# Memo

DRAFT

**To:** Francis Dubé, CGS Project Manager

**From:** Virginia Fisher, Project Manager, Dillon

**CC:** Sarah Collins, Meggie Letman, Jeff Melanson

**Date:** December 21, 2023

**Subject:** Grise Fiord Hydrologic Assessment

**Our File:** File #23-5971-2300

## Introduction

Dillon Consulting Limited (Dillon) is pleased to provide this technical memorandum describing the data collection efforts undertaken in support of the new proposed Grise Fiord water treatment plant (WTP). The study area and key features of the existing water collection and storage system are presented in **Figure 1**. The historical water source for the community is seasonal overland snow-melt that is generated from the surrounding mountainous watershed. The melt water is collected in an excavated pond, from where the water storage tanks are filled. The surface runoff reaches the existing pond via a series of small streams that convey runoff during the snow-melt season.

The existing storage tanks located near the existing water treatment plant (see **Figure 1**) have experienced damage from corrosion and differential settlement of the foundations throughout their operational life. Emergency repairs were undertaken to prolong their useful life until new storage tanks can be constructed as part of the overall construction of the new WTP. As part of this project, a desktop water balance study was undertaken (exp, 2022) during the planning stage which suggested that the pond would not be able to reliably supply water in both adequate quantity and quality to meet the long-term needs for the community water supply system. This same desktop study suggested that Airport River, which runs through the community of Grise Fiord, should be considered as an alternative water source to improve source reliability. The desktop study recommended a field program be undertaken to confirm suitability of Airport River as the new water source.

The hydrologic conditions in Airport River were observed during the 2023 melt-season to estimate its suitability as source water for the community. It is proposed that water will be pumped from Airport River directly into the new storage tanks. This memo will provide an overview of the collected field data, an analysis of the Airport River flow, and a discussion about the suitability of Airport River as the source water for the community, considering both the depth of flow required and the available water volume. It is noteworthy that this assessment is based on a single melt-season (2023) and therefore does not fully capture the annual variations in runoff volume/depth that may occur in Airport River.

## Future Water Demand

The community water demand was calculated at the design population (assumed 20-year population) based on the pre-determined daily per capita rate of 120 L/capita/day (Standardized Water Treatment Train, 2020). Based on both historic and recurring challenges with resupply and reliability of water storage within Grise Fiord, the Client has determined that a fully redundant storage tank be included, which equates to a full annual storage volume of 150% of community demand. This annual storage volume, inclusive of dead storage required within the tanks, is 13,200 $m^3$. Details on this volume calculation can be found within the Schematic Design Report (Dillon, 2023). Daily pumping volumes from Airport Creek are limited by the current water license to be 299 $m^3$/day.

## Community Knowledge

Community observations about water in Grise Fiord were shared during a meeting with Council on July 18, 2023, as well as through ongoing communication between Dillon and CGS. According to these sources, it is understood that flow conditions in Airport River were typical for that time of year during Dillon's field visit in July 2023. In general, Airport River is understood to be fed by glacier/snowmelt, and starts to flow in late June with flows peaking in early July, and decreases steadily throughout the summer. Rain events result in higher flows and decreased water quality; several Council members agreed that the colour of the water becomes brown when it rains. Further conversations have revealed that the river does not generally reach bank-full flow conditions. This is hypothesized to be due to the shrinking glacial contributions to Airport River, which may have historically contributed to high flows during the melt season, creating the high banks that are still seen today.


**GOVERNMENT OF NUNAVUT**

Grise Fiord Water Treatment Plant

▲ Logger Locations

**SITE PLAN**

FIGURE 1

DILLON CONSULTING

MAP DRAWING INFORMATION:
DATA PROVIDED BY ESRI, NRCAN

MAP CREATED BY: SCM
MAP CHECKED BY: MML
MAP PROJECTION: NAD 1983 CSRS UTM Zone 17N

N W E S

SCALE 1:6,000
0 37.5 75 m

PROJECT: 23-5971
STATUS: DRAFT
DATE: 2023-11-27

FILE LOCATION: K:\2023\235971\Product\Client\F1_SitePlan.mxd

## Field Data Collection

Dillon conducted a field visit on July 17 – 19, 2023 to observe flow conditions in Airport River. Dillon personnel installed 2 temporary ONSET (Hobo) water level pressure loggers and associated staff gauges within the watercourse; their locations are shown on **Figure 1** as sites GF-01 (upstream) and GF-02 (downstream). Photos of the staff gauges and loggers at the time of installation and removal are shown in **Photo 1**. The loggers were each programmed to collect water level measurements at 15-minute intervals.


**Photo 1: Installation of GF-01 (A) on July 19, 2023, and (B) on September 13, 2023; Installation of GF-02 (C) on July 19, 2023, and (D) on September 13, 2023.**

To estimate water levels, the data collected from the loggers needed to be compensated for barometric pressure. A separate barometric pressure logger (GF-AT) was installed on the side of the WTP building and used for barometric compensation. The loggers remained in place throughout the summer and

were collected on September 13, 2023. During installation and retrieval, the depth of water was recorded on the staff gauge; these observations are presented in **Table 1**. It is noteworthy that the loggers were installed into a variable substrate (rocky) during a period of fast and turbulent flow, therefore it was difficult to achieve vertical installation. The observed measurements were translated into water surface elevations by subtracting a correction factor for the starting measurement on the staff gauge of 0.025 m, and further corrected based on the angle of the installed logger and staff gauge.

**Table 1: Observed Water Depths in Airport River**

| | Observed Flow Depth, m | | |
|---|---|---|---|
| **Date** | July 18, 2023 | September 12, 2023 | September 13, 2023 |
| **GF-01 (upstream)** | 0.59 (0.53) | | 0.03 (0.005) |
| **GF-02 (downstream)** | 0.52 (0.48) | 0.08 (0.05) | |

The water surface elevation plot for sites GF-01 and GF-02 can be seen in **Figure 2**. The observations from July 18 to September 13 suggest that the depth of the water began to decrease dramatically in late August. This is likely due to the river source being primarily snow-melt, which peaks during the summer months and is depleted by late-summer as well as declining temperatures at the end of August and early September. Small daily variations in the water surface elevation were also observed. For instance, these changes were in the order of 0.1 m in July and are likely related to the changes of the rate of melt in the upper reaches of the watershed as the angle of the sun changes throughout the day.

Two peak events were captured during the observation period: one on August 16$^{th}$, and another on August 19$^{th}$. According to the active Grise Fiord Environment and Climate Change Canada [ECCC] station (Station ID 46568), the corresponding precipitation totals in the two days prior to the peak events were 13.6 mm and 10.4 mm, respectively.

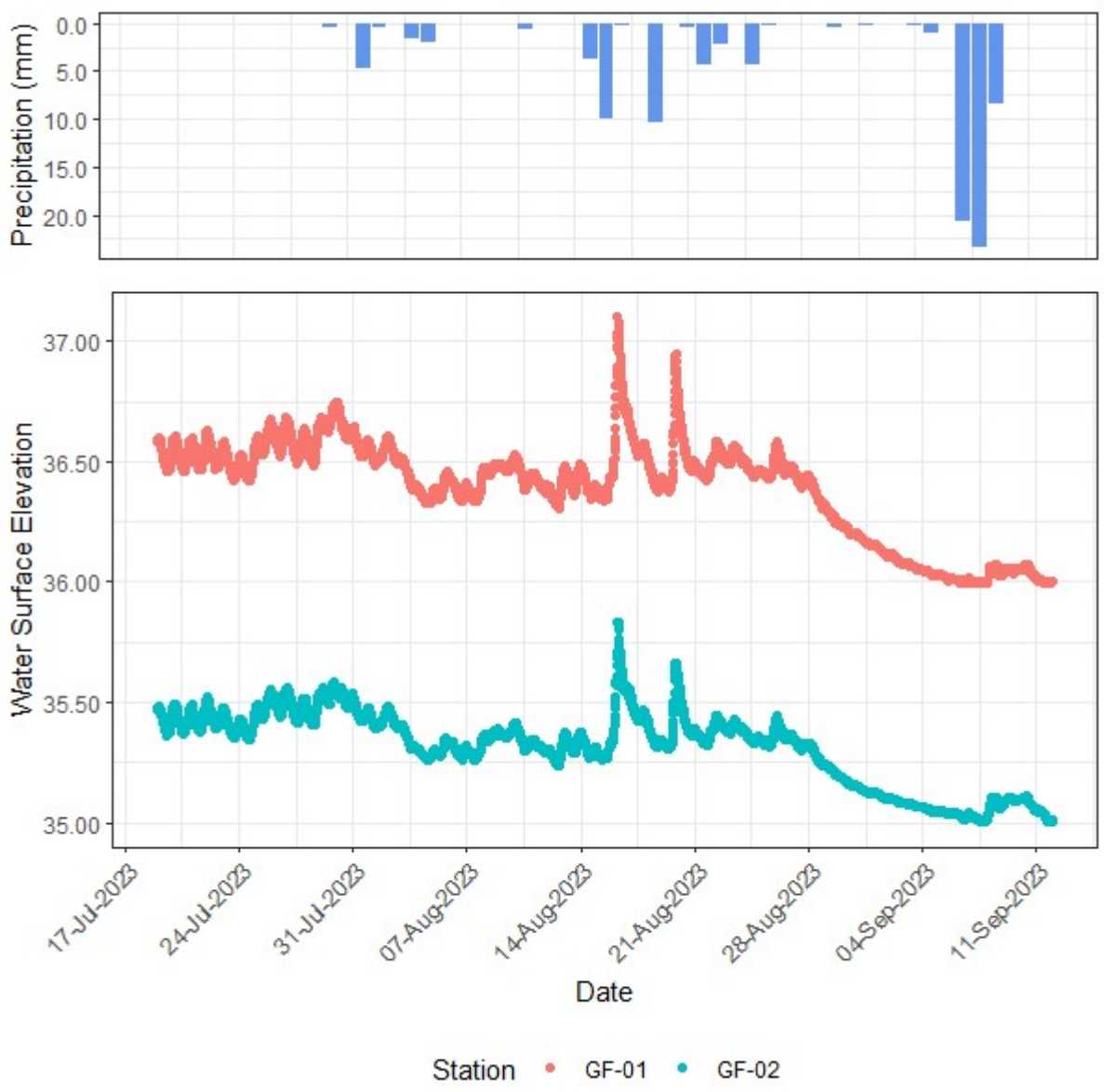


**Figure 2: Precipitation and Water Depth at Sites GF-02 and GF-01**

In addition to installing the loggers, field staff conducted stream gauging at site GF-02. The stream velocity was measured using a YSI FP111 velocity probe, and the mid-point method was used to estimate discharge. Due to the velocity of the stream at the time of the assessment, the velocity was measured at irregular intervals across the stream cross-section. Using these methods, the flow in Airport River on July 18 is estimated to be in the order of 3 $m^3/s$.

The cross-sectional profile along the river was surveyed by SubArctic for 3 locations, labelled as Section 1 0+191, Section 2 0+213, and Section 3 0+233 on **Figure 3**. The profiles for these 3 locations can be seen in **Figure 4**. The downstream cross-section, Section 3 0+233, was the closest point to loggers GF-01 and GF-02 and was therefore used to estimate flow rate at the gauge locations.

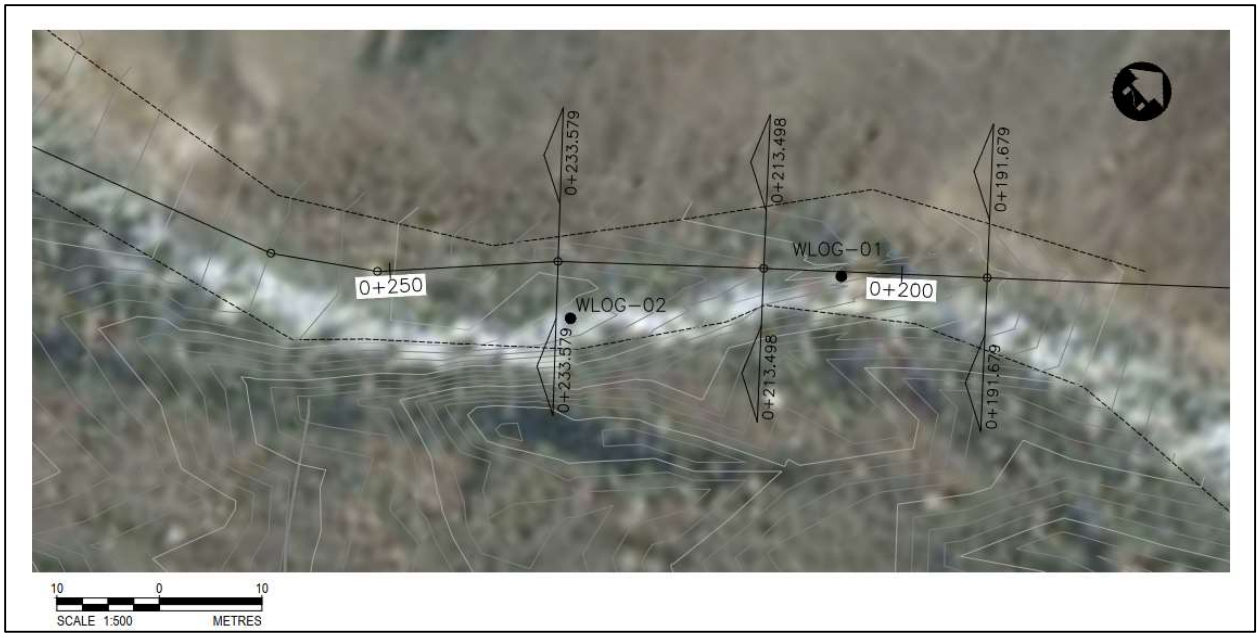


**Figure 3: Relative Locations of Section 1 0+191, Section 2 0+213, and Section 3 0+233**

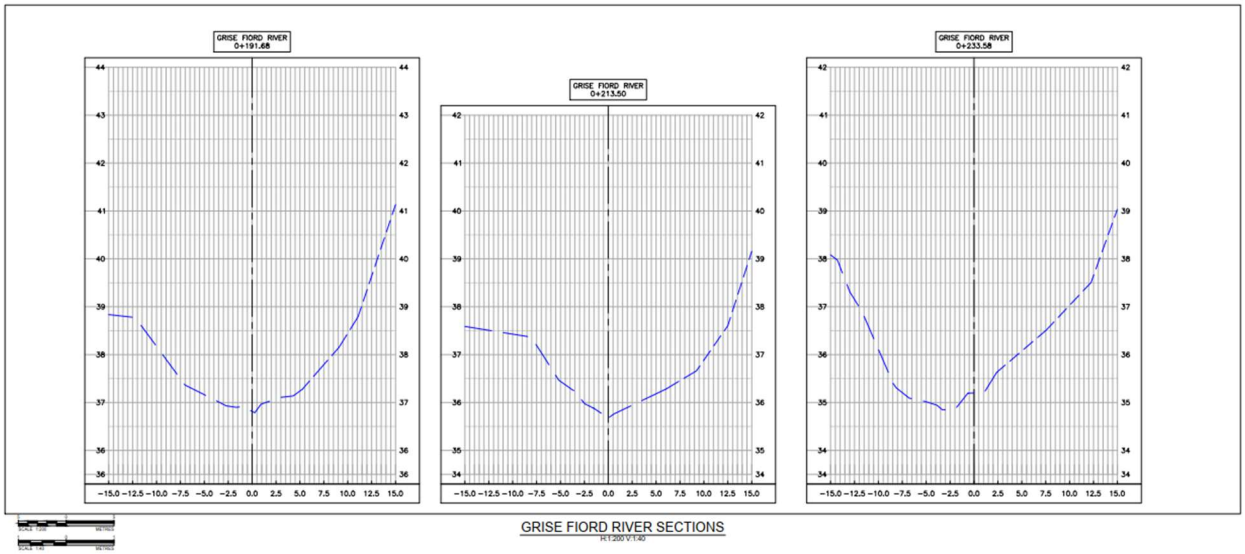


**Figure 4: Cross-Sectional Profiles of Section 1 0+191, Section 2 0+213, and Section 3 0+233**

## Estimation of Airport River Flow

To assess the suitability of Airport River as a potential potable water source for the community, a stage-discharge curve was developed to relate observed water depths to flow rate. The measured stream velocity and surveyed stream cross sections were used to estimate flow on the day of the site visit. This

observed data was assumed to represent a "typical" flow condition at this time of year, which aligns with community knowledge (i.e. flows on this day were typical for the time of year).

To estimate a typical low and high flow condition, representing the rise and fall of river depth due to seasonal changes, assumptions were made regarding the maximum depth of the river during these conditions. The Manning's equation was used to calculate the flow rate of the river during low and high flow conditions using the river cross-section survey data collected during the July site visit. When the staff gauge and loggers were removed, the measurement on the staff gauge for GF-02 was 0.05 m, which was used to represent the low flow condition, along with a roughness of 0.10 to represent a flow path in which 30-50% of the flow is obstructed. The highest measured depth during the observation period was 0.9 m on August 16. This depth was used with a roughness coefficient of 0.055 to represent the high flow condition. A summary of the low-flow, high-flow, and the observed flow can be seen below in **Table 2**.

**Table 2: Input Parameters for the Stage-Discharge Curve.**

| Flow Condition | Roughness coefficient | Flow Depth (adjusted) (m) | Water Level Elevation (m asl) | Flow Rate $(m^3)/s$ |
|---|---|---|---|---|
| **Low Flow (Manning's equation)** | 0.10 | 0.05 | 34.98 | 0.79 |
| **Observed Flow, July 19, 2023** | N/A | 0.48 | 35.41 | 2.91 |
| **High Flow (Manning's equation)** | 0.055 | 0.90 | 35.83 | 12.42 |

Using these 3 flows, a Stage-Discharge curve was generated for Airport River and was applied to the recorded elevations throughout the period of observation to obtain corresponding flow rates, as shown in **Figure 5**, below.

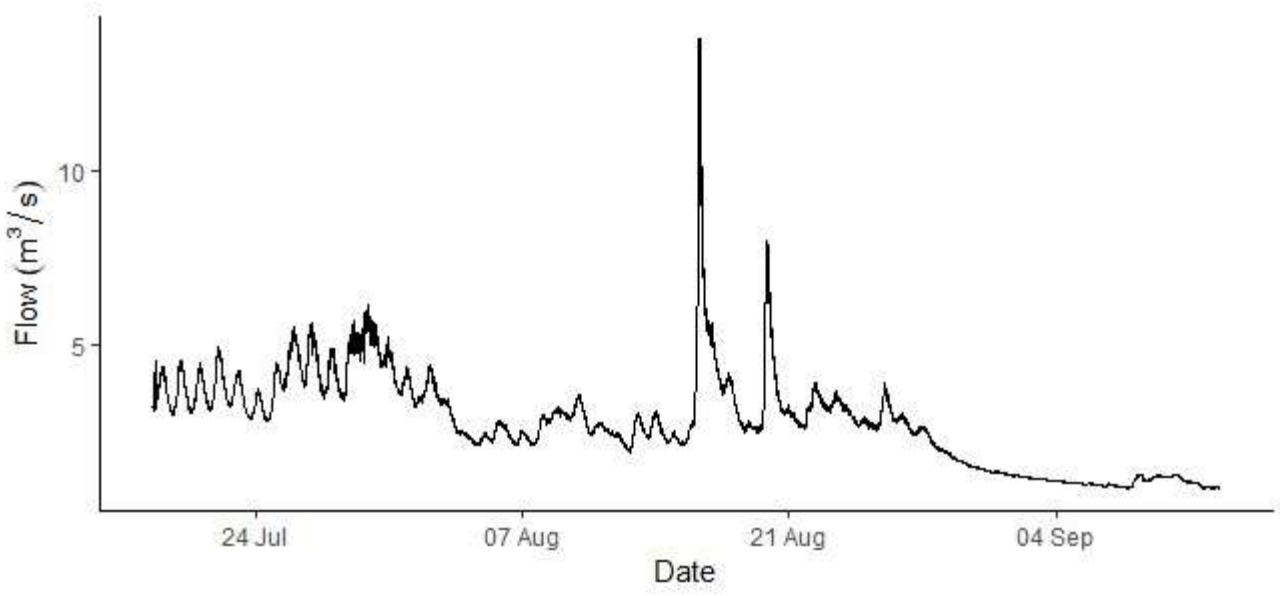


**Figure 5: Flow Rates**

The observation period demonstrates that the average depth of water at SF-02 from July 19 to August 28 was 0.38, which is expected to be sufficient for pumping needs. However, it is noteworthy that flow depth during the melt season will be below this level roughly half the time which could cause challenges submerging the pump intake. It is recommended that the flow depth be monitored closely to ensure that the community commences pumping as soon as feasible. It may also be necessary to construct a sump or shallow wet well next to the river to accommodate the pump intake.

The average daily flow rate during the observation period was 2.83 $m^3/s$, which corresponds to approximately 244,000 $m^3$/day. The required daily water taking of 299 $m^3$/day corresponds to approximately 0.12% of the observed average daily flow. As discussed above, flow rates are generally understood to peak in late June or early July, which was prior to the installation of the flow meters in 2023, so water availability may improve earlier in the season. Care should be taken during these higher flows to monitor that water quality (i.e. total suspended solids) remains within an acceptable range, particularly following heavy rainfall events.

According to community members, flows were within a typical seasonal range during the observation period. There are two ECCC stations that have recorded precipitation in Grise Fiord since 1984 (Station IDs #1754 and #23586). Using a water year of October to September, the average annual precipitation in Grise Fiord is 189 mm, with a median of 185 mm. This average includes recorded measurements as early as 1985, but has excluded years with more than 10% of the data missing (Between the two stations, 29 years were found to have sufficient data). In the 2022/23 water year, the total measured precipitation was 184 mm, which is slightly less than the recorded median. This further supports that the observed flows were within a typical range.

Given that the observation period only considered the 2022/23 season, this assessment does not account for potential changes in water availability due to climate change. However, a water source reliability review was conducted by Hayward et al. (2021) for 24 Nunavut communities and found that water shortage vulnerability is expected to increase in Grise Fiord. Furthermore, a review of Environment and Climate Change Canada (ECCC) Climate Data Viewer online tool (climate-viewer.canada.ca/climate-maps) suggests that annual average temperatures in Grise Fiord are expected to increase significantly (+10 C°) for the 2080-2100 time horizon. Similarly, both annual and winter precipitation is expected to increase in the future (+50-80% increase). While there is expected to be more precipitation available, the projected increase in temperature may change the seasonality and/or quality of runoff in Airport River. Changes in the amount of precipitation that falls as rain as opposed to snow may also significantly impact water availability/quality. These potential changes should be monitored in the future along with the development of appropriate contingency measures.

## Conclusions

The following outlines the conclusions relating to the water resupply system and use of Airport River as the primary water source for Grise Fiord:

- Based on the field monitoring and assessment completed for a single year, the water taking requirements correspond to 0.12% of the total annual river flow. This indicates that there is adequate water to supply the community for the design horizon of the new WTP.
- Observed water depths averaged 0.38 m. While this is adequate for the resupply pumping system, if lower depths are experienced for prolonged periods during resupply, a small modification to the river bed or adjacent to the bed may be required to create a sump zone for the pump. Also, to note, the resupply pump is intended to be mobile and could easily be moved to deeper locations within the vicinity of the resupply location to achieve required depths.