UPPER BEAVER
PROJECT

Upper Beaver Gold Project Impact Statement

Appendix G-1:

Baseline Hydrology Report

Baseline Hydrology Report

Upper Beaver Gold Project

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August 2025

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1 Introduction

1.1 Background

The Upper Beaver Gold Project ("the Project"), is located approximately six kilometres ("km") northeast of the town of Dobie in the Township of Gauthier, Ontario and approximately 14 km east of the town of Kirkland Lake, Ontario (Figure 1.2.1). Agnico Eagle Mines Limited ("Agnico Eagle") is currently evaluating opportunities to develop, operate and eventually reclaim an underground and open pit, gold-copper mine, processing facility and related infrastructure at the Project site. The proposed mine would be built on the site of a former producing mine, expanding on its historical underground workings. The Project entered the Advanced Exploration phase in 2024 and is currently completing a federal Impact Assessment for the proposed production phase Project. Before deciding to move into the construction/production phase, Agnico Eagle has implemented an Advanced Exploration program to increase confidence in the feasibility of the Project.

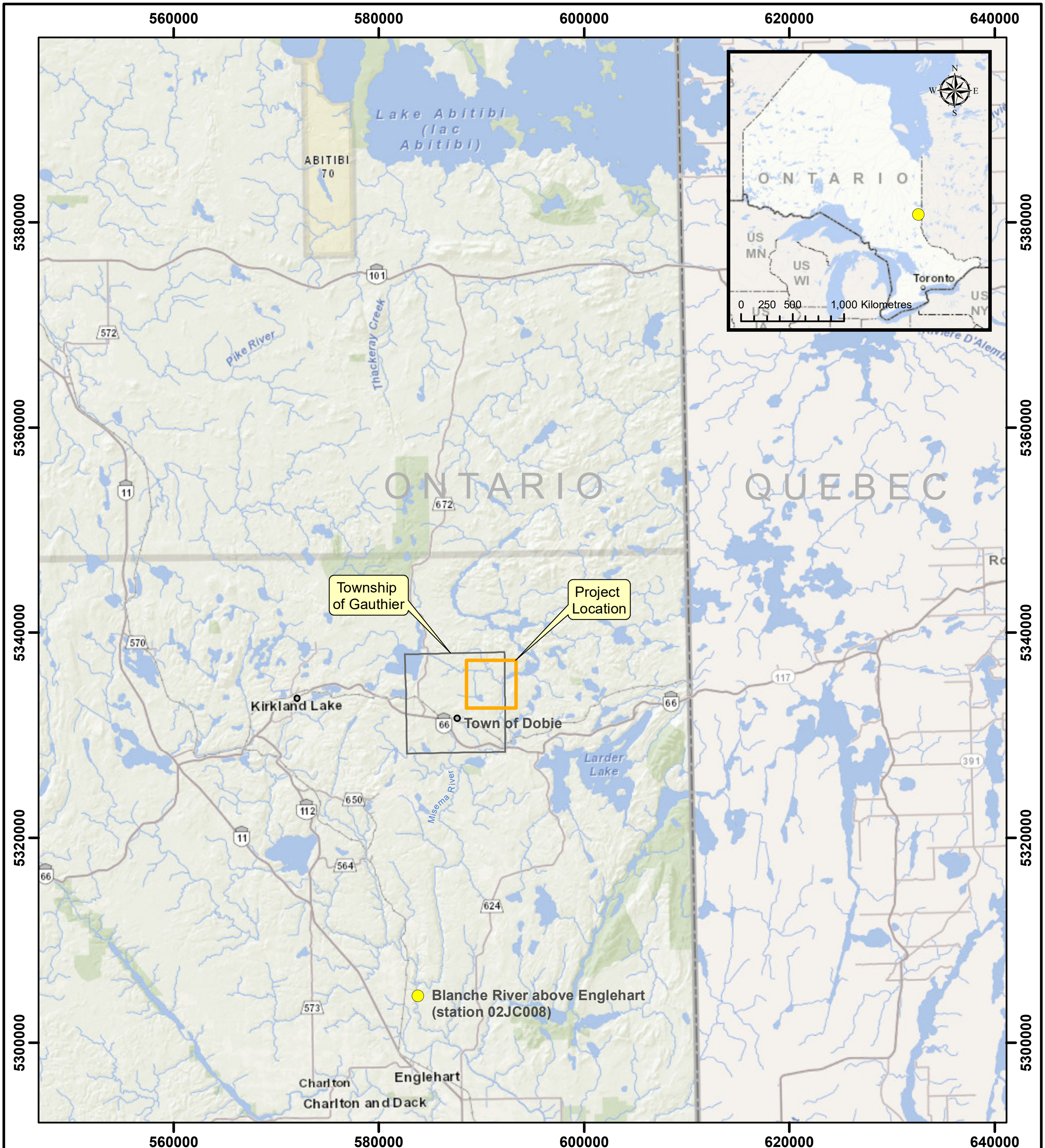
Since July 2018, Story Environmental Inc. ("SEI") has been collecting water level and flow data for this Project under contract with Agnico Eagle Mines Limited (SEI, 2019, 2020, 2021, 2022, 2023, 2024, 2025). SEI also collected hydrological data in this area for Queenston Mining Inc. from 2011 to 2013 (SEI, 2013). These data have been used to develop the level – flow models for each of the Project stations and compare the derived flow data to data from a nearby regional Water Survey of Canada ("WSC") station (02JC008 on the Blanche River -- Figure 1.2.1).

1.2 Purpose of Report

This baseline report has been prepared to support the following proposed activities that will require regulatory approval for the advancement of the Project:

- surface water taking;
- groundwater taking from underground workings;
- discharge of treated effluent from an industrial sewage works facility to the receiving waterbody;
- diversion of water from a natural waterbody into another natural waterbody; and
- closure planning.

This report updates previous flow modelling work (SEI, 2020), providing long-term modelled flows for the Project hydrological stations using the longer record from the reference station (WSC station 02JC008). The choice of this reference station is discussed in Section 4.1.



Legend

- WSC Gauging Station
- Geographic Township of Gauthier
- Project Location

UTM NAD83 Zone17N

Kilometres

0 2.5 5 10

Service Layer Credits: OMNRF-OPM: LIO Topographic Basemap (Oct. 2023). Land Information Ontario: Geographic Township Improved (2023). Locations are approximate.

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AGNICO EAGLE

Agnico Eagle Mines Limited	Baseline Hydrology Report
Upper Beaver Project	Project Location
Drawn by: JALD / Rev'd by: ACS	Drawing No.: SEI-105-101-09-2024-001.3
Date: 08-Aug-2025	**Figure 1.2.1**

Project Location

Document Path: T:\SEI\105 Agnico\105AB_KL_CSD_Explore\Figures\101_Upper Beaver\09_Hydrology\2024\SEI-105-101-09-2024-001 UB_Project Location_8.5x11P.mxd

1.3 Hydrometric Stations

The Project is located in the Misema River watershed east of Kirkland Lake, Ontario. The Misema River flows south to the Blanche River (Figure 1.2.1) and has a watershed area of 254 square kilometres ("km^2") at the Beaverhouse Lake outflow (Figure 1.3.1). Near the Project, there are two small lakes (Ava Lake, and York Lake) which are essentially widenings of the Misema River (Figure 1.3.1, inset). At the downstream end of York Lake, Victoria Creek flows into the Misema River, creating a larger total watershed area of approximately 400 km^2. Victoria Creek originates at Victoria Lake approximately 10 km to the west of the Project area (Figure 1.3.1).

This baseline report provides streamflow data for six Project area stations: M2 on the Misema River downstream of the Project, M1 on the Misema River at the outflow of Beaverhouse Lake, MUSF1 on the Misema River where Beaverhouse Lake narrows upstream of the Project, V3F and V3G on Victoria Creek near the Project, and V1 at the Victoria Lake outflow (Figure 1.3.1).

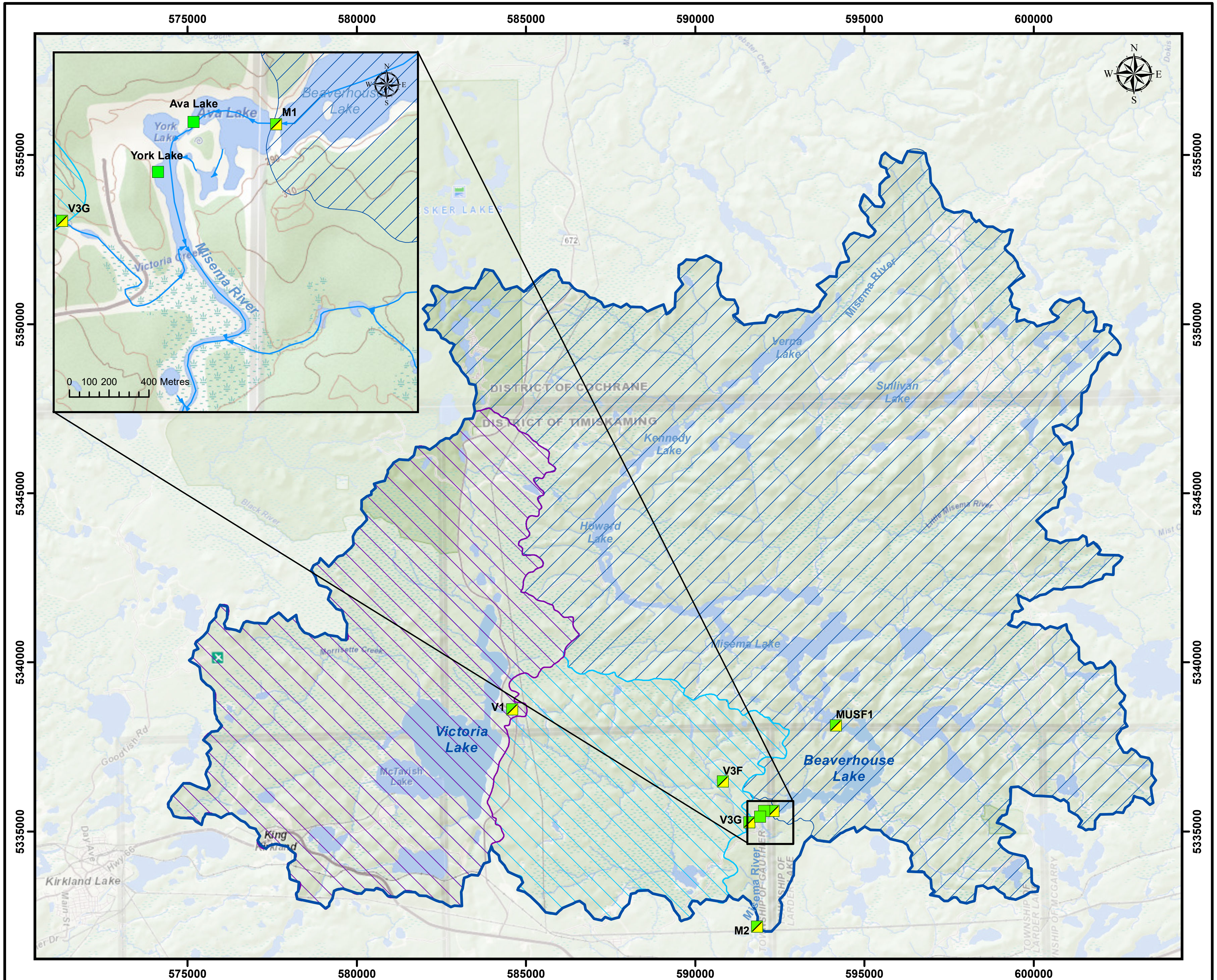
The annual streamflow pattern of the Misema River and its tributaries is characterized by high flows in the spring (typically April and May), receding flows during early summer (June), low flows in middle to late summer (July, August, and early September), increasing flows during fall (mid-October to December, and moderately low flows in winter months (January, February, and early March). Extreme low flows such as the annual $7Q_2$ and $7Q_{20}$ flows (7-day average low flow with recurrence intervals of 2 and 20 years, respectively), occur in the summer.

Table 1.3.1 provides the drainage areas for stations V1, M1, V3F, V3G, MUSF1, and M2. The sum of the M1 drainage area (254 km^2) and Victoria Creek (V3F or V3G) drainage areas (142 km^2 or 145 km^2) contributes nearly the entirety of the M2 drainage area (404 km^2). This is useful for quality control of the flow data (i.e., the M2 daily flow should approximately equal the sum of the daily flows at M1 and V3F (or V3G)).

Table 1.3.1 Watershed Drainage Areas for the Project Hydrometric Stations

Hydrometric Monitoring Station	Watershed Area (km^2)
M2 (Misema River)	404
M1 (Misema River at Beaverhouse Lake outflow)	254
MUSF1 (Misema River at Beaverhouse Lake narrows)	234
V1 (2019) (Victoria Lake outflow)	98
V3F[Note 1] (Victoria Creek)	142
V3G (Victoria Creek)	145

Notes:
km^2 = square kilometres
Note 1: The V3F location includes both the V3F US and U3F DS stations. Both are in close proximity.



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Upper Beaver Hydrometric Monitoring Stations

Legend

Hydrology Station Parameters

- Flow and Water Level
- Water Level
- V1 Watershed
- V3G Watershed
- M1 Watershed
- M2 Watershed
- Watercourse and Flow Direction

Credits: OMRNF-OPM: LIOTopographic Basemap (2022). Stream layer provided by Ontario Integrated Hydrology and field truthed by SEI personel in 2018. Watershed generated using OIH DEM. Locations are approximate.

UTM NAD 83 Zone 17N

Kilometres

0 1 2 4

Figure 1.3.1

Agnico Eagle Mines Limited

Upper Beaver Project

Baseline Hydrology Report

Upper Beaver Hydrometric Monitoring Stations

Project Number: 105A-101-09-2024

Drawing Number: SEI-105-101-09-2024-002.4

Drawn by: JALD | Rev'd by: ACS | Date: 07-Aug-2025

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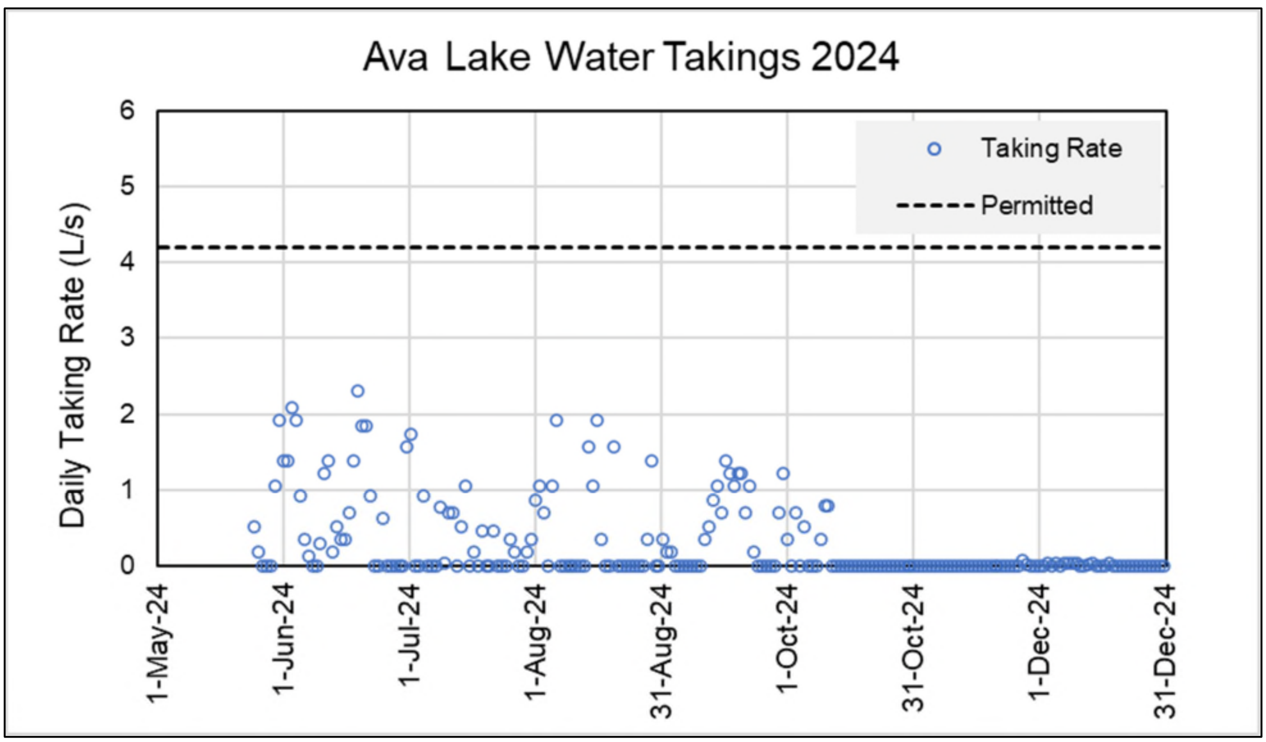
1.4 Permit to Take Water

The maximum approved groundwater taking under the Ontario Permit to Take Water Number 8357-C5SR58 ("PTTW") is 39 Litres per second ("L/s"). The maximum surface water takings rate under the same PTTW, from Ava Lake, is 4.2 L/s. Therefore, the combined total permitted water taking, groundwater and surface water, is 43.2 L/s.

Beginning on 25 May 2024, surface water was taken from Ava Lake under the above mentioned PTTW. Water taking data provided by Agnico Eagle are plotted in Figure 1.4.1. The maximum surface water taking was 2.3 L/s on 19 June 2024, which is less than the maximum permitted surface water taking 4.2 L/s. No water was taken from underground workings in 2024.

During 2024, the lowest average daily streamflow recorded at the M1 station, just upstream of Ava Lake at the Beaverhouse Lake outlet, was 0.27 cubic metres per second ("m^3/s") or 270 L/s, on 26 August 2024. Therefore, the maximum rate of water taken from Ava Lake was less than 1 percent [i.e., (2.3 L/s / 270 L/s) x 100] of the flow through the lake. This would not cause a measurable reduction in Ava Lake water levels or downstream flows. Based on this fact, users of the hydrometric data provided with this report may choose how they wish to include this data in the baseline dataset. For modelling of long-term baseline flows (Section 2.6), 2024 data have been included as part of the relevant analyses within this report.



2024 Daily Water Tracking File_24FEB2025_SEI notesAdded

Figure 1.4.1 Ava Lake Water Takings in 2024

2 Methods

2.1 Overview of Hydrometric Stations and Instrumentation

There are eight hydrometric stations within the Upper Beaver project (Table 2.1.1). Data collection at six of the eight stations (i.e., M1, M2, V1, V3F, Ava Lake and York Lake) first began in 2011/2012 and ceased in 2013 (SEI, 2013). In 2018, all these stations except V1 were re-established. Since 2018, four new stations (i.e., MUSF1, V1(2019), V3F DS, and V3G) were established at various times (Table 2.1.1).

Table 2.1.1 History of Upper Beaver Hydrometric Stations

Flow Monitoring			
Station Name	**Waterbody**	**Date Established**	**Notes**
M1	Beaverhouse Lake outflow	July 2011	Re-established at the same location in July 2018
M2	Misema River	July 2011	Re-established at the same location in July 2018
MUSF1	Misema River	September 2021	Continuous (open-water) water-level monitoring not implemented at this location until June 2022. Established at the request of MECP.
V1 (2011)	Victoria Creek	July 2011	Station discontinued after 2012
V1 (2019)[1]	Victoria Lake	June 2019	Station moved approximately 200 m upstream in 2019 compared to the 2011-2012 location
V3F US[2]	Victoria Creek	July 2011	In 2011-2012, this station was known simply as V3F. Re-established at the same location as V3F US in June 2019.
V3F DS[2]	Victoria Creek	July 2018	This station was established in July 2018 approximately 30 m downstream of V3F US to avoid beaver activity that occurred in summer 2011 and 2012 near V3F US
V3G	Victoria Creek	June 2020	Established in 2020 at request of MECP[3]
Lake Level Monitoring			
Station Name	**Waterbody**	**Date Established**	**Notes**
Ava Lake	Ava Lake	July 2012	Re-established at same location in July 2018
York Lake	York Lake	July 2012	Re-established at same location in July 2018

Notes:

1) All references to station V1 from this point forward in the report refer to the separate stations (e.g., V1(2011) and V1(2019) only when it is necessary to distinguish between the two sub-stations. A reference to "V1" without the year of installation indicates the general location of the V1 site, encompassing both stations.
2) US = upstream; DS = downstream.
3) MECP = Ministry of the Environment, Conservation and Parks

Water level monitoring stations were instrumented with level-recording data-loggers, housed in protective polyvinyl chloride piping, and securely anchored within the channel using rebar posts driven into the bed of the waterbody or other similar methods such as installations on cinder blocks. Data loggers recorded water levels continuously at 15-minute intervals. A separate level logger was placed in the atmosphere for purposes of correcting for the effects of variations in barometric pressure on the recorded water level data, where necessary (i.e., for unvented loggers). Seven of the eight stations are instrumented on a year-round basis, while the eighth (MUSF1) is deployed from June to October due to safety concerns about accessing that site in winter.

Care was taken to ensure historical continuity of the gauge datum at each station, by establishing multiple survey benchmarks near the cross-section at the time of instrumentation. This is especially important for this Project because the rating curves have been refined through multiple years of data collection. To ensure consistency in the historical record of flow gauging and water level monitoring, optical surveying was conducted at all stations every spring and fall.

Visits were made through the spring, summer, and fall, and during a range of flow conditions, to conduct manual measurements of water level at all stations and to measure streamflow at the flow stations. Streamflow was measured using a range of standard methods and instruments (see Section 2.2.1). Each data point collected for the development of rating curves included the name of the instrument used for measurement, as specified in the Project data tables in Appendix A of this report.

At many hydrometric stations in northern Ontario, winter ice has a substantial effect on water levels. This can lead to erroneous continuous flow monitoring results if the ice effects are not taken into consideration. However, at several of the Project stations (i.e., M1, V1, and Ava Lake), the level loggers were installed close to the lake outlets, where water velocities are sufficient to maintain open water conditions or only very thin ice cover throughout the winter. Therefore, at these stations there was no need to adjust the winter level and/or flow data to account for substantial ice effects. Stations M2 and York Lake were susceptible to ice formation; however, the effects were minor and detailed analysis demonstrated that the water level and flow data were not substantially affected by ice at these two stations (SEI, 2022). At the Victoria Creek stations (V3F[1] and V3G), thicker ice developed at the cross-sections, which could influence the winter flow data. Any data points affected by ice were excluded from data used for development of the rating curves, and for modelling long-term baseline Project flow data.

[1] The V3F station includes two sets of level logging instrumentation at separate cross-sections (V3F US and V3F DS) separated by approximately 30 m. From a flow data perspective (but not a water level perspective), results from the two sets of instrumentation are considered interchangeable. Therefore, V3F is considered a single flow station, but with two sets of instrumentation in close proximity.

2.2 Field Methods

2.2.1 Flow Measurement

At low-to-moderate water levels, streamflow was measured using the area-velocity method and a wading current meter (either Marsh-McBirney Flo-Mate, or, more commonly, a Sontek FlowTracker). For measuring streamflow in high flow streams where wading was not possible, an Acoustic Doppler Current Profiler ("ADCP") boat (Teledyne RD Instruments StreamPro) was used in 2019 and 2020. In 2021, SEI purchased their own ADCP boat (Sontek RS5) and this was used to measure high flows in 2021, 2022, 2023, and 2024, using standard moving boat or stationary boat methods.

2.2.2 Calibration of Flow Measurement Devices

Calibration of flow measuring equipment is an important consideration for hydrometric monitoring programs. The FlowTracker instrument features an automatic quality control ("QC") test which was used daily in the field before measuring flows. The QC test assesses several criteria including Noise Level, Signal-to-Noise-Ratio, Peak Shape, and Peak Location. No QC Test warnings were observed during the hydrology fieldwork. The Flo-Mate was calibrated every two years (2021, 2023, and 2025) on a flow testing bench by ACG Envirocan in Woodbridge, Ontario.

The Sontek RS5 ADCP boat user manual states that "Each system is individually calibrated during the manufacturing process. Since there are no moving parts and the beams are built into the RS5 head, recalibration is not necessary unless the RS5 is physically damaged." The RS5 ADCP unit used in 2021, 2022, 2023, and 2024 was not physically damaged over the 2021 to 2024 period and before each flow measurement all standard checks such as compass calibration were conducted resulting in accurate and reliable data.

2.2.3 Level-logging Instrumentation.

Two types of water level loggers were used from 2011 to 2024. At most stations, Onset Hobo U20 level loggers were used [0 to 4 metres ("m") range], which require barometric compensation and do not include direct-read cables. Vented loggers (Solinst brand) were also used at some stations in 2021-2022, but damage due to ice effects and animal activity discouraged further use of the vented loggers in the short term.

2.2.4 Water Level Benchmarks for Beaverhouse, Ava, and York Lakes

Detailed information about the benchmarks and measurement points used to monitor lake water levels at Ava, Beaverhouse, and York Lakes is provided in Appendix B. This information is provided due to the close proximity of the lakes to the Project and the importance of this information at this stage of the Project development. As discussed in Appendix B, recent

(May 2024) geodetic surveying checks on elevations for key benchmarks near the three lakes showed variations of up to +0.043 m compared to previous surveying work in 2018. This difference in elevations (0.043 m) is typical of data variability associated with survey-grade GPS technology. The geodetic lake water levels provided in this report continue to use the older surveying results from 2018 (2019 for York Lake). However, these checks also indicate that the geodetic lake water levels are associated with uncertainties of at least approximately ±0.04 m.

2.3 Data Analysis

2.3.1 Rating Curve Development

Rating curves were developed for the flow monitoring stations to calculate flows based on measured water levels. Rating curves were generally developed using the following equation:

$$Q = C * \ (H - h_0)^b, where,$$

- *Q* is streamflow;
- $H - h_0$ represents the effective depth of water, or hydraulic head, above the control. Here, '*H*' is the gauge height relative to the station datum, while 'h_0' is the gauge height indicating zero flow, also known as the offset;
- *C* is the calibration parameter, which is affected by factors such as width, slope, bed roughness, and other characteristics of the channel; and
- *b* is the calibration parameter influenced by the control geometry (Rainville et al., 2016).

The development of rating curves is an ongoing process. The Project stations are mainly controlled by bedrock features in the channels, which has allowed data to be collected over multiple years during which the hydraulic characteristics of these stable channels have not changed substantially between 2018 and 2024 (an exception is the V1 station, as discussed further in Section 3.5). Small changes in the M1 and M2 rating curves between the earlier 2011-2013 dataset and the 2018-2024 dataset have also been applied (Sections 3.1 and 3.2).

According to the Hydrometric Manual by the WSC (Rainville et al., 2016), at least six calibration measurements are required for development of a rating curve for a location or segment. A rating curve segment describes that portion of a rating curve which is defined by a separate curve segment due to variations in channel geometry. For instance, rating curves often feature separate "low flow" segments where the channel geometry is influenced more by a narrower and deeper part of the channel than at higher water levels. In this study, rating curves for all flow gauging stations have more than six data points, although not all rating curve segments have six measurement points yet. Often this is because extreme low flows (e.g., $7Q_{20}$ flows) have not yet occurred during the period of data collection.

In developing these rating curves, the range of flows across which the rating curves for the Upper Beaver stations can be reasonably applied was considered. Rantz *et al.* (1982) state that extrapolation of rating curves beyond twice the largest measured flow is generally not valid for deriving flow data. High flows of this magnitude occurred rarely in the 2011-2024 dataset. However, in April 2025, SEI was able to directly measure flows and water levels at higher-flow conditions than during any of the 2011 to 2024 field campaigns. These higher flow data have been incorporated into this report. As a result, none of the rating curves for the year-round Project stations have been extrapolated beyond twice the largest measured flows.

2.3.2 QA/QC

In general, the QA/QC methods for this work have focused on two approaches:

a. comparison of water level logger data to concurrent manual water level measurements to identify any substantial discrepancies in the water level logger data due to biofouling of the level logger sensor or other effects such as ice formation; and

b. mass balance checks to identify any issues in flow data at one or more stations (e.g., the sum of Victoria Creek flow(s) and Misema River flow (M1) should approximately equal the downstream flow at M2).[2]

The data collected by the Teledyne RD Instruments StreamPro ADCP boat in 2020 were discovered to be inaccurate when compared to both manual measurements taken in the same year and measurements conducted using all other methods between 2018 and 2024. All flows measured with this instrument at all Project stations in 2020 were not used in the development of the rating curves.

2.3.3 Estimation of Continuous Winter Flows for Victoria Creek

The continuous water level data and gauging cross-sections at V3F and V3G were substantially influenced by ice cover in the winter. Therefore, it was necessary to estimate the continuous winter flow data for these Victoria Creek stations.

Data from the upstream station, V1(2019), were used as a proxy for V3F and V3G stations based on the following reasons:

- V1(2019) winter flow data were not substantially influenced by ice cover, and

[2] For instance, where the sum of sum of Victoria Creek daily flow(s) and Misema River daily flow (M1) did not fall within the range of 85% to 115% of the M2 daily flows, all three datasets were reviewed for potential erroneous influences such as beaver effects, ice effects, or level logger error.

- Direct measurements of baseflow conditions during both winter and summer conditions at V3F and V3G were within the error margins of typical V1 flow data (i.e., often less than 115% of V1).

2.3.4 Data Gaps (2018 to 2024)

Animal interference (beaver effects) and ice effects were two of the most common reasons for data gaps at the Project stations. Table A1 in Appendix A summarizes the gaps in level/flow data and the methods used by SEI, where possible to fill in these gaps. Sometimes, when the flow rates from two out of three key stations (M1, M2, and V3F or V3G) were known, the mass balance method was employed to estimate the data for the third station. In winter, due to unreliable data recorded at V3F and/or V3G, the flows were estimated to be equal to V1, with the exception of data from winter 2024 when ice cover was unusually thin (in 2024, the V3F and V3G flow data were used without any infilling with V1 data). In winter 2023, ice conditions were also unusually thin at V3F, and the winter flow data from V3F were deemed valid based on comparison to upstream flows at V1 and other mass balance considerations.

2.3.5 Use of Edited and Infilled Data

Any edited or infilled data are identified as such in a “Notes” column adjacent to the data column in the electronic data files. These edited and infilled data have not been used when developing relationships between the Project stations and reference station for modelling of long-term Project flows.

2.4 2011-2013 Data

Appendix F contains the data collected at M1, M2, V1(2011), V3F US, as well as Ava and York Lake stations for the years 2011-2013. All but one of these stations was re-established in 2018 at the same locations as in 2011; therefore, water level data (and flow data where available) from these stations are fully comparable across the 2011-2024 period. From a flow perspective, data from the V1(2011) station are considered interchangeable with those from V1 (2019) since the two stations are separated by only 200 m distance and there are no significant tributaries between the two locations. However, the water level data from the two stations are <u>not</u> interchangeable.

2.5 Project Station Data Compared to WSC Data

For statistical analysis of long-term hydrologic conditions at a hydrometric station, a minimum record length of at least 10 years is required (e.g., Khaliq, 2022). None of the Project stations have records this long. Therefore, SEI evaluated relationships between flow data from the Project stations and concurrent data from regional WSC stations in northeastern Ontario to select a long-term reference station for the Project hydrometric stations. The results of this evaluation are presented in Section 4.1.

There are several historical WSC stations in the region of the Project. The closest active station is the 02JC008 station (Blanche River above Englehart), which is located approximately 35 km south of Ava Lake (see Figure 1.2.1). This is likely to be a useful reference station since the Project stations and their drainage areas are an integral part of this larger Blanche River watershed (station 02JC008). For instance, the M2 station watershed (404 km^2) contributes a total of 23% of the 02JC008 watershed (1780 km^2).

2.6 Long-term Flow Modelling for Project Stations

2.6.1 Chronological and Ranked Regression Methods

This section briefly describes the methods used to model long-term flow records for the Project hydrometric stations. More detail related to the long-term modelling approach is provided in Appendix C and Section 4.2.

SEI used two methods for this modelling work: chronological linear regression and ranked regression. Chronological linear regression is more straightforward: the flow measured on a particular day at the Project station is plotted against the flow measured at the reference station on the same day. Numerous data points plotted like this are used to develop a linear least-squares regression relationship between flows at the two stations. Conventional statistics for linear regressions are used to describe the resulting relationship.

Ranked regression is another method. It has been cautiously adopted by consulting firms across Canada (e.g., Sentlinger, 2025)[3] as a useful method to supplement the chronological linear regression method. This technique is similar to ordinary least-squares regression, but the data are ranked from lowest to highest values prior to analysis. A major advantage of the ranked approach is that subtle differences in the relationships between the Project station and the long-term reference station at different flow conditions (e.g., low flows) are more evident using the ranked approach. One disadvantage of the ranked approach is that conventional statistics such as the coefficient of determination ("R^2") cannot be used to describe the relationship. In this report, the ranked regression has only been used for the months of June to October, during which annual low flows are most likely to occur at the Project hydrometric stations.

2.6.2 Seasons used in Long-Term Modelling

The following hydrological seasons were selected for long-term modelling of flows at the Project hydrometric stations based on typical annual streamflow patterns:

- Spring Freshet -- April and May;

[3] Personal communication between Anthony Story and Gabe Sentlinger, P.Eng. (Fathom Scientific Limited, Vancouver, BC), June 2025.

- Summer -- June to October;
- Fall -- November and December; and
- Winter -- January to March.

Average monthly flows tend to be lower in winter than in summer, but winter flows are more consistent from year-to-year due to limited precipitation and snowmelt in the winter months, as well as low rates of evapotranspiration. More extreme low flows such as the $7Q_2$ and $7Q_{20}$ annual flows (7 day average low flow with recurrence intervals of 2 and 20 years, respectively), occur in the warm months from June to October (especially July to September), when evapotranspiration is highest.

2.6.3 Generating Long-Term Flow Records

First, relationships between the Project station and reference station were developed for each of the seasons described in Section 2.6.2, using all available Project data from 2011 to 2024. Then, these relationships were applied to the longer data record from the reference station, where complete flow records are available from 1974 to 2024. As a result, modelled flow data for the Project stations are available for a 51 year period from 1974 to 2024.

2.6.4 Low-Flow Statistics

Multiple methods were used to calculate, check, and verify statistical low flow statistics (annual 7Q2, 7Q5, 7Q10, 7Q20) calculated for the Project stations. Frequent use was made of the National Research Council publication of Khaliq (2022), which provided low-flow statistics for all WSC stations in Ontario with suitable records. In brief, simple graphical techniques were used to estimate low flow statistics for the Project stations from the relationship of the Project Station flows to flows at a key WSC reference station for which Khaliq (2022) calculated the low flow statistics. Additional information is provided in Appendix D.

2.6.5 Regional Low Flow Analysis

As a final check on the validity of the low flow statistics calculated in this study, SEI also carried out regional low flow analysis using the dataset of Khaliq (2022). This involved plotting the annual low flow indices for 45 WSC stations against their drainage areas.

The selected 45 stations were all located within a 400 km distance of the Project, which was deemed to be a relatively homogeneous climatic zone in northeastern Ontario. Stations in the far north of Ontario and to the west of Sault Ste. Marie were not included in the dataset. All selected stations were reported to have natural flow regimes (i.e., not substantially regulated by hydroelectric dams, etc.).

Figure 2.6.1 shows an example plot of Khaliq's (2022) dataset, as well as the best estimate 7Q2 for one of the Project stations from this study. The Project station 7Q2 estimate from this study is somewhat lower than would be predicted from the best-fit power regression in Figure 2.6.1, but it is consistent with the pattern in Khaliq's (2022) dataset given the significant scatter around the line of best fit. Figure 2.6.1 is provided as an example of the method only. Plots showing results for all Project stations, and all four low flow statistics, are provided in Section 4.5.

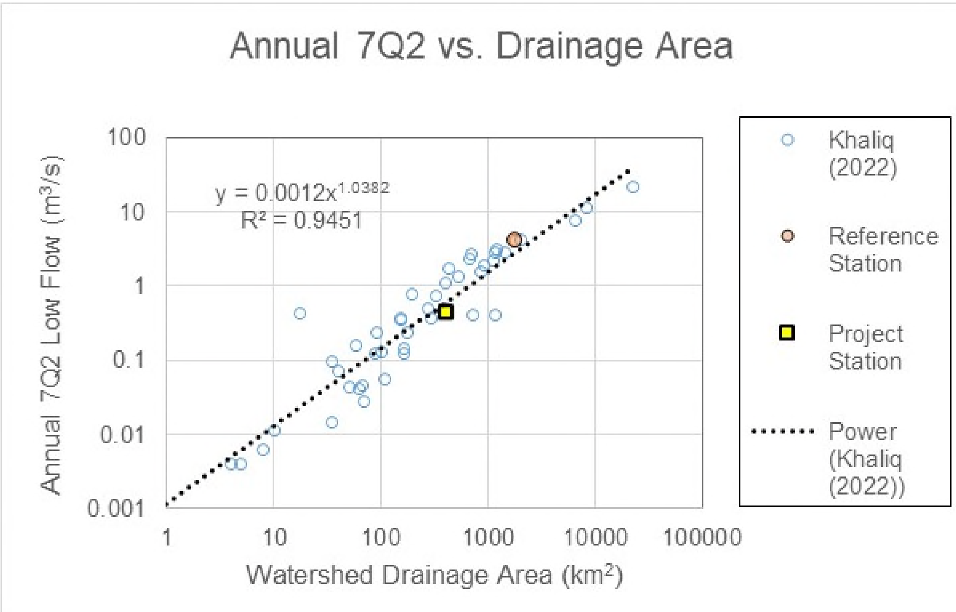


Figure 2.6.1 Example of Regional Low Flow Analysis Used as a Check

3 Results – Project Station Data

An important goal of this report was to update the flow records (all the daily data) for all stations from 2011 to 2024, using the most recent rating curves established for each station as applicable. The rating curves have been refined from year-to-year as more data has become available, especially for higher flows and water levels. The evolution of the rating curves for all stations is provided in Table A2 of Appendix A.

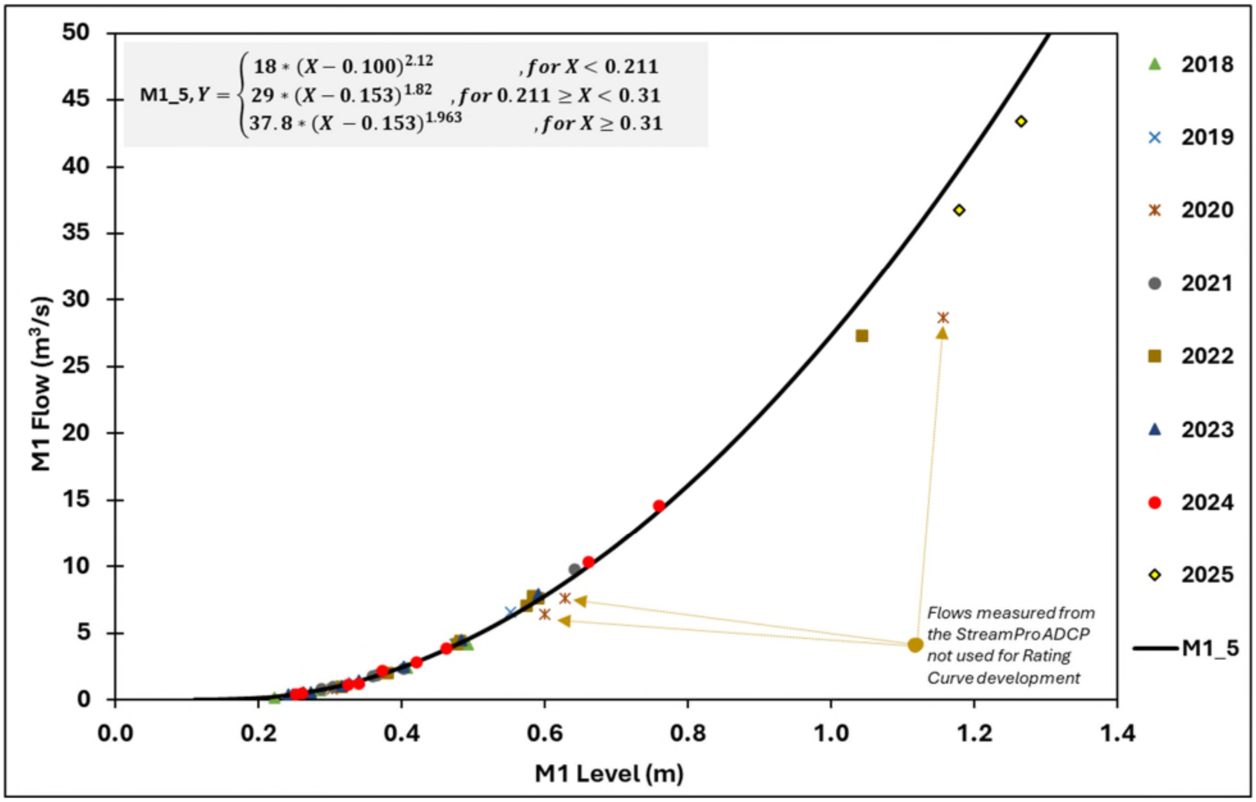
3.1 M1 Rating Curve

Following the nomenclature suggestions by the WSC in their 2016 document (Rainville et al., 2016), the current rating curve for the M1 station is notified as M1_5, as this is the fifth iteration of the development of the curve at this station. Figure 3.1.1 shows the current rating curve (M1_5) for the M1 station.

As shown in Figure 3.1.1, three equations are used to describe the rating curves: one segment for moderate to high flows that is valid for water levels greater than or equal to ~0.31 m, a second segment for low to moderate flows that is valid for water levels less than 0.31 m and greater than or equal to 0.211 m, and a third segment for low flows that is valid for water levels less than 0.211 m.

Data used to develop the M1 rating curve are shown in Table A3, Appendix A. As noted previously in Section 2.3.2, the flow measurements made in 2020 with the StreamPro ADCP were not considered in the development of the Project rating curves.

For the 2011-2013 dataset, the M1_0 rating curve was applied to derive daily flow results. The M1_0 curve is identical to M1_5 at water levels greater than 0.49 m. There are small differences in the curve below those water levels, including use of a second-order polynomial fit, which fits the direct gauging results better (Figure 3.1.2). The M1_0 curve also provided superior results from a mass balance perspective for those periods of 2011 and 2012 when flow data were available from all three stations (M1, V3F, and M2).



"R:\SEI\105 Agnico Eagle\105-101_Upper Beaver\09 - Hydrology\Work\2025\Rating Curves and Survey with 2024 Data -- COPIED for 2025 work\M1_AllData_wRatingCurve_31July2025_AS_ACS.xlsx"

Figure 3.1.1 Rating Curve (M1_5) for M1 Station, used for 2018-2024 Dataset

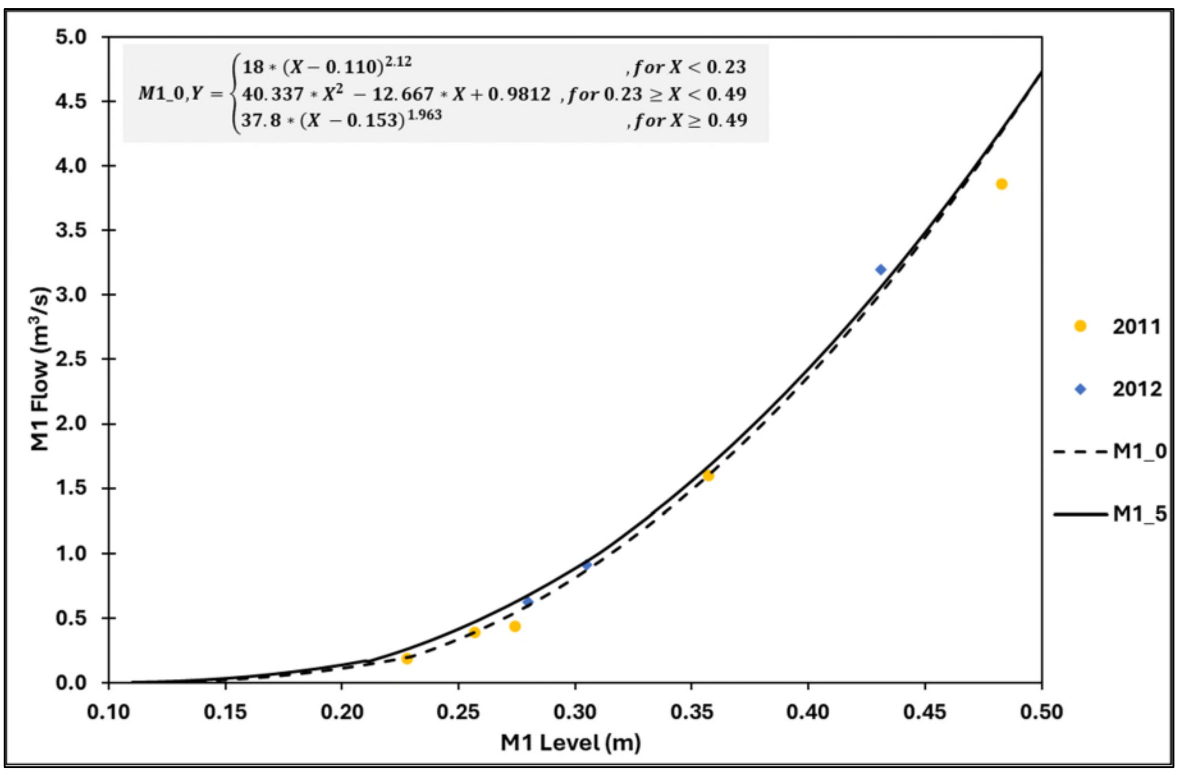
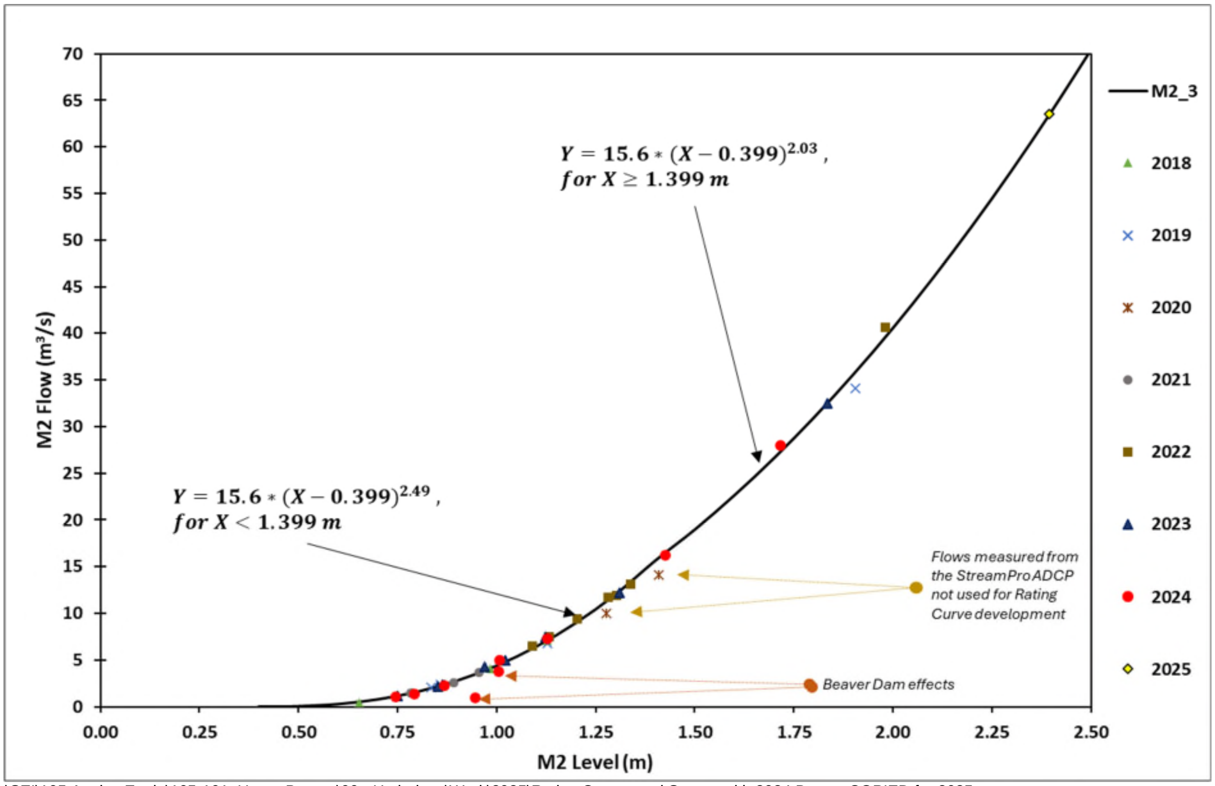


Figure 3.1.2 Rating Curve (M1_0) for M1 Station, used for 2011-2013 Dataset

For the 2011-2013 dataset, the M1_0 rating curve was applied to derive daily flow results. The M1 rating curve (M1_5) updated for the 2024 Hydrometric Report (SEI, 2025), was applied to derive daily flow results from 2018 to 2024. Moving forward, M1_5 will be used.

3.2 M2 Rating Curve

There is a strong relationship between water level and flow over the range of measured flows at the M2 station (Figure 3.2.1). The current rating curve is M2_3, as this is the third iteration of the development of the curve at this station. Two equations are used to describe the curve: one for moderate to high flows that is valid for water levels greater than or equal to 1.399 m and one for lower flows that is valid for water levels less than 1.399 m. Data used to develop the M2 station rating curves are provided in Table A4, Appendix A.



"R:\SEI\105 Agnico Eagle\105-101_Upper Beaver\09 - Hydrology\Work\2025\Rating Curves and Survey with 2024 Data -- COPIED for 2025 work\M2_AllData_wRatingCurve_31July2025_ACS,AS.xlsx"

Figure 3.2.1 Rating Curve (M2_3) for M2 Station, used for 2018-2024 Dataset

A separate M2 rating curve (denoted as M2_0) was used for the 2011-2013 data (Figure 3.2.2). This M2_0 rating curve is the same as M2_3, except that the offset is 0.019 m different than M2_3 (0.38 m in M2_0 versus 0.399 m in M2_3). M2_0 provides a good fit to the low-to-moderate flow data available from 2011 and 2012 (Figure 3.2.2). Because no direct measurements of high flow data were completed in 2011 and 2012, it has been assumed that the high flow segment of the rating curve for those years is valid by making the same adjustment to the offset as for the low flow segment (i.e., adjusting it from 0.399 to 0.38 m). Simple mass balance evidence (e.g., plotting M2 versus M1 flows for both periods (2011-2013 and 2018-2024) indicated that this assumption is valid.

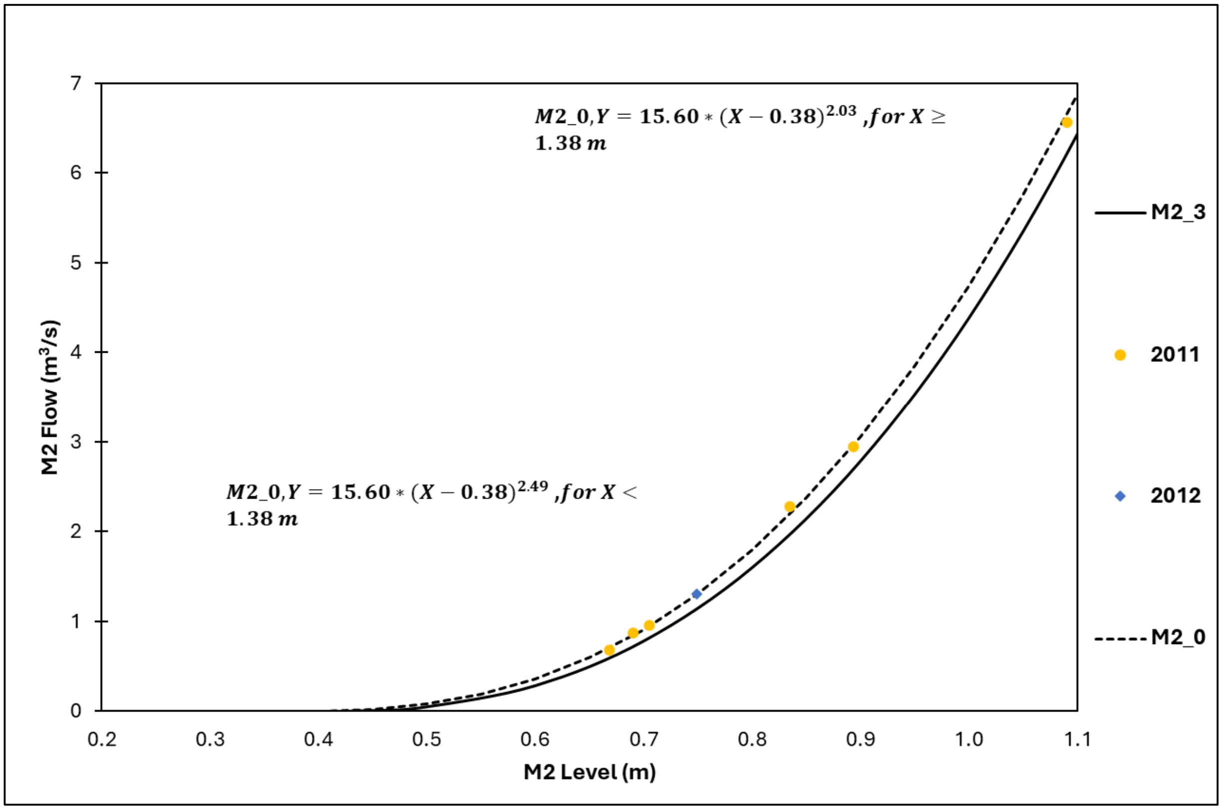


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Figure 3.2.2 Rating Curve (M2_0) for M2 Station, used for 2011-2013 Dataset

The rating curve developed for M2 in 2022 (i.e., M2_3), was applied to the level data recorded for the years 2018 to 2024. The rating curve has not required refinement since it was last updated in 2022.

3.3 V3F Rating Curve

This station has two water level stations in close proximity: the original V3F station (now called V3F US) and V3F DS. V3F DS was established as a pro-active measure to avoid beaver activity that occurred upstream in 2011 and 2012. However, no beaver activity was observed at V3F US over the 2018 to 2024 period. Manual measurements have been conducted at both locations beginning in 2018, which are provided in Table A5, Appendix A.

The current rating curve for V3F US (i.e., V3F_U4; Figure 3.3.1) is the fourth iteration of the development of this rating curve. Two equations are used to describe the rating curve: one for moderate to high flows that is valid for water levels greater than or equal to 0.295 m and one for lower flows that is valid for water levels less than 0.295 m.

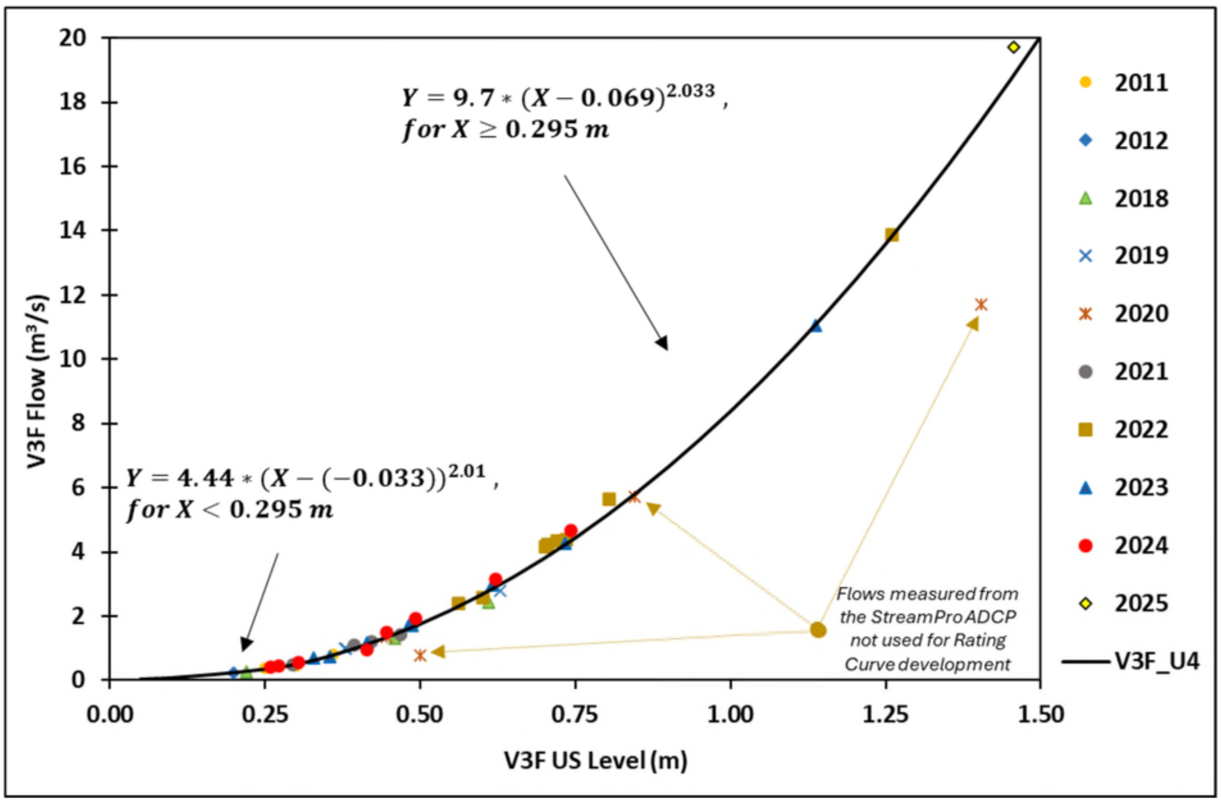

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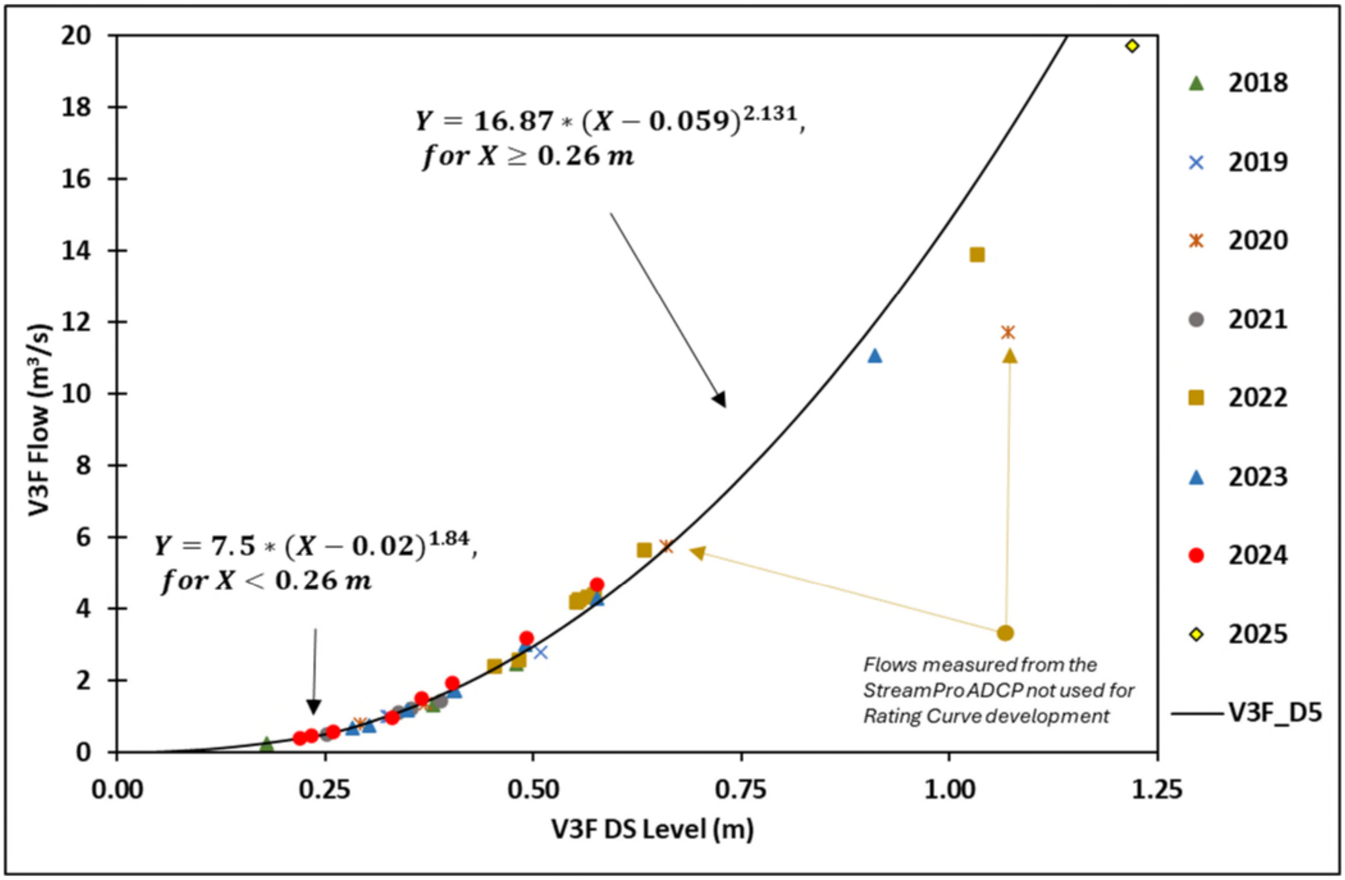
Figure 3.3.1 Rating Curve for Victoria Creek Station V3F US (V3F_U4)

The current rating curve for V3F DS (i.e., V3F_D5) is the fifth iteration of the development of the rating curve (Figure 3.3.2). Two equations are used to describe the curve: one for high flows that is valid for water levels greater than or equal to 0.26 m and one for lower flows that is valid for water levels less than 0.26 m.



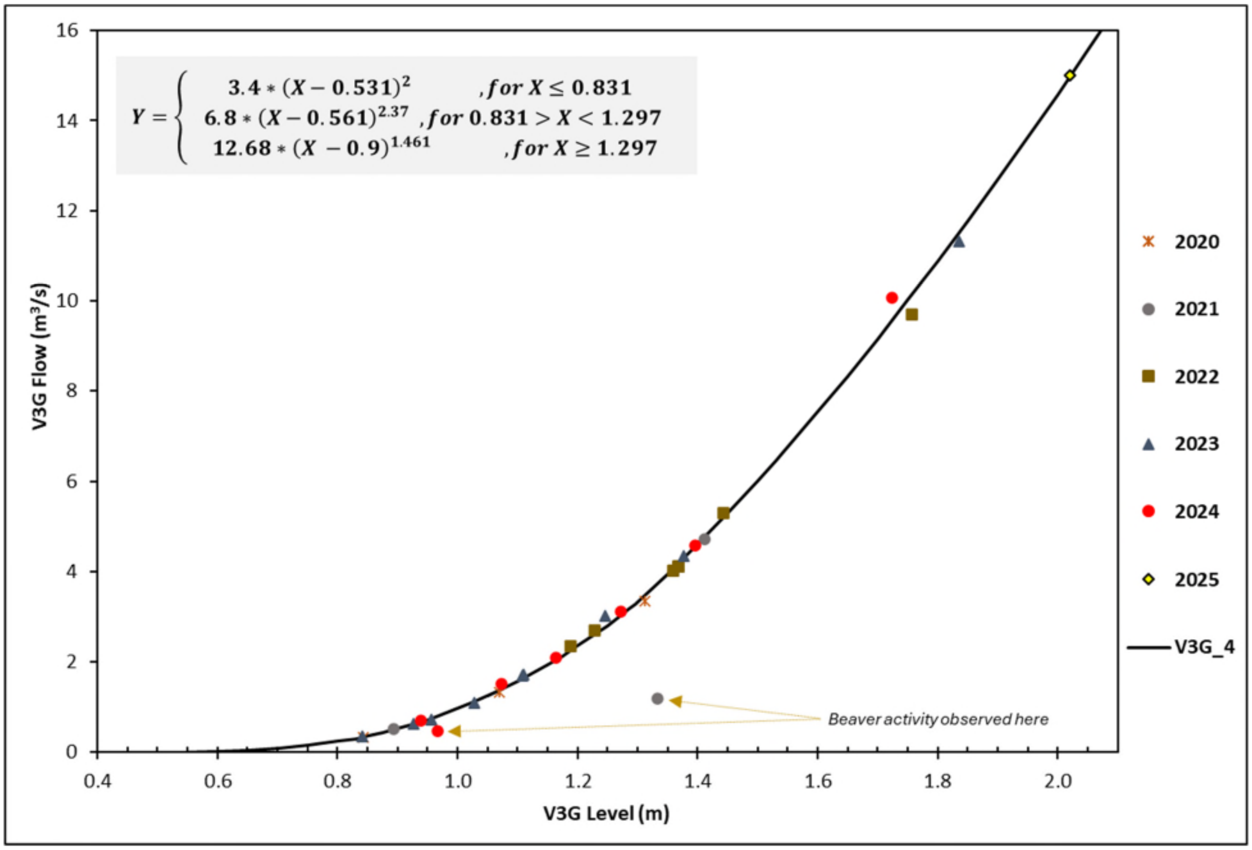
"R:\SEI\105 Agnico Eagle\105-101_Upper Beaver\09 - Hydrology\Work\2025\Rating Curves and Survey with 2024 Data -- COPIED for 2025 work\V3F_AllData_wRatingCurve_31July2025_AS.xlsx"

Figure 3.3.2 Rating Curve for Victoria Creek Station V3F DS (V3F_D5)

The rating curve developed for V3F US in 2022 (i.e., V3F_U4) as well as the rating curve developed for V3F DS in 2024 (i.e., V3F_D5), were applied to the level data recorded for the years 2018 to 2024. The V3F US rating curve has not required refinement since it was last updated in 2022.

3.4 V3G Rating Curve

The current rating curve for the V3G station is depicted on Figure 3.4.1 as V3G_4, as this is the fourth iteration of the development of the curve. This rating curve was updated in August 2025 based on inclusion of April 2025 high flow data (see Section 2.3.1). Three equations are used to describe the rating curve: one for high flows that is valid for water levels greater than or equal to 1.297 m, one for low-to-moderate flows between water levels of 0.831 and 1.297 m, and one for low flows that is valid for water levels less than or equal to 0.831 m. The data used to develop the rating curve for V3G are shown in Table A6, Appendix A. The V3G_4 rating curve was applied to all data available from 2020 to 2024.



"R:\SEI\105 Agnico Eagle\105-101_Upper Beaver\09 - Hydrology\Work\2024\Rating Curves\For Baseline Report\105A_101_V3G Rating Curve_Cleaned_28Jan2025_ACS_AS.xlsx"

Figure 3.4.1 Rating Curve for the V3G station (V3G_4) (w Apr 2025)

3.5 V1 Rating Curve (2019 to 2024)

The V1 rating curve was updated in 2023 because large woody debris was observed at the edges of the V1 dam spillway since the gauging work began at V1(2019) in 2019. This debris was relatively stable and had not had any obvious effects on the flow gauging results. However, in communications with MECP staff through 2022, it was decided that V1 would be a key source of water level and flow data. To ensure a clear starting point, the woody debris was removed from the spillway on 30 August 2022. This did not affect the lowest-flow portion of the rating curve (below 0.14 m or 0.86 m^3/s), presumably because the water was able to flow under the woody debris relatively unimpeded at low flows and water levels. However, the higher flow portion of the curve was affected as shown in Figure 3.5.1 and further explained below.

Data measured up to and including the year 2025 are depicted in Figure 3.5.1. For the 2022 data, two distinct symbols represent the data before and after the “Large Woody Debris Removal” (“LWDR”) in 2022, denoted as “2022_B4_LWDR” and “2022_Aftr_LWDR”, respectively. The rating curve V1_2 is also presented, which was the rating curve used at this station until 30 August 2022. All four data points measured in 2022 after the woody debris removal (“2022_Aftr_LWDR”), as well as all higher-flow data from 2023 to 2025, plot above the V1_2 rating curve (Figure 3.5.1). Therefore, for flows greater than 0.86 m^3/s, a different rating curve (V1_4) was developed for that segment of the curve. After 30 August 2022, the V1_4 rating curve has been applied to all level data for the V1 station.

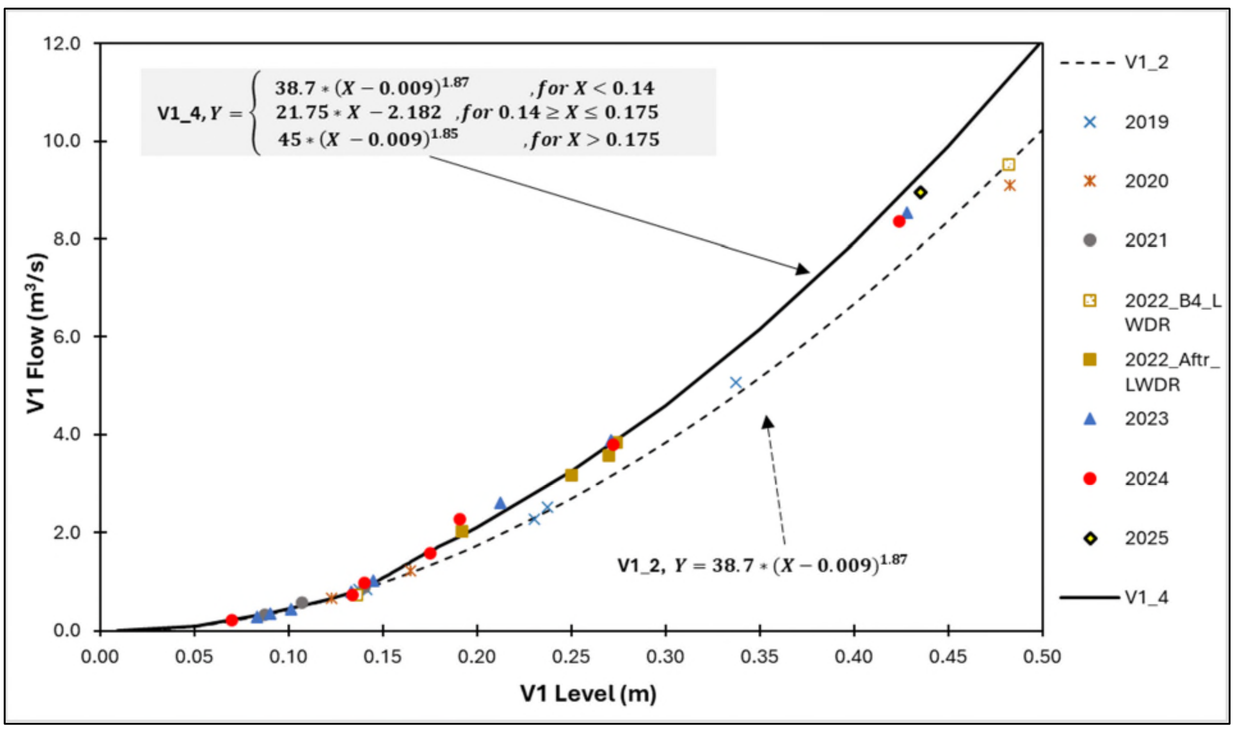


Figure 3.5.1 Rating Curve (V1_2) and the Current Rating Curve (V1_4) at V1(2019) Station

Rating curves developed for the 2011 and 2012 data are shown in Figure 3.5.2. It is noted that the V1 (2011) station was at a different location than V1 (2019) and therefore these rating curves are entirely unrelated to the newer rating curves for the V1 (2019) station. The data used to develop the rating curves are shown in Table A7, Appendix A.

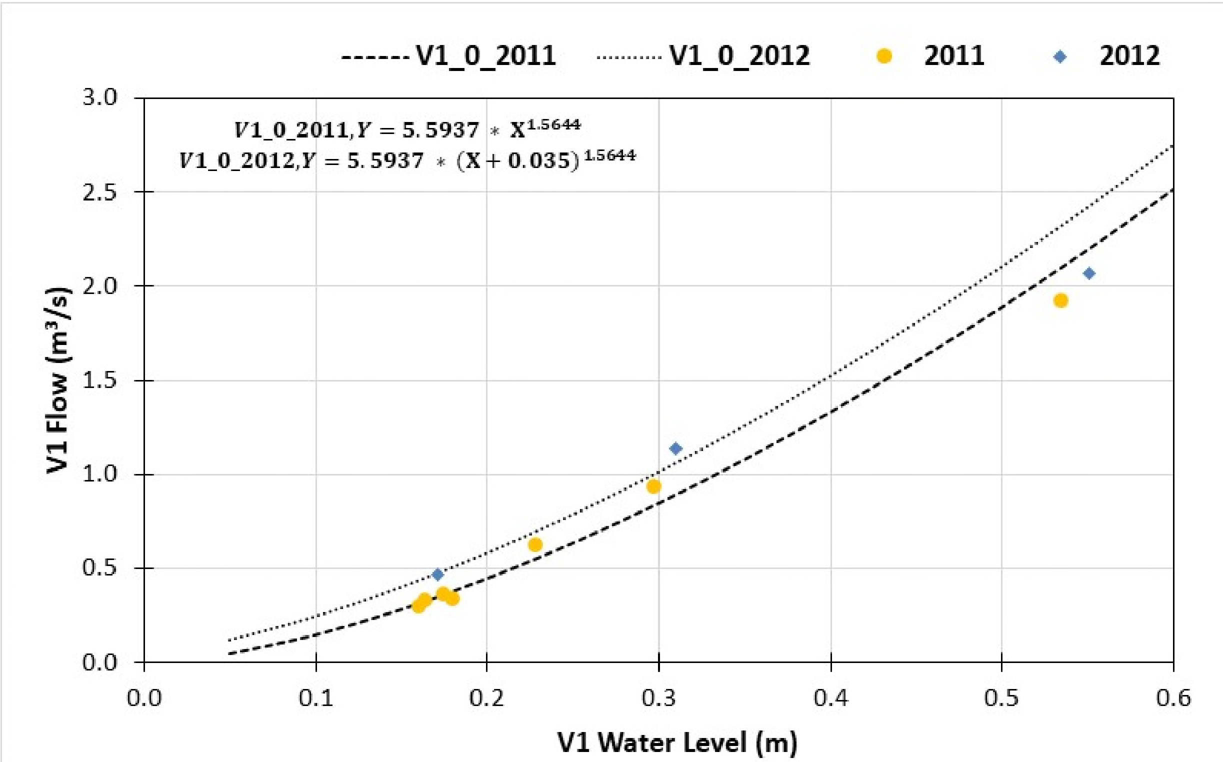
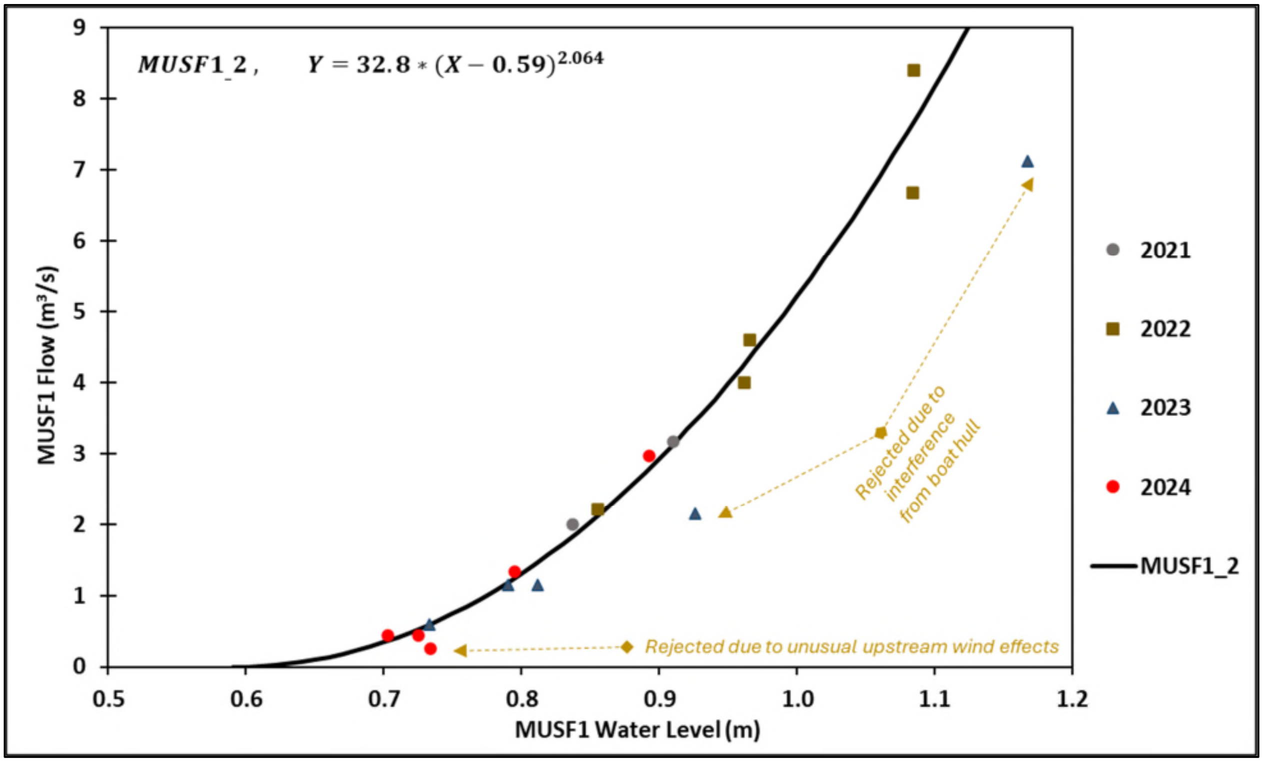


Figure 3.5.2 Rating Curves (V1_0_2011 and V1_0_2012) for V1 (2011) Station, used for 2011-2012 Dataset

3.6 MUSF1 Rating Curve

MUSF1 is the newest Project station, established in fall 2021. The data used to develop the rating curve for this station (Figure 3.6.1) are provided in Table A8, Appendix A. The current rating curve is MUSF1_2, which was updated in 2024, and it has been applied to all available level logger data from this station (2022 through 2024). For this station, a total of four derived daily flows have been flagged as “C grade” in the electronic dataset since these flows were greater than twice the highest directly measured flow value (16.8 m^3/s or two times the highest directly measured flow of 8.4 m^3/s).



"R:\SEI\105 Agnico Eagle\105-101_Upper Beaver\09 - Hydrology\Work\2025\2024 Baseline Report Work\Rating Curves For Baseline Report\105A_101_MUSF1 RatingCurve_Cleaned_10March2025_AS.xlsx"

Figure 3.6.1 Rating Curve for the MUSF1 Station (MUSF1_2)

4 Results – Modelling Long-Term Project Flows

4.1 Project Station Data Compared to Concurrent WSC Station Data

The first step toward modelling long-term flows for the Project hydrometric stations was to select an appropriate reference station with long-term (ideally 20 years or more) records. This reference station should ideally be an active WSC station with concurrent data that span the full length of the Project hydrometric station records.

The Blanche River station (WSC ID 02JC008) had been selected as the reference station for this Project in earlier work (SEI, 2020) since it is the closest active station with a long data record. To be certain that station 02JC008 is the best reference station, SEI reviewed records for 45 WSC stations in the northern Ontario region, and an additional 34 WSC stations in western Quebec.[4] The purpose of this review was to identify if any suitable candidate stations were: 1) closer to the Project hydrometric stations than 02JC008 (~35 km distant); and 2) had smaller watersheds than 02JC008 (at 1780 km^2). Table 4.1.1 lists six potential candidate watersheds in northern Ontario within 150 km of the Project[5], and an additional six candidate watersheds in northwestern Quebec that were identified as the best potential stations from the longer list of 79 stations initially reviewed (45 stations in Ontario and 34 in Quebec).

Aside from the Blanche River station (02JC008), only one other candidate watershed was deemed worthy of consideration as a reference station for this Project. The Porcupine River at Hoyle (Station 04MD004) is relatively close to the Project (105 km distant) and its watershed is smaller than the Blanche River station. This station is no longer active, but data are available until March 2022, providing several years of concurrent data for the Project stations. SEI carried out additional analyses to evaluate the suitability of the Porcupine River station as a potential reference station for the Project.

Figure 4.1.1 shows the results of linear regressions for M2 station flow data against the two candidate WSC stations, using all available concurrent data. The coefficient of determination (R^2) is higher for the regression against the Blanche River (0.93 – Figure 4.1.1A) than against the Porcupine River (0.82 – Figure 4.1.1B), suggesting that the Blanche River would be the better reference station. Figure 4.1.2 considers the important low flow season from June to October. For these months, the fit between the M2 station and the Blanche River is much better (R^2=0.86) than the fit between the M2 station and the Porcupine River (R^2=0.45). Therefore, the Blanche River station (02JC008) was selected as the reference station for generating long-term flow records for the Project stations.

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[4] Low flow statistics (e.g., Khaliq, 2022) are not readily available for these Quebec stations and they were therefore not included in the regional low flow analysis described in Sections 2.6.5 and 4.5.
[5] This 150 km radius differs from the 400 km radius described in Section 2.6.5 because close proximity of stations is not as important for regional low flow analysis.

Table 4.1.1 WSC Stations Considered as Potential Reference Stations

WSC Station ID / Province	Station Name	Drainage Area (km^2)	Distance to Project (km)	Carried forward for Evaluation?
02DC012 (ON)	Sturgeon River at Upper Goose Falls	1200	143	No – too distant
02JC008 (ON)	Blanche River above Englehart	1780	35	Yes (closest)
02JE018 (ON)	Farr Creek at North Cobalt	62.9	84	No – not active
04LA003 (ON)	Tatachikapika River near Timmins	872	136	No – too distant
04LB002 (ON)	Kamiskotia River above Enid Creek	926	147	No – too distant
04MD004 (ON)	Porcupine River at Hoyle	408	105	Yes – smaller watershed and closest after 02JC008
02JB003 (QC)	Kinojevis (Riviere) en aval de la Riviere Villemontel	1680	109	No – not active
02JB004 (QC)	Kinojevis (Riviere) en aval du Lac Preissac	984	107	No – not active
02JB013 (QC)	Kinojevis (Riviere) a 0.3 km en amont du - pont Route a Cléricy	2590	71	No – larger than 02JC008
02JE017 (QC)	Kipawa (Lac) a Laniel	5980	130	No – water level only
04NA001 (QC)	Harricana (Riviere) 3,1 km en aval du pont-Route 111 a Amos	3680	132	No – larger than 02JC008
04NA002 (QC)	Harricana a (Riviere) A Amos-2	3680	129	No – not active

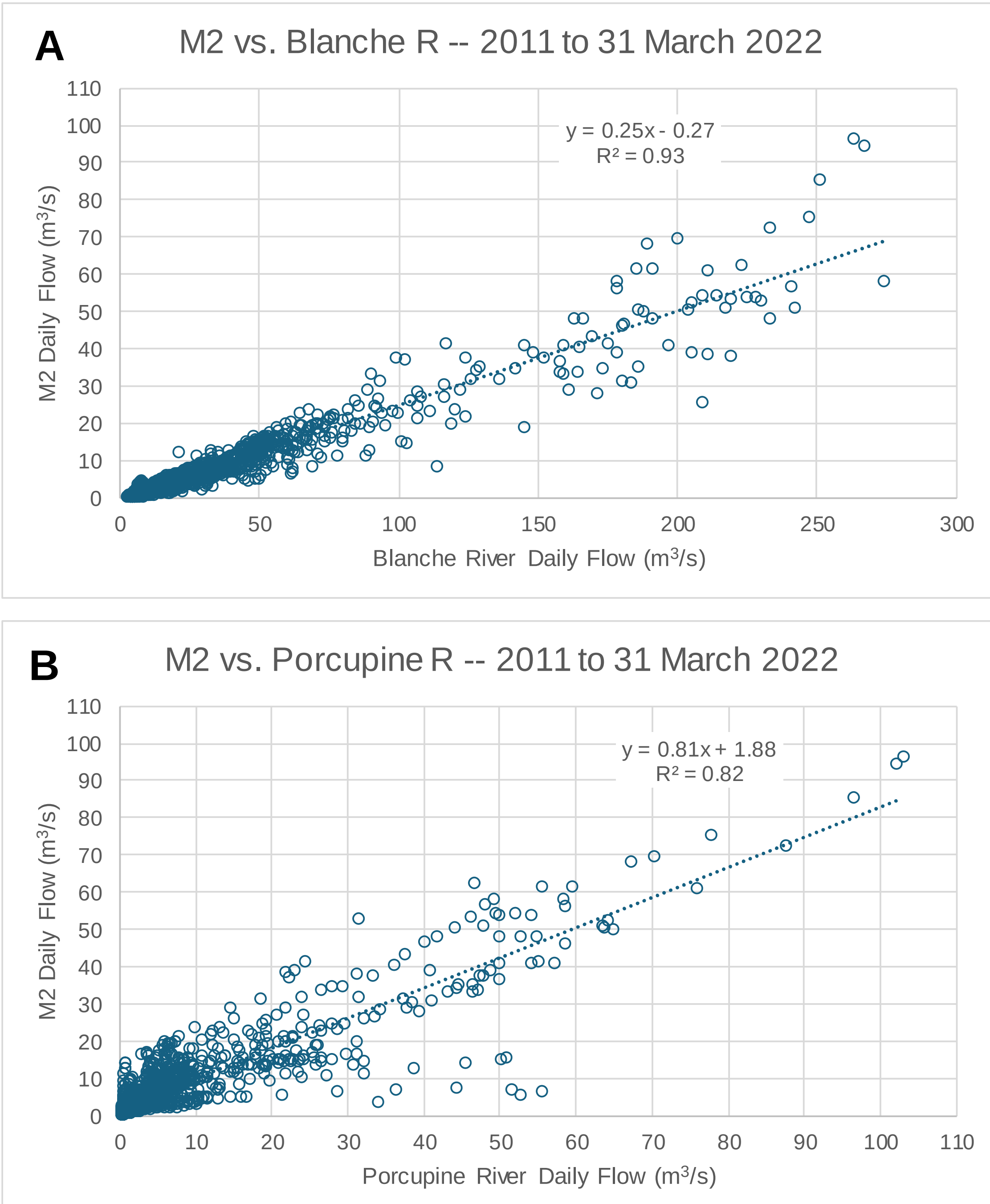

Figure 4.1.1 M2 Flows Plotted against two Potential Reference Stations

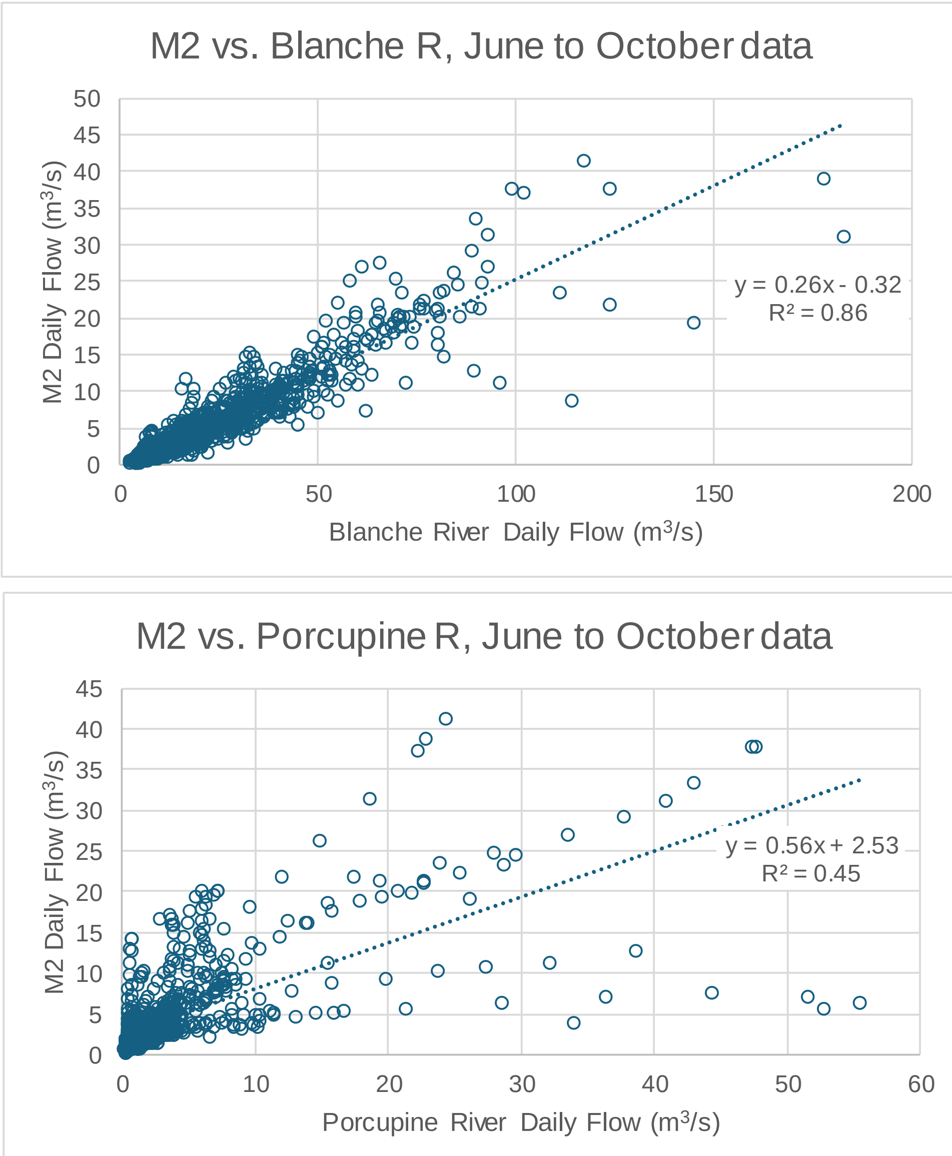

Figure 4.1.2 M2 Flows Plotted against two Potential Reference Stations, June-October

4.2 Long-Term Modelled Flows

4.2.1 Long-Term Modelled Flows and Seasonal Approach

Section 4.2 summarizes the models used at each of the six main project stations (M2, M1, V1, V3F, V3G, and MUSF1).

In general, SEI used chronological linear regression to develop relationships between the Blanche River reference station and the Project stations. The intercept was usually forced through the origin (zero on both axes) in chronological linear regressions for Winter, Spring freshet, and Fall, under the assumption that if the Blanche River ceased to flow in some hypothetical dry scenario, there would also be no flow at the Project stations. However, at some stations it was necessary to calculate an intercept in the regressions to provide an accurate model of Project station flows as noted below for V3F and V1 in Sections 4.2.4 and 4.2.5.

For the important low flow months of June to October (Summer), the ranked regression approach was used for low flows, as explained further in Appendices C and D. Curvilinear regressions were applied to the lowest flows to mimic the patterns in the ranked low flow data (e.g., Figure 4.2.1A for M2). For moderate and high flows in the Summer, the chronological regression method was applied (e.g., Figure 4.2.1B for M2). For these chronological linear regressions in Summer, the intercept was not forced through the origin since it was necessary to calculate the intercept to provide a realistic merging point with the curvilinear ranked regressions for the low flows.

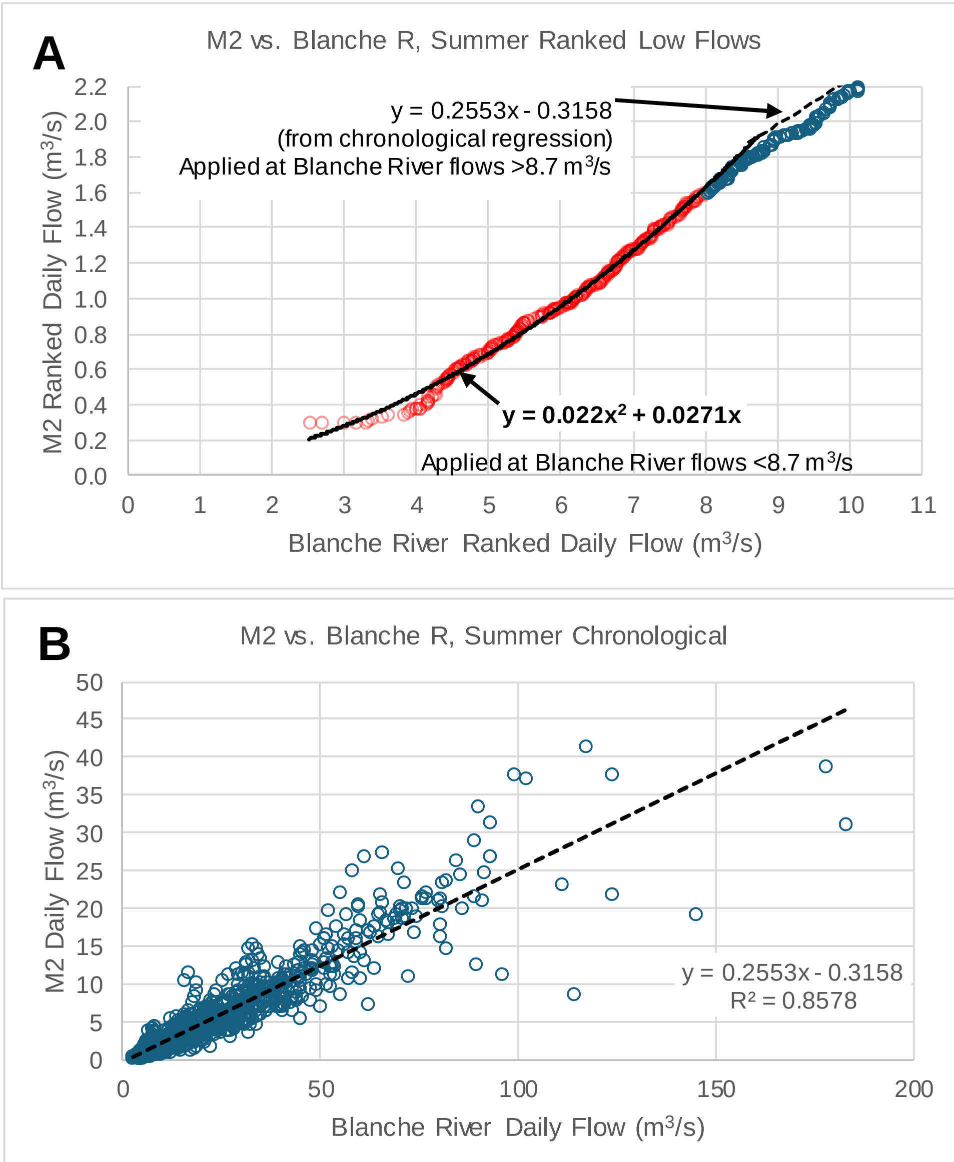

Figure 4.2.1 M2 Low Flow modelling using Ranked Regression for Summer (A – Upper Panel) and M2 Moderate to High Flow Modelling using Chronological Linear Regression for Summer (B – Lower Panel).

4.2.2 M2 Seasonal Models

Table 4.2.1 provides a summary of the seasonal regression models developed for the M2 station. The M2 watershed has a drainage area of 404 km^2 and the Blanche River watershed has a drainage area of 1780 km^2, therefore a regression slope of 0.227 (404/1780 km^2) is anticipated fundamentally. All linear regressions for M2 (Table 4.2.1) have slopes similar to, but slightly higher, than this fundamental theory. Plots of the chronological regression results for Winter, Freshet, and Fall, are provided in Appendix C. The regression results for the Summer were plotted above in Figure 4.2.1 to provide an example of the approach for that season in the main body of the report.

Table 4.2.1 M2 Summary Table of Seasonal Regression Modelling

Season (Months)	Regression Equation	Moderate-to-High Flow Regression, if any
Winter (January to March)	Y = 0.250x	
Freshet (April-May)	Y = 0.239x	
Summer (June to October)	$Y = 0.022x^2 + 0.027x$ (low flow)	Y = 0.255x - 0.316
Fall (November-December)	Y = 0.252x	

4.2.3 M1 Seasonal Models

Table 4.2.2 provides a summary of the seasonal regression models developed for the M1 station. The M1 watershed has a drainage area of 254 km^2 and the Blanche River watershed has a drainage area of 1780 km^2, therefore a regression slope of 0.143 (254/1780 km^2) is anticipated. Like the M2 station, all linear regressions for M1 (Table 4.2.2) have slopes similar to, but slightly higher, than this fundamental theory. Plots of the regression results for all seasons are provided in Appendix C.

Table 4.2.2 M1 Summary Table of Seasonal Regression Modelling

Season (Months)	Regression Equation	Moderate-to-High Flow Regression, if any
Winter (January to March)	Y = 0.162x	
Freshet (April-May)	Y = 0.160x	
Summer (June to October)	$Y = 0.0145x^2 + 0.002x$ (low flow)	Y=0.161x - 0.274
Fall (November-December)	Y = 0.157x	

4.2.4 V3F Seasonal Models

Table 4.2.3 provides a summary of the seasonal regression models developed for the V3F station. The V3F watershed has a drainage area of 142 km^2 and the Blanche River watershed has a drainage area of 1780 km^2, therefore a regression slope of 0.080 (142/1780 km^2) is anticipated. The linear regression slopes for V3F (Table 4.2.3) are similar to this fundamental theory. Notably, the linear regression for Winter includes a calculated intercept (0.239 m^3/s). This intercept was required to provide an accurate model of winter low flows. Similarly, an intercept was included in the Fall regression to provide a consistent approach across the Fall and Winter seasons for V3F. Plots of the regression results for all seasons are provided in Appendix C.

Table 4.2.3 V3F Summary Table of Seasonal Regression Modelling

Season (Months)	Regression Equation	Moderate-to-High Flow Regression, if any
Winter (January to March)	Y = 0.072x + 0.239	
Freshet (April-May)	Y = 0.078x	
Summer (June to October)	$Y = 0.0074x^2 + 0.027x$ (low flow)	y = 0.092x - 0.055
Fall (November-December)	Y = 0.091x – 0.125	

4.2.5 V1 Seasonal Models

Table 4.2.4 provides a summary of the seasonal regression models developed for the V1 station. The V1 watershed has a drainage area of 98 km^2 and the Blanche River watershed has a drainage area of 1780 km^2, therefore a regression slope of 0.055 (98/1780 km^2) is anticipated. The linear regression slopes for V1 are similar to this theory with slopes higher in some seasons and lower in others (Table 4.2.4). Notably, the chronological linear regression for Winter includes a calculated intercept (0.461 m^3/s). This intercept was required to provide an accurate model of winter low flows. Similarly, an intercept was included in the Fall regression to provide a consistent approach across the Fall and Winter seasons for V1. Also, an intercept was not required for the Summer season since use of the intercept provided unrealistic summer low flows. Plots of the regression results for all seasons are provided in Appendix C.

Table 4.2.4 V1 Summary Table of Seasonal Regression Modelling

Season (Months)	Regression Equation	Moderate-to-High Flow Regression, if any
Winter (January to March)	Y = 0.036x + 0.461	
Freshet (April-May)	Y = 0.051x	
Summer (June to October)	$Y = 0.0058x^2 + 0.022x$ (low flow)	y = 0.064x
Fall (November-December)	y = 0.064x + 0.11	

4.2.6 V3G Long-Term Modelling

The V3G watershed (145 km^2) on Victoria Creek is approximately 2% larger than the upstream V3F watershed (142 km^2). SEI explored the relationship between flows at the two stations using chronological linear regression. The linear regression results are consistent with the difference in watershed size between the two stations, with a slope of 1.02 (Figure 4.2.2). Therefore, rather than develop an additional set of seasonal models for the V3G station and calculate long-term flows based on relationships with the Blanche River, the long-term flow statistics (e.g., monthly average flows) have been estimated for V3G based on the relationship between its flows and those at V3F (Figure 4.2.2).

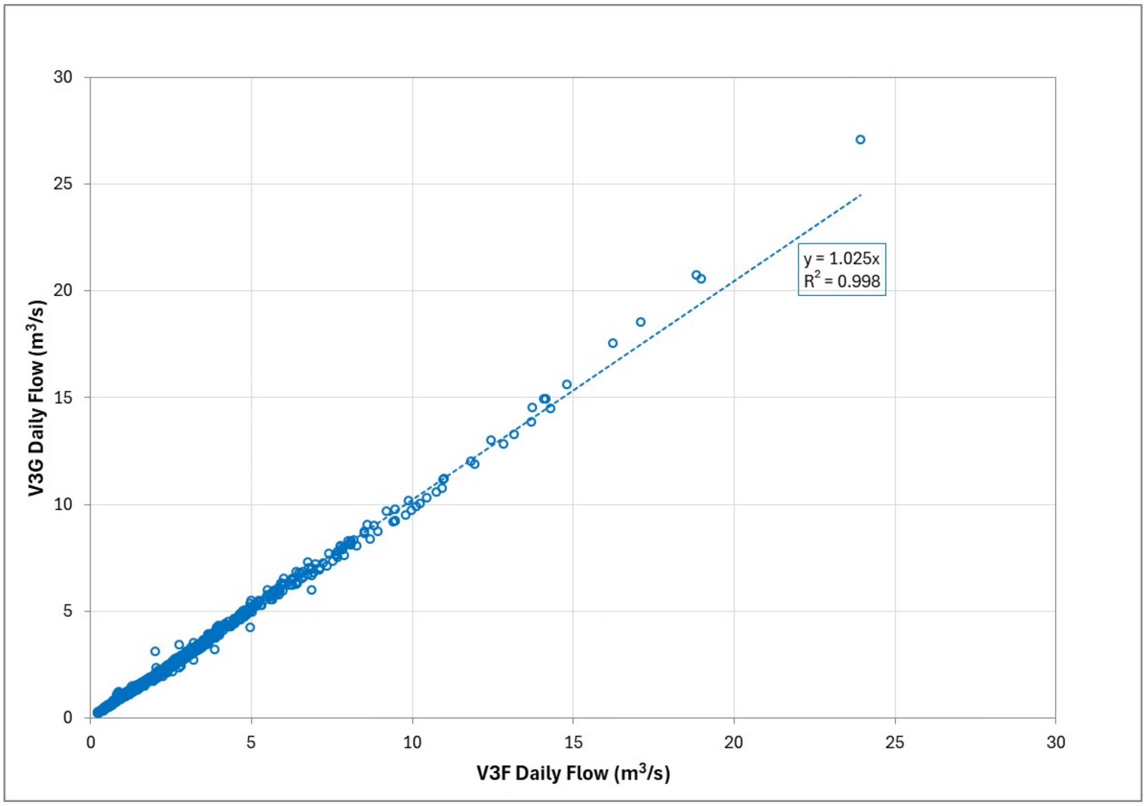

Figure 4.2.2 Daily Flows at V3F versus Daily Flows at V3G

4.2.7 MUSF1 Long-Term Modelling

At MUSF1, flow has only been measured during the months of June to October. Therefore, a seasonal relationship between the Blanche River and MUSF1 flows was only developed for those months (Table 4.2.5). A plot of the regression results for MUSF1 is provided in Appendix C.

Table 4.2.5 MUSF1 Summary Table of Seasonal Regression Modelling

Season (Months)	Regression Equation	Moderate-to-High Flow Regression
Summer (June to October)	$Y = 0.006x^2 + 0.047x$ (low flow)	$Y = 0.175x - 0.239$

Long-term modelled flow data for MUSF1 flows outside of the months to June to October have not been provided here. If MUSF1 streamflow data are required for modelling or other applications, SEI suggests that it would be reasonable to assume that MUSF1 monthly flows are equal to M1 flows during November to May. This assumption should be accurate to within ±10% since the M1 watershed (254 km^2) is only 8.5% larger than the MUSF1 watershed (234 km^2).

4.2.8 Goodness of Fit Statistics for Long-Term Modelling

The Nash-Sutcliffe model efficient coefficient (NSE) was calculated for the flow data derived from the seasonal models for the Project. An NSE value of greater than 0.65 has been reported as indicating satisfactory goodness-of-fit for evaluation of daily modelling results (Lin et al., 2017). For all Project stations, a single NSE value was calculated using all of the modelled daily flow data versus the available observed daily flow data . Figure 4.2.3 provides an example plot for the M2 station. Table 4.2.6 summarises the NSE results for the Project stations. All NSE values are greater than 0.65, indicating that the models are of satisfactory quality for calculating long-term flows at the Project stations. The somewhat lower NSE (but still >0.65) at MUSF1 is likely due to the smaller dataset available for that station.

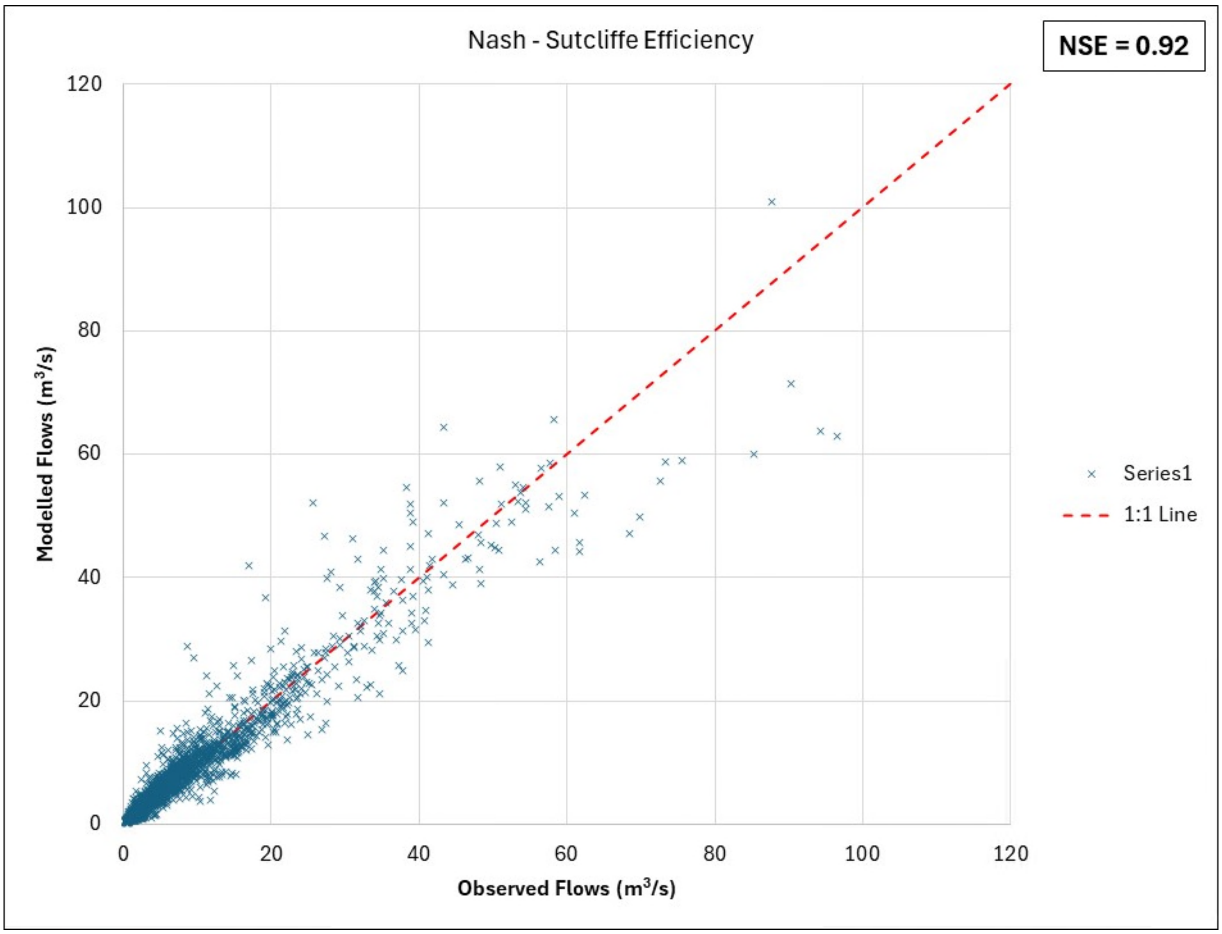

Figure 4.2.3 Modelled Daily Flows at M2 versus Observed Daily Flows

Table 4.2.6 Nash-Sutcliffe Model Efficiency Coefficients Calculated for Project Stations

Station-→	**M2**	**M1**	**V3F**	**V1**	**MUSF1**
Nash-Sutcliffe Model Efficiency	0.92	0.89	0.94	0.84	0.70

4.3 Long-Term Modelled Flows and Runoff for Upper Beaver Stations

Using the seasonal relationships (Section 4.2), long-term average monthly flow data, and average annual flow data, for the Project Stations were calculated (Table 4.3.1). These calculations are based on the available data record from the WSC station 02JC008 on the Blanche River. Table 4.3.2 shows the average monthly flow data converted to runoff depths in millimetres ("mm") using the watershed areas for each station and appropriate unit conversion.

Table 4.3.1 Long-Term Modelled Average Monthly and Annual Flows for Project Stations

Month	02JC008 Average (m^3/s)	M2 Average (m^3/s)	M1 Average (m^3/s)	V3F Average (m^3/s)	V1 Average (m^3/s)	V3G Average (m^3/s)	MUSF1 Average (m^3/s)
Jan	9.3	2.3	1.5	0.91	0.79	0.93	NA
Feb	6.7	1.7	1.1	0.72	0.70	0.73	NA
Mar	10.6	2.6	1.7	1.0	0.84	1.0	NA
Apr	64.8	15.5	10.4	5.1	3.3	5.2	NA
May	68.4	16.4	10.9	5.4	3.5	5.5	NA
Jun	25.9	6.3	3.9	2.3	1.7	2.4	4.2
Jul	13.7	3.1	1.9	1.2	0.87	1.2	1.9
Aug	8.9	1.8	1.1	0.73	0.54	0.75	1.1
Sep	10.9	2.3	1.4	0.91	0.67	0.93	1.4
Oct	21.2	5.0	3.1	1.9	1.3	1.9	3.3
Nov	26.1	6.6	4.1	2.3	1.8	2.3	NA
Dec	17.3	4.4	2.7	1.5	1.2	1.5	NA
Annual	23.6	5.7	3.7	2.0	1.4	2.0	NA

Notes
NA = Not Available

Table 4.3.2 Long-Term Modelled Average Monthly and Annual Runoff for Project Stations

Month	02JC008 Average (mm)	M2 Average (mm)	M1 Average (mm)	V3F Average (mm)	V1 Average (mm)	V3G Average (mm)	MUSF1 Average (mm)
Jan	14	15	15	17	21	17	NA
Feb	9	10	10	12	17	12	NA
Mar	16	18	18	19	23	19	NA
Apr	94	100	106	93	88	93	NA
May	103	108	115	101	96	101	NA
Jun	38	40	40	43	44	43	46
Jul	21	21	20	23	24	23	22
Aug	13	12	11	14	15	14	12
Sep	16	15	14	17	18	17	16
Oct	32	33	33	36	37	36	38
Nov	38	42	42	41	47	41	NA
Dec	26	29	29	27	33	27	NA
Annual	419	443	454	441	463	441	NA

Notes
NA = Not Available

4.4 Low Flow Statistics

Table 4.4.1 below is a summary of estimated low flow statistics for the five Project stations, as well as the reference station (02JC008). Additional information is provided in Appendix D.

Table 4.4.1 Best Estimate Annual Low Flow Statistics

Station	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
02JC008	4.03	3.23	2.85	2.57
M2	0.42	0.32	0.27	0.25
M1	0.20	0.15	0.13	0.12
V3F	0.22	0.17	0.14	0.12
V1	0.18	0.14	0.13	0.12
MUSF1	0.35	0.28	0.25	0.23

Note: the low flow statistics in this table have been rounded to two decimal places.

4.5 Check of Low Flow Statistics Against Regional Low Flow Results

Figure 4.5.1 plots the Project station low flow statistics alongside the results of regional low flow analysis conducted using the data of Khaliq (2022). The station with the largest Project watershed (M2) plots close to the line of best fit (a power law regression) from the regional analysis, especially for the 7Q20 results (upper-most panels). Results for the other Project stations tend to scatter uniformly around the line of best fit, with M1 typically plotting on the low side, both Victoria Creek stations (V1 and V3F) plotting on the high side, and MUSF1 also plotting on the high side. Overall, the low flow statistics for the Project stations are consistent with results from the regional analysis using data from Khaliq (2022) (Figure 4.5.1).[6]

[6] The somewhat higher low flow statistics at the Victoria Creek stations (V1 and V3F) relative to their watershed sizes could be due to groundwater inflow from glaciofluvial deposits (eskers) adjacent to Victoria Lake (SEI, 2020). The lower low flow statistics at M1, compared to MUSF1, could be at least partly due to evaporation from Beaverhouse Lake in the absence of abundant groundwater inflow.

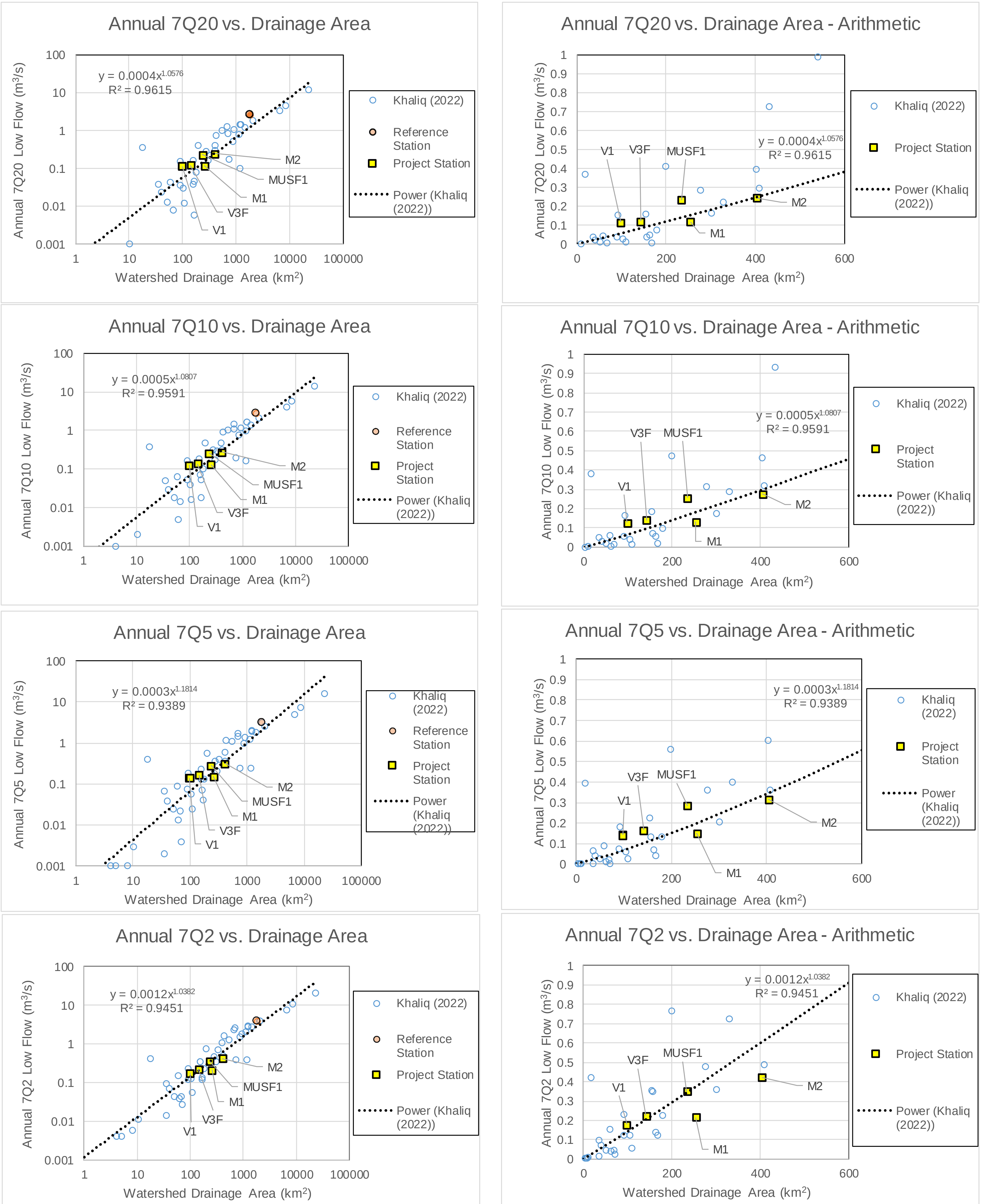

Figure 4.5.1 Project Station Best Estimate Low Flow Statistics Plotted with Regional Results

Left side plots show the full range of data on logarithmic axes (base 10), whereas the right side plots focus on the lower ranges closer to the Project stations values, with arithmetic axes.

4.6 1:100 Wet and Dry Year Conditions

Using a conventional Log-Pearson III statistical analysis, SEI calculated annual average flows that have recurrence intervals of 100 years for both wet and dry conditions (Table 4.6.1). Using those "1 in 100 Wet Year" and "1 in 100 Dry Year" statistics, monthly average flows were calculated in each of these hypothetical years assuming that the monthly flows were proportional to Average conditions (i.e., the same percentage of annual flow occurred in each month of the Wet Year and Dry Year as it did in the Average Year).

Table 4.6.1 Annual and Monthly Average Flows in Average, Wet, and Dry Years

Blanche River Flows (m^3/s) -- WSC Station 02JC008													
	Annual Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Year	**23.6**	9.3	6.7	10.6	64.8	68.4	25.9	13.7	8.9	10.9	21.2	26.1	17.3
1 in 100 Wet Year	**37.4**	14.7	10.6	16.8	102.7	108.3	40.9	21.7	14.1	17.2	33.5	41.3	27.4
1 in 100 Dry Year	**14.8**	5.8	4.2	6.6	40.5	42.7	16.1	8.6	5.6	6.8	13.2	16.3	10.8
M1 Flows (m^3/s)													
	Annual Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Year	**3.7**	1.5	1.1	1.7	10.4	10.9	3.9	1.9	1.1	1.4	3.1	4.1	2.7
1 in 100 Wet Year	**5.9**	2.4	1.7	2.8	16.7	17.6	6.3	3.1	1.8	2.3	5.0	6.6	4.4
1 in 100 Dry Year	**2.2**	0.9	0.7	1.0	6.3	6.7	2.4	1.2	0.7	0.9	1.9	2.5	1.7
M2 Flows (m^3/s)													
	Annual Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Year	**5.7**	2.3	1.7	2.6	15.5	16.4	6.3	3.1	1.8	2.3	5.0	6.6	4.4
1 in 100 Wet Year	**9.2**	3.8	2.7	4.3	25.0	26.4	10.1	5.0	3.0	3.8	8.1	10.6	7.0
1 in 100 Dry Year	**3.5**	1.4	1.0	1.6	9.5	10.0	3.8	1.9	1.1	1.4	3.1	4.0	2.7
V3F Flows (m^3/s)													
	Annual Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Year	**2.0**	0.9	0.7	1.0	5.1	5.4	2.3	1.2	0.7	0.9	1.9	2.3	1.5
1 in 100 Wet Year	**3.2**	1.5	1.2	1.6	8.2	8.6	3.8	1.9	1.2	1.5	3.0	3.6	2.3
1 in 100 Dry Year	**1.2**	0.6	0.4	0.6	3.1	3.3	1.4	0.7	0.5	0.6	1.2	1.4	0.9
V3G Flows (m^3/s)													
	Annual Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Year	**2.0**	0.9	0.7	1.0	5.2	5.5	2.4	1.2	0.7	0.9	1.9	2.3	1.5
1 in 100 Wet Year	**3.2**	1.5	1.2	1.6	8.4	8.8	3.8	2.0	1.2	1.5	3.1	3.7	2.4
1 in 100 Dry Year	**1.2**	0.6	0.5	0.6	3.2	3.4	1.5	0.8	0.5	0.6	1.2	1.4	0.9
V1 Flows (m^3/s)													
	Annual Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Year	**1.4**	0.8	0.7	0.8	3.3	3.5	1.7	0.9	0.5	0.7	1.3	1.8	1.2
1 in 100 Wet Year	**2.3**	1.3	1.1	1.3	5.3	5.5	2.6	1.4	0.9	1.1	2.1	2.8	1.9
1 in 100 Dry Year	**0.9**	0.5	0.4	0.5	2.1	2.2	1.1	0.6	0.3	0.4	0.9	1.1	0.8

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5 Summary

This report presents the rating curves, detailing the water level-flow relationships, for multiple Project stations within the Upper Beaver area. These stations include the Misema River at Beaverhouse Lake outflow (M1), Misema River (M2), Victoria Creek (V3F and V3G), Victoria Lake Outflow (V1), and Misema River at Beaverhouse Lake narrows (MUSF1). Additionally, it documents all manual measurements conducted at these stations from 2011 to 2024 and includes daily average flow and water level data in electronic form.

This report updates previous flow modelling work (SEI, 2020), providing long-term modelled flow data for the Project stations. Finally, low-flow statistics (7Q2, 7Q5, 7Q10, and 7Q20) are also provided.

6 References

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7 Qualifications and Limitations

This document was prepared and reviewed by the undersigned.

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A description of the limitations, which are inherent to these types of studies, is outlined below. This information forms an integral part of this document.

This report is intended to provide information to Agnico Eagle Mines Limited. SEI is not a party to the various considerations underlying Agnico Eagle Mines Limited's business decisions, and does not make recommendations regarding such business decisions. In providing this report, SEI accepts no liability or responsibility in respect of the site described in this report or for any business decisions relating to the station. SEI accepts no liability or responsibility for any damages that may be suffered or incurred by any third party as a result of the use of, reliance on, or any decision made based on this report.

The findings, conclusions, and recommendations in this report have been developed in a manner consistent with the level of skill normally exercised by environmental professionals currently practicing under similar conditions in the area. The findings contained in this report are based, in part, upon information provided by others. If any of the information is inaccurate, modifications to the findings, conclusions, and recommendations may be necessary.

The findings, conclusions, and recommendations presented by SEI in this report reflect SEI's best judgment based on the station conditions on the date(s) set out in this report and on information available at the time of preparation of this report. They have been prepared for specific application to this station and are based, in part, upon visual observation of the site, and information available from historical databases. The findings cannot be extended to previous or future site conditions or to portions of the site, which were unavailable for direct observation.

The findings and conclusions of this report are valid only as of the date of this report. If site conditions change, new information is discovered, or unexpected site conditions are encountered in future work, SEI should be requested to re-evaluate the findings, conclusions, and/or recommendations of this report, and to provide amendments as required.

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Appendix A

Tables

Table A1. Gaps in Flow Data (2018 to 2024)

Station	Data Gaps / Editing	Reason	Estimation Method
M1	16 Dec 2020 to 20 Dec 2020	Likely ice formation on level logger	M1 water levels were corrected using a linear regression relationship between M1 and Ava Lake water levels
M2	26 Aug 2018 to 5 Sept 2018	Beaver activity.	Flows were estimated to be equal to the sum of flows from M1 and V3F.
	30 July 2019 to 7 August 2019	Likely beaver activity.	Flows were estimated to be equal to the sum of flows from M1 and V3F.
	21 Aug 2020 to 28 Sept 2020	Beaver activity.	Flows were estimated to be equal to the sum of flows from M1 and V3F.
	17 Aug 2023 to 8 Sept 2023	Beaver activity.	Flows were estimated to be equal to the sum of flows from M1 and V3G.
	17 June 2024 to 19 June 2024	Probable Logger Biofouling	Flows were estimated to be equal to the sum of flows from M1 and V3F.
	18 Aug 2024 to 5 Nov 2024	Beaver activity.	Flows were estimated to be equal to the sum of flows from M1 and V3F.
V3F	16 Nov 2018 to 8 Jun 2021	DS Level logger not deployed, because of ice conditions from Nov 2018 to Mar 2019 and due to high-water levels in Apr-May 2019.	US Logger data available from 14 Jun 2019 and was used to calculate flows.
	30 October 2019	Logger not deployed	NA
	6 Dec 2019 to 4 Apr 2020	US data unavailable due to ice conditions.	NA
	8 Dec 2020 to 14 Dec 2020	Unreliable flow data due to ice effects.	Data interpolated using flow on 7 Dec 2020 at V3F, and flow on 15 Dec 2020 at V1.
	15 Dec 2020 to 18 Mar 2021	Unreliable flow data due to ice effects.	Flows were estimated to be equal to V1.
	19 Mar 2021 to 24 Mar 2021	Unreliable flow data due to ice effects.	Flows were estimated to be equal to the difference of flows at M2 and M1.
	9 Jun 2021 to 31 Dec 2021	US logger malfunction.	DS logger data used to calculate flows.
	27 Nov 2021 to 28 Nov 2021	DS Logger malfunction.	Flows were interpolated using flow on 26 Nov 2021 and 29 Nov 2021.
	1 Jan 2022 to 31 Mar 2022	US logger malfunction. DS logger could not be read out due to ice conditions.	Flows estimated to be equal to V1.
	1 Apr 2022 to 4 Apr 2022	US logger malfunction discovered when went to download logger.	Flows were estimated to be equal to the difference in flows at M2 and M1.
	1 Apr 2022 to 24 Jan 2023	DS logger could not be read out on 24 Jan 2023 due to ice conditions.	US Logger data used to calculate flows.
	23 Nov 2022 to 24 Jan 2023	Inaccessibility to the logger at the US.	NA
	25 Jan 2023 to 16 Jun 2023	US logger damage.	DS logger data used to calculate flows.
	27 Feb 2023 to 1 Mar 2023	DS Logger unreliable data due to ice effects.	Flows were estimated to be equal to V1.
	6 May 2023 to 16 Jun 2023	DS Level logger error.	NA
	12 Aug 2023 to 16 Jan 2024	DS data not available due to damage to logger.	US Logger data used to calculate flows.
	14 Nov 2024 to 10 Jan 2025	US Level logger not read out due to ice conditions.	NA
V3G	28 Aug 2020 to 27 Sept 2020	Beaver activity	Flows were estimated to be equal to V3F.
	6 Nov 2020 to 25 Nov 2020	Level logger not deployed.	Flows were estimated to be equal to V3F.
	8 Dec 2020 to 14 Dec 2020	Unreliable flow data due to ice effects.	Flows interpolated using flow on 7 Dec 2020 at V3G, and flow on 15 Dec 2020 at V1.
	15 Dec 2020 to 18 Mar 2021	Unreliable flow data due to ice effects.	Flows were estimated to be equal to V1.
	19 Mar 2021 to 24 Mar 2021	Unreliable flow data due to ice effects.	Flows were estimated to be equal to the difference of flows at M2 and M1.
	30 Aug 2021 to 31 Dec 2021	Beaver dam effects.	Flows were estimated to be equal to V3F.
	1 Jan 2022 to 31 Mar 2022	Unreliable flow data due to ice effects.	Flows were estimated to be equal to V1.
	1 Apr 2022 to 13 Apr 2022	Unreliable flow data due to ice effects.	Flows were estimated to be equal to V3F.
	1 Feb 2023 to 5 Apr 2023	Unreliable flow data due to ice effects.	Flows were estimated to be equal to V1.
	6 Apr 2023 to 13 Apr 2023	Unreliable flow data due to ice effects.	Flows were estimated to be equal to V3F.
	10 Aug 2024 to 29 Sept 2024	Beaver dam effects.	Flows were estimated to be equal to V3F.
V1	30 October 2019	Logger not deployed	NA
	8 Jan 2020 to 23 Mar 2020	Instrument was damaged due to ice.	NA
	20 Aug 2022 to 30 Aug 2022	Large woody debris was removed.	NA
MUSF1	24 Oct 2022 to 14 June 2023	Station was only operational from June to October (open water)	NA
	17 Oct 2023 to 25 June 2024	Station was only operational from June to October (open water)	NA
	30 Oct 2024 to 10 Jan 2025	Station was only operational from June to October (open water)	NA

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Notes:
NA – Not available

Table A2. Rating Curve Evolution Table

	2011 - 2013				2018			2019			2020		
				Segment transitions	Hydrometric Report			Hydrometric Report			Hydrometric Report		
M1	C	a	n		C	a	n	C	a	n	C	a	n
	37.8	0.153	1.963	> =0.49	29	0.153	1.82	29	0.153	1.82	33.5	0.153	1.93
	40.34*X^2 - 12.67*X + 0.98			>=0.23 & <0.49									
	18	0.110	2.12	<0.23	18	0.100	2.12	18	0.100	2.12	18	0.100	2.12
	M1_0				M1_1			M1_1			M1_2		
M2	C	a	n		C	a	n	C	a	n	C	a	n
	15.6	0.38	2.49	<1.38	15.6	0.399	2.49	15.6	0.399	2.49	13.85	0.399	2.4
	15.6	0.38	2.03	>=1.38				18	0.48	1.75	13.85	0.399	2
	M2_0				M2_1			M2_1			M2_2		
V1	5.59 * X^1.56										C	a	n
	V1_0_2011										38.7	0.009	1.87
								46.088 x^2 - 0.465x + 0.0046					
	5.59*(X + 0.035)^1.56												
	V1_0_2012												
								V1_1			V1_2		
V3F (DS)					C	a	n	C	a	n	C	a	n
					11	0.059	1.80	11	0.059	1.80	12.4	0.059	1.88
					V3F_D1			V3F_D1			V3F_D2		
V3F (US)					C	a	n	C	a	n	C	a	n
	V3F_U4 applied in Baseline Report				7.4	0.059	1.82	7.4	0.059	1.82	7.58	0.059	1.82
					V3F_U1			V3F_U1			V3F_U2		
V3G											C	a	n
											6.616	0.561	2.37
											V3G_1		
MUSF1													

	2021			2022			2023			
	Hydrometric Report			Hydrometric Report			Hydrometric Report			
M1	C	a	n	C	a	n	C	a	n	
	33.5	0.153	1.93	37.8	0.153	1.963	35.69	0.153	1.873	High
										Moderate
	18	0.100	2.12	18	0.100	2.12	18	0.100	2.12	Low
	M1_2			M1_3			M1_4			
M2	C	a	n	C	a	n	C	a	n	
	13.85	0.399	2.4	15.6	0.399	2.49	15.6	0.399	2.49	Low
	13.85	0.399	2	15.6	0.399	2.03	15.6	0.399	2.03	High
	M2_2			M2_3			M2_3			
V1	**C**	**a**	**n**	C	a	n	C	a	n	
	38.7	**0.009**	**1.87**	38.7	0.009	1.87	38.7	0.009	1.87	
				45	0.009	1.85	45	0.009	1.85	
				(After LWD removal)						
	V1_2			V1_3			V1_3			
V3F (DS)	C	a	n				C	a	n	
	16.57	0.059	2.145				16.87	0.059	2.131	High
	7.5	0.02	1.84							Low
	V3F_D3						V3F_D4			
V3F (US)	C	a	n	C	a	n	C	a	n	
	7.581	0.069	1.76	9.7	0.069	2.033	9.7	0.069	2.033	High
				4.44	-0.03	2.01	4.44	-0.03	2.01	Low
	V3F_U3			V3F_U4			V3F_U4			
V3G	C	a	n	C	a	n	C	a	n	
	6.616	0.561	2.37	6.8	0.561	2.37	6.8	0.561	2.37	High
										Low
	V3G_1			V3G_2			V3G_2			
MUSF1				C	a	n	C	a	n	
				28.07	0.55	2.291	28.07	0.55	2.291	
				MUSF1_1			MUSF1_1			

	2024					2025			
	Hydrometric Report			Segment transitions		**Baseline Report (Aug 2025)**			Segment transitions
M1	C	a	n			C	a	n	
	37.8	0.153	1.963	>= 0.31	**High**	37.8	0.153	1.963	>= 0.31
	29	0.153	1.82	>=0.211 & <0.31	**Moderate**	29	0.153	1.82	>=0.211 & <0.31
	18	0.100	2.12	<0.211	**Low**	18	0.100	2.12	<0.211
	M1_5					**M1_5**			
M2	C	a	n			C	a	n	
	15.6	0.399	2.49	<1.399	**Low**	15.6	0.399	2.49	<1.399
	15.6	0.399	2.03	>=1.399	**High**	15.6	0.399	2.03	>=1.399
	M2_3					**M2_3**			
V1	C	a	n			C	a	n	
	38.7	0.009	1.87	<0.14		38.7	0.009	1.87	<0.14
	21.75*x - 2.182			>=0.14 & <= 0.175		21.75*x - 2.182			>=0.14 & <= 0.175
	45	0.009	1.85	>0.175		45	0.009	1.85	>0.175
	V1_4					**V1_4**			
V3F (DS)	C	a	n			C	a	n	
	16.873	0.059	2.1306	>=0.26	**High**	16.87	0.059	2.13	>=0.26
	7.5	0.02	1.84	<0.26	**Low**	7.5	0.02	1.84	<0.26
	V3F_D5					**V3F_D5**			
V3F (US)	C	a	n			C	a	n	
	9.7	0.069	2.033	>=0.295	**High**	9.7	0.069	2.033	>=0.295
	4.44	-0.03	2.01	<0.295	**Low**	4.44	-0.033	2.01	<0.295
	V3F_U4					**V3F_U4**			
V3G	C	a	n			C	a	n	
	6.8	0.561	2.37	>0.831	**High**	12.68	0.900	1.461	>=1.297
	3.4	0.531	2	<=0.831	**Moderate**	6.8	0.561	2.37	>0.831 $ <1.297
					Low	3.4	0.531	2	<=0.831
	V3G_3					**V3G_4**			
MUSF1	C	a	n			C	a	n	
	32.8	0.59	2.064			32.8	0.59	2.064	
	MUSF1_2					**MUSF1_2**			

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Table A3. M1 Manual Flow Data Used to Develop the Rating Curve

Date	Water Level (m)	Measured Flow (m^3/s)	Instrument	
06-Jul-11	0.357	1.60	FlowTracker	
12-Aug-11	0.228	0.19	FlowTracker	
07-Sep-11	0.257	0.39	FlowTracker	
10-Oct-11	0.274	0.44	FlowTracker	
09-Nov-11	0.483	3.86	FlowTracker	
31-May-12	0.431	3.20	FlowTracker	
26-Jun-12	0.280	0.62	FlowTracker	
22-Aug-12	0.305	0.91	FlowTracker	
26-Jul-18	0.286	0.73	FlowTracker	
20-Aug-18	0.222	0.21	FlowTracker	
27-Sep-18	0.408	2.41	FlowTracker	
16-Nov-18	0.492	4.16	FlowTracker	
13-Jun-19	0.552	6.61	FlowTracker	
11-Jul-19	0.333	1.30	FlowTracker	
23-Aug-19	0.317	1.10	FlowTracker	
30-Oct-19	0.474	4.22	FlowTracker	
24-Mar-20	0.303	0.84	Flo-Mate	
25-Feb-21	0.288	0.79	Flo-Mate	
14-Apr-21	0.642	9.80	RS5 ADCP	
20-Aug-21	0.304	0.95	FlowTracker	
22-Oct-21	0.403	2.35	FlowTracker	
29-Oct-21	0.365	1.86	FlowTracker	
29-Nov-21	0.359	1.75	FlowTracker	
23-Feb-22	0.317	1.00	Flo-Mate	
04-May-22	1.043	27.33	RS5 ADCP	
19-May-22	0.588	7.66	FlowTracker	
21-Jun-22	0.482	4.43	FlowTracker	
25-Jul-22	0.584	7.77	FlowTracker	
29-Aug-22	0.380	2.06	FlowTracker	
26-Sep-22	0.591	7.60	FlowTracker	
24-Oct-22	0.477	4.15	FlowTracker	
21-Nov-22	0.575	7.06	FlowTracker	
29-Mar-23	0.317	1.07	Flo-mate	
30-May-23	0.403	2.54	FlowTracker	
29-Jun-23	0.273	0.61	FlowTracker	
20-Jul-23	0.338	1.43	FlowTracker	
10-Aug-23	0.263	0.56	FlowTracker	
24-Aug-23	0.241	0.41	FlowTracker	
05-Sep-23	0.248	0.41	FlowTracker	
18-Oct-23	0.591	7.96	FlowTracker	
13-Nov-23	0.483	4.54	FlowTracker	
13-Feb-24	0.339	1.26	Flo-Mate	
26-Apr-24	0.760	14.59	RS5 ADCP	
29-May-24	0.462	3.90	FlowTracker	
20-Jun-24	0.421	2.85	FlowTracker	
26-Jul-24	0.325	1.13	FlowTracker	
16-Aug-24	0.260	0.50	FlowTracker	
05-Sep-24	0.252	0.41	FlowTracker	
29-Oct-24	0.373	2.19	FlowTracker	
12-Nov-24	0.661	10.36	FlowTracker	
28-Apr-25	1.180	36.75	RS5 ADCP	
29-Apr-25	1.266	43.39	RS5 ADCP + FlowTracker	
The following data points were excluded from the development of the Rating Curve				***Rationale***
14-Apr-20	0.628	7.59	ADCP StreamPro	Faulty Instrument
28-Apr-20	0.600	6.39	ADCP StreamPro	Faulty Instrument
01-May-20	1.160	28.70	ADCP StreamPro	Faulty Instrument

105A_101_M1 RatingCurve_Cleaned_28Jan2025_AS

Notes:

1) Water Level (metres) is measured with respect to a local (2012) datum.
2) Units of flow are cubic metres per second (m^3/s)
3) ADCP = Acoustic Doppler Current Profiler
4) ADCP StreamPro = Teledyne RD Instruments StreamPro (Rental)
5) RS5 ADCP = RS5 ADCP purchased new by SEI in 2021

Table A4. M2 Manual Flow Data used to develop the Rating Curve

Date	Water Level (m)	Measured Flow (m^3/s)	Instrument	
06-Jul-11	0.835	2.28	FlowTracker	
11-Jul-11	0.893	2.95	FlowTracker	
12-Aug-11	0.668	0.68	FlowTracker	
29-Sep-11	0.690	0.87	FlowTracker	
11-Oct-11	0.705	0.96	FlowTracker	
08-Nov-11	1.090	6.57	FlowTracker	
31-Aug-12	0.749	1.31	FlowTracker	
26-Jul-18	0.789	1.51	FlowTracker	
20-Aug-18, 7:15 a.m.	0.659	0.51	FlowTracker	
20-Aug-18, 4:30 p.m.	0.649	0.48	FlowTracker	
27-Sep-18	0.983	4.07	FlowTracker	
16-Nov-18	1.127	7.06	FlowTracker	
08-Mar-19	0.791	1.49	FlowTracker	
2-May-19	1.906	34.10	ADCP StreamPro	
11-Jul-19	0.858	2.36	FlowTracker	
23-Aug-19	0.836	2.03	FlowTracker	
30-Oct-19	1.128	6.78	FlowTracker	
19-Mar-20	0.788	1.50	FlowTracker	
26-Feb-21	0.769	1.34	FlowTracker	
20-Aug-21	0.783	1.46	FlowTracker	
22-Oct-21	0.956	3.66	FlowTracker	
30-Nov-21	0.893	2.57	FlowTracker	
23-Feb-22	0.821	1.86	FlowTracker	
03-May-22	1.981	40.66	RS5 ADCP	
20-May-22	1.281	11.72	RS5 ADCP	
23-Jun-22	1.134	7.47	FlowTracker	
26-Jul-22	1.338	13.14	RS5 ADCP + FlowTracker	
30-Aug-22	1.204	9.41	RS5 ADCP	
27-Sep-22	1.302	11.92	RS5 ADCP	
25-Oct-22	1.090	6.53	RS5 ADCP + FlowTracker	
22-Nov-22	1.254	10.79	RS5 ADCP	
28-Feb-23	0.850	2.32	FlowTracker	
25-Apr-23	1.834	32.48	RS5 ADCP	
30-May-23	0.969	4.24	FlowTracker	
16-Jun-23	0.863	2.37	FlowTracker	
21-Jul-23	0.852	2.13	FlowTracker	
10-Aug-23	0.749	1.12	FlowTracker	
22-Sep-23	1.021	4.93	FlowTracker	
18-Oct-23	1.309	12.24	RS5 ADCP	
14-Nov-23	1.124	7.53	RS5 ADCP + FlowTracker	
13-Feb-24	0.868	2.29	FlowTracker	
24-Apr-24	1.716	28.00	RS5 ADCP	
28-May-24	1.129	7.33	RS5 ADCP	
21-Jun-24	1.007	4.96	RS5 ADCP	
30-Jul-24	0.793	1.41	FlowTracker	
15-Aug-24	0.746	1.02	FlowTracker	
12-Nov-24	1.425	16.23	RS5 ADCP	
29-Apr-25	2.394	63.50	RS5 ADCP	
The following data points were excluded from development of the Rating Curve				***Rationale***
23-Apr-20	1.277	10.00	ADCP StreamPro + FlowTracker	Faulty Instrument
28-Apr-20	1.409	14.10	ADCP StreamPro + FlowTracker	Faulty Instrument
04-Sep-24	0.947	0.95	FlowTracker	Beaver Effects
28-Oct-24	1.004	3.76	FlowTracker	Beaver Effects

105A_101_M2 RatingCurve_Cleaned_28Jan2025_ACS

Notes:

1) Level (metres) is measured with respect to a local (2018) datum.
2) Units of flow are cubic metres per second (m^3/s).
3) ADCP = Acoustic Doppler Current Profiler
4) ADCP StreamPro = Teledyne RD Instruments StreamPro (Rental)
5) RS5 ADCP = RS5 ADCP purchased new by SEI in 2021

Table A5. V3F Manual Flow Data used to develop the Rating Curves

Date	Water Level (m)		Measured Flow (m^3/s)	Instrument	
	Upstream Station	Downstream Station			
08-Jul-11	0.360	NA	0.81	FlowTracker	
12-Aug-11	0.301	NA	0.46	FlowTracker	
07-Sep-11	0.252	NA	0.39	FlowTracker	
07-May-12	0.486	NA	1.73	FlowTracker	
28-Jun-12	0.200	NA	0.24	FlowTracker	
20-Aug-18	0.218	0.184	0.26	FlowTracker	
27-Sep-18	0.457	0.380	1.30	FlowTracker	
16-Nov-18	0.610	0.480	2.44	FlowTracker	
12-Jul-19	0.378	0.324	0.99	FlowTracker	
22-Aug-19	0.381	0.327	0.99	FlowTracker	
31-Oct-19	0.630	0.508	2.79	FlowTracker	
22-Jan-20	NA	0.292	0.78	FlowTracker	
23-Jul-20	0.447	0.370	1.36	FlowTracker	
20-Aug-21	0.295	0.252	0.48	FlowTracker	
28-Sep-21	0.469	0.389	1.42	FlowTracker	
21-Oct-21	0.421	0.353	1.21	FlowTracker	
29-Nov-21	0.394	0.338	1.11	FlowTracker	
04-May-22	1.260	1.034	13.89	RS5 ADCP	
19-May-22	0.720	0.565	4.33	RS5 ADCP	
22-Jun-22	0.602	0.482	2.57	FlowTracker	
26-Jul-22	0.705	0.554	4.24	RS5 ADCP	
30-Aug-22	0.804	0.633	5.65	RS5 ADCP	
27-Sep-22	0.735	0.573	4.39	RS5 ADCP	
25-Oct-22	0.562	0.453	2.38	FlowTracker	
22-Nov-22	0.702	0.551	4.16	RS5 ADCP	
24-Apr-23	1.136	0.909	11.05	RS5 ADCP	
29-May-23	0.482	0.404	1.71	FlowTracker + RS5 ADCP	
16-Jun-23	0.414	0.349	1.17	FlowTracker	
21-Jul-23	0.354	0.303	0.73	FlowTracker	
11-Aug-23	0.328	0.283	0.69	FlowTracker	
22-Sep-23	0.488	0.405	1.70	FlowTracker	
17-Oct-23	0.733	0.577	4.27	RS5 ADCP	
14-Nov-23	0.616	0.489	2.98	RS5 ADCP	
14-Feb-24	0.414	0.330	0.97	Flo-Mate	
29-May-24	0.621	0.491	3.17	RS5 ADCP	
21-Jun-24	0.493	0.402	1.91	RS5 ADCP	
30-Jul-24	0.304	0.260	0.56	FlowTracker	
15-Aug-24	0.260	0.220	0.40	FlowTracker	
04-Sep-24	0.272	0.233	0.45	FlowTracker	
30-Oct-24	0.447	0.366	1.48	FlowTracker	
13-Nov-24	0.743	0.577	4.66	RS5 ADCP	
29-Apr-25	1.457	1.219	19.72	RS5 ADCP	
The following data points were excluded from the development of the Rating Curve					***Rationale***
22-Jan-20	0.500	NA	0.78	FlowTracker	Ice effects
28-Apr-20	0.845	0.660	5.73	ADCP StreamPro	Faulty Instrument
01-May-20	1.403	1.070	11.70	ADCP StreamPro	Faulty Instrument
24-Feb-22	NA	0.357	0.83	FlowTracker	Ice effects
27-Feb-23	0.433	0.296	0.93	FlowTracker	Ice effects

105A_101_V3F RatingCurve_Cleaned_28Jan2025_AS

Notes:
1) Water Level (metres) for US and DS are measured with respect to the 2018 local datum and local datum, respectively.
2) Units of flow are cubic metres per second (m^3/s).
3) ADCP = Acoustic Doppler Current Profiler
4) ADCP StreamPro = Teledyne RD Instruments StreamPro (Rental)
5) RS5 ADCP = RS5 ADCP purchased new by SEI in 2021
6) NA = Not Available
7) Water level at the older station was elevated (~0.15 m) on 22-Jan-20 due to ice effects in the channel.

Table A6. V3G Manual Flow Data used to develop the Rating Curve

Date	Water Level (m)	Measured Flow (m^3/s)	Method	
23-Jul-20	1.070	1.35	FlowTracker	
18-Aug-20	0.843	0.33	FlowTracker	
06-Nov-20	1.313	3.35	FlowTracker	
09-Apr-21	1.411	4.71	RS5 ADCP	
10-Jun-21	0.893	0.52	RS5 ADCP	
28-Apr-22	1.757	9.70	RS5 ADCP	
19-May-22	1.367	4.11	RS5 ADCP	
22-Jun-22	1.228	2.69	RS5 ADCP	
25-Jul-22	1.368	4.11	RS5 ADCP	
30-Aug-22	1.443	5.30	RS5 ADCP	
27-Sep-22	1.358	4.02	RS5 ADCP	
25-Oct-22	1.188	2.36	RS5 ADCP	
24-Apr-23	1.841	11.33	RS5 ADCP	
29-May-23	1.116	1.72	RS5 ADCP	
16-Jun-23	1.028	1.10	FlowTracker	
21-Jul-23	0.956	0.73	FlowTracker	
01-Aug-23	0.841	0.36	FlowTracker	
11-Aug-23	0.927	0.64	FlowTracker	
22-Sep-23	1.107	1.71	RS5 ADCP	
17-Oct-23	1.376	4.34	RS5 ADCP	
14-Nov-23	1.245	3.02	RS5 ADCP	
23-Apr-24	1.724	10.07	RS5 ADCP	
29-May-24	1.272	3.12	RS5 ADCP	
20-Jun-24	1.164	2.10	RS5 ADCP	
30-Jul-24	0.938	0.70	RS5 ADCP	
16-Aug-24	0.880	0.42	RS5 ADCP	
28-Oct-24	1.072	1.51	RS5 ADCP	
13-Nov-24	1.397	4.57	RS5 ADCP	
28-Apr-25	2.021	15.00	RS5 ADCP	
The following data points were excluded from development of the Rating Curve				***Rationale***
25-Feb-21	0.957	0.60	FlowTracker	Ice effects
22-Oct-21	1.332	1.19	RS5 ADCP	Beaver effects
28-Feb-22	1.043	0.89	FlowTracker	Ice effects
01-Mar-23	1.040	0.89	FlowTracker	Ice effects
14-Feb-24	1.025	0.87	FlowTracker	Ice effects
04-Sep-24	0.967	0.47	RS5 ADCP	Beaver effects

105A_101_V3G Rating Curve_Cleaned_28Jan2025_ACS_AS

Notes:

1) Water Level (metres) is measured with respect to a local datum.
2) ADCP = Acoustic Doppler Current Profiler
3) Units of flow are cubic metres per second (m^3/s).
4) RS5 ADCP = RS5 ADCP purchased new by SEI in 2021

Table A7. V1 Manual Flow Data used to develop the Rating Curves

Station Location	Date	Water Level (m)	Measured Flow (m^3/s)	Instrument
V1 (2011)	5-Jul-11	0.228	0.63	FlowTracker
	11-Jul-11	0.297	0.94	FlowTracker
	12-Aug-11	0.175	0.37	FlowTracker
	6-Sep-11	0.163	0.33	FlowTracker
	29-Sep-11	0.160	0.30	FlowTracker
	10-Oct-11	0.180	0.34	FlowTracker
	8-Nov-11	0.534	1.92	FlowTracker
	31-Aug-12	0.171	0.47	FlowTracker
	27-Sep-12	0.310	1.13	FlowTracker
	22-Nov-12	0.551	2.07	FlowTracker
V1 (2019)	14-Jun-19	0.337	5.07	FlowTracker
	11-Jul-19	0.141	0.83	FlowTracker
	22-Aug-19	0.137	0.84	FlowTracker
	30-Oct-19	0.237	2.53	FlowTracker
	31-Oct-19	0.230	2.28	FlowTracker
	24-Mar-20	0.123	0.66	Flo-Mate
	1-May-20	0.483	9.11	FlowTracker
	23-Jul-20	0.165	1.23	FlowTracker
	26-Feb-21	0.107	0.56	Flo-Mate
	23-Jun-21	0.087	0.33	FlowTracker
	21-Oct-21	0.140	0.88	FlowTracker
	24-Feb-22	0.136	0.73	Flo-Mate
	03-May-22	0.482	9.53	FlowTracker
	30-Aug-22	0.250	3.17	FlowTracker
	27-Sep-22	0.274	3.85	FlowTracker
	25-Oct-22	0.192	2.02	FlowTracker
	21-Nov-22	0.270	3.57	FlowTracker
	28-Feb-23	0.133	0.80	FlowTracker
	25-Apr-23	0.428	8.54	RS5 ADCP
	14-Jun-23	0.145	1.02	FlowTracker
	01-Aug-23	0.083	0.28	FlowTracker
	10-Aug-23	0.101	0.44	FlowTracker
	05-Sep-23	0.090	0.35	FlowTracker
	17-Oct-23	0.271	3.89	FlowTracker
	13-Nov-23	0.212	2.60	FlowTracker
	13-Feb-24	0.134	0.73	Flo-Mate
	24-Apr-24	0.424	8.36	RS5 ADCP
	28-May-24	0.191	2.27	FlowTracker
	19-Jun-24	0.175	1.57	FlowTracker
	27-Aug-24	0.070	0.22	FlowTracker
	29-Oct-24	0.140	0.97	FlowTracker
	13-Nov-24	0.272	3.80	FlowTracker
	28-Apr-25	0.435	8.96	RS5 ADCP

105A_101_V1 RatingCurve_Cleaned_28Jan2025_AS

Notes:

1) Water Level (metres) is measured with respect to a local datum.
2) Units of flow are cubic metres per second (m^3/s).
3) ADCP = Acoustic Doppler Current Profiler
4) ADCP StreamPro = Teledyne RD Instruments StreamPro (Rental)
5) RS5 ADCP = RS5 ADCP purchased new by SEI in 2021

Table A8. MUSF1 Manual Flow Data used to develop the Rating Curve

Date	Water Level (m)	Measured Flow (m^3/s)	Instrument	
30-Sept-21	0.910	3.17	RS5 ADCP	
29-Oct-21	0.837	2.00	RS5 ADCP	
21-Jun-22	0.966	4.59	RS5 ADCP	
25-Jul-22	1.085	8.39	RS5 ADCP	
29-Aug-22	0.855	2.21	RS5 ADCP	
26-Sep-22	1.084	6.68	RS5 ADCP	
24-Oct-22	0.962	4.00	RS5 ADCP	
15-Jun-23	0.790	1.16	FlowTracker	
20-Jul-23	0.811	1.15	FlowTracker	
01-Aug-23	0.734	0.60	FlowTracker	
26-Jun-24	0.893	2.97	RS5 ADCP	
26-Jul-24	0.795	1.33	RS5 ADCP	
25-Aug-24	0.703	0.44	FlowTracker	
05-Sep-24	0.725	0.44	FlowTracker	
29-Oct-24	0.843	1.97	RS5 ADCP	
The following data points were excluded from development of the Rating Curve				***Rationale***
21-Sep-23	0.926	2.15	Flo-mate	Interference from boat hull
16-Oct-23	1.167	7.12	Flo-mate	Interference from boat hull
16-Aug-24	0.734	0.26	RS5 ADCP	Unusual upstream wind effects

105A_101_MUSF1 RatingCurve_Cleaned_28Jan2025_AS

Notes:

1) Relative to BM1, with BM1 assigned an arbitrary gauge datum of 1.0 metres.
2) Units of flow are cubic metres per second (m^3/s).
3) ADCP = Acoustic Doppler Current Profiler
4) RS5 ADCP = RS5 ADCP purchased new by SEI in 2021

Appendix B

Benchmark Data for Beaverhouse, Ava, and York Lake Water Levels

Beaverhouse Lake Benchmark Information

Two key benchmarks were used at the M1 station on Beaverhouse Lake (near the existing boat launch), as shown in Table B1 and Photos B1 and B2 (on the following pages).

Note that two sets of elevation data for BM4 and M1C are reported in Table B1: one set from 2011/2012 and a second set based on surveying work carried out in 2018. An elevation check on BM4 was also carried out on 8 May 2024.

For flow gauging purposes, the 2011 Elevation datum has been used at the M1 station since 2011. That is, the M1C iron bar was assigned an elevation of 285.162 m, based on repeated optical survey work that showed no movement of the iron bar relative to BM4. Water levels that are used for flow purposes such as rating curves (e.g., Figure 3.2.1) and resulting continuous derived flows, are converted to local elevations by subtracting 285 m from the water elevations. This both reduces error in the calculations (e.g., due to use of exponents in the rating equations) but also serves as a reminder that even survey-grade Global Positioning System ("GPS") elevation data are not accurate enough for flow gauging purposes. Optical surveying is better for achieving the sub-centimetre scale accuracy on local elevations required for gauging purposes.

For geodetic lake water level purposes (e.g., electronic datasets), all 2011-2024 data were reported with respect to the BM elevations measured in September 2018 by Agnico Eagle.

Table B1 Key Benchmarks used at the M1 Station on Beaverhouse Lake

Benchmark→	BM4	M1C
Description	Surveyor's pin installed in bedrock near rapids by Northland Technical Surveys in July 2011	Submerged iron bar installed in bedrock below the typical low water level of Beaverhouse Lake, installed in 2012 by Northland Technical Surveys
2011 (or 2012) Elevation (m)	285.834	285.162
Source of Elevation Data	Northland Technical Surveys (Ben Larose)	Multiple optical surveys by SEI, 2012 to 2024
2018 Elevation (m)	285.961	285.289
Source of 2018 Elevation Data	Agnico Eagle (Martyn Herrington), September 2018	Multiple optical surveys by SEI, 2018 to 2024
8 May 2024 Elevation Check (m)	286.004	not available
Source of 2024 Elevation Data	Hamel Arpentage Inc.	not applicable

On 8 May 2024, surveyors from Hamel Arpentage Inc. re-surveyed the BM4 benchmark elevation using survey-grade GPS technology. Their result (286.004 m) was more consistent with the 2018 elevation than the 2011/2012 elevation, but was also higher than the 2018 elevation by 0.043 m. This difference in elevations (0.043 m) is typical of data variability associated with survey-grade GPS technology, but it also indicates that the geodetic lake water levels are associated with uncertainties of at least ±0.04 m. If more accurate results are required, local surveying relative to a known arbitrary local elevation should be used (i.e., use BM4).

Photo B1 Position of BM4 Surveyor's Pin Installed near the Rapids Leaving Beaverhouse Lake

Photo B2. Position of M1C submerged iron bar on the boat landing side of rapids.

Ava Lake Benchmark Information

Table B2 and Photos B3, B4, and B5 provide information on Ava Lake water level benchmarks used for monitoring purposes between 2018 and 2024. For geodetic lake water data in the electronic data files, the 2018 elevation datum has been used in this baseline hydrology report.

Table B2 Key Benchmarks used at the Ava Lake Water Level Monitoring Station

Benchmark→	June 13-1 BM	Ava Bar BM
Description	Surveyor's pin installed in bedrock near rapids by Northland Technical Surveys in 2011	Submerged iron bar installed in bedrock below the low water level of Ava Lake, installed in 2012 by Northland Technical Surveys
2018 Elevation (m)	284.610	284.137
Source of 2018 Elevation Data	Agnico Eagle (Martyn Herrington), September 2018	Multiple optical surveys by SEI, 2018 to 2024
8 May 2024 Elevation Check (m)	284.636	not available
Source of 2024 Elevation Data	Hamel Arpentage Inc.	not applicable

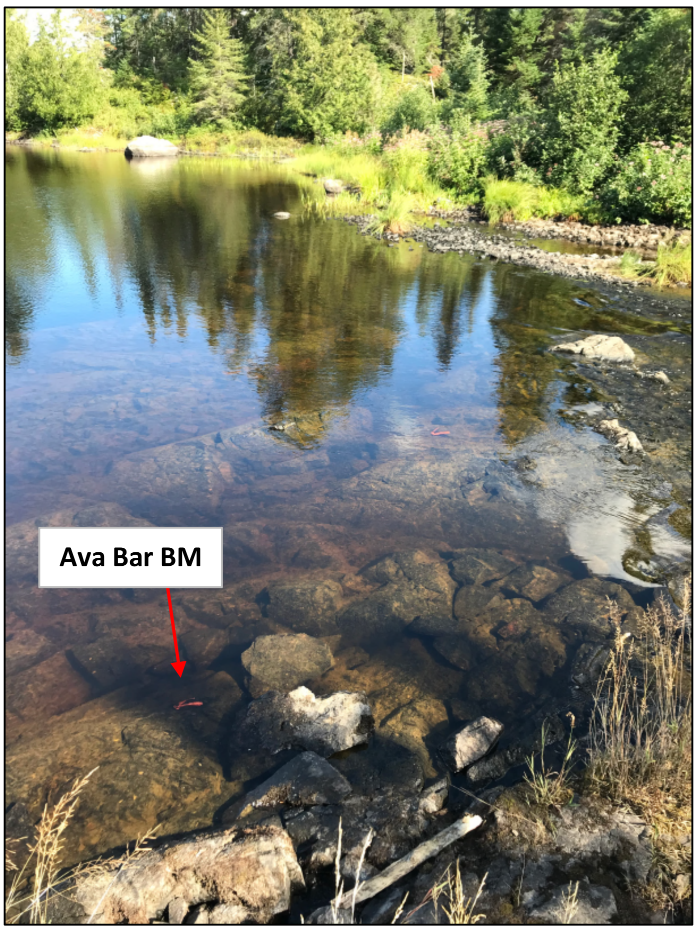

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Photo B3 Position of Ava iron bar used for water level measurements at Ava Lake

Following are the photos of the "June-13-1" benchmark.

Photo B4 June 13-1 Benchmark Location at Head of Ava Lake Rapids
N:\079 Queenston\079-01\Photos\AS Queenston 22 Nov 2012

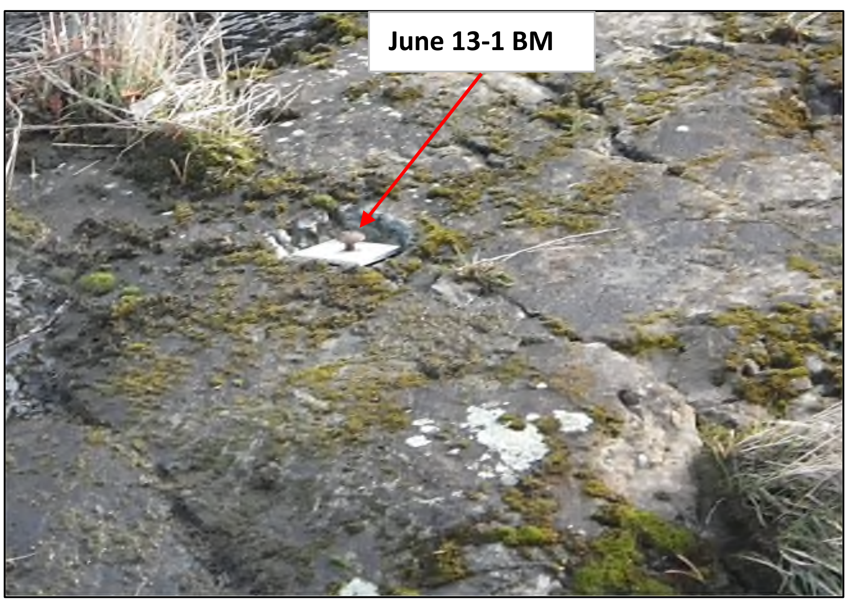


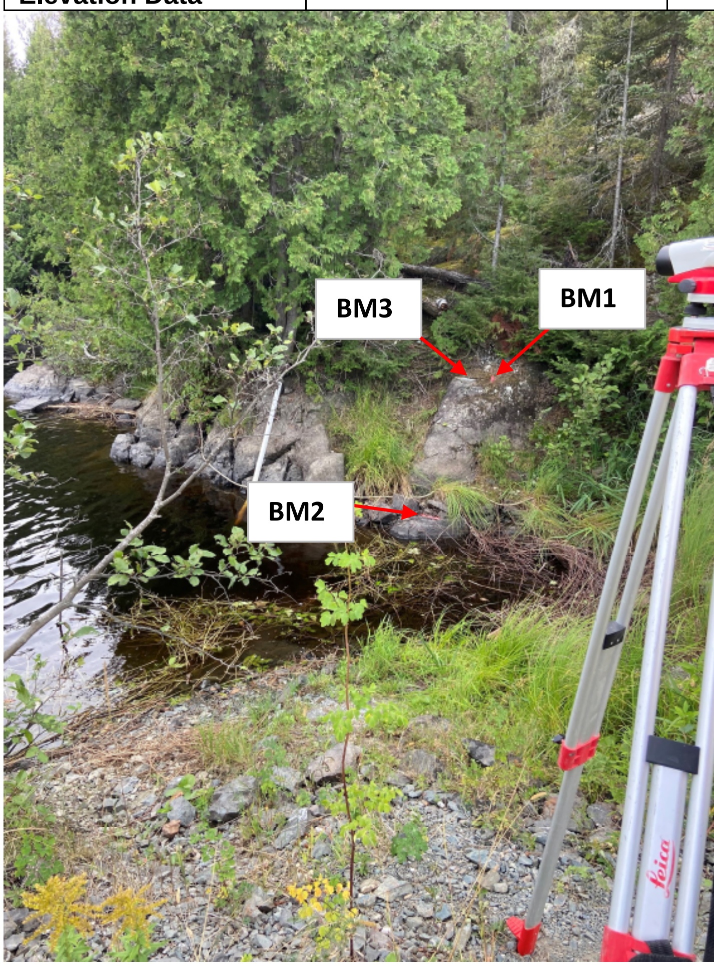
Photo B5 Close-up View of June 13-1 Benchmark

York Lake Benchmark Information

Table B3 and Photo B6 provide information on York Lake water level benchmarks used for monitoring purposes between 2018 and 2024. For geodetic lake water data (e.g., electronic data files), the 2019 benchmark elevation data for BM1 have been used in this report.

Table B3 Key Benchmarks used at the York Lake Water Level Monitoring Station

Benchmark→	BM1	BM2	BM3
Description	Vertical anchor bolt installed in bedrock by SEI in 2018	Vertical anchor bolt installed in bedrock by SEI in 2018	Surveyor's pin installed in bedrock by SEI in 2024
2018 Elevation (m)	282.272	281.016	not available
Source of 2018 Elevation Data	Agnico Eagle (Martyn Herrington), September 2018	Multiple optical surveys by SEI, 2018 to 2024	not applicable
2019 Elevation (m)	282.326	not available	282.275
Source of 2019 Elevation Data	Agnico Eagle (Martyn Herrington), October 2019	not applicable	SEI (optical survey)
8 May 2024 Elevation Check (m)	282.292	not available	not available
Source of 2024 Elevation Data	Hamel Arpentage Inc.	not applicable	not applicable



R:\SEI\105 Agnico Eagle\105-101_Upper Beaver\09 - Hydrology\Photos\2024\8-August\York Lake

Photo B6. BM1, BM2, and BM3 benchmarks for water level monitoring at York Lake

Appendix C

Long-Term Modelling of Project Station Data

Modelling Long-Term Station Flows

This appendix provides additional information about the methods used for modelling long-term flow data for the Project stations, as introduced briefly in the main body of this report (Section 2.6). Figure C1 provides an example of a dataset analysed using both chronological linear regression and the ranked regression approach.

Figure C1A (upper panel) shows the more than 1300 daily flow data for one of the Project hydrometric stations plotted against the daily flow at the nearby reference station (WSC station 02JC008) that occurred on the same day. This is the chronological linear regression approach. There is a strong linear relationship between daily flows at the two stations, with a coefficient of determination of 0.8578, meaning that nearly 86% of the variability in the Project station daily flows can be explained by variation in the reference station flows. However, Figure C1B (middle panel) reveals that for the lowest flows, when the reference station flows are 10 m^3/s or less, the Project station data tend to plot below the linear regression line or "line of best fit". Zooming in on low flow data using the chronological linear regression approach (e.g., Figure C1B) is one way to identify patterns at different flow conditions. But Figure C1B does not clearly identify where the breakpoint might be between a linear relationship at moderate-to-high flows and another relationship at lower flows.

The ranked regression approach, shown in Figure C1C, indicates that the linear relationship developed in Figures C1.A and C1.B provides a reasonably good fit to data near the highest flow portion of Figure C1C (>~8 m^3/s at the reference station), where the chronological linear regression line plots within 15% of the ranked dataset. Below ~8 m^3/s flow at the reference station, the curvilinear relationship developed with a second-order polynomial provides a better fit. At reference station flows of ~4 m^3/s, the ranked regression Project station flows are approximately 30% lower than would be predicted from the chronological linear regression (Figure C1C).

One disadvantage of the ranked regression approach is that it can be biased by low sample size (especially at the extreme ends of the flow ranges – high or low), leading to potentially misleading results. In this study, the ranked regression technique has been used only as necessary. The ranked approach has only been used for the months of June to October, during which annual low flows are most likely to occur at the Project stations. As indicated by Figures C1B and C1C this approach is more robust at these low flows.

Appendix D provides additional information on estimation of low flow indices for the Project stations.

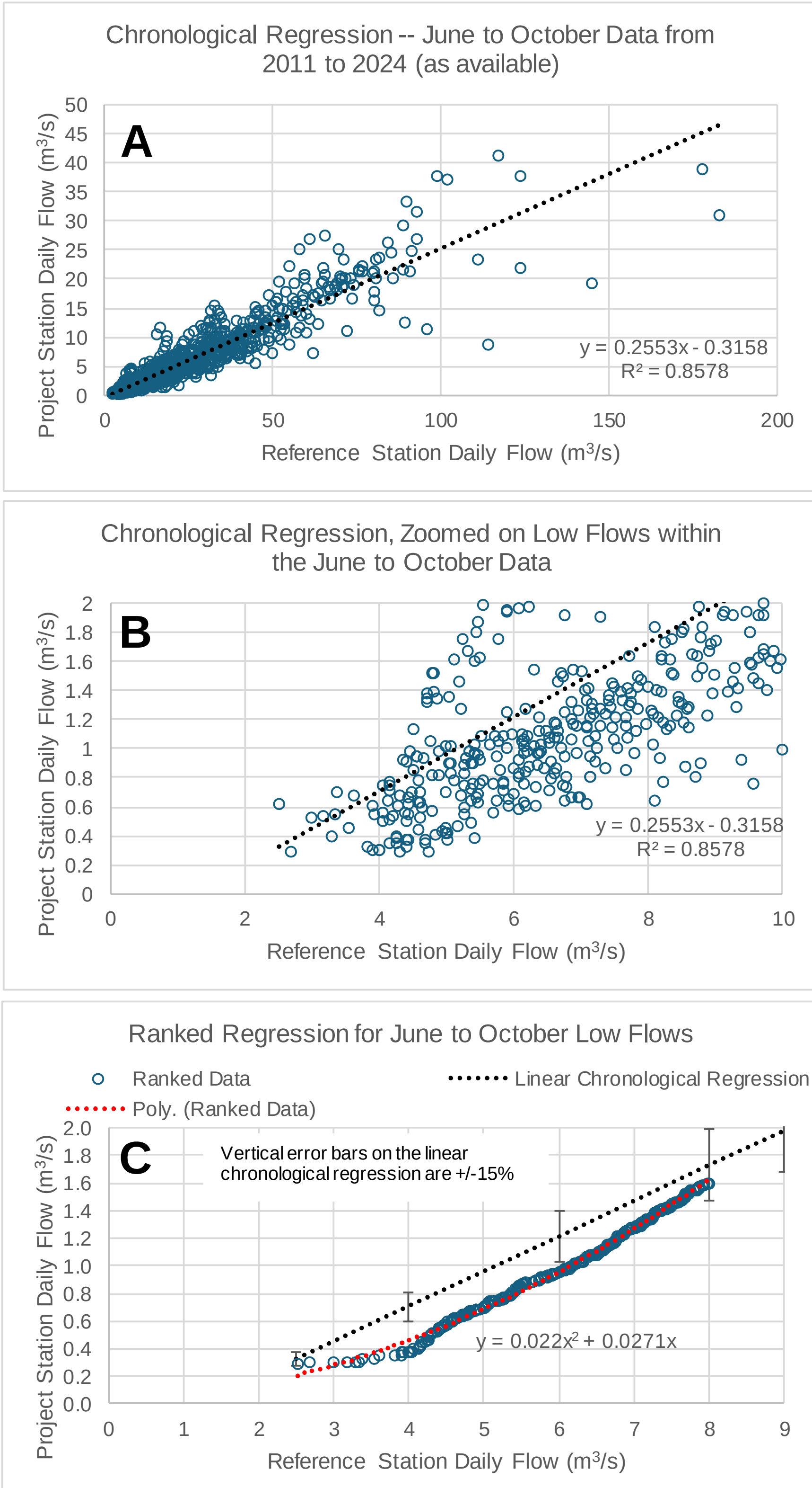


Figure C1 Example of Project Station (M2) Flow Plotted against Reference Station Flow

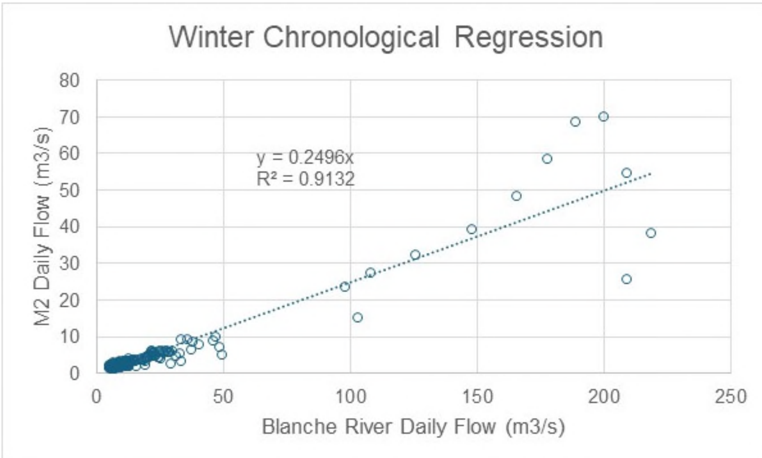


Figure C2. M2 Winter Chronological Linear Regression

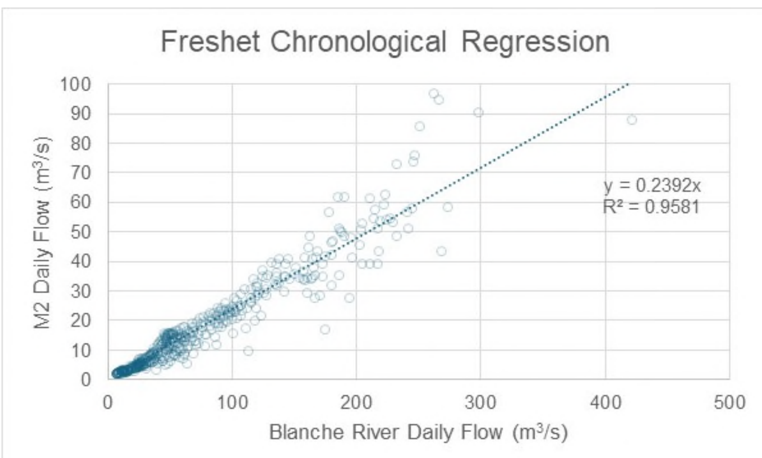


Figure C3. M2 Freshet Chronological Linear Regression

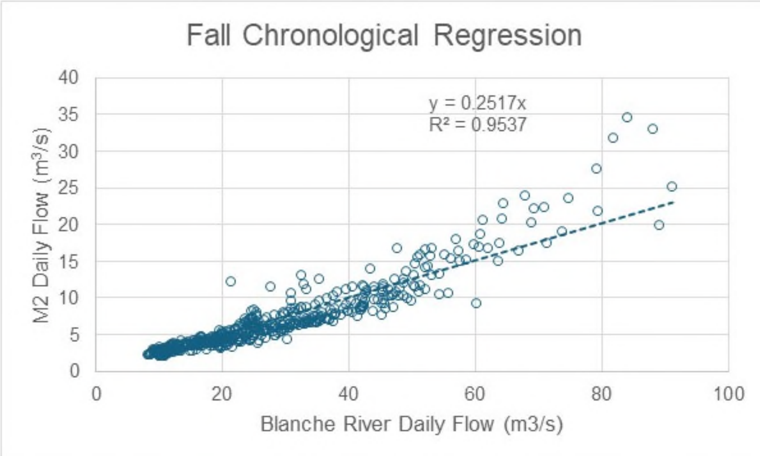


Figure C4. M2 Fall Chronological Linear Regression

Note: the Summer regression plots for the M2 station are shown in the main body of the report (Section 4.2.1).

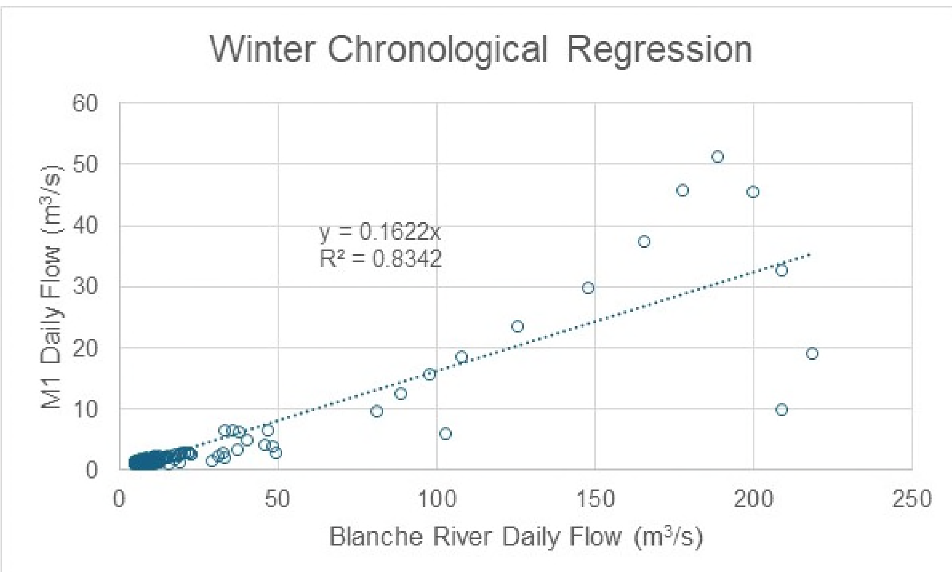


Figure C5. M1 Winter Chronological Linear Regression

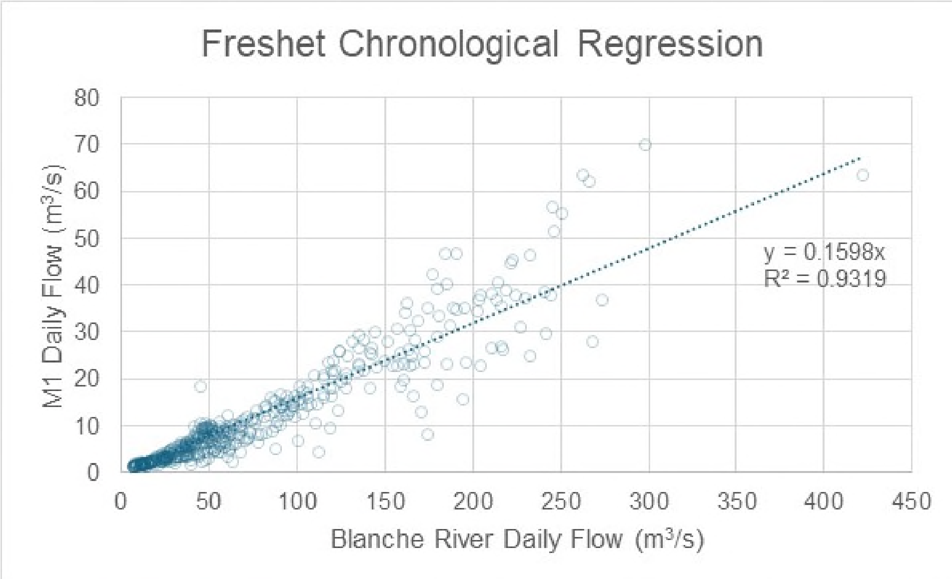


Figure C6. M1 Freshet Chronological Linear Regression

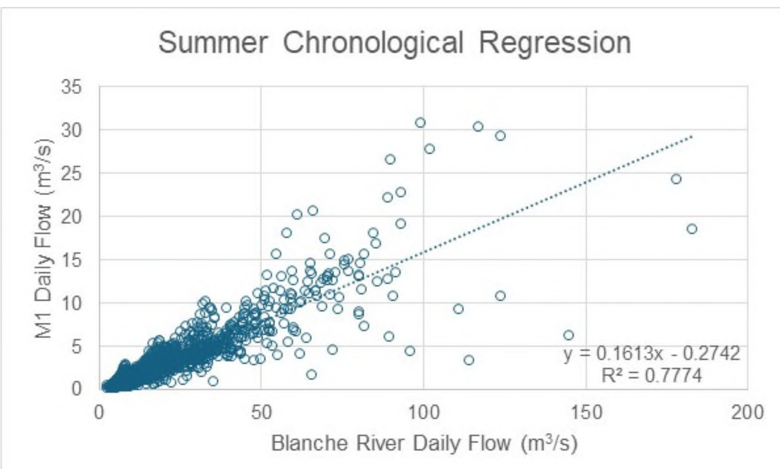


Figure C7A. M1 Summer Chronological Linear Regression

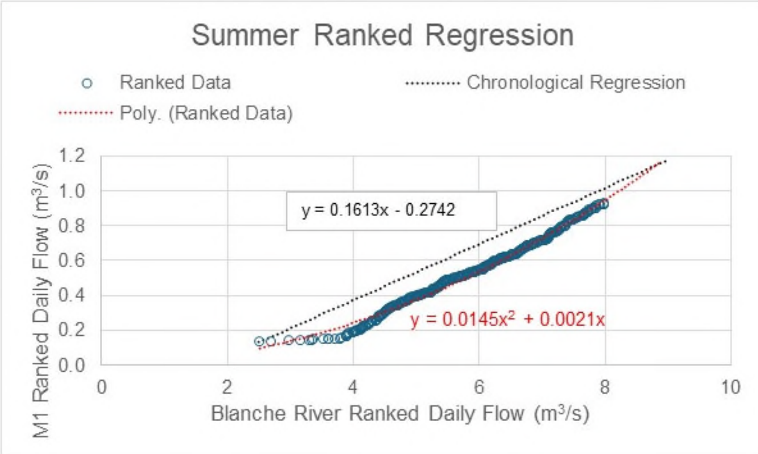


Figure C7B. M1 Summer Ranked Regression for Low Flows

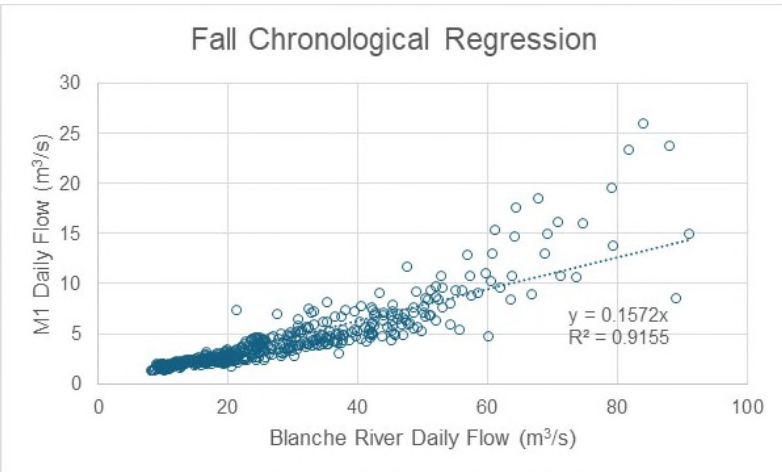


Figure C8. M1 Fall Chronological Linear Regression

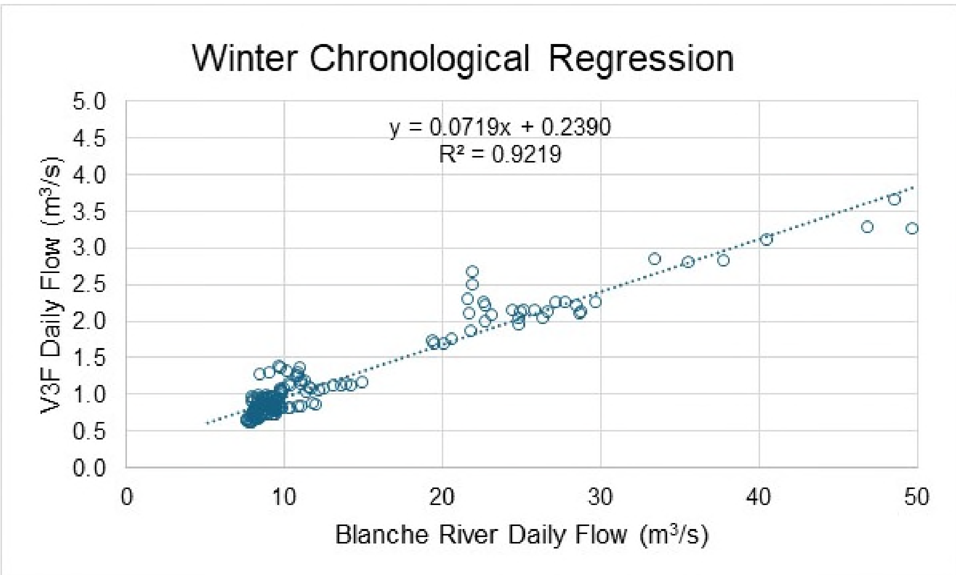


Figure C9. V3F Winter Chronological Linear Regression

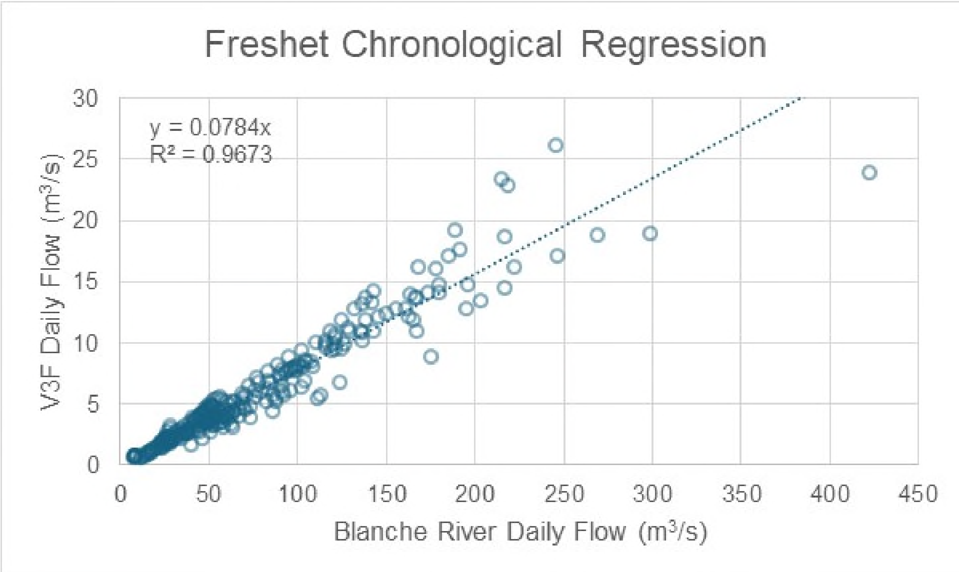


Figure C10. V3F Freshet Chronological Linear Regression

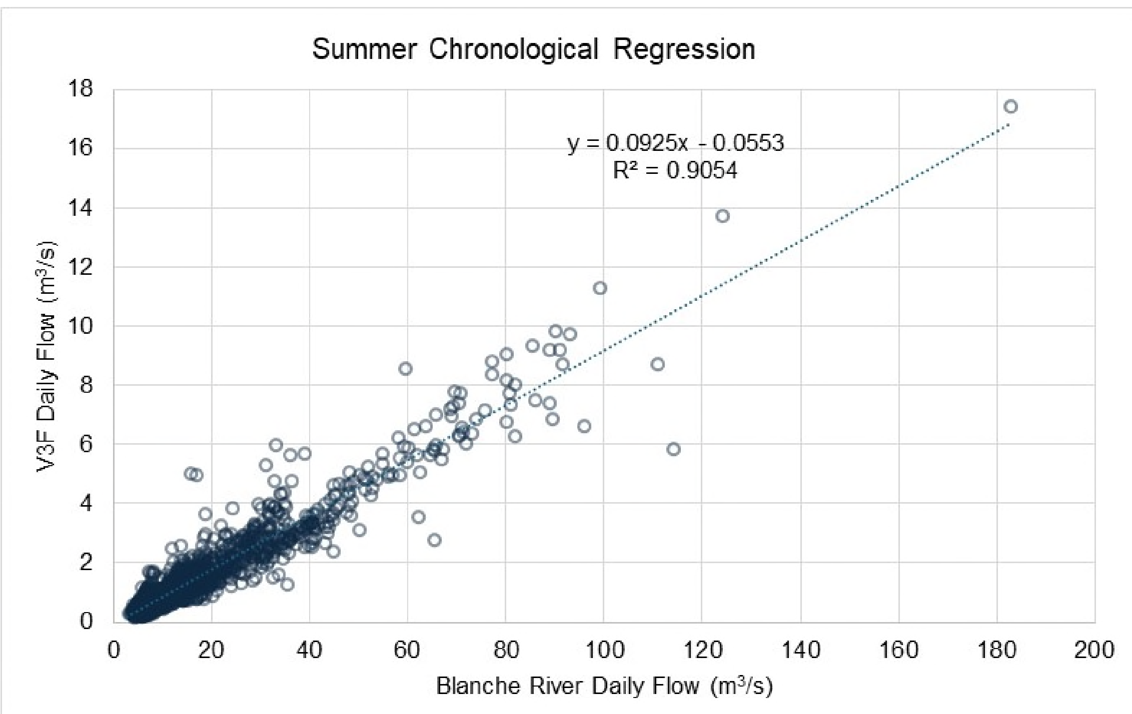


Figure C11A. V3F Summer Chronological Linear Regression

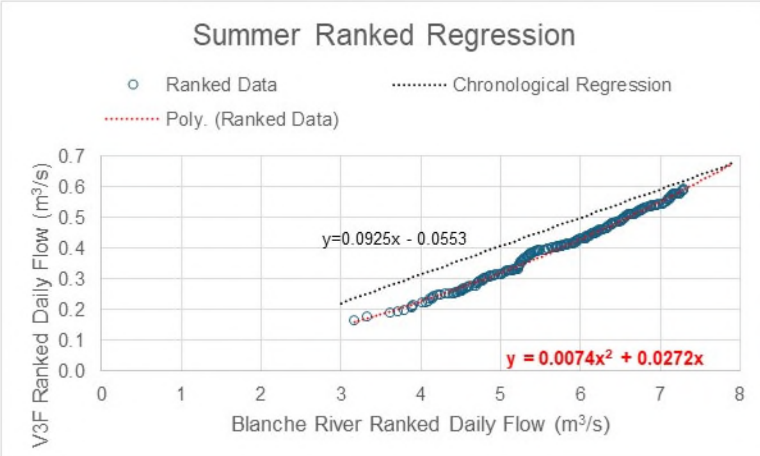


Figure C11B. V3F Summer Ranked Regression

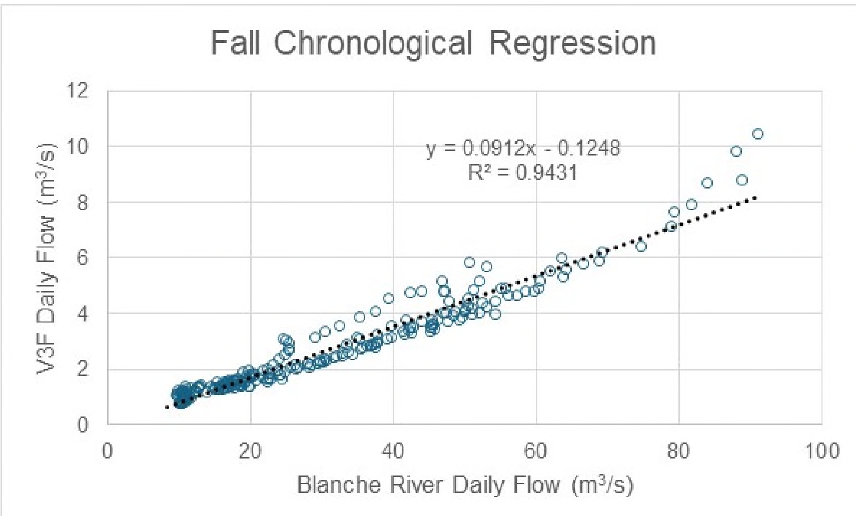


Figure C12. V3F Fall Chronological Linear Regression

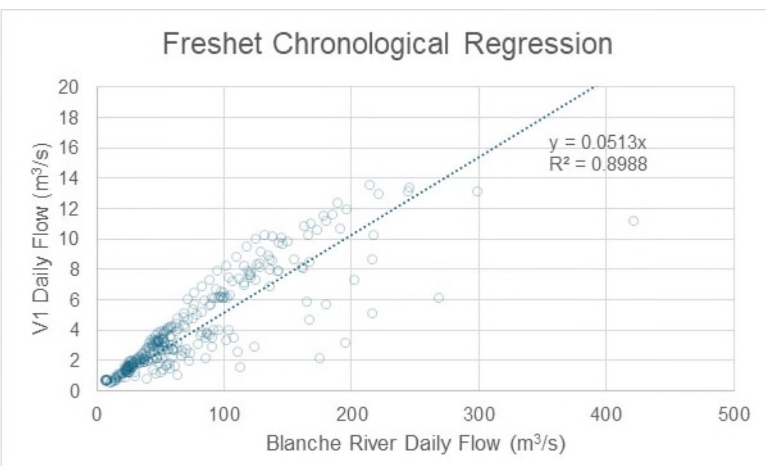


Figure C14. V1 Freshet Chronological Linear Regression

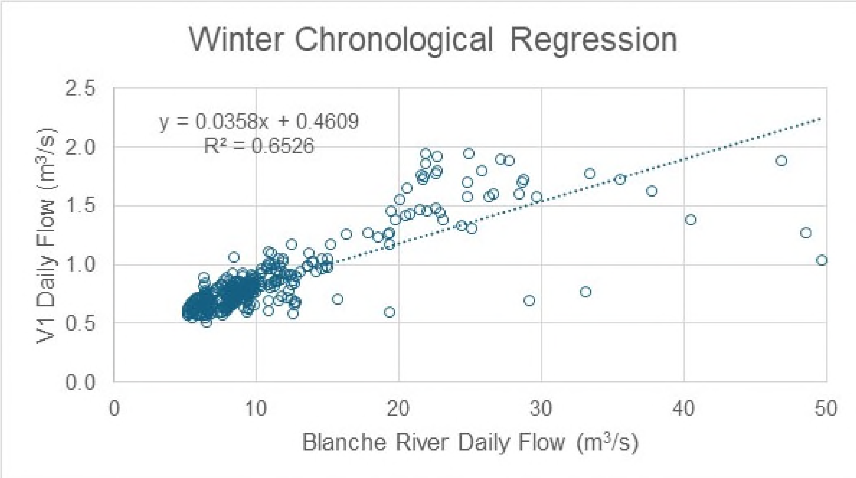


Figure C15. V1 Winter Chronological Linear Regression

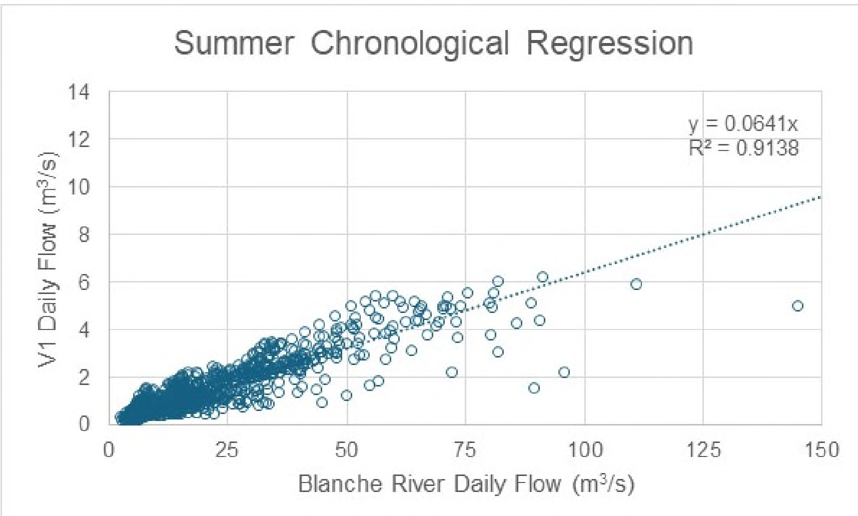
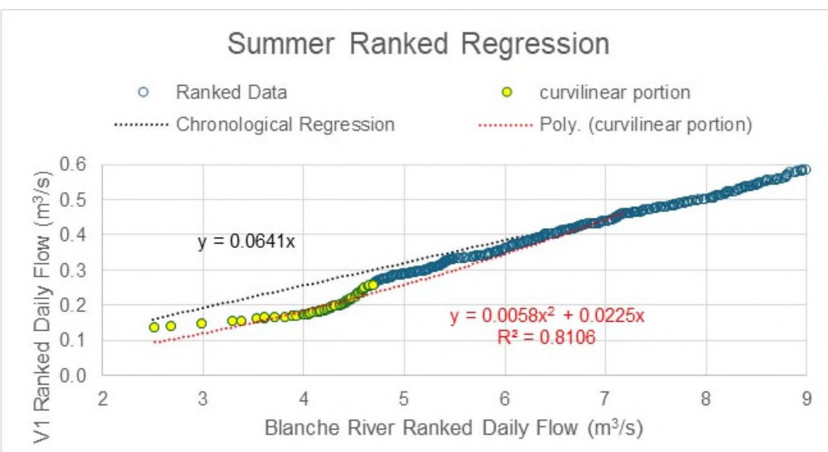


Figure C16A. V1 Summer Chronological Linear Regression



Note: the polynomial fit for summer low flows (equation in red font above) was fit to the data at Blanche River flows of less than or equal to 4.7 m^3/s since the curvilinear pattern in the data begins there. Those points are shown with yellow shading on the plot.

Figure C16B. V1 Summer Ranked Regression

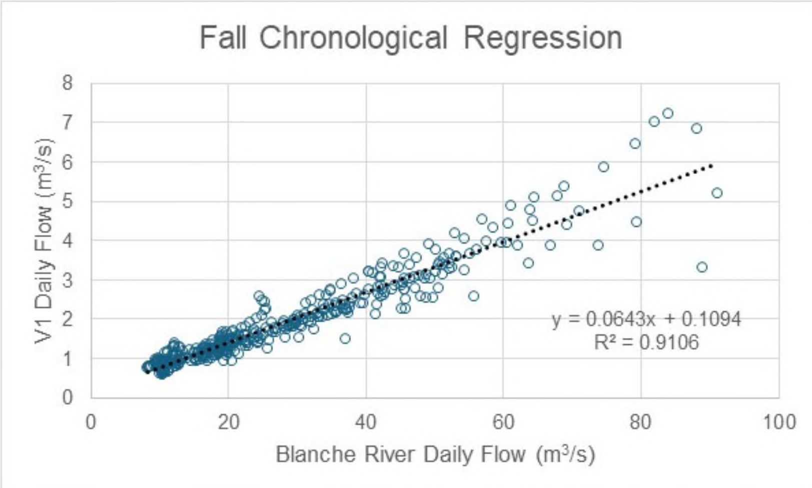


Figure D17. V1 Fall Chronological Linear Regression

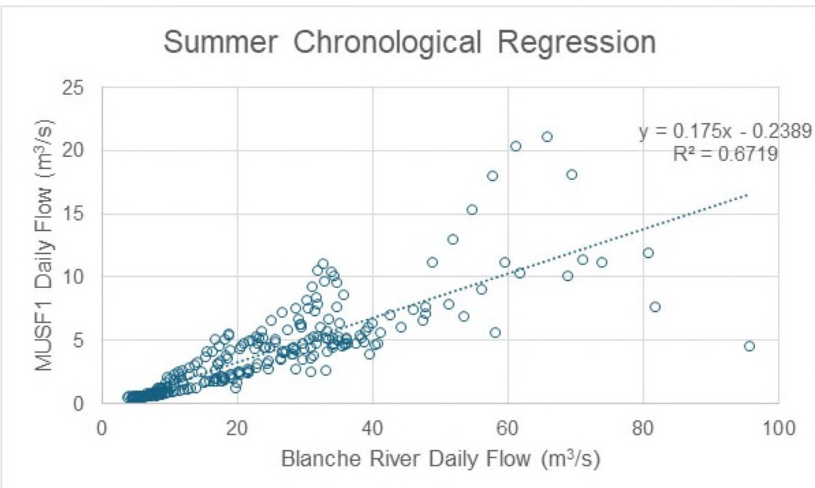


Figure D18A. MUSF1 Summer Chronological Linear Regression

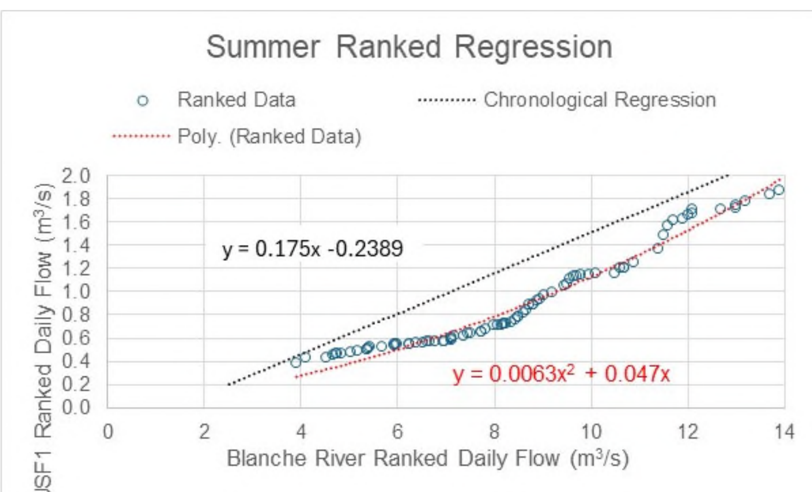


Figure D18B. MUSF1 Summer Ranked Regression

Appendix D

Estimating Low Flow Statistics

Estimation of Low Flow Indices

To calculate the annual low flow indices (7Q2, 7Q5, 7Q10, and 7Q20), SEI used a graphical approach based on ranked regression plots (e.g., Figure C1C in Appendix C). As shown on Figure D1 for the estimation of an annual 7Q2 flow at one of the Project stations (M2), a published value of 4.03 m^3/s for the 7Q2 at the reference station is available from Khaliq (2022). Figure D1 shows a zone of steeply declining Project station flows below 4.5 m^3/s at the reference station. Below reference station flows of ~4 m^3/s, the limited number of Project station data indicate a gradual reduction in flow. Due to the limited number of Project station flows at the extreme low end, it is unclear how much weight should be assigned to these data (<4 m^3/s at the reference station). Therefore, two separate regression equations have been developed. The first, a linear equation, is based only on the more gradually sloping portion of data less than or equal to 4.05 m^3/s at the reference station (shown with the dashed black line in Figure D1). The second, a curvilinear equation (second-order polynomial) is based on the ranked dataset at reference station flows of less than 8.0 m^3/s (shown with the dotted red line in Figure D1). These two equations were used to obtain two estimates of the low flow indices (7Q2, 7Q5, 7Q10, and 7Q20), with the averages of the two estimates used to obtain a single best estimate. As an example, the 7Q2 results for the Project station (M2) are shown in Figure D1 and are also documented in Table D1.

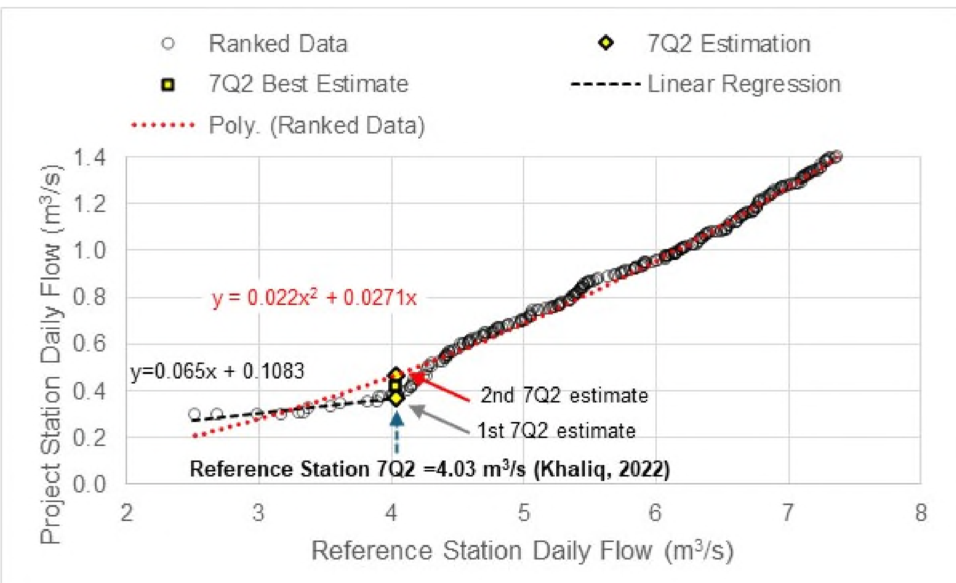


Figure D1 Example of Graphical Approach Used for 7Q2 Estimation

It is noted that the curvilinear equation, a second-order polynomial, in Figure D1 has been forced through the origin (zero points on both axes). This will provide a conservatively low estimate of the most extreme low flows (7Q20), which coincides with a reference station flow of 2.52 m^3/s, equal to the lowest reference station flow plotted on Figure D1.

This graphical approach avoids:

- laborious fitting of a single (or multiple breakpoint) curve to the low-flow portions of the ranked dataset to mimic exactly the shape of the relatively few data points at the extreme low end of the ranking;
- subjective judgment as to how to weight those few data points at the extreme low end of the ranking; and
- ignoring uncertainty in these estimates, which is never entirely absent.

The best estimate of the 7Q2 was obtained as the average of the 1st and 2nd 7Q2 estimates in Figure D1. The same method was used for estimation of other annual low flow indices including 7Q5, 7Q10, and 7Q20.

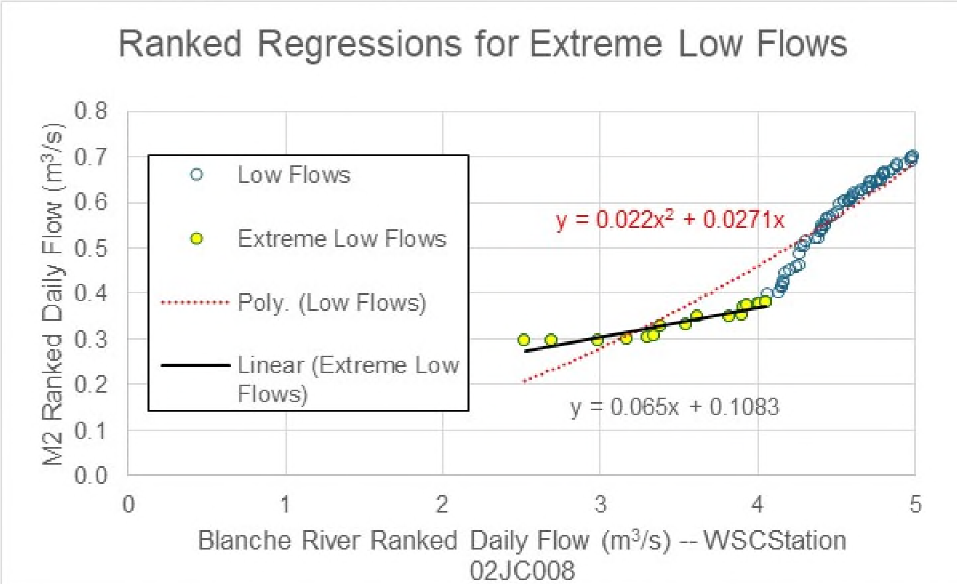
Table D1. Estimates of the 7Q2 Annual Low Flow for the Project Station M2

Estimate	Method	Equation	Reference 7Q2 Note 1 (m^3/s)	Project Station 7Q2 (m^3/s)
1st	Linear regression on extreme low flows (≤4.05 m^3/s at reference station)	y=0.065x + 0.1083	4.03	0.371
2nd	Polynomial regression on low flows (<8.0 m^3/s at reference station)	$y = 0.022x^2 + 0.0271x$	4.03	0.467
Best	Average of 1st and 2nd estimates	N/A	4.03	0.419

Notes
Note 1 = Khaliq (2022)
N/A = Not Applicable
m^3/s = cubic metres per second

Figures D2 through D6 present the ranked regression equations (line and polynomial) used for the low flow stations at stations M2, M1, V3F, V1, and MUSF1. Tables D2 through D6 summarize the low flow statistics results for the same five stations. Table D7 is a summary table of the low flow statistics.

For estimates of long-term Project flow data used to derive monthly average station flows, polynomial equations shown in Figures D1 through D6 have been used at all stations for the Summer period low flows. For those purposes, the relatively rare occurrence of extreme low flows will have minimal effects on the long-term monthly average data.

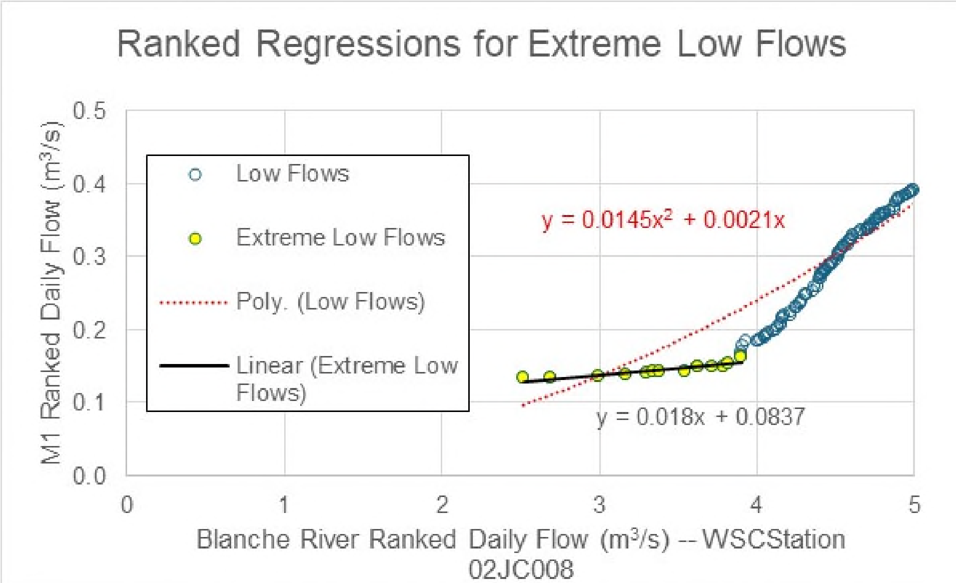


Note: the Low Flow dataset plotted above also includes the Extreme Low Flows.

Figure D2 M2 Ranked Regression for Low Flow Statistics

Table D2 M2 Low Flow Statistics Results

Station	Estimate	Method	Regression Equation	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
02JC008	Khaliq (2022)	See Khaliq (2022)	not applicable	4.034	3.225	2.848	2.572
M2	1st	Linear regression on lowest flows (≤4.05 m^3/s at reference station)	$y=0.065x + 0.1083$	0.371	0.318	0.293	0.275
M2	2nd	Polynomial regression on low flows (<8.0 m^3/s at reference station)	$y = 0.022x^2 + 0.0271x$	0.467	0.316	0.256	0.215
M2	Best	Average of 1st and 2nd estimates	not applicable	0.419	0.317	0.275	0.245

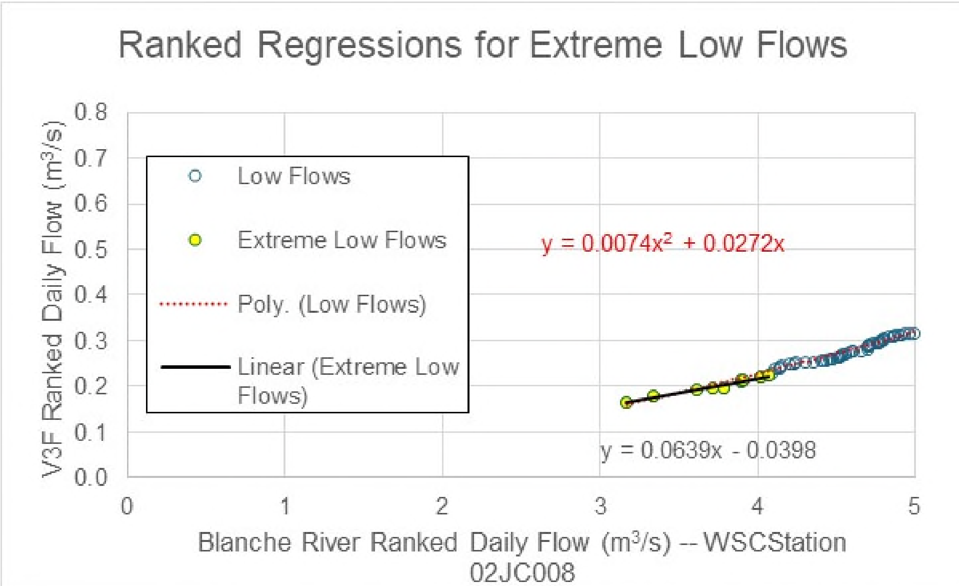


Note: the Low Flow dataset plotted above also includes the Extreme Low Flows.

Figure D3 M1 Ranked Regression for Low Flow Statistics

Table D3 M1 Low Flow Statistics Results

Station	Estimate	Method	Regression Equation	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
02JC008	Khaliq (2022)	See Khaliq (2022)	not applicable	4.034	3.225	2.848	2.572
M1	1st	Linear regression on lowest flows (≤3.9 m^3/s at reference station)	y=0.018x + 0.0837	0.156	0.142	0.135	0.130
M1	2nd	Polynomial regression on low flows (<8.0 m^3/s at reference station)	$y = 0.0145x^2 + 0.0021x$	0.244	0.158	0.124	0.101
M1	Best	Average of 1st and 2nd estimates	not applicable	0.200	0.150	0.129	0.116

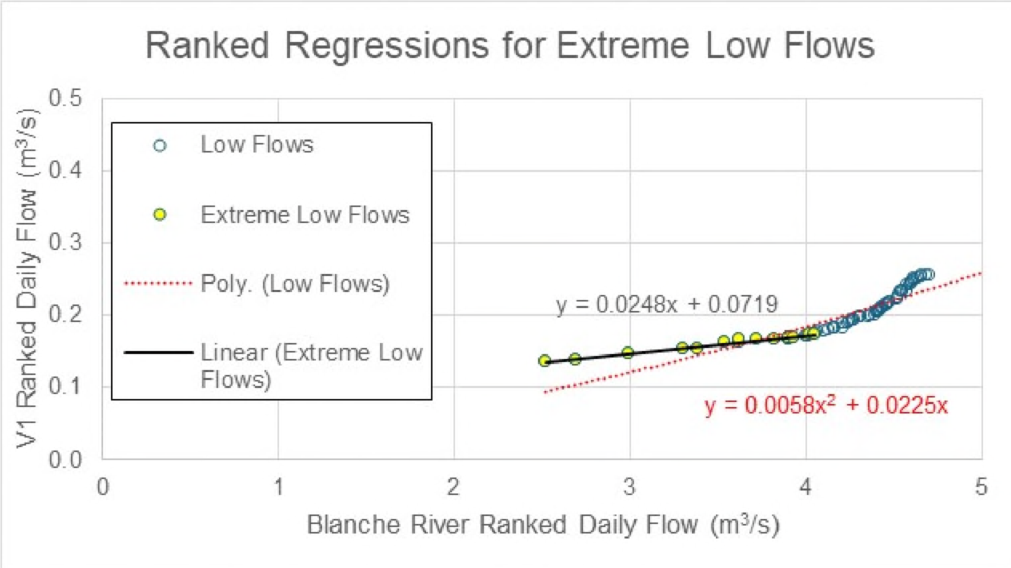


Note: the Low Flow dataset plotted above also includes the Extreme Low Flows.

Figure D4 V3F Ranked Regression for Low Flow Statistics

Table D4 V3F Low Flow Statistics Results

Station	Estimate	Method	Regression Equation	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
02JC008	Khaliq (2022)	See Khaliq (2022)	not applicable	4.034	3.225	2.848	2.572
V3F	1st	Linear regression on lowest flows (≤4.1 m^3/s at reference station)	y=0.0639x + 0.0398	0.218	0.166	0.142	0.125
V3F	2nd	Polynomial regression on low flows (<7.3 m^3/s at reference station)	$y = 0.0074x^2 + 0.0272x$	0.230	0.165	0.137	0.119
V3F	Best	Average of 1st and 2nd estimates	not applicable	0.224	0.165	0.140	0.122



Note: the Low Flow dataset plotted above also includes the Extreme Low Flows.

Figure D5 V1 Ranked Regression for Low Flow Statistics

Table D5 V1 Low Flow Statistics Results

Station	Estimate	Method	Regression Equation	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
02JC008	Khaliq (2022)	See Khaliq (2022)	not applicable	4.034	3.225	2.848	2.572
V1	1st	Linear regression on lowest flows (≤4.05 m^3/s at reference station)	$y=0.0248x + 0.0719$	0.172	0.152	0.143	0.136
V1	2nd	Polynomial regression on low flows (<4.7 m^3/s at reference station)	$y = 0.0058x^2 + 0.0225x$	0.185	0.133	0.111	0.096
V1	Best	Average of 1st and 2nd estimates	not applicable	0.179	0.142	0.127	0.116

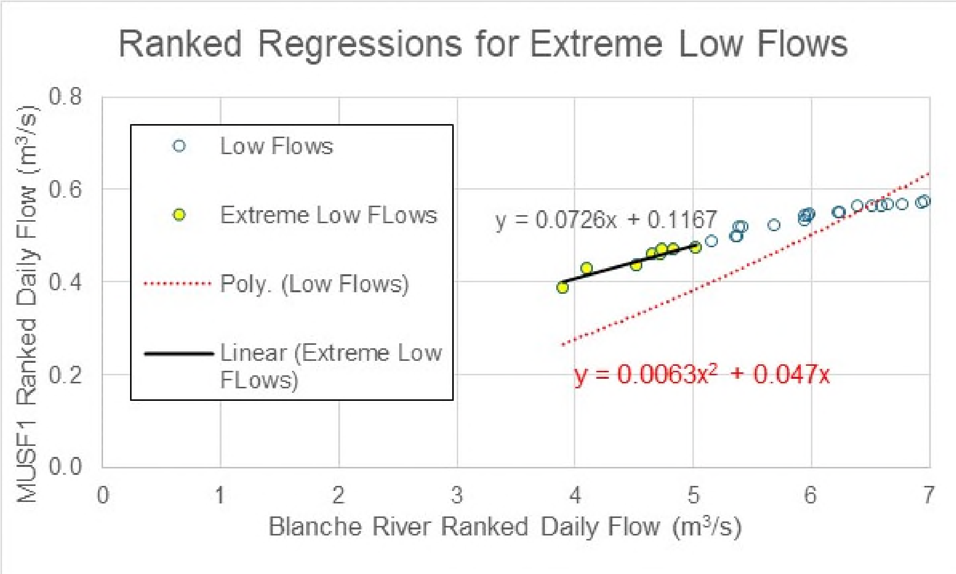


Figure D6 MUSF1 Ranked Regression for Low Flow Statistics

Table D6 MUSF1 Low Flow Statistics Results

Station	Estimate	Method	Regression Equation	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
02JC008	Khaliq (2022)	See Khaliq (2022)	not applicable	4.034	3.225	2.848	2.572
MUSF1	1st	Linear regression on lowest flows (≤5.1 m^3/s at reference station)	$y=0.0726x + 0.1167$	0.410	0.351	0.323	0.303
MUSF1	2nd	Polynomial regression on low flows (<14 m^3/s at reference station)	$y = 0.0063x^2 + 0.047x$	0.292	0.217	0.185	0.163
MUSF1	Best	Average of 1st and 2nd estimates	not applicable	0.351	0.284	0.254	0.233

Table D7 Project Station Annual Low Flow Statistics

Station	Estimate	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
02JC008	Khaliq (2022)	4.034	3.225	2.848	2.572
M2	1st	0.371	0.318	0.293	0.275
M2	2nd	0.467	0.316	0.256	0.215
M2	Best	0.419	0.317	0.275	0.245

Station	Estimate	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
M1	1st	0.156	0.142	0.135	0.130
M1	2nd	0.244	0.158	0.124	0.101
M1	Best	0.200	0.150	0.129	0.116

Station	Estimate	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
V3F	1st	0.218	0.166	0.142	0.125
V3F	2nd	0.230	0.165	0.137	0.119
V3F	Best	0.224	0.165	0.140	0.122

Station	Estimate	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
V1	1st	0.172	0.152	0.143	0.136
V1	2nd	0.185	0.133	0.111	0.096
V1	Best	0.179	0.142	0.127	0.116

Station	Estimate	7Q2 (m^3/s)	7Q5 (m^3/s)	7Q10 (m^3/s)	7Q20 (m^3/s)
MUSF1	1st	0.410	0.351	0.323	0.303
MUSF1	2nd	0.292	0.217	0.185	0.163
MUSF1	Best	0.351	0.284	0.254	0.233

Appendix E

2018 to 2024 Baseline Hydrometric Data
Provided in Electronic Format Only

Appendix F

2011 to 2013 Baseline Hydrometric Data
Provided in Electronic Format Only