake subwatershed is much larger than the other subwatersheds that make up the majority of the project area though is not expected to vary climatically and even hydrologically; however, sections of the watershed that are included in the baseline study are small and expected to retain the same physical properties as the Wabigoon and Bending Lake watersheds. The physical properties of Bending Lake in the Bending Lake watershed are assumed to apply to Beak Lake within the Wapageisi Lake subwatersheds.

Creek and river flows are generally low through the winter months (between November and April) with increased flows from early May to July. Spring freshet generally happens in late May and June and is characterized by higher runoffs contributing to creek flow. Precipitation is often highest in the summer months (June-July), causing a period where creek flow is predominantly recharged by surface runoff, while groundwater recharge is expected to be the main source of surface water baseflow in the winter months (December through April).

2.5.1 Bending Lake Subwatershed

The Bending Lake mainstem length is approximately 28 km and encompasses an area of approximately 325 km^2. Bending Lake is the receiving basin for streams and creeks in the northern reaches of the watershed. The tributaries to Bending Lake include Bending Creek to the north and smaller tributaries connecting Page Lake and West Hawk Lake to Bending Lake along with various other smaller creeks. The Turtle River flows into the southeast part of Bending Lake, flows through the lake, and then drains Bending Lake to the southwest, eventually draining into Rainy Lake (Beak, 1977).

2.5.2 Wabigoon Lake Subwatershed

The Wabigoon lake mainstem length is approximately 48 km and encompasses an area of approximately 4,336 km^2. Stormy Lake, within the Wabigoon Lake watershed is the closest major water body in proximity to the Project within the watershed. Tributaries from the east flowing to Stormy Lake are mainly unnamed and interconnect small lakes and marshlands along the gradient from the border of the watershed to Bending Lake watershed divide. Stormy Lake drains to the north through the adjoining Long Lake and further drains in the Wabigoon River East.

2.5.3 Wapageisi Lake Watershed

The Wapageisi Lake watershed mainstem length is approximately 16 km and encompasses an area of approximately 529 km^2. Beak Lake, within the Wapageisi River watershed is the closest major water body in proximity to the project within the watershed. Other notable lakes within the watershed include Drum lake, approximately 2 km from Bending Lake and to the south and east are Osprey Lake and Sandbar Lake. These smaller lakes are found higher in the watershed and gradually drain via marshlands and streams to Beak Lake to the southwest. Beak Lake and Wapageisi Lake are the major waterbodies within the watershed and both drain southwards and join before entering the Turtle River.

2.5.4 Turtle River-White Otter Watershed

The Turtle River watershed has a mainstem length of approximately 35 km and encompasses an area of approximately 1,238 km^2. The watershed is located to the east of the Bending Lake watershed and is the headwaters of Turtle River-White Otter Provincial Park. The watershed is mostly protected from human activity as accessibility to the region is limited. The watershed has a vast amount of small to medium sized lakes interconnected by slow flowing streams and marshlands. The watershed drains to the south west via the Turtle River.

Table 2-1. Local study area watershed details

Subwatershed	Drainage Area (km^2)	Minimum Elevation (m ASL)	Maximum Elevation (m ASL)	Mean Elevation (m ASL)
Wabigoon Lake	4,336	365	502	419
Wapageisi Lake	529	380	491	419
Turtle River	1,238	394	531	444
Bending Lake	325	394	494	429

3 PHYSICAL SETTING

3.1 Geology and Physiography

The Ambershaw Project site is located within the Severn Upland physiographic subdivision of the James Region of the Canadian Shield (Beak, 1977). The Severn Upland primarily consists of Precambrian bedrock, with a shallow cover of Quaternary glacial deposits. Where present, the overburden comprises lacustrine clays or peat, the Sipiwesk moraine, and several esker chains. The topography of the region is generally described as undulating to gently rolling.

The Project Development Site lies adjacent to the southwestern most arm of Bending Lake. Despite the occurrence of a southwesterly moving glacial ice sheet, the topography at the property consists of a northwesterly trending, sub-parallel series of glacially sculpted ridges and topographic depressions, controlled by underlying geology. A steep escarpment is present trending northwestwards along the southwest shore of Bending Lake, and through the center of the Project site (Fladgate Exploration, 2011).

The Quaternary geology in the Project Study Area mostly comprises different types of glacial deposits which accumulated over the course of several glacial advances and retreats during the Late Wisconsinan. Much of the older till and glaciolacustrine deposits are uncommon, as they have been removed by subsequent glacial advances.

In the Project Development Area, the surficial geology is primarily exposed bedrock, with minor amounts of heterogenous drift sediments. Most Quaternary deposits in the area, including glaciofluvial outwash deposits, glaciofluvial ice-contact deposits of gravel and sand, and glaciolacustrine deposits of till, are located north of the TransCanada Highway. This was confirmed during the 2008 and 2011 borehole drilling investigations by Bending Lake Iron Group, and the 2017 borehole drilling investigation by PECG as part of the Hydrogeology Baseline program, where the thickness of the overburden was found to range between 0.38 m to 9.0 m. Where present, overburden units were associated with glaciofluvial or glaciolacustrine deposits of sand, clay and gravels. A thick unit of fine to medium sand and silt with some gravel was encountered southeast of the proposed pit along the southern shoreline of Bending Lake. It is anticipated that alluvial deposits of sand, silt, and clay are present near watercourses, and that low-lying wetlands are lined with deposits of organics and peat. The thickness of these deposits is expected to be highly variable.

As a result of the geology, the region is scattered with bedrock bound small to medium sized lakes. Many of the lakes are controlled by bedrock-controlled networks of streams and drainageways. Bedrock outcrops are common, and the lowlands are poorly drained peat dominated wetlands (Wiken *et al.*, 1989). The watersheds within the project area are part of the English and Winnipeg subsystems of the Nelson system, and eventually flow into Hudson Bay (Beak, 1977).

3.2 Climatology

The project is located in the Boreal Shield ecozone and more specifically the Thunder Bay-Quetico ecoregion and extends westward from Thunder Bay to Sioux Lookout and Rainy Lake in northwestern Ontario. The ecoregion is classified as having low boreal eco-climate. It is marked by warm summers and cold winters. The mean annual temperature is approximately 2°C to 3°C with mean daily maximum temperatures in the study area ranging from -10°C in January to 23°C in July, and mean daily minimum temperatures ranging from around -20°C in January to 13 in July (RWDI, 2017). The annual rainfall in the area is in the range of 500 to 600 mm, with the highest rainfall occurring in June and July (over 100 mm per month). The area receives between 100 and 200 cm of snowfall annually, which is evenly distributed throughout the winter months (November through March) (RWDI, 2017).

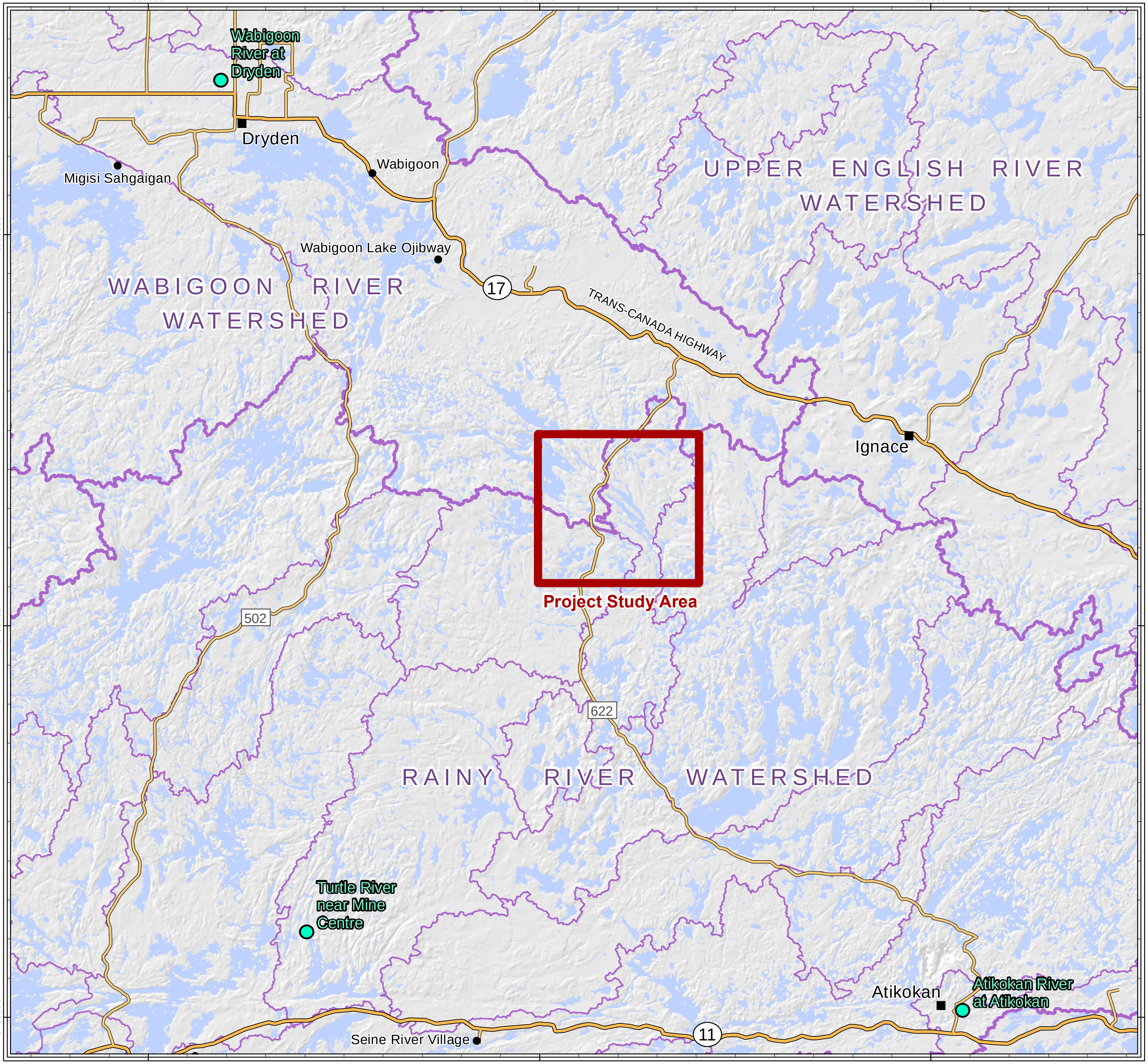
3.3 Regional Hydrology

Long-term hydrological records have not been established within or near the Project Study Area (PSA). As such, three (3) Water Survey of Canada (WSC) gauges within the Rainy River and Wabigoon River watersheds were examined to provide insights into hydrological processes near the PSA: Atikokan River at Atikokan, ON, Wabigoon River at Dryden, and Turtle River near Mine Centre (**Figure 3-1**). A summary of these stations in provided on (**Table 3-1**).

The hydrological regime of the project region is snow-melt dominated and the mean discharge from these stations is compiled from roughly 40 years of long-term stage and discharge monitoring. As such, all three WSC stations are characterized by high flows in the late spring due to snow melt (i.e. freshet) and low flows during the winter months (**Figure 3-2**). Flows decrease through the drier summer months, and water levels in the autumn begin to rebound with the onset of fall storms and increased precipitation. The hydrographs of the unregulated gauges during this period are characterized by high flows in July 2017 (summer convective storms), October 2017 (abnormally high precipitation in September), and May 2018 (rising limb of hydrograph). The hydrograph of Wabigoon River is characterized by abrupt shifts in flow due to active regulation at the Wainright Dam.

From 1981 to 2010 the two unregulated stations (Atikokan River and Turtle River) had similar unit yields throughout the year whereas unit yields along the regulated Wabigoon River were generally less than the unregulated gauges (**Figure 3-3**). Between June 1, 2017 and May 31, 2018 (roughly the period of recent hydrometric monitoring near the PSA), unit yields for the unregulated catchments were 7.9 L/s/km^2 (Turtle River) and 10.9 L/s/km^2 (Atikokan River).

It should be noted that the catchment areas of these gauges are significantly larger than catchment areas of the PECG gauges discussed in this report. Only general trend comparisons are made due to the distance between the PSA and the WSC gauges and the differences in catchment areas. The 2018 data for the Wabigoon River gauge was unavailable at the time of report submission. Climate Normals included on **Figure 3-3** are from Environment Canada's 1981-2010 Climate Normals and Averages dataset (Dryden), and precipitation is from the Mine Centre Southwest climate station (climate identifier 6025205).



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Ambershaw Metallics, Inc.

LEGEND

- Major Highway
- Minor Highway
- Watershed Boundary
- Subwatershed Boundary
- WSC Site

Data Sources: Ministry of Natural Resources and Forestry (Watersheds), Natural Resources Canada (Roads, Place Names), Esri basemap service (Imagery).

0 10 20 kilometres

N

DRAWN: B. Elder/S. Feist
CHECKED: J. Cole
PROJECT: 17018
DATE: Feb 15, 2019

Scale 1:700000
UTM Zone 15N
NAD 1983

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

CLIENT: Ambershaw Metallics Inc.
PROJECT: AMI Bending Lake AEP

Water Survey of Canada Gauges

FIGURE 3-1

Table 3-1. WSC Gauge Summary

Parameter	Atikokan River at Atikokan, ON	Wabigoon River at Dryden	Turtle River near Mine Centre
Station ID	05PB018	05QD016	05PB014
Watershed	Rainy River	Wabigoon River	Rainy River
Zone 15 U Easting (m)	604090	509289	520276
Zone 15 U Northing (m)	5400848	5519645	5410818
Catchment Area (km^2)	358	2340	4770
Period of Record	1978-2018	1905-2018	1914-2018
Regulated?	No	Yes	No
Mean Annual Discharge 1981 – 2010 (m^3/s)	2.9	15.4	41.4
Mean Annual Unit Discharge 1981 – 2010 (L/s/km^2)	8.1	6.6	8.7
Minimum Monthly Discharge on Record (m^3/s)	0.012 (Sept. 1998)	1.1 (Dec. 2002)	2.3 (Feb. 1918)
Minimum Monthly Discharge on Record (m^3/s)	15.6 (Jun. 2014)	97.3 (Jan. 1987)	242.0 (Jun. 2002)
Mean Discharge - June 1, 2017 to June 1, 2018 (m^3/s)	3.9	-	37.8
Mean Unit Discharge - June 1, 2017 to June 1, 2018 (L/s/km^2)	10.9	-	7.9

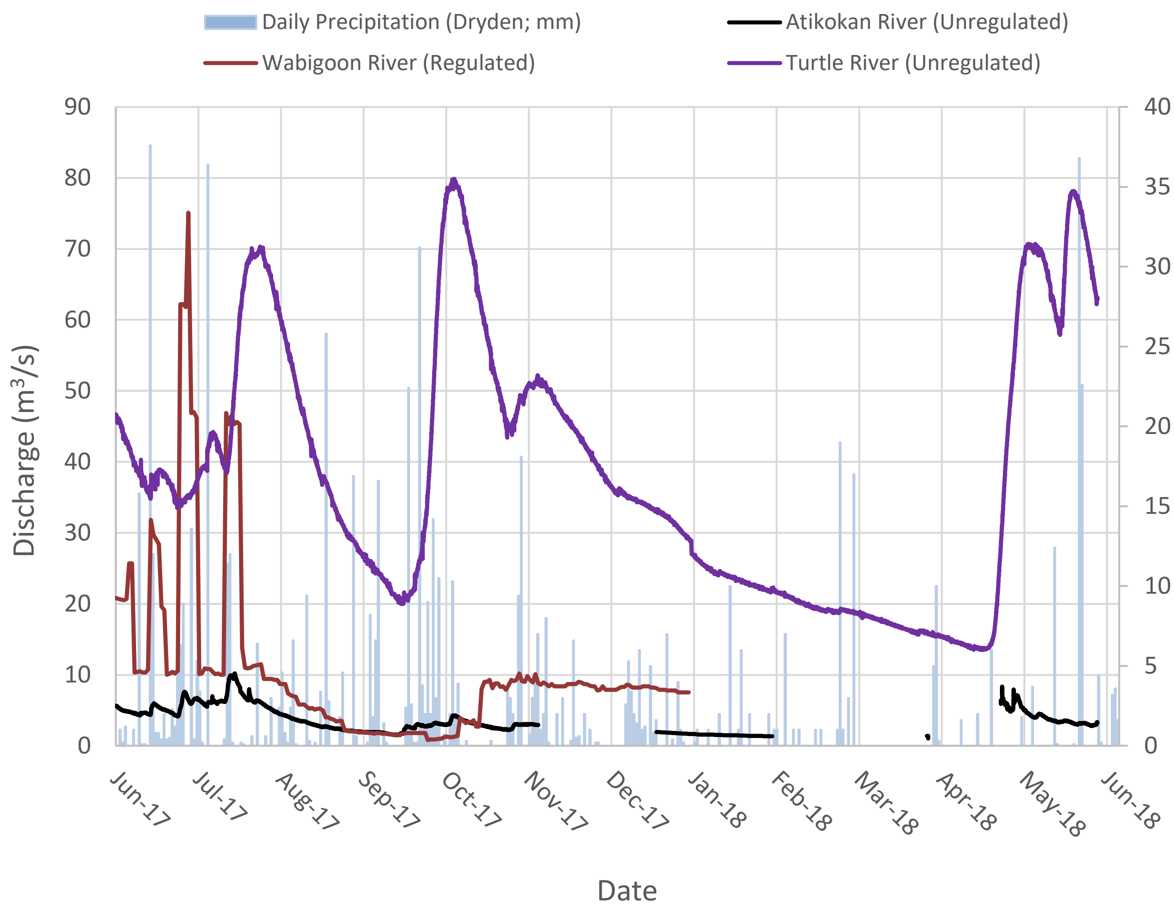


Figure 3-2. Daily discharge for WSC gauges from June 1, 2017 to May 31, 2018

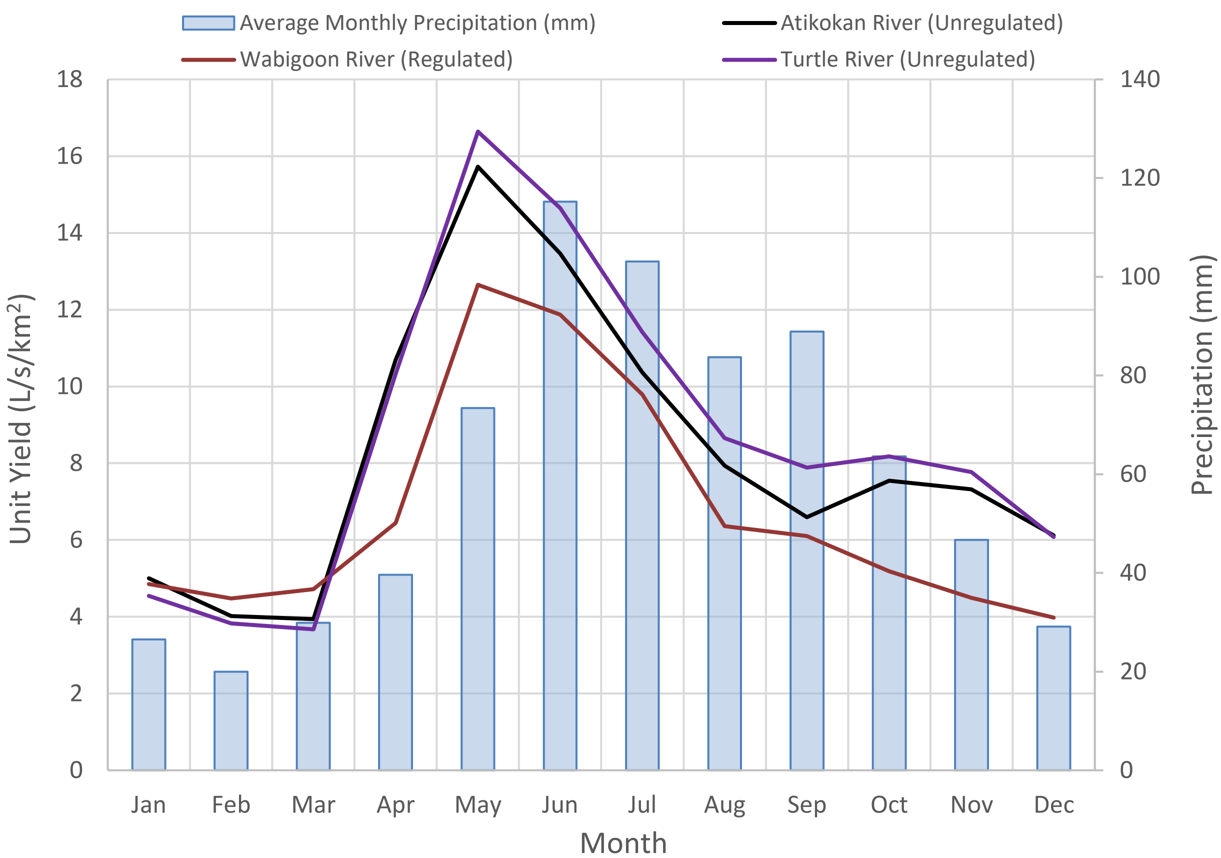


Figure 3-3. Daily unit yield for WSC gauges from June 1, 2017 to May 31, 2018

4 METHODOLOGY

4.1 Hydrometric Monitoring

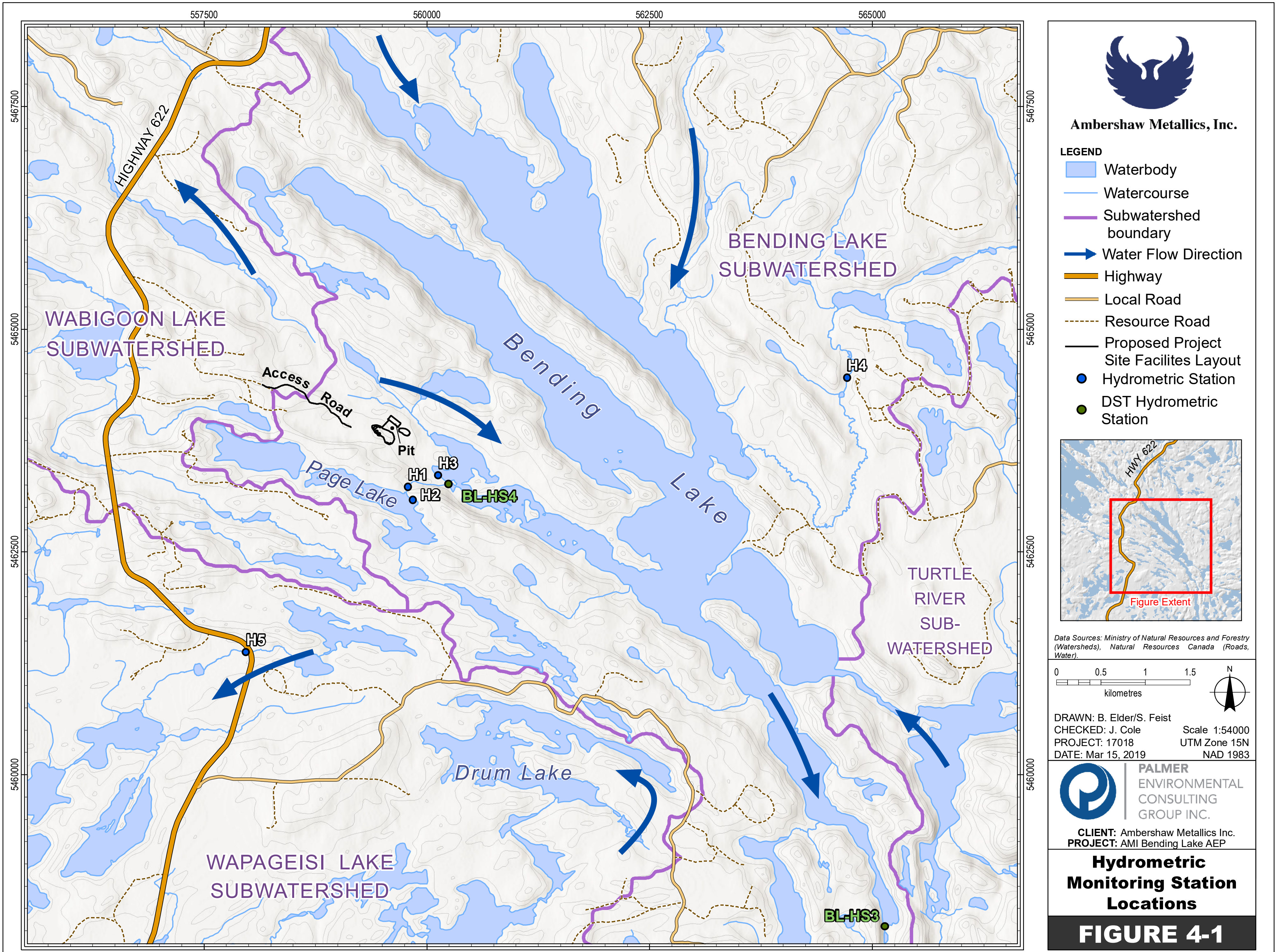
Hydrometric monitoring activities were reinitiated in May 2017 to collect additional hydrology data to build upon the data previously collected by DST. Best practices typical for mining projects in Ontario were used for the installation of hydrology stations and the collection of manual and continuous stream flow data. As an additional quality control practice the results were compared against British Columbia Ministry of the Environment (BC MOE) hydrology station installation and measurement standards, as they are the most robust in Canada and will help ensure that a high-quality data set is collected that can be relied upon for future monitoring and permitting activities. Best efforts were made to meet the criteria required to collected high quality steam flow and level measurements over multi-year periods: (1) annually-calibrated equipment was used to record water levels within 2 mm; (2) sites with stable channel conditions were selected; (3) a minimum of three benchmarks were installed at each station; (4) a minimum of five flow measurements were conducted per year, and (5) discharge measurements were performed with an accuracy rating of less than 10% (BC MOE, 2012).

Conditions for hydrometric monitoring in the project area were difficult; with shallow streams and creeks located in low lands with minor elevation changes. Under these conditions, where stream flows are generally low it was often challenging to obtain accurate discharge measurements. The combinations of these factors posed unique challenges for this hydrometric monitoring program. Detailed reconnaissance was conducted on catchments of interest, and stations were selected that were expected to provide good quality hydrometric records.

The baseline study included the installation of three (3) hydrometric stream monitoring stations and two (2) lake gauging stations. These data were collected to supplement and build upon the hydrology data collected by DST between 2011 and 2012 within the PSA. The hydrometric program included continuous and non-continuous monitoring of water levels and, when possible, quarterly flow measurements at each stream gauging station. Flow measurements, water stage height, logger data downloads and instrumentation inspections were conducted in May, June and October 2017, and May 2018.

4.1.1 Project Hydrometric Monitoring Stations

Hydrometric stations locations within the Project Study Area are shown on **Figure 4-1**, and details on each station provided in **Table 4-1.** All five hydrometric monitoring stations were located within the Bending Lake and Wapageisi Lake watersheds, the main drainage basins of the Project Study Area. Hydrometric stations were installed to allow for accurate water level readings and discharge measurements at all stages where control was stable. Required station characteristics included straight banks where there was a single channel with stable laminar flows and minimal backflow effects. Station locations were influenced by accessibility and safety considerations.



Hydrometric Monitoring Station Locations

FIGURE 4-1

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Table 4-1. Summary of active site hydrometric stations and barometric stations.

Station Name	Waterbody/ Watercourse	Sub-watershed	Station Coordinates (Zone 15 U)		Elevation (m ASL)	Approximate Catchment Area (km^2)	Period of Record	Logging Interval (min)	Instrument	Description/Rationale
			Easting	Northing						
H1	Page Lake Outlet Channel (Page Creek)	Bending Lake	559806 m E	5463254 m N	417	3.9	May 30, 2017 – May 26, 2018	10	Solinst Levelogger Edge	Records water levels in channel draining Page Lake into Bending Lake
H2	Page Lake	Bending Lake	559866 m E	5463076 m N	427	3.9	May 30, 2017 – May 26, 2018	10	Solinst Levelogger Edge	Records water levels in Page Lake
H3	Bending Lake	Bending Lake	560223 m E	5463595 m N	397	147.4	May 30, 2017 – May 26, 2018	-	Staff Gauge	Records water level in Bending Lake
H4	Unnamed Tributary of Bending Lake	Bending Lake	564734 m E	5464474 m N	410	19.8	May 31, 2017 – May 26, 2018	10	Solinst Levelogger Edge	Records water levels in an unnamed tributary draining into Bending Lake from the north
H5	Unnamed Tributary of Beak Lake	Wapageisi Lake	557977 m E	5461383 m N	419	2.0	August 10, 2017 – May 27, 2018	15	Solinst Levelogger Edge	Records water levels in an unnamed tributary draining into Beak Lake
H2-B	-	Bending Lake	559866 m E	5463076 m N	427	-	May 30, 2017 – March 4, 2018	10	Solinst Barologger Edge	Barometric pressure sensor installed at Page Lake (H2) water level gauge

Four of the stations (H1, H2, H3, and H4) were established in May 2017 (shown on **Figure 4-1**). In June 2017, a secondary reconnaissance trip was completed to determine feasibility of H5, located in the Wapageisi Lake watershed. Based off the findings from the June 2017 investigation, the H5 site was confirmed and installed in August 2017. The sites were selected to build an understanding of the hydrologic conditions in Bending Lake which will be important in future water management plans for the site. A barometric pressure sensor was installed at the Page Lake (H2) water height survey site in May 2017.

Each hydrometric station, with the exception of H3, was instrumented with a Solinst Levelogger Edge to measure water pressure (level) and temperature. The logger was fastened to a schedule 40 PVC pipe which in turn was fastened to 8 cm channel iron anchored in streambed or secured to exposed bedrock. Each logger was installed as deep into the main as possible and the loggers remained static within the PVC housing for the entire open water field season. The pressure and temperature loggers were set to record at 10 or 15-minute intervals.

Continuous water levels were recorded through the open water season in 2017, winter 2018 and through a portion of the 2018 spring freshet. Staff gauges were installed at 4 locations (H1, H2, H3, and H5) and due to the dynamic nature and high variability in stage and discharge at H4, no reference gauges (staff gauges) were installed.

All stations were equipped with three permanent benchmarks of known elevation relative to the arbitrary gauge datum. Benchmarks were used so that gauge height could be confirmed and adjusted relative to gauge datum (station datum). These benchmarks were anchor bolts placed into pre-drilled holes in exposed bedrock, boulders and mature tree trunks and were accessible at all water levels. Full benchmark surveys were conducted during most field visits to directly compare the water level to a known stage datum. These surveys were completed using a surveyor's rod and a Nikon AX-2s automatic level. All level notes were recorded, and water levels were calculated in the field to confirm accuracy and precision prior to leaving the site. **Table 4-2** below summarizes all site visits to the hydrometric stations since May 2017.

Table 4-2. Summary of site visits to Ambershaw hydrometric stations

	Summary of Site Visits to Ambershaw Hydrometric Stations					
Station Name	**May-17**	**Jun-17**	**Aug-17**	**Oct-17**	**May-18**	**NOTES**
H1	X	X		X	X	Page Lake outlet (Page Creek) monitoring site
H2	X	X		X	X	Page Lake gauge
H3	X	X		X	X	Bending Lake gauge
H4	X	X		X	X	Bending Lake tributary gauge
H5			X	X	X	Wapageisi Lake tributary gauge south of project site
H2-B	X	X		X	X	Barometric pressure sensor

4.1.2 Discharge Measurements

Discharge measurements were taken quarterly between May and October 2017, and in May 2018. Sampling frequency was established to capture a wide range of discharges and stages throughout the year. Streams were safe to wade, and all flow conditions and current velocity measurement were obtained with a SonTek- FlowTracker2. Current velocities were measured using a high-resolution acoustic

Doppler velocimeter with a fixed sampling interval of 20 seconds. This meter's range was 0.001 m/s – 4.0 m/s with a minimum water depth of 0.02 m. Its accuracy was ±1% of measured velocity of 0.0025 m/s to 4 m/s. The area-velocity method was used to calculate the mean discharge using the velocity and cross-sectional area of the stream.

Ideally, 20 measurements of stream depth and velocity were taken at selected intervals across the stream. Due to the small size of many of the streams, the best practice was to ensure that each subsection between measurement stations was at least 10 cm in width, so fewer than 20 measurements were taken in the smaller stream sections (H1 and H5), where wetted widths less than 2.0 m could occur at low-flow conditions. When less than 20 measurements were taken, attempts were made to ensure that no single measurement accounted for more than 10% of the total discharge. In these small streams, distances between measurements points were typically less because water depth and velocity near the wetted edges changed significantly due to the streambed features. To avoid erroneous values near the wetted edges, the measurement points were taken near areas of change in the streambed profile.

The measurements of velocity and using the flow meter followed the Manual of British Columbia Hydrometric Standards prepared by the Ministry of Environment, Science and Information Branch for the Resource Information Standards Committee (BC MOE, 2009). A top set wading rod was used to determine stream depth at each measurement point so average velocity could be measured. Velocity measurements were taken with the sensor positioned at 0.6 of the water depth (from the water's surface).

The quality of the velocity measurements was improved by selecting the correct measurement cross-sections, where flow direction at each measurement point was parallel to the bank and perpendicular to the cross-section. The channel was also required to isolate all flow and if side channels were observed, the cross-section was relocated.

4.1.3 Data Management and Quality Assurance/Control

As no hydrology QA/QC standards exist in Ontario, the Resource Information Standards Committee (RISC) hydrometric standards and methods outlined in the Manual of British Columbia Hydrometric Standards prepared by the Ministry of Environment, Science and Information Branch for the Resource Information Standards Committee (BC MOE, 2009) were used throughout the hydrometric monitoring program. This manual outlines Data Grades and the give criteria used to define the grade. The five grades include: Grade A National Standard, Grade B Provincial Standard, Grade C Manually-Operated Sites, Grade E Estimate, and Grade U Unknown. The data grades are assigned to instrumentation, stream channel conditions, field procedures, and data calculations and assessment. The goal of the baseline monitoring station installs was to achieve the highest quality grade while balancing budget and time constraints.

For the instrumentation criteria, the Grade A standard can be assigned to all sensors, data loggers, levels and current meters were calibrated according to the manufacturer's instruction prior to each site visit. The Solinst Levelogger Edge pressure sensor had an accuracy rating of 0.05% of the data range, which, for the observed water levels, was well below the maximum 22 mm standard for Grade A stage data.

Stream channel conditions criteria met the Grade C for H1 and H5 due to in-channel vegetation, significant boulders and prevalence of backflow effects. The H4 monitoring site achieved Grade B, with minor hydraulic problems related to boulders and backflow effects. It is not expected that any hydrometric station will experience changes in bedload due to erosion and thus the rating curve will be unaffected.

Field procedures followed the Grade A, RISC standards in some areas, such as a minimum of three benchmarks and 20 or more vertical sections in manual flow measurements when using a current meter if stream wetted width is greater than 2.0 m. However, some verticals were more than 10% of total discharge, particularly in stations where the wetted width was less than 2.0 m. These gauges merited a Grade B standard. Additionally, only 3 site visits were conducted in 2017; therefore, they only met the Grade B standard, which requires 5 or more site visits in a year prior to the rating curve being stabilized.

The data were used to develop site-specific preliminary rating curves where possible with the data provided and hydrographs were compared against regional stations to further verify the curve and hydrological trends. If any anomalies were identified, the field crew and senior hydrologist met to discuss, assess and determine appropriate ways to address any shortcomings with field-level solutions.

4.2 Historical Data

Various monitoring programs have taken place within the Project Study Area between 1978 to 2011. Hydrometric monitoring data specific to the development proposed by AMI and comparable to the 2017-18 data in this baseline assessment were collected between 2011 to 2012 by DST Consulting Engineers. DST sites that were selected to be included in this report reflect PECG's confidence in interpretation of the historic data. There are two DST sites within the PSA that are considered in this report; BL-HS4 on Bending Lake by the outlet of Page Creek, and BL-HS3 at the outlet of Bending Lake (**Figure 4-1**). The stations cover the period from April/May 2011 to April 2012, including both logger data and manual measurements (**Figure 4-2**). The logger data for both BL-HS3 and BL-HS4 was impacted by ice cover over the winter of 2012, so data past December 2012 is erroneous and not included in the water level hydrograph. A manual measurement for the Bending Lake (BL-HS4) water level in April 2012 gives an approximation of early spring water levels in Bending Lake.

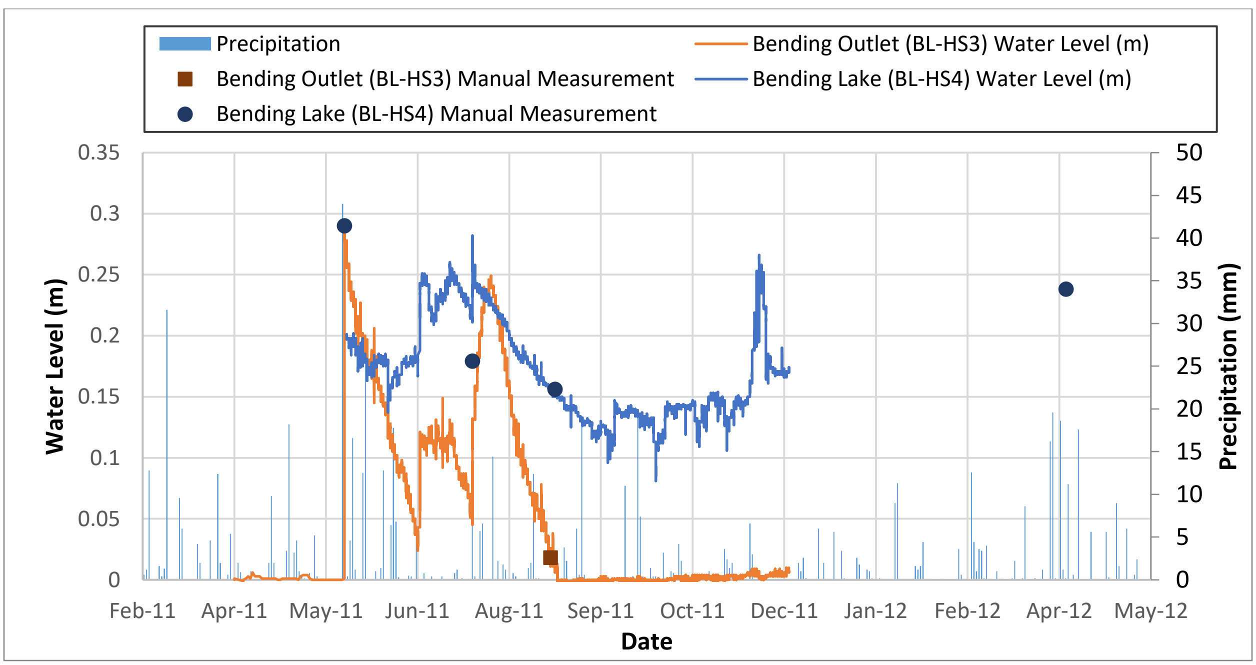

Figure 4-2 DST Bending Lake hydrometric monitoring stations

Despite the truncated dataset, the logger data indicates typical spring freshet occurrence of high water levels mid-end of May 2011 at BL-HS3. The water levels at BL-HS3 before mid-May 2011 and after early September 2011 are at or near zero. Since BL-HS3 is recording water levels at the outlet to Bending Lake, it can therefore be implied that the outlet to Bending Lake only flows between May and September, overtopping during the spring freshet, and stopping after water levels decrease over the summer. Otherwise, the lake is either frozen (winter) or not spilling out of its basin. The BL-HS4 gauge is nearby PECG's H3 gauge, and therefore can be compared to lake levels recorded during the 2017-2018 monitoring.

5 SITE HYDROLOGY

5.1 Station H1

Hydrometric station H1 is located on Page Creek (**Figure 4-1**). Page Creek drains from Page Lake to Bending Lake to the northeast over a stretch of approximately 500 m. The station was monitored between May 2017-May 2018. **Photo 5-1** and **Photo 5-2** show upstream and downstream views of the stream, respectively, at the gauging station.

The stream at H1 is contained within a low gradient channel section with low vegetative cover. At the hydrometric station, the channel is approximately 1.5 m wide. The staff gauge and pressure transducer PVC pipe are attached to an 8-cm wide steel channel iron embedded in the channel. The levelogger is suspended within the PVC and protected from dynamic movements by the perforated PVC. The substrate consists of sands, gravels and boulders. The stream flow is confined for most of the 500 m reach with braided segments of the stream to the north of H1 and near the northern outlet to Bending Lake. The stream has been modified with the addition of a culvert beneath Bending Lake Road 10 m to the north of H1, and the northern terminus of the stream towards Bending Lake has been altered due construction of a boat launch near Bending Lake.

Photo 5-1. H1 Hydrometric Station – upstream

Photo 5-2. H1 Hydrometric Station – downstream

5.1.1 Water Level Elevation

Recorded and manually surveyed water levels for the monitoring period are shown on **Figure 5-1**. Instantaneous water levels were matched to the initial stage reading and a benchmark survey was used to confirm that manual measurements match the local datum. The water level elevation does not represent true elevation above sea level. The peak water level elevations were recorded on July 13th, 2017 at a level of 0.374 m and January 30, 2018 at 0.398 m, while the lowest water levels were recorded on September 8, 2017 at 0.105 m and October 18, 2017 at 0.114 m. Page Creek is sensitive to precipitation events and quickly responds to periods of high precipitation and gradually dissipates. The creek levels trended downwards throughout the summer months as days warmed and precipitation decreased. Water levels increased during early autumn, coinciding with more precipitation events, less evapotranspiration, and decreased temperatures, before dropping mid-autumn due to less precipitation. Water levels increased over the late fall and remained higher through the winter months, likely as a result of freezing effects due to dropping temperatures starting in late October 2017.

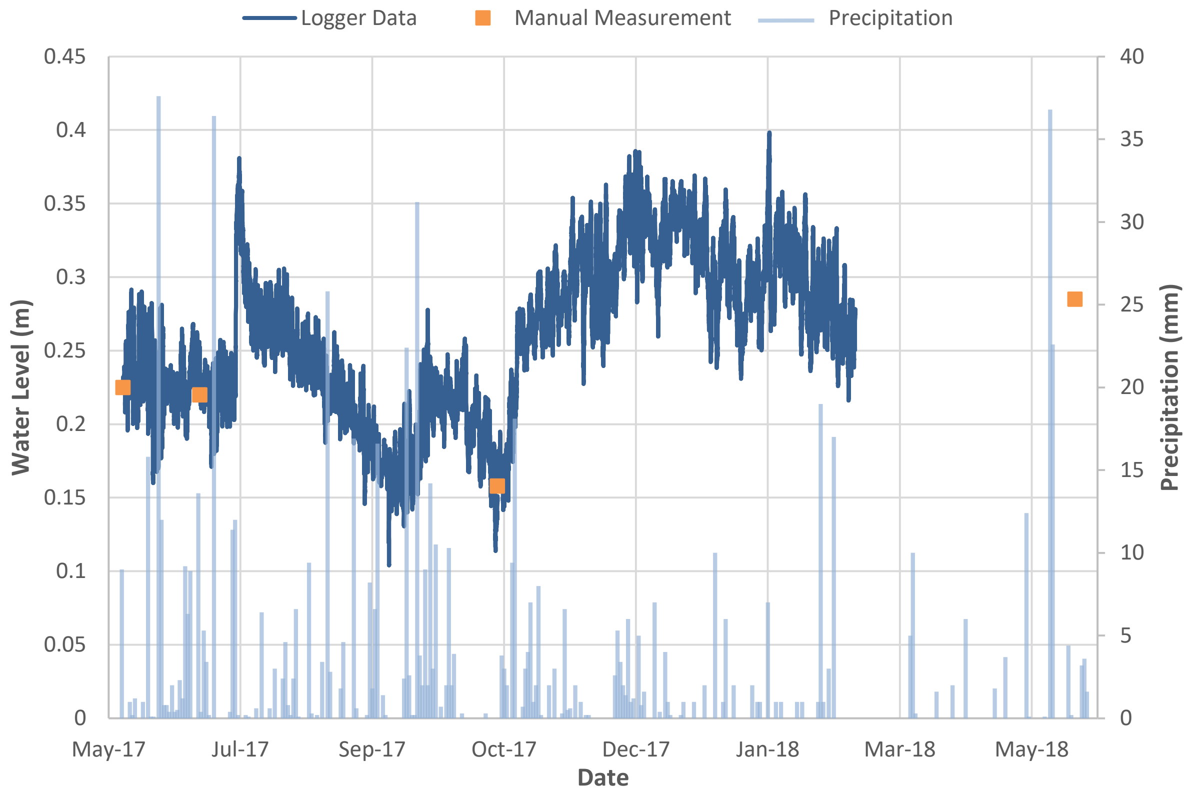

Figure 5-1. Water level elevations for station H1

5.1.2 Stage-Discharge Relationship

Discharge measurements were taken at this station during each of the four site visits between May 2017 and May 2018. Discharge measurements were typically taken on a straight, shallow section of the stream upstream from the hydrometric station. The measurements are summarized in **Table 5-1.** The average manual water level observed was 0.223 m, with an average manual discharge of 0.027 m^3/s.

Table 5-1. Summary of discharge measurements at H1

Measurement #	Date	Surveyed Water Level (m) *	Average Measured Discharge (m^3/s) **	Unit Yield ($L/s/km^2$)
1	May 30, 2017	0.23	0.015	3.77
2	June 27, 2017	0.22	0.047	12.03
3	October 19, 2017	0.16	0.002^E	- ^{E}
4	May 26, 2018	0.29	0.045	11.46

NOTE:
Surveyed water levels are referenced to an assumed benchmark elevation datum of 1.0 m
*   average of two measurements taken during the same site visit
** average of two transects taken during the same site visit
E – discharge was estimated. Unit yield is not calculated for estimated discharge values.

A stage-discharge relationship was developed for H1, however due to the limited record of discharge and stage measurements within periods of high and low flow can only be considered preliminary. The preliminary stage-discharge relationship is provided in **Figure 5-2**. Additional long-term stage and discharge hydrometric monitoring is required to continue to develop a more representative stage-discharge relationship at H1 for all flow conditions.

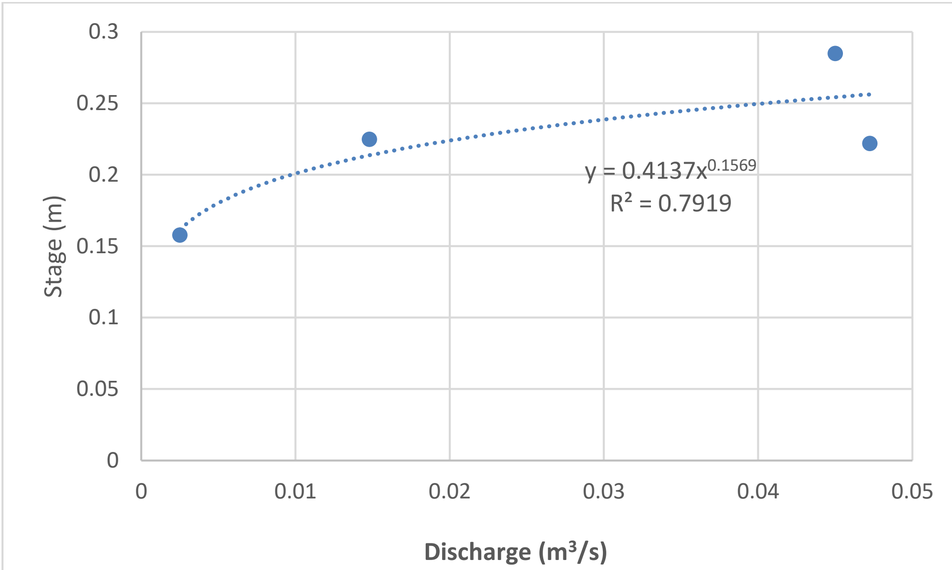

Figure 5-2. Stage-discharge relationship for station H1

The preliminary stage-discharge relationship was used to convert the recorded logger water levels to discharges to create a hydrograph for the period of record available in this report (**Figure 5-3**). The estimated maximum discharge from the dataset is 0.352 m^3/s on July 17, 2018. This appeared to occur after a total rainfall of 23.9 mm the preceding week. The estimated minimum discharge value recorded was 0.0004 m^3/s on September 8, 2017 after a cumulative 76.1 mm of precipitation in August, lower than the expected climate normal of 83.7 mm.

The hydrograph for H1 correlates well with the precipitation record. After decreasing through the summer months, discharge increases starting in early October 2017 after a particularly wet September. There was a total of 141 mm of precipitation recorded in the month of September, 106.2 mm of which fell between September 14th to 30th. This is above the climate normal of 88.9 mm of precipitation expected for the month of September, which explains the large increase in both water levels and discharge in October 2017. Continued high discharge and water level values are likely the effects of colder weather and ice conditions as daily temperatures started to abruptly decrease starting in early November 2017.

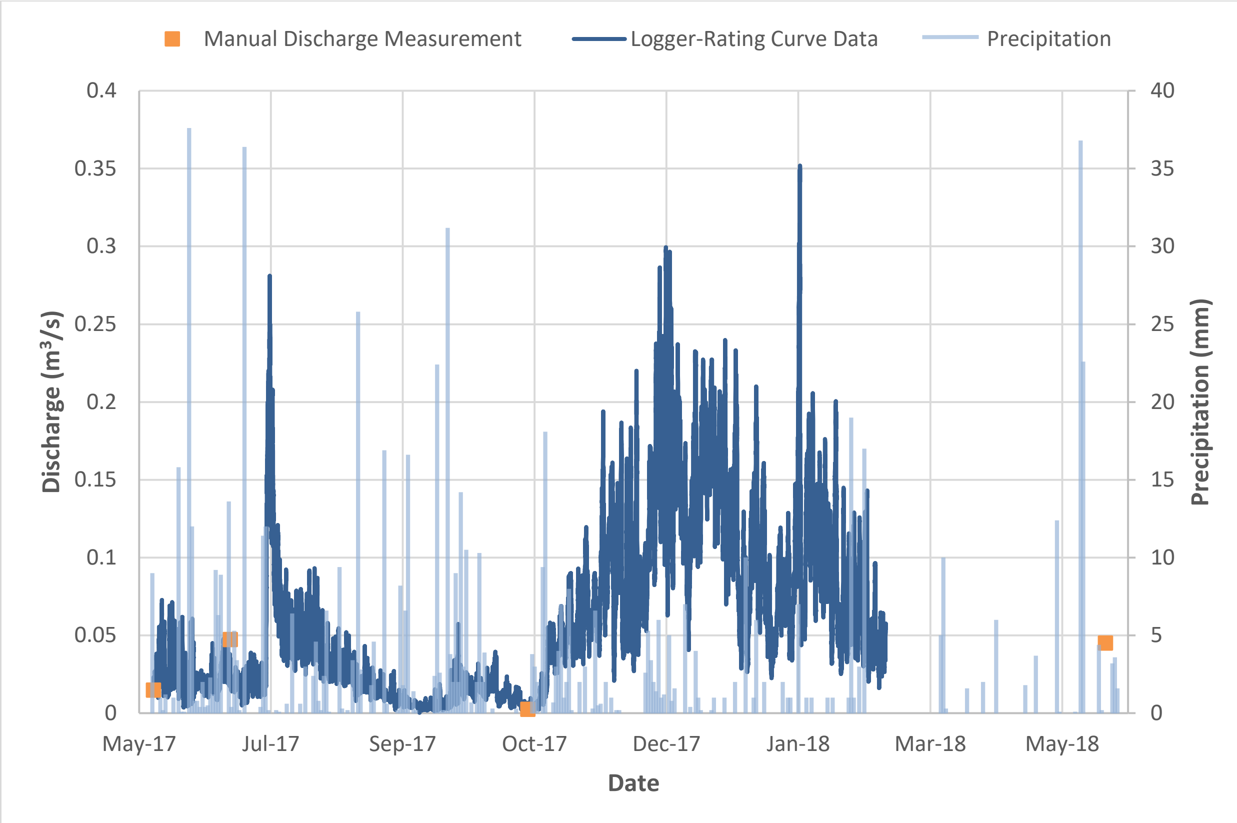

Figure 5-3. Hydrograph for Station H1

5.1.3 Data Limitations and QA/QC

While the channel conditions for H1 fall within the Grade A criteria due to the stable channel, relatively straight reach and minimal weeds and boulders (BC MOE, 2009), due to the width (approx. 1.5 m) and depth of the stream (approx. 0.06 m), obtaining representative discharge measurements was often challenging. The discharge value for October 2017 was estimated rather than measured due to low flow conditions.

The hydrograph was created from the preliminary stage-discharge relationship. The stage-discharge relationship should be considered preliminary due to limited record of discharge and stage measurements.

5.2 Station H2

Hydrometric station H2 is located on shores of Page Lake, approximately 400 m upstream of H1 (**Figure 4-1**). The station has been monitored since May 2017. **Photo 5-3** shows a view of the Page Lake water level gauge. H2 is installed roughly 1 m from the shore of Page Lake at a depth of 0.40 m. The staff gauge and pressure transducer PVC pipe are attached to an 8-cm wide steel channel iron embedded in lake sediments along the shore. The pressure transducer is suspended within the PVC and protect from dynamic movement by the perforated PVC. The lake floor substrate consists of fine sediments and boulders.

Photo 5-3. H2 Lake Hydrometric Station

5.2.1 Water Level Elevation

Recorded and manually surveyed water levels for the monitoring period are shown in **Figure 5-4** for H2**.** Instantaneous water levels were matched to the initial stage reading and a benchmark survey was used to confirm that manual measurements match the local datum. The water level elevation does not represent true elevation above sea level.

Page Lake water levels fluctuated during the monitoring period with the lowest levels recorded on September 14st, 2017 with a level of 0.279 m. The peak lake level of 0.607 m was recorded on November 10th, 2017, approximately 0.3 m above the lowest measured level. The lake level followed similar trends as observed in H1, with levels decreasing during the summer months and rising in the autumn. Lake elevations values are provided in **Table 5-2.**

Table 5-2. Summary of water level elevations at H2

Measurement #	Date	Surveyed Water Level (m) *
1	May 30, 2017	0.53
2	June 27, 2017	0.53
3	October 19, 2017	0.46
4	May 26, 2018	0.39

NOTE:
Surveyed water levels are referenced to an assumed benchmark elevation datum of 1.0 m
* average of two measurements taken during the same site visit

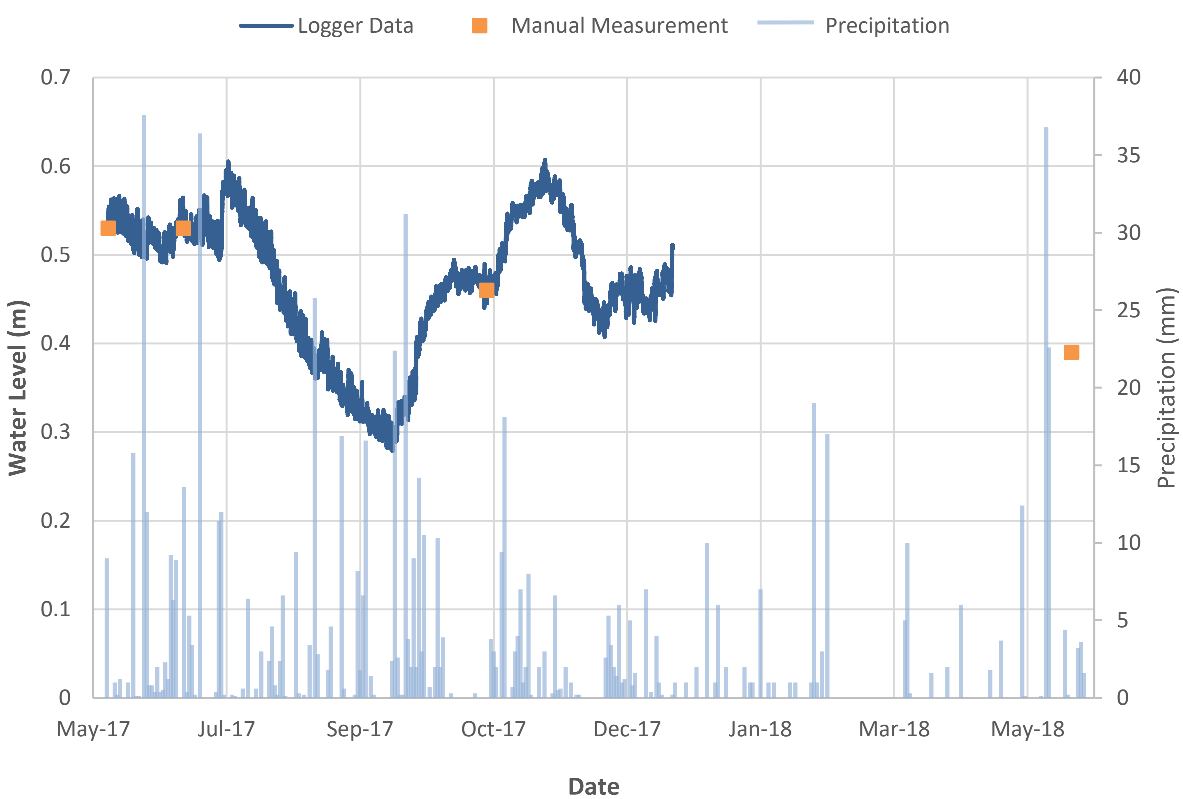

Figure 5-4. Water level elevations for Station H2

The water level for H2 correlates well with the precipitation record. After decreasing through the summer months, the water level increases starting in early October 2017 after a particularly wet September. There was a total of 141 mm of precipitation recorded in the month of September, 106.2 mm of which fell between September 14th to 30th. This is far above the climate normal of 88.9 mm of precipitation expected for the month of September, which explains the large increase in water levels in October 2017. A manual measurement taken on October 19th, 2017 verified these results. A continued increase in water level values into November 2017 are reflective of precipitation through the fall. The lake appears to have frozen near the end of December in 2017, likely later than is typical due to the persistence of warm temperatures during the autumn months.

5.2.2 Data Limitations and QA/QC

Lake levels were confirmed by completed a closed loop benchmark survey. The datalogger installed at the hydrometric monitoring station was calibrated by the manufacturer before deployment. Only 4 manual measurements were collected, and while one of them was during the high fall water levels, none were collected during the peak summer levels in July 2017, or the low September levels.

5.3 Station H3

Hydrometric station H3 is located on the shores of Bending Lake near the outlet of Page Creek, roughly 400 m downstream of H1. The station was monitored between May 2017 and May 2018. **Photo 5-4** shows a view of the Bending Lake water level gauge. H3 is installed roughly 3 m from the shores of Bending Lake at a depth of 0.50 m. The station is equipped with a staff gauge fastened to an 8-cm wide steel channel iron embedded in lake sediments along the shore. The lake floor substrate consists of fine sediments, organics and boulders.

Photo 5-4. H3 Lake Water Elevation Station

5.3.1 Water Level Elevation

Manually surveyed water levels for the monitoring period are shown in **Figure 5-5** for H3**.** Water levels were matched to the initial stage reading and a benchmark survey was used to confirm that manual measurements match the local datum. The water level elevation does not represent true elevation above sea level.

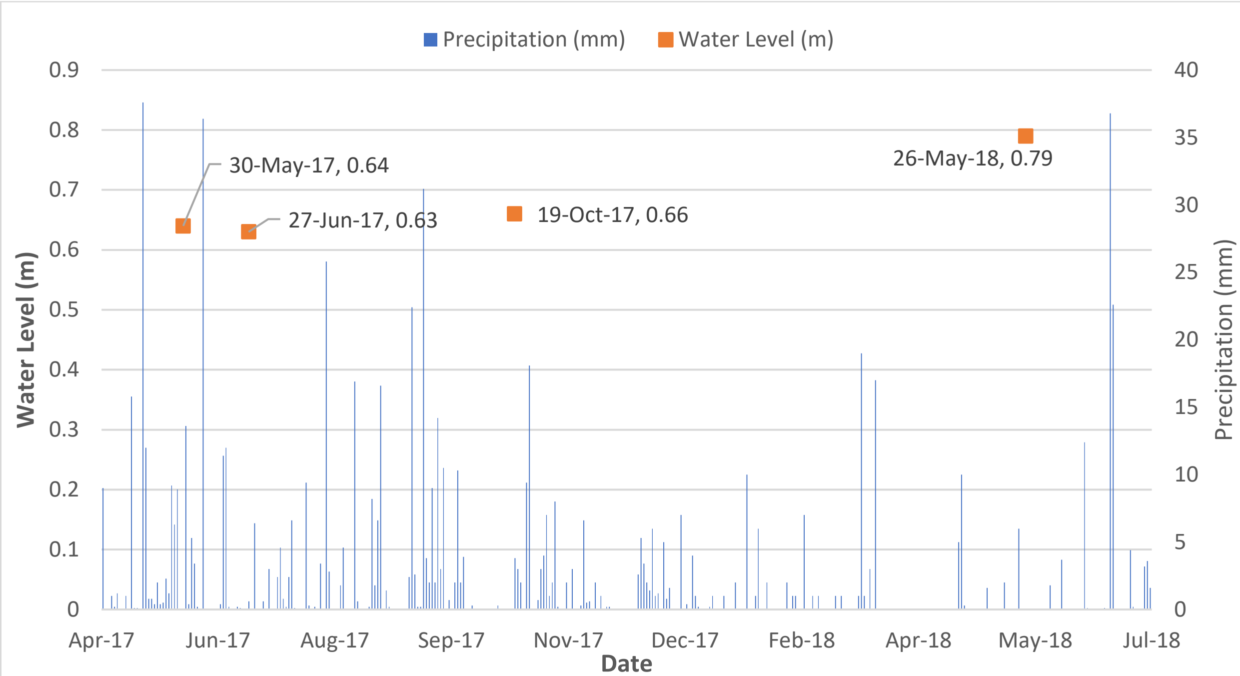

Figure 5-5. Water level elevations for Station H3

Bending Lake water surface elevations did not fluctuate greatly during the 2017 monitoring season. All measurements were within 0.03 m of the original measurement taken in May 2017. Although the water level measurements were all within a small range, high and low lake levels could have been missed due to timing of site visits. However, May 2018 water levels were 0.15m higher than May 2017 water levels. The peak observed lake level (0.79 m) was recorded on May 26, 2018, and the lowest lake levels were observed on June 27th, 2017 at 0.63 m. The highest lake levels on record are in May 2018 after a winter with a higher than average snow pack depth that also persisted longer into the spring than usual. As temperatures warm, a deeper snow pack translates to a larger volume of water during the spring freshet. This may explain the high water levels in May 2018 in comparison to May 2017, especially with Bending Lake's large size and numerous inputs. Lake elevations values are provided in **Table 5-3**.

Table 5-3. Summary of water level elevations at Station H3

#	Date	Surveyed Water Level (m) *
1	May 30, 2017	0.64
2	June 27, 2017	0.63
3	October 19, 2017	0.66
4	May 26, 2018	0.79

NOTE:
Surveyed water levels are referenced to an assumed benchmark elevation datum of 1.0 m
* average of two measurements taken during the same site visit

The Bending Lake water levels recorded at H3 are not reflective of the pattern of Page Lake levels recorded at H2. While relatively constant lake levels were experienced at both sites in May and June 2017, Page Lake levels dropped in October 2017. Bending Lake levels in October 2017 were about the same as initially recorded in May 2017. Additionally, Bending Lake experienced the highest lake levels recorded in May 2018, while Page Lake levels were the lowest recorded at that time. Page Lake is perched above Bending Lake and drains into Bending Lake through Page Creek (H1 station). Page Lake is approximately 30m higher in elevation (above sea level) than the H3 location in Bending Lake (see **Figure 1-3** for elevation data). It appears that Page Lake's decreasing water levels over the 2017 monitoring season could mean that Page Lake overtops its outlet point much more easily than Bending Lake overtops its outlet. Additionally, Bending Lake is much larger and would therefore experience fewer notable water level fluctuations than the smaller Page Lake.

5.3.2 Data Limitations and QA/QC

Lake levels were confirmed by completed a closed loop benchmark survey. Only 4 manual measurements were collected on Bending Lake through the monitoring period, and there is no continuous record at the site. Therefore, it is possible that Bending Lake may have experienced lower water levels in summer 2017 outside of field site visits.

5.3.3 Historical Data

The data collected by DST in 2011-2012 (**Figure 4-2**) at BL-HS3 (Bending Lake outlet) and BL-HS4 (Bending Lake, nearby PECG's H3 Station) can be compared to the May 2017 to May 2018 data at H3. While H3 does not have continuous monitoring data, the DST data includes continuous data from 2011 to 2012 over the same seasonal time period as the monitoring completed by PECG (May to December).

The DST data shows that water levels are relatively consistent in May and June 2011, similar to H3 in May and June 2017. Water levels in October 2011, however, are slightly lower than in spring 2011, which contrasts to the 2017 trend recorded for Bending Lake at H3. However, 2011 had a relatively dry September and October with 44.8 and 52.6 mm of precipitation recorded respectively, which is less than the Climate Normals of 88.9 and 63.6 mm, respectively. Since water levels were consistently high through to October 2017, it is also expected that the Bending Lake outlet would likely have been flowing at that time, in contrast to the 2011 data where the outlet appeared to have stopped at the end of August with decreasing water levels in Bending Lake.

5.4 Station H4

Hydrometric Station H4 is located on a tributary of Bending Lake and has been monitored since May 2017 (**Figure 4-1**). The creek drains from the north to south with the outlet into the western reaching arm of Bending Lake. **Photo 5-5** and **Photo 5-6** show upstream and downstream views of the stream, respectively.

The creek at H4 is contained within a medium gradient channel section with bedrock banks on both sides and vegetated banks where lower gradients are observed. The stream flow is confined in a valley setting and is not braided along its length. At the hydrometric station, the channel is approximately 3 m wide with a maximum depth of 0.5 m. The pressure transducer PVC pipe is attached to an 8-cm wide steel channel iron fastened to bank bedrock in the channel. The pressure transducer is suspended within the

PVC and protected from dynamic movements by the perforated PVC. The river substrate consists of bedrock, sand and boulders. Due to site conditions and a bedrock lined channel, there was no staff gauge installed at this site. Alternatively, 3 benchmarks were installed within the bank bedrock to use as the local datum.

Photo 5-5. H4 Hydrometric Station – facing downstream

Photo 5-6. H4 Hydrometric Station – facing upstream

5.4.1 Water Level Elevation

Recorded and manually surveyed water levels for the monitoring period are shown in **Figure 5-6.** Instantaneous water levels were matched to the initial stage reading and a benchmark survey was used to confirm that manual measurements match the local datum. The water level elevation does not represent true elevation above sea level.

The peak water level elevations were recorded on July 13, 2017 at a level of 1.30 m while the lowest water levels were recorded on March 1, 2018 at 0.728 m. The creek is sensitive to precipitation events and quickly responds to periods of high precipitation and gradually dissipates. The creek levels trended downwards throughout the summer months as days warmed and precipitation decreased, following highest water levels in June. Water levels increased during early autumn, coinciding with more precipitation events and decreased temperatures, before dropping mid-autumn due to less precipitation. Water levels dropped mid-fall, and remained relatively stable through the winter months, possibly as a result of freezing effects due to dropping temperatures starting in late October 2017.

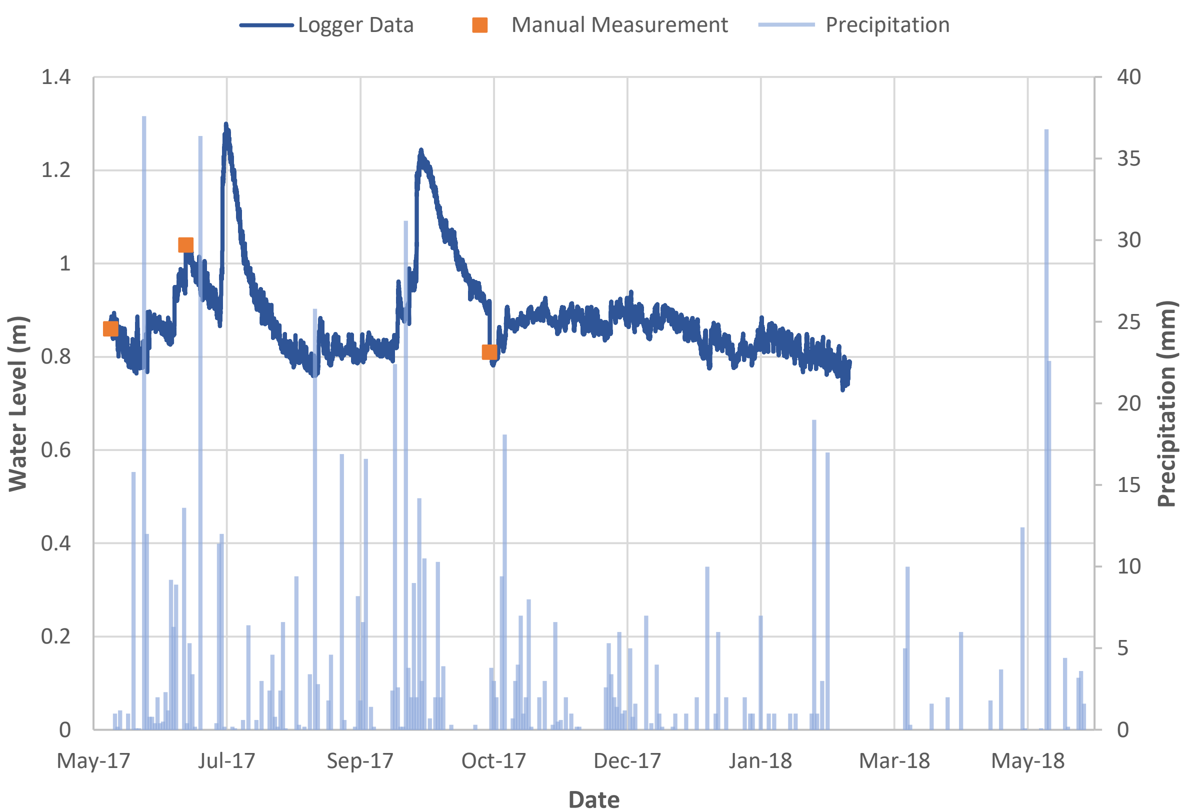

Figure 5-6. Water level elevation for station H4

5.4.2 Stage-Discharge Relationship

Four discharge measurements were taken at this station during each of the four site visits between May 2017 and May 2018. Discharge measurements were typically taken on a straight, shallow section of the stream downstream from the hydrometric station. The discharge and stage measurements are summarized in **Table 5-4.** The average manual water level observed was 0.903 m, with an average manual discharge of 0.168 m^3/s.

Table 5-4. Summary of discharge measurements at station H4

#	Date	Surveyed Water Level (m) *	Average Measured Discharge (m^3/s) **	Unit Yield ($L/s/km^2$)
1	May 30, 2017	0.86	0.055	2.78
2	June 28, 2017	1.04	0.285	14.39
3	October 19, 2017	0.81	0.045[E]	- [E]
4	May 26, 2018	N/A	0.286	14.42

NOTE:
Surveyed water levels are referenced to an assumed benchmark elevation datum of 1.0 m
* average of two measurements taken during the same site visit
** average of two transects taken during the same site visit
E – discharge was estimated. Unit yield is not calculated for estimated discharge values.

A stage-discharge relationship was developed for H4, however due to the limited record of discharge and stage measurements within periods of high and low flow can only be considered preliminary. Stage and discharge hydrometric monitoring is required to continue to develop a more representative stage-discharge relationship at H4, particularly during higher flow events. The preliminary stage-discharge relationship is provided in **Figure 5-7**.

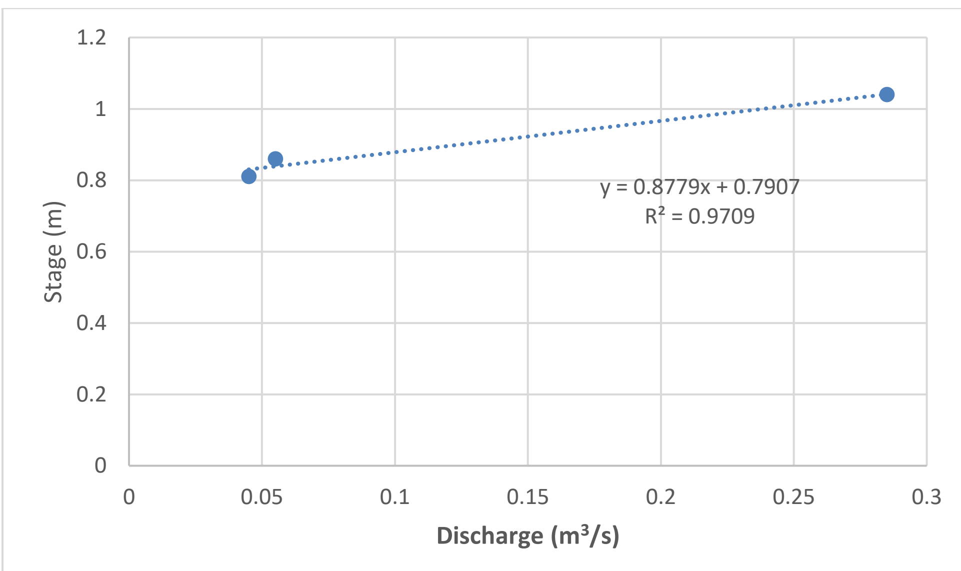

Figure 5-7. Preliminary stage-discharge relationship for H4

The preliminary stage-discharge relationship was used to convert the recorded logger water levels to discharges to create a hydrograph for the period of record available in this report (**Figure 5-8**). The estimated maximum discharge from the dataset is 0.567 m^3/s on July 13, 2018. This appeared to occur after a total rainfall of 23.6 mm the preceding two days, indicating the creek is sensitive to precipitation events. The estimated minimum discharge value recorded was 0.00011 m^3/s on August 7, 2017 after a cumulative 52 mm of precipitation the four weeks preceding. The cumulative precipitation for July 2017 was 81.9 mm—over half of which fell in the first half of the month—lower than the expected climate normal of 103.1 mm for July. The hydrograph reflects the spring freshet and several significant rain events in May and June 2017 with increased discharge.

The hydrograph for H4 seems to correlate well with the precipitation record. Discharge peaks in early July after a significant rainfall event, then decreases through the summer months with decreased precipitation. Discharge increases starting around September 15th and peaking on September 24th. There was a cumulative 90 mm of precipitation recorded in this time period, above the climate normal of 88.9 mm of precipitation expected for the entire month of September. This explains the large increase in both water levels and discharge in the second half of September 2017. Discharge tapers off along with precipitation then reaching a low in mid-October, before stabilizing as daily temperatures started to decrease in early November.

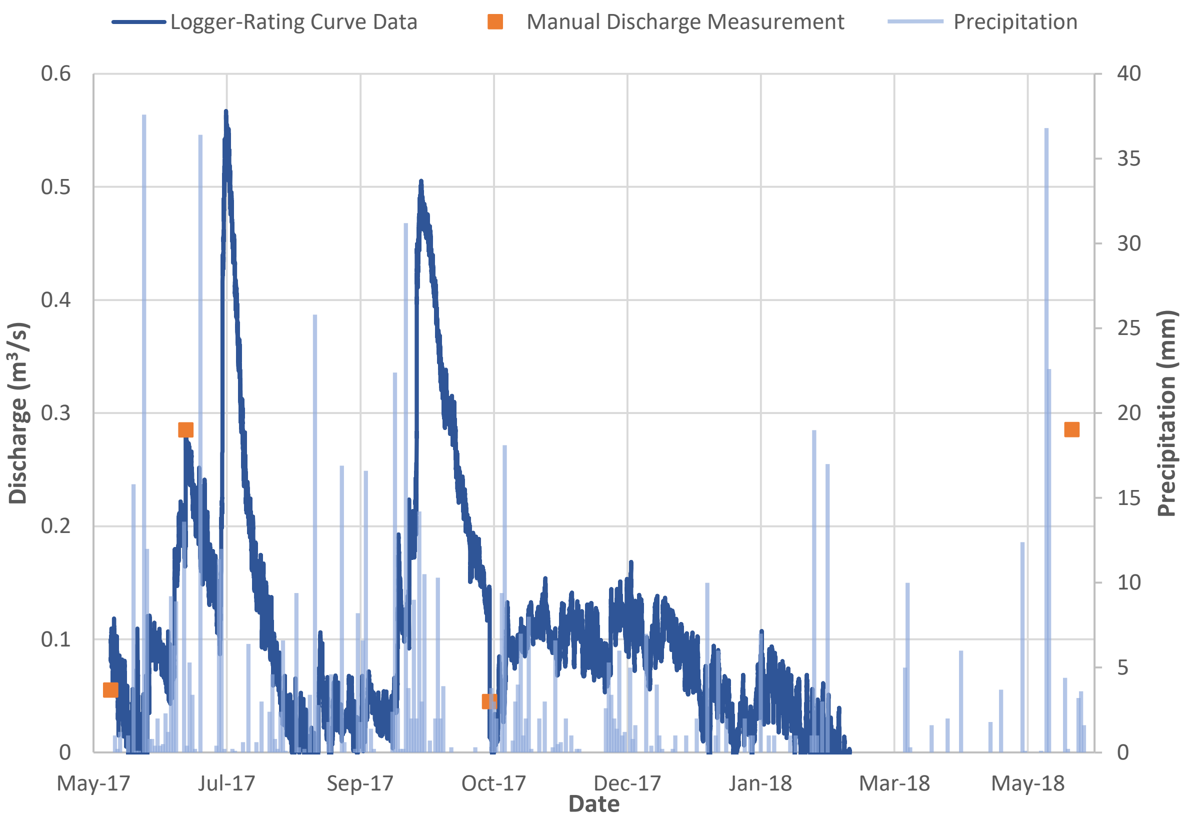

Figure 5-8. Hydrograph for station H4

5.4.3 Data Limitations and QA/QC

The October 19, 2017 discharge measurement was a visual observation estimate due to a malfunctioning current meter. The estimate was based on comparison to water levels recorded during previous site visits and visual observation. Channel conditions for H4 fall within the Grade A criteria due to the stable channel, relatively straight reach and minimal weeds and boulders (BC MOE 2009). The discharge value for October 2017 was estimated rather than measured due to low flow conditions.

The data loggers installed at the hydrometric monitoring stations were calibrated by the manufacturer before deployment. The current meter equipment was calibrated by the rental agency before every site visit.

The hydrograph was created from the preliminary stage-discharge relationship. The stage-discharge relationship can only be considered preliminary due to limited record of discharge and stage measurements. As such, as a more representative relationship is developed through further monitoring, the hydrograph for H4 may change for the May 2017 to May 2018 monitoring period. Additionally, while the June and October field visits coincided with local high and low discharge values respectively, the major peaks in the discharge record were not confirmed by site visits.

5.5 Station H5

Hydrometric station H5 is located on a tributary of Beak Lake within the Wapageisi Lake Subwatershed and has been monitored since August 2017 (**Figure 4-1**). The creek drains from the northeast to southwest with the outlet into the eastern reaching section of Beak Lake. **Photo 5-7** and **Photo 5-8** show downstream and upstream views of the stream, respectively.

The stream at H5 is contained within a low gradient channel section with low vegetative banks. At the hydrometric station, the channel is approximately 0.7 m wide and maximum depth of 0.05 m. The staff gauge and pressure transducer PVC pipe are attached to an 8-cm wide steel channel iron embedded in the channel pool below the road culvert. The pressure transducer is suspended within the PVC and protected from dynamic movements by the perforated PVC. The substrate consists of sands, gravels and boulders. The stream flows are confined for most of the 200-m reach south of the highway culvert before the outlet to a marshy wetland unit. The stream has been modified with the addition of a culverts beneath Highway 622, approximately 2 m to the east of H5.

Photo 5-7. H5 Hydrometric station facing downstream

Photo 5-8. H5 Hydrometric station facing upstream

5.5.1 Water Level Elevation

Recorded and manually surveyed water levels for the monitoring period are shown in **Figure 5-9.** Instantaneous water levels were matched to the initial stage reading and a benchmark survey was used to confirm that manual measurements match the local datum. The water level elevation does not represent true elevation above sea level. A conversion factor was used to convert 10 minute barometric data to 15 minutes to match the H5 logger data collection interval.

Three water level measurements and two discharge estimates were taken at this station during 3 site visits between August 2017 and May 2018. Discharge measurements were visually estimated due to equipment limitations within the shallow and small channel transect. The discharge and stage measurements are summarized in **Table 5-5.** The average manual water level observed was 0.295 m and the average estimated discharge was 0.0013 m^3/s.

Table 5-5. Summary of discharge measurements at H5

#	Date	Surveyed Water Level (m) *	Estimated Discharge (m^3/s)
1	August 10, 2017	0.289	0.0015
2	October 19, 2017	0.285	0.001
3	May 27, 2018	0.31	-

NOTE:
Surveyed water levels are referenced to an assumed benchmark elevation datum of 1.0 m
* average of two measurements taken during the same site visit

The peak water level elevations were recorded on September 26, 2017 at 0.414, while the lowest water levels were recorded on August 15, 2017 at 0.267 m. The creek levels respond relatively quickly to precipitation events but remained relatively consistent through the period of record. However, the period of record starts in the middle of the dry summer season, so the earlier spring conditions were not captured in 2017. Unit yield is not calculated for discharge measurements at H5 because they are estimates rather than measurements using a flow (current) meter.

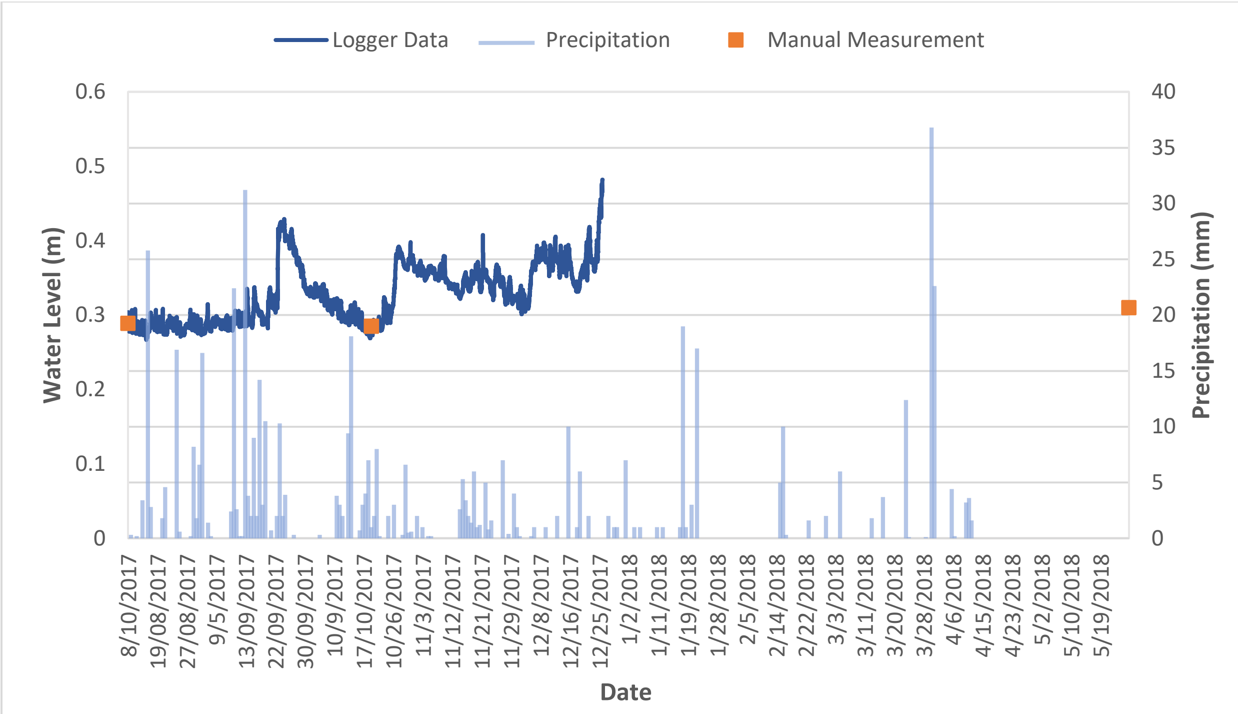

Figure 5-9. Water level elevation for station H5

The estimated maximum water level from the dataset is September 26, 2017 at 0.414 m. This appeared to occur after a total rainfall of 48 mm the preceding four days, indicating the creek is responsive to precipitation events. The estimated minimum water level value recorded was August 15, 2017 at 0.267 m during the drier summer months. The water levels at H5 do seem to correlate well with the precipitation record, however water levels do not significantly peak after precipitation events. This may be a result of the low channel banks and the likeliness that the channel regularly overtops its banks during higher flow events.

5.5.2 Stage-Discharge Relationship

A stage-discharge relationship could not be developed due to the limited record of discharge and stage measurements at this station. Additional stage and discharge hydrometric monitoring is required to continue to develop a representative stage-discharge relationship at H5.

5.5.3 Data Limitations and QA/QC

Due to the width (approx. 0.70 m) and depth of the stream (approx. 0.05 m), obtaining representative discharge measurements became challenging with current meter limitations. As a result, flow measurements were estimated by PECG staff. Channel conditions for H5 fall within the Grade A criteria due to the stable channel, relatively straight reach and minimal weeds and boulders (BC MOE, 2009). Future hydrometric monitoring should consider methods to isolate the small channel flow to allow for measured discharge values to be collected.

5.6 Comparison to Water Survey of Canada Data and Unit Yield

The hydrometric station data for H1 through H5 were compared with the WSC gauge data for daily discharge. Despite the WSC gauges having much larger drainage areas, they can be used for a general comparison of the measured flow through a unit yield relationship comparing discharge (m^3/s) to subwatershed area (km^2). The correlation of discharge for H1, H4 and the WSC gauges in relation to drainage area is shown on **Figure 5-10** for May 30-31, 2017, and **Figure 5-11** for June 28, 2017.

Varying conditions and response times in the varying drainage area sizes impact how closely the WSC gauges relate to H1 and H4. In general, both the Atikokan River and Turtle River gauges seem to behave similarly to H1 and H4. However the Atikokan River station has the smallest drainage area of the two WSC stations and is unregulated, therefore making it the most reasonable comparison to hydrometric stations installed as part of this baseline program. The Wabigoon River gauge is not reflective of watershed conditions due to the fact it is regulated and is not included in the comparison.

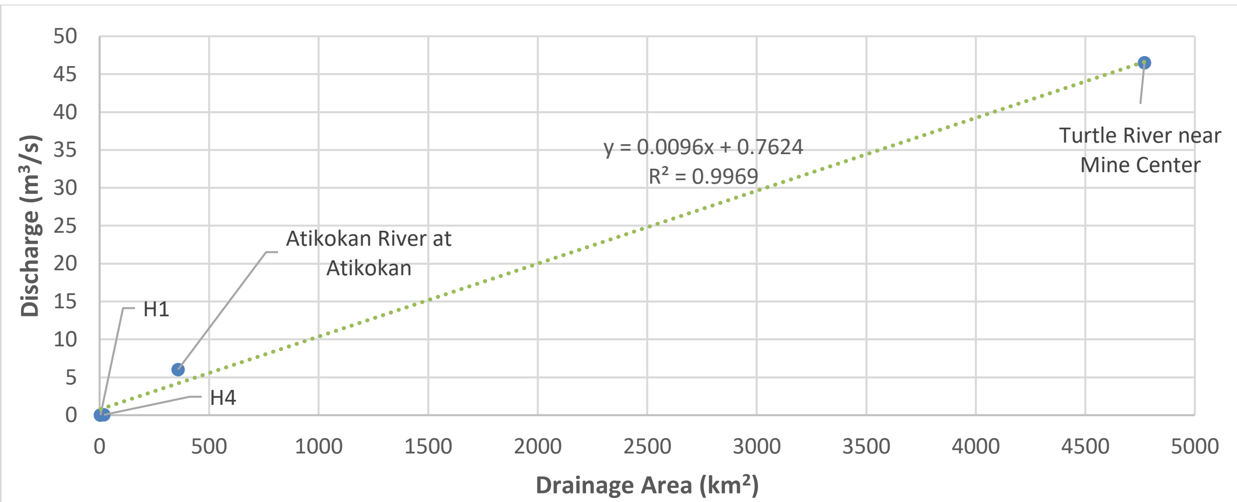

Figure 5-10. May 30, 2017 discharge and drainage area for H1, H4, and two WSC gauge stations.

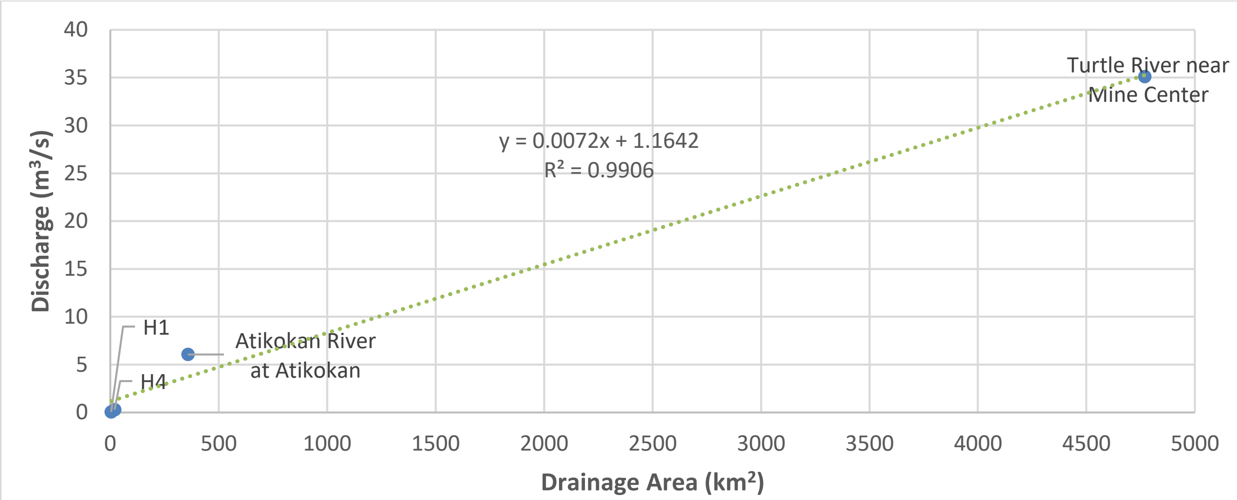

Figure 5-11. June 28, 2017 discharge and drainage area for H1, H4, and two WSC gauge stations.

6 SUMMARY

The objective of the baseline hydrology monitoring program was to establish and characterize baseline hydrology conditions within the PSA from which to evaluate potential changes that could occur as a result of the proposed bulk sampling activities. The baseline hydrology program for the Bending Lake Advanced Exploration Project was established to develop a better understanding of the hydrological setting within the area of the proposed bulk sample from which to make future water quantity and quality predictions during later permitting and design stages.

The baseline monitoring network consists of 5 hydrometric monitoring sites, include 3 stream stations and 2 lake elevation stations. Two stream gauges and two lake gauges are located within the Bending Lake watershed, while one stream gauge is located within the Wapageisi Lake watershed. Both subwatersheds discharge into the larger Turtle River-White Otter watershed. The baseline monitoring program was initiated in the spring of 2017 and continued to May 2018. During the 2017-2018 monitoring program, peak water levels typically occurred during late spring (June) and levels receded as the summer months progressed. The water began to rise again with the onset of the autumn storms season in the region, with levels peaking again during October before falling into winter.

Based on the proposed Project facilities layout, as shown on **Figure 1-3**, no watercourses or significant hydrological features within the study are expected to be affected by the bulk sample activities. The project avoids major watercourse crossings and dewatering from the pit is expected to be directed to a wetland area following water quality treatment (see Project Description; AMI, 2018). Long term monitoring of the project study area will be required if the project advances to further characterize the hydrological conditions and develop a water budget model and long-term management plan.

7 PROPOSED MONITORING AND MITIGATION PROGRAM

A new hydrometric monitoring station should be established within a small drainage feature located in a wetland area north of the proposed Project facilities. This drainage features ultimately discharges into Bending Lake north of the H3 Station. While it is likely that collecting discharge measurements from this station could be challenging due to wetland vegetation and likely backwater conditions from the lake and wetland, this is likely the nearest receiving body for the pit dewatering discharge.

To continue to establish long-term baseline conditions to support future permitting and approvals, it is recommended that the hydrology field program be continued to obtain additional data. Some of the key hydrometric stations should also be winterized to collect water level information over the winter months and to capture the peak flows during spring freshet. Consideration could be given to adding a hydrometric station at the outlet of the Turtle River subwatershed to determine the contribution from this subwatershed to the level of Bending Lake.

Based on the proposed Project facility layout for the bulk sample, no hydrology specific mitigation measures are recommended at this time. Any water discharged to a surface water body must meet the applicable water quality standards and steps should be taken to reduce the discharge velocity to prevent channel scour and bed erosion.

8 CERTIFICATION

This report was prepared, reviewed and approved by the undersigned:

Prepared By:

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Samantha Feist, M.Sc., G.I.T.

Environmental Scientist

Reviewed By:

____

Jason Cole, M.Sc., P. Geo.

Principal

Approved By:

____

Rob Frizzell, M.Sc., P. Geo.

Vice President

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Appendix A

2017-2018 HYDROMETRIC MONITORING PHOTOGRAPHIC LOG

Photograph Log

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Client Name:	Project No.	Site Location:
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	Date.	Direction Photo Taken
1	2/6/2017	H1 – Upstream view

Description

H1 – Hydrometric Station, Page Creek between Page Lake and Bending Lake

Photo #:	Date.	Direction Photo Taken
2	2/6/2017	H1 - Downstream below culvert

Description

H1 – Hydrometric Station, Page Creek between Page Lake and Bending Lake

Photograph Log

Client Name:	Project No.	Site Location:
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	Date.	Direction Photo Taken
3	2/6/2017	Staff gauge installed looking upstream

Description

H1 – Hydrometric Station, Page Creek between Page Lake and Bending Lake

Photo #:	Date.	Direction Photo Taken
4	2/6/2017	Staff gauge looking downstream

Description

H1 – Hydrometric Station, Page Creek between Page Lake and Bending Lake

Photograph Log

Client Name:	Project No.	Site Location:
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	Date.	Direction Photo Taken
5	6/2/2017	Staff gauge

Description

H1 – Hydrometric Station, Page Creek between Page Lake and Bending Lake

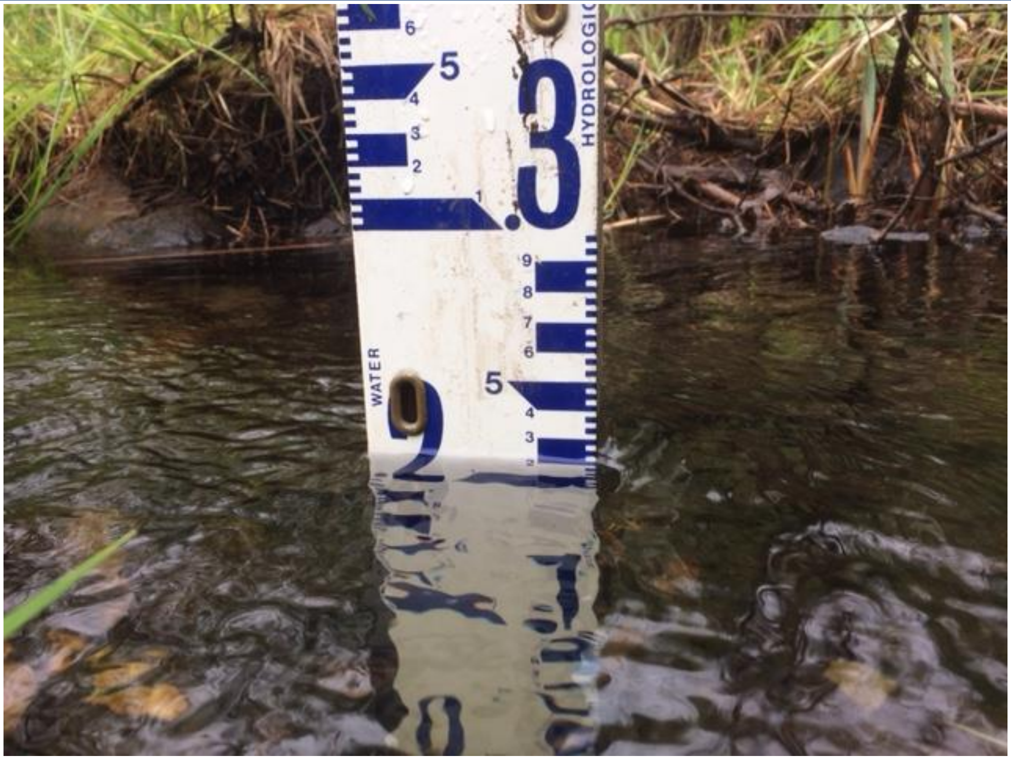

Photo #:	Date.	Direction Photo Taken
6	6/2/2017	Page Lake Staff Gauge

Description

H2 – Page Lake water level gauge

Photograph Log

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Client Name:	*Project No.*	*Site Location:*
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	*Date.*	*Direction Photo Taken*
7	6/2/2017	Staff gauge and BM1 (tree base)

Description

H2 – Page Lake water level gauge

Photo #:	*Date.*	*Direction Photo Taken*
8	6/2/2017	BM2 (base of tree) + Barometric Pressure Sensor (in PVC tube)

Description

H2 – Page Lake water level gauge

Photograph Log

Client Name:	Project No.	Site Location:
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	Date.	Direction Photo Taken
9	6/2/2017	Staff Gauge water level

Description

H2 – Page Lake water level gauge

Photo #:	Date.	Direction Photo Taken
10	6/2/2017	Staff Gauge water level

Description

H2 – Page Lake water level gauge

Photograph Log

Client Name:	Project No.	Site Location:
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	Date.	Direction Photo Taken
11	2/6/2017	Bending Lake staff gauge looking eastward

Description

H3 – Bending Lake Gauge

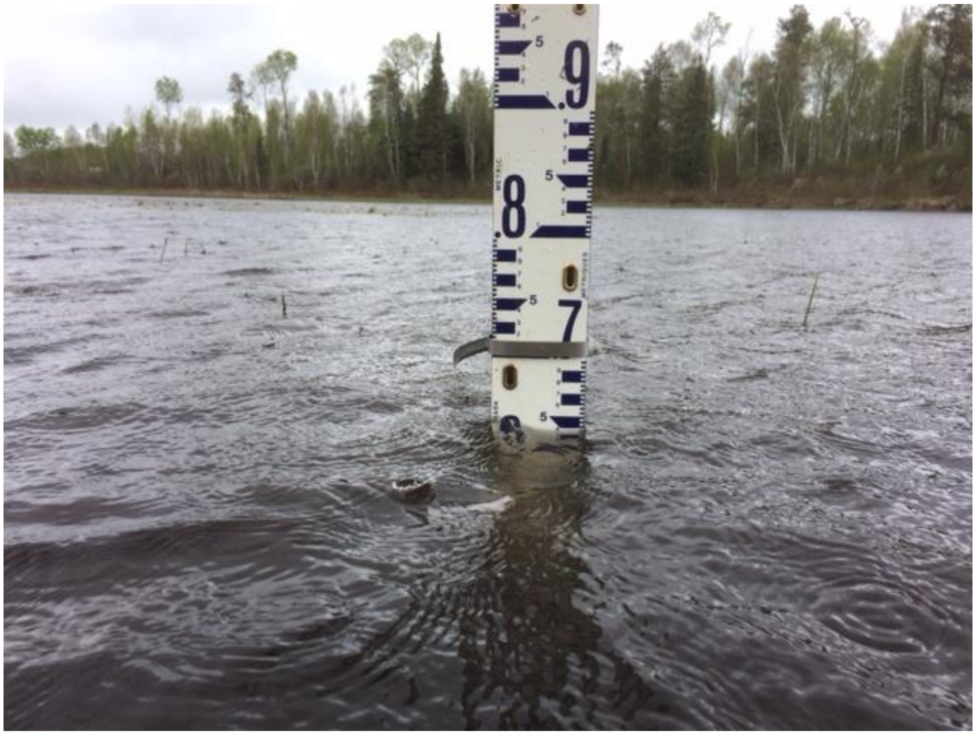

Photo #:	Date.	Direction Photo Taken
12	2/6/2017	Hydrometric gauge installed

Description

H4 – Hydrometric Station, creek entering Bending Lake on northern shore

Photograph Log

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Client Name:	Project No.	Site Location:
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	Date.	Direction Photo Taken
13	2/6/2017	Gauging station looking upstream

Description

H4 – Hydrometric Station, creek entering Bending Lake on northern shore

Photo #:	Date.	Direction Photo Taken
14	6/2/2017	Downstream below gauging station – discharge measurement location.

Description

H4 – Hydrometric Station, creek entering Bending Lake on northern shore

Photograph Log

Client Name:	Project No.	Site Location:
Ambershaw Metallics	17018	Bending Lake AEP

Photo #:	Date.	Direction Photo Taken
15	10/21/2017	Upstream

Description

H5 – Beak Lake Tributary hydrometric monitoring site. Culvert below Hwy 622

Photo #:	Date.	Direction Photo Taken
16	10/27/2017	Upstream

Description

H5 – Beak Lake Tributary Hydrometric monitoring site.