

APPENDIX E

LONG-TERM WATER OPTIONS ANALYSIS REPORT



**Comparative Evaluation of Sylvia
Grinnell River and Unnamed Lake
as Long-Term Water Supply for
City of Iqaluit**

Final

December 6, 2022

Prepared for:

City of Iqaluit

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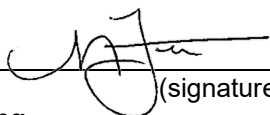
Nunami Stantec Ltd.






COMPARATIVE EVALUATION OF SYLVIA GRINNELL RIVER AND UNNAMED LAKE AS LONG-TERM WATER SUPPLY FOR CITY OF IQALUIT

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Executive Summary

The City of Iqaluit has been studying options for expanding its capability to provide a long-term water supply for its growing population. Based on the Iqaluit Water Storage Pre-Feasibility Study (EXP 2020), the City's population is currently approximately 9,000 residents, and could grow to 24,000 by the year 2050 under a high growth scenario. The City's water supply, Lake Geraldine, has for several years been inadequate on its own to address the City's water demands, which are approximately 400 litres per person per day (Lpcd). The City has previously commissioned several studies to identify options for additional supply and storage to address its future water needs, including studies of the Sylvia Grinnell River, Apex River, and Unnamed Lake.

This report provides a comparison of Sylvia Grinnell River and Unnamed Lake as the primary options for the City's long term water supplies, including a discussion on how the Apex River can contribute. The evaluation criteria were organized under three main categories: Technical, Economic, and Environmental. Within each of these, the following were considered:

Capacity	Pumping during summer (open-water) only, or also during winter
Supply	Can the source meet predicted quantities in the short term (2026) and in the long term (2050)
Accessibility	Infrastructure to access Sylvia Grinnell or Unnamed Lake, such as roads, power, pipeline, and pumps
Implementation	Constructability, O&M complexity, and asset security
Costs	Capital, operational, and life cycle
Environmental / Socio-cultural	Biophysical and socio-cultural environments, regulatory approvals, land use planning, and consultation results and requirements



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The evaluation determined that:

1. SGR could be a sustainable supply for a population of 24,000, however, it would require an additional storage reservoir as it can only be used during open-water season.
2. UNL by itself could be a sustainable supply up to a population of 17,000 (with additional supply potential from Apex River). UNL does not require an additional reservoir as it, in itself, is a functioning reservoir.

The pumping scenario reviewed for SGR indicates that a three-month pumping regime would be used during open water. Because of the elevation increase from SGR to Lake Geraldine, this is paired with additional pumping requirements. The additional pumping requirements add cost and O&M requirements.

We consider that the optimal pumping scenario for UNL is to continuously resupply Lake Geraldine from UNL. That recommendation will require further analysis during detailed design to optimize pumping and other operational details. Required equipment and controls will also be determined later in design. UNL has minimal pumping requirements and could potentially generate power. While continuous pumping is optimal for the UNL system and would not require an additional reservoir (\$65M), winter operations may present risk to the City. As such, it has been requested to move forward with three-month, summer operation of the UNL system and additional reservoir.

The estimated costs for SGR and UNL are summarized below:

	Sylvia Grinnell River	Unnamed Lake
Capital	\$32.5M + \$65M	\$15M + \$65M
Power, O&M	\$1M, \$300k	-\$150k, \$150k

SGR optimal concept indicates that intake Site B with a pipeline route towards the airport runway then overland be selected. For UNL, at the pre-conceptual level, considering the minor differences in cost between Options 1 and 2, we suggest that both pipeline routing options remain considered for UNL until detailed topography is evaluated during design.

Consultation determined a preference for development of the UNL option as SGR is an active and important cultural resource.



COMPARATIVE EVALUATION OF SYLVIA GRINNELL RIVER AND UNNAMED LAKE AS LONG-TERM WATER SUPPLY FOR CITY OF IQALUIT

Abbreviations

City	City of Iqaluit
DFO	Department of Fisheries and Oceans
HP	Horsepower
km	kilometre
KWH	Kilowatt Hours
L	litre
LGHC	Lake Geraldine Headwater Creek
m	metre
Nunami Stantec	Nunami Stantec Ltd.
NWB	Nunavut Water Board
s	Second
SGR	Sylvia Grinnell River
UNL	Unnamed Lake



COMPARATIVE EVALUATION OF SYLVIA GRINNELL RIVER AND UNNAMED LAKE AS LONG-TERM WATER SUPPLY FOR CITY OF IQALUIT

Introduction

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF EVALUATION

The City of Iqaluit (the “City”) has been studying options for expanding its capability to provide a long-term water supply for its growing population. Based on the Iqaluit Water Storage Pre-Feasibility Study (EXP 2020), the City’s population is currently approximately 9,000 residents, and could grow to 24,000 by the year 2050 under a high growth scenario. The City’s water supply, Lake Geraldine, has for several years been inadequate on its own to address the City’s water demands, which are approximately 400 litres per person per day (Lpcd). The City has previously commissioned several studies to identify options for additional supply and storage to address its future water needs, including studies of the Sylvia Grinnell River, Apex River, and Unnamed Lake.

Nunami Stantec Limited (Nunami Stantec) was retained by the City to complete a comparative evaluation of the Sylvia Grinnell River (SGR) and Unnamed Lake (UNL) as options for supplemental long-term water supply based on available reports and information. This report presents the outcomes of this evaluation. This report’s scope includes engineering and environmental considerations associated with obtaining and conveying supplemental water from supply (SGR or UNL) to storage (Lake Geraldine and/or a new reservoir as discussed in EXP 2020). In all cases, the evaluation assumes that Lake Geraldine remains the primary source of water for the City. This report relies on and does not include evaluation of storage nor supply as reported on by others, and the findings are limited by the assumptions and limitations made in these other reports, as identified in the following section.

1.2 PREVIOUS STUDIES

This evaluation of the SGR and UNL benefits from and relies on studies and information previously presented in the following reports:

- Iqaluit Water Storage Pre-Feasibility Study (EXP 2020)
- Water Balance Assessment for Unnamed Lake – Modelling Report (Golder 2021)
- Options Evaluation for Raw Water Supplementation from the Sylvia Grinnell River (Nunami Stantec 2018)
- Conceptual Design Advancement for Raw Water Supplementation from the Sylvia Grinnell River (Nunami Stantec 2019a)
- Unnamed Lake Fish and Fish Habitat Assessment Technical Report (WSP 2021)
- Iqaluit DFO Bathymetric Lake Surveys (Tetra Tech 2019)

These previous studies have provided information to enable an evaluation of the SGR and UNL supply concepts. An additional pre-concept level description of UNL as a water source has been developed by

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Introduction

Nunami Stantec specifically to benefit this evaluation (see Appendix A). A summary description of the concepts is provided in the following sections.

1.3 FORECAST WATER DEMAND

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 10,800 people by 2026. Based on a raw water consumption rate to be 400 Lpcd, the raw water demands for the City of Iqaluit in 2026 are estimated to be 4,320 m³/d, or 1,576,800 m³ per year. Under the high growth scenario (3.38%) as defined in the Iqaluit General Plan (2015) and further described in EXP (2020), the City is expected to have a population of 24,000 people by 2050. Based on a raw water consumption rate to be 400 Lpcd, raw water demand in 2050 may be as high as 9,600 m³/d, or 3,500,000 m³ per year. Under a medium growth scenario (2.87%) Iqaluit may have a population of 20,500 people by 2050, with 8,200 m³/d, or 3,000,000 m³ per year. The City has requested that this report consider the high growth scenario for this evaluation.

This report uses these projections to complete the evaluation of raw water supply options to year 2050, with a general discussion provided of water source considerations for a planning window of 75 years into the future.

COMPARATIVE EVALUATION OF SYLVIA GRINNELL RIVER AND UNNAMED LAKE AS LONG-TERM WATER SUPPLY FOR CITY OF IQALUIT

Description of Options Evaluated

2.0 DESCRIPTION OF OPTIONS EVALUATED

Two general options for water supply are evaluated, with variations described in the text. The Sylvia Grinnell (SGR) and Unnamed Lake (UNL) options are generally illustrated in Figure 2.1., with “New Lake” referring to the reservoir discussed in EXP (2020). These two options occur within two separate watersheds: UNL is a sub-watershed within the larger Apex River watershed; the SGR occurs within the Sylvia Grinnell watershed. The Lake Geraldine reservoir is within a smaller watershed between the two. Figure 2.2 shows the three referenced watershed and sub-watersheds.



Figure 2.1 Overview of SGR and UNL Options

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Description of Options Evaluated

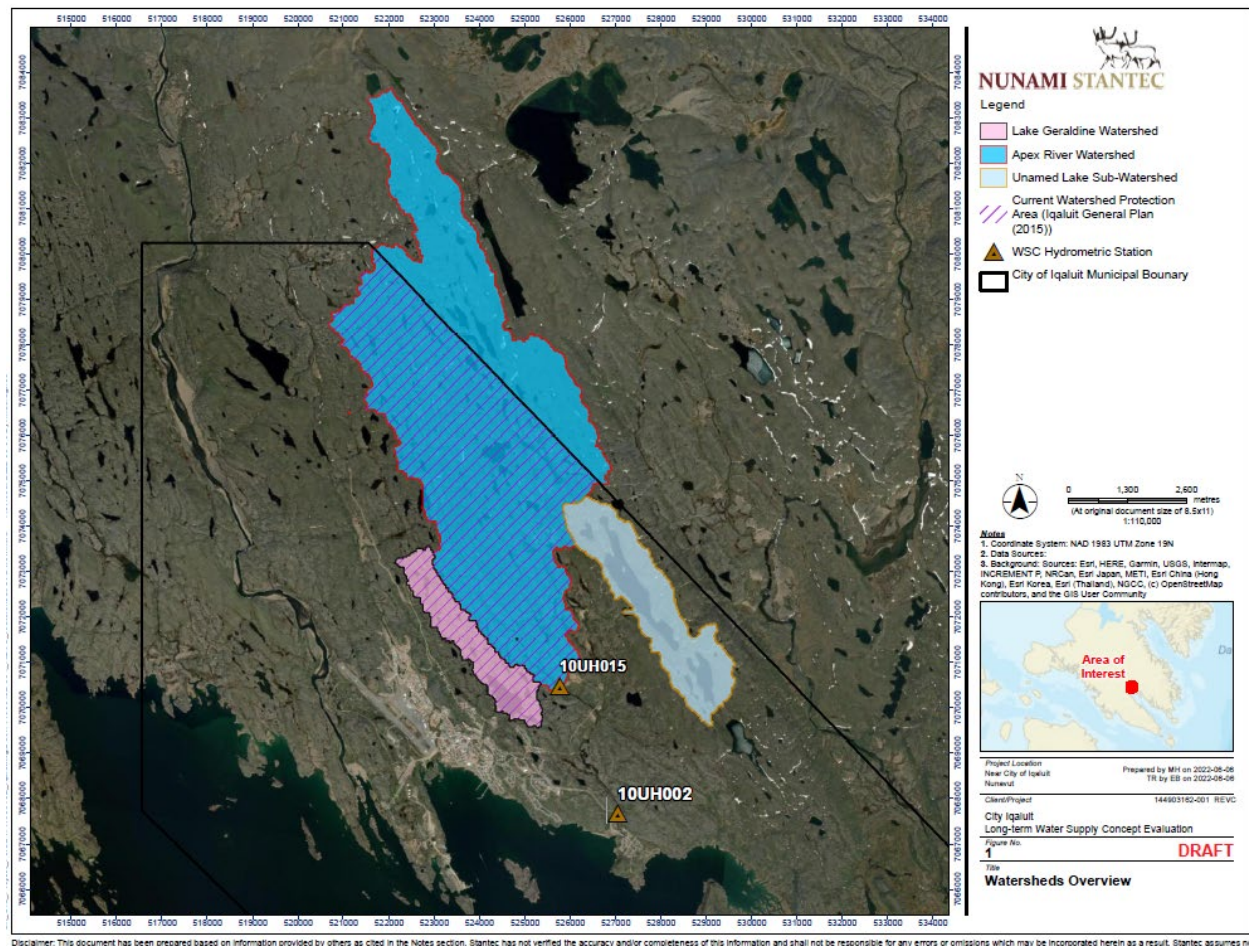


Figure 2.2 Lake Geraldine, Apex River and Unnamed Lake Watersheds

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Description of Options Evaluated

2.1 SYLVIA GRINNELL RIVER OPTION

The SGR option includes supplemental water supply from the SGR and conveyance to Lake Geraldine Reservoir and the New Lake (Figure 2.1). The SGR supply consists of a wet well intake operated seasonally, and a pipeline system that moves water uphill to the headwaters of Lake Geraldine.

2.1.1 Sylvia Grinnell River Intake

Nunami Stantec's report *Options Evaluation for Raw Water Supplementation from the Sylvia Grinnell River* (Nunami, 2018) compared five possible river intake site locations. Following that report, two sites were selected for further evaluation as possible intake locations. The selected sites included Site A and Site B. Site A was located near the end of the airport runway and Site B was located approximately 2 kilometres (km) upstream from there. While more costly, Site B was found to have a lower level of design and operational risk than Site A. Site B was therefore considered in this evaluation.

Site B is a run located on a pronounced outside bend of the river channel. The left (north) bank at Site B is actively eroding and would require stabilization for any infrastructure placed at this site; however, a bedrock outcrop is present downstream. The outcrop provides some limit to the progression of erosion at left bank and downcutting of the river channel.

The Site B intake concept involves a protruding bank structure that takes advantage of the bank's natural geometry and the access platform of the protruding wall structure can be placed well above the estimated flood and ice elevations (see Figure 2.3). As a result, there is no need for separate screen chamber and wet well infrastructure and there is opportunity for the instrumentation building to be placed on top of the wet well to serve as a combined instrumentation and mechanical building. The building and wet well would be accessed using the gravel pad formed by the protruding wall structure.

The concept uses concrete to form the wall of the protruding structure. Pending sub-surface conditions, the wall could be formed of sheet pile, or an alternate material that can resist ice forces. The structure would require a suitable foundation. Selection of the wall material would be dependent upon geotechnical investigation and foundation design as part of preliminary engineering.

The intake chamber is incorporated into the structure with maintenance access provided by a manhole. The chamber is abutted to the wall and has an opening to the river that is fitted with two 2 metre (m) x 1 m intake screens. The screens, trash rack and any protective plates could be raised and lowered along slotted guides using the davit shown on the concept drawings.

A submersible style pump was deemed the most appropriate for use at Site B and it would be lowered into the wet well and secured to the discharge pipe seasonally. At the end of each annual withdrawal window the pump would be removed from the wet well for winterization and protection against possible ice formation in the well.

The Site B geometry has the added benefit of the hydraulic control provided by the bedrock outcrop located approximately 50 m downstream. The hydraulic control provided by the bedrock outcrop provides added

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Description of Options Evaluated

assurance to the hydraulic stability of the site at low flow. In this geometry, the Site B protruding wall structure is not overtopped by flood events and though ice scars were not seen during the site visit in 2018, it is expected that this structure would not be overtopped by ice.

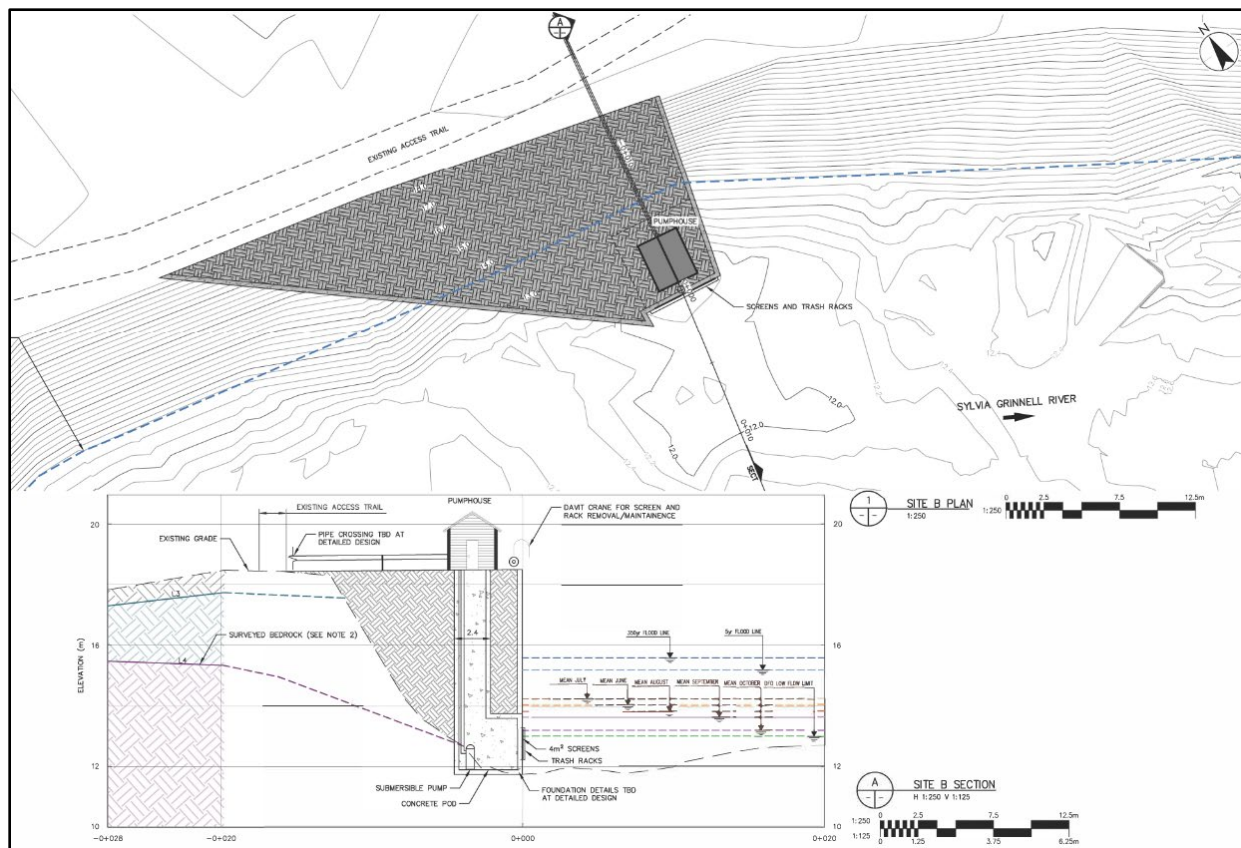


Figure 2.3 SGR Concept Intake Site B (from Stantec 2019)

The protruding wall structure puts the intake screens into the channel's thalweg as shown by bathymetric survey. Hydraulic modeling results show that have the screens placed in this location would allow for withdrawals at the shoulders of the open water season (June and October), if conditions permit, and would also allow withdrawals in flows as low as those permitted by Fisheries and Oceans Canada (DFO) for withdrawal specific to this location.

The Site B concept considered maintenance requirements related to screen clogging, sediment accumulation in the wet well, seasonal operation, and preliminary measures to protect against ice floes or jams that might occur at the intake site. The screen face and trash racks at Site B could also be designed with some provision for ice resistance but there would be residual risk of damage over winter and the screens should be removed as part of winterizing. The Site B intake can also be designed with an air

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Description of Options Evaluated

bubbler or air scour system to reduce the frazil ice build-up on the intake screens should the City wish to have the intake operational in the late fall season and prior to complete freeze-up of the river.

2.1.2 Sylvia Grinnell Pipeline Routing

Site B is located approximately 12 m above sea level (asl), with Lake Geraldine located at about 95 m asl, with topography generally sloping uphill from Site B towards Lake Geraldine, although there are many high and low points between Site B Lake Geraldine.

Pipeline routing from Site B was originally presented as two options, Route B and Route BA. Using information from a Light Detection and Ranging (LiDAR) topographic survey (partially completed, to date), two optimal routes from Intake Site B to Lake Geraldine were identified in the concept design.

Route B follows a less direct path to Lake Geraldine Headwater Creek (LGHC), east from the intake site past Upper Base to discharge. Route BA follows a path from the intake site at approximately 30 m above sea level (asl), downstream along the river edge toward the end of the airstrip, where it then routes uphill through the North 40 and Plateau subdivisions to LGHC at an elevation of approximately 110 m asl. Route BA was selected as the optimal route and used in this evaluation, and is the route shown in Figure 2.1. Routing to a “New Lake” reservoir was not identified at the time of the study.

2.1.3 Sylvia Grinnell Resupply Scenario

Resupply from Sylvia Grinnell River would include annual withdrawal when flows are more than 30% of the river’s mean annual discharge, which generally, but not necessarily continuously, occurs from June to October. Water would be transferred to supplement (top up) both Lake Geraldine and the New Lake during the open-water season. There would be no resupply from the SGR during winter. All over-winter supply would have to be stored within these two reservoirs.

2.2 UNNAMED LAKE

The UNL option includes supplemental water supply from UNL and conveyance to Lake Geraldine Reservoir and/or the New Lake (Figure 2.1). The UNL supply consists of a permanent intake to be operated either year-round or seasonally, and a pipeline system that moves water downhill to Lake Geraldine or the New Lake.

2.2.1 Unnamed Lake Intake

The intake at UNL would be comprised of a pumphouse on the west shore and a raw water line extending out into the lake and running along the lakebed to the withdrawal location. At the withdrawal location, the pipe would be screened with an orb type screen(s) with the pipe and screen affixed to an anchor block or pile footing to keep it in place and above the lakebed. The screens must be sized in accordance with DFO code of practice for end of pipe fish screening for the type of fish anticipated to be present. Environmental deoxyribonucleic acid (eDNA) samples taken from the lake (WSP 2021) identified the presence of arctic char, but no other fish, though Ninespine stickleback have potential to be present. Arctic char and Ninespine

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Description of Options Evaluated

stickleback both have a subcarangiform mode of swimming and under the code of practice, a screen area of 0.51 m² would be required for a withdrawal rate of 50 litres per second (L/s) to prevent entrainment and impingement. This screen area can be accommodated with a single drum type orb screen with openings no larger than 2.54 mm, in accordance with the code. The screens would also be fitted with an air scour that is operated by an airline running in parallel with the raw water line and connected to a compressor at the pumphouse. The air scour can be run continuously in winter to mitigate frazil or in bursts to control biofouling.

The withdrawal should occur in an area of the lake that is deep enough to accommodate the screens without risk of entrainment of lake sediment from being too close to the bottom; or damage from ice, or the entrainment of frazil from being too near the surface. The screens contemplated in this pre-concept and should be placed no less than 2 m from the lakebed. The screens should have at least a minimum of 2 m of water above them to accommodate ice thickness however Nunami Stantec has recommended a minimum of 4 m in the pre-concept configuration (see Appendix A). Totalling these assumed values suggests the intake should be in a minimum of 8 m of water. Bathymetry of the lake bottom (Tetra Tech 2019) suggests the maximum depth in UNL is 22 m and there are a several areas in UNL where the recommended 8 m depth is exceeded. Based on desktop review of the bathymetry, Nunami Stantec recommends that the intake withdraw from the deeper portions of the lake located around the location of 7072500N 527400E Zone19. The pumphouse would be located on shore near this location. This assumption served the basis for pipeline and access road routing for the pre-concept.

2.2.2 Unnamed Lake Pipeline Routing

Unnamed Lake is located approximately 3.5 km northeast of Lake Geraldine. It is located approximately 200 m above sea level (asl), with Lake Geraldine located at about 95 m asl, with topography generally sloping towards Lake Geraldine. The Apex River runs between these lakes, creating a topographic valley. In the limited analysis of routing options, a general approach to routing has been taken, which would require further optimization based on detailed topographic information prior to detailed design. In this approach, two routes from UNL to Lake Geraldine have been identified; one running from the intake location along the northwest side of UNL, running directly into either Lake Geraldine or New Lake, and a second running from the intake location along the south western side of UNL, running past the current Apex River supplementary pumping program location¹, to the New Lake or Lake Geraldine. To compensate for future route grade optimization, 30% has been added to the length of each of these pipelines in the costing analysis.

The assumed discharge locations are to locations within Lake Geraldine that are accessible by the Water Treatment Plant (WTP intake), as estimated from bathymetric data. This would be further confirmed during detailed design.

¹ The Apex River supplementary pumping program currently transfers water from the Apex River to Lake Geraldine Reservoir during summer months.

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Description of Options Evaluated

2.2.2.1 UNL Pre-Concept Pipeline Routing – Option 1

Option 1 for pipeline routing consists of a pipeline running from the intake location (central UNL) past the northwest side of UNL directly to Lake Geraldine at a location accessible by the current WTP intake. This discharge location would feed Lake Geraldine directly without requiring any modifications to the current WTP intake structure. Following this path, the pipeline would generally move water downgradient from 200 m asl at UNL to about 95 m asl at Lake Geraldine. This route Option 1 is shown in Figure 2.1.

Alternatively, the pipeline could terminate at the New Lake, requiring construction of additional infrastructure to transfer water from New Lake to Lake Geraldine on an as-needed or continuous basis.

2.2.2.2 UNL Pre-Concept Pipeline Routing – Option 2

Option 2 for pipeline routing consists of a pipeline running from the intake in the central region of UNL past the western side of UNL to eastern side of Lake Geraldine. This discharge location would feed either into the New Lake, or Lake Geraldine directly at a location that remains accessible by the current WTP intake as based upon bathymetric data. Following this path, the pipeline would generally move water downgradient from 200 m asl at UNL to about 95 m asl at Lake Geraldine. This route was selected as it generally aligns with the current pipeline route from the Apex River to Lake Geraldine installed and in use seasonally for supplemental pumping from the Apex River, allowing integration of this additional sources if needed (further discussed in Section 3.1).

2.2.3 Updated Unnamed Lake Resupply Scenarios

Since the completion of the UNL Concept Memo, Nunami Stantec has prepared some additional pumping and flow scenarios as requested by the City. Based upon the pipeline routing options from UNL to Lake Geraldine described in Section 2.2.2, pumping and flow conditions have been analyzed based upon three flow conditions:

1. Year-round Resupply

Year-round resupply represents the lowest required flow rate. For this condition, it is estimated that a continuous pump rate of 937 USGPM (59 L/s) is required to meet the 2050 additional water demand. A continuous resupply will not require additional water storage near Lake Geraldine if provided from UNL. Continuous resupply treats UNL as a reservoir, where water is drawn during all seasons. Freeze protection in the pipeline will be needed.

2. 5-Month Resupply

To meet the 2050 additional water demands, it is estimated that resupply over five months will require a resupply (pump) rate of 2,219 USGPM (140 L/s). Additional over-winter storage (New Lake) will be required. It is worth noting that the 5-month resupply option will be required to include some freeze protection engineering similar to the year-round option, as early spring and late fall may experience sub-zero temperatures.

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Description of Options Evaluated

3. Summer-only Resupply.

To meet the estimated 2050 additional water demands, it is estimated that a summer-only (3-month) resupply will require a resupply rate of 3,698 USGPM (233 L/s). Additional over-winter storage (New Lake) will be required.

COMPARATIVE EVALUATION OF SYLVIA GRINNELL RIVER AND UNNAMED LAKE AS LONG-TERM WATER SUPPLY FOR CITY OF IQALUIT

Evaluation

3.0 EVALUATION

This section presents the results of a comparative evaluation of the SGR and UNL supplementation options based on criteria previously used in the *Conceptual Design Advancement for Raw Water Supplementation from the Sylvia Grinnell River* (Nunami Stantec 2019a) and others as relevant to this study. The following criterial are used:

- Capacity
- Supply
- Accessibility and Routing
- Implementation
- Costs
- Environmental and Socio-Cultural

3.1 CAPACITY

Capacity is used to describe the amount of water available from each water supply source, as based on available reports including Golder (2021) and Nunami Stantec (2018). As discussed by Golder (2021), the average annual outflows from Lake Geraldine are estimated to be 829,754 m³ (2,273 m³/d), which represents the annual regeneration of Lake Geraldine and the supplemented approximate self-sustaining water supply volume for the City.

3.1.1 Open Water vs. Winter Supply

Open water season refers to the period of time when the water source is without ice cover. In Iqaluit, this period can last up to five months each year, however, it has been shown to be as short as three months. As based on the Sylvia Grinnell studies, water can only be taken from the SGR during the open water season due to flows that are too low in the winter. At UNL, though some volume is lost due to ice formation, water can be withdrawn year-round. As such, SGR supply is considered open water only and UNL supply is available year-round

3.1.2 Sylvia Grinnell River Capacity

The SGR conceptual report (Nunami Stantec 2019a) considers a withdrawal rate of 233 litres per second (L/s) during a three month (90 day) open water season. Assuming this flow is available within regulatory flow limits (10% instantaneous flow when flows are greater than 30% mean annual discharge, MAD), the SGR will be able to provide 1,811,808 m³, which is generally less than 2% of its flow. This satisfies the future requirement for the City's predicted demand; however, this water will not be able to be captured during winter conditions. To store and make this water available after the conclusion of the open water pumping season and over the winter, an additional holding reservoir is likely to be required (New Lake). Additional storage is discussed in EXP (2020).

COMPARATIVE EVALUATION OF SYLVIA GRINNELL RIVER AND UNNAMED LAKE AS LONG-TERM WATER SUPPLY FOR CITY OF IQALUIT

Evaluation

3.1.3 Unnamed Lake Capacity

A water balance assessment of UNL was prepared in March 2021 (Golder, 2021). That study assumed that water from UNL is withdrawn to top up lake Geraldine over a four-week period prior to freeze up. The report found that “under current climate conditions, the UNL supplementation has the potential to be a feasible additional water supply for the City of Iqaluit.”

According to Golder (2021), the average annual outflows from UNL are estimated to be 1,591,928 m³ (4,361 m³/d) based on the limited available data. For the purposes of the pre-concept description (Appendix A) it was assumed that all of the outflow from UNL as estimated by Golder (2021) is available for use (supplementation). While this amount would not reflect the available volumes on an annual basis, it approximates potentially available water once other lake variables are accounted for (for example, lake evaporation). Nunami Stantec acknowledges that additional work is required to provide additional confidence to the hydrology of UNL; however, the volumes presented in Golder (2021) will be used throughout this report as the amount of available water for use, annually, from UNL and Lake Geraldine.

The UNL water balance study (Golder 2021) assumed that UNL’s outlet channel invert elevation is at 202.1 m. Stage-storage curves for each of UNL’s three sub-basins were provided in that study and suggest that there is a total volume of 5,534,000 m³ in UNL during open water, and at the point where no outflow occurs from the lake (e.g at freeze-up or at ‘full supply level’). Golder assumed that ice thickness on UNL ranges between 1.3 m and 1.8 m under current climate. For the purposes of the pre-concept, Nunami Stantec conservatively used an ice thickness of 1.8 m. This translates to an under ice water elevation of 200.3 m. Referring to the stage-storage curves provided in Golder 2021, and summing them to capture total volume, but omitting abandonment of sub-basins from the drawdown, this results in a total minimum under ice volume in UNL of 4,252,000 m³. This is nearly four times the volume of water available in winter than what can be stored in Lake Geraldine.

3.1.4 Additional Capacity of Apex River

The amounts reported for UNL do not include additional capacity that may be available from the Apex River, which is currently being used for temporary supplementation. While not included in the evaluation, the Apex River at a location 1 km upstream of the bridge on the Road to Nowhere (which is upstream of the confluence of UNL outflows) provides additional potential summer capacity to the UNL option, as most of the Apex River is hydrologically separate from the UNL sub-watershed (see Figure 2.2). Based on an analysis of 37 years of historical data collected at Water Survey of Canada station 10UH002 between 1973 and 2021 (data were not available in 1984 and from 1996 to 2005), scaled to the pumping location (now WSC location 10UH015), between 6,800,371 m³ and 36,333,915 m³ of additional water was available annually from the Apex River during unfrozen conditions using an unrestricted withdrawal scenario (all water taken from the river). Additional scenarios were evaluated to reflect fixed pumping rates (see Table 3.1). The methods, analysis and limitations of this study are further described in a memo provided as Appendix B.

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Table 3.1 Water Available in Apex River (scaled to 10UH015) 1973-2021 Under Different Pump Scenarios (refer to Appendix B)

Statistics	Period of Record (days)	Unrestricted Pumping Scenario (m ³)	Pumping Scenario-50 L/s (m ³)	Pumping Scenario-100 L/s (m ³)	Pumping Scenario-200 L/s (m ³)
Average	141	17,697,765	543,183	1,054,989	2,005,389
Minimum	64	6,800,371	276,480	552,960	1,088,640
Maximum	225	36,333,915	747,360	1,451,520	2,782,080

3.1.5 Capacity Summary

To summarize, the following will be used as sustainable amounts that can be withdrawn from SGR, UNL, and Lake Geraldine.

- Annual potential withdrawal from SGR: 1,811,808 m³ (20,131 m³/d), for 90 days only
- Annual overflow from UNL: 1,591,928 m³ (4,361 m³/d)
- Annual regeneration from Lake Geraldine: 829,754 m³ (2,273 m³/d)

3.2 SUPPLY

Supply describes the ability of the source option to supply the additional volume of potable water needed to supplement the Lake Geraldine Reservoir source during the high growth scenario up to year 2050 as defined in the Iqaluit General Plan (2015) and further described in EXP (2020). This evaluation report will look at the available annual supply from UNL, as well as the pumping rate scenario used within the Sylvia Grinnell River concept report.

Lake Geraldine currently has a capacity of 1,680,500 m³ (4,600 m³/d), of which 1,100,000 m³ is accessible during winter months due to ice formation and only when the reservoir is full prior to freeze up. The calculations for winter months, considered conservatively to be from October to May, do not consider any inflows from precipitation or runoff (Nunami Stantec, 2019b).

3.2.1 Required Additional Annual Supply 2050

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City is expected to have a population of 24,000 people by 2050. Based on a raw water consumption rate to be 400 L per person per day, future demands are estimated to be 9,600 m³/d. This is important data when considering the potential future supplemental water source. Based on this projected daily demand, the evaluation described herein considers an annual raw water demand requirement of 3,500,000 m³ by 2050. Between October and May, or 8 months (242 days), the predicted 2050 over winter demand equates to a required raw water demand of 2,323,200 m³ during this period. This means that Lake Geraldine will have a shortfall of about 1,223,200 m³ by 2050 (or population of 24,000)

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during winter months. Considering the projected annual demand, the required amount of water to supplement future needs of Iqaluit would be about 1,820,000 m³, or 4,990 m³/d (915 USGPM). This amount does not take into consideration supply contingency for unforeseen demand (water line breakage, fire suppression, etc.).

3.2.2 Required Additional Annual Supply 2026

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 10,800 people by 2026. Based on a raw water consumption rate of 400 Lpcd, 2026 demands are estimated to be 4,320 m³/d. Based on this projected daily demand, the evaluation described herein considers an annual raw water demand requirement of 1,576,800 m³ by 2026. Between October and May, or 8 months (242 days), the predicted 2026 over winter demand equates to a required raw water demand of 1,045,440 m³ during this period. This means that Lake Geraldine has the capacity to supply water to the City (assuming the reservoir is full before freeze up) to 2026 (or population of 10,800) during winter months, not taking into account any allowance for unforeseen demand (water line breakage, fire suppression, etc.). Supplementation from Apex River, as has been carried out since 2019, will likely still be required to maximize volume in Lake Geraldine prior to freeze-up.

3.2.3 Climate Change Resilience

Climate resilience is a term that is becoming commonplace when discussing both social and economic futures. It is often used when describing the frequency and impact of extreme weather events, such as abnormal temperatures, precipitation events (rain, snow, droughts), wildfires, and sea level rises on planned and existing infrastructure, and adaptations that are needed to increase resilience to such events that will become more intense or less predictable as climate changes.

The Canadian Arctic is vulnerable to climate change. The cryosphere is a term is used to describe parts of the Earth that contain frozen oceans, glaciers, permafrost, and land with seasonal snow cover. Climate change is resulting in rising global temperatures and cryosphere temperatures are increasing at a faster rate than other parts of the world. This is directly resulting in periods shorter seasons of snow cover and sea ice, retreating glaciers, and permafrost degradation or disappearance.

The City has been observing recurring annual changes in temperature, precipitation, and permafrost degradation. The impact of permafrost degradation is costly for the City, affecting many components of the built environment. Foundations of buildings that rely on piling systems within permafrost are settling, buried infrastructure (water and sanitary piping systems) are settling and ground stability is being reduced. By encompassing resilient infrastructure design and replacement (i.e. flexible connections at access vaults), some defense can be offered to reduce the risk of expensive repairs and unintentional water demand increases due to line breaks and leaks.

Some specific climate change related considerations for long-term water supply may include:

1. Road Design

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Roads will be required to access the intake locations and various parts of the designs. It is important that road construction be considerate of a sensitive sub surface environment and temperature. Constructing roads should minimize and disturbance to permafrost and completed in such a way to encourage permafrost migration within the road structure. Material placement and drainage are also important considerations to any road in the arctic.

2. Foundation Design

Foundations of any infrastructure (i.e. pumping stations and intake houses) should be considerate of changing subsurface conditions. The decision on best foundation design will be considered during future design by a structural engineer and complimented with adequate site drainage.

3. Pipe Placement

How the pipe is fixed will become important. If placed on the ground, avoid lateral shifting, appropriate lateral location staple design should be considerate of changing ground conditions. Considerations should be given to type and size of material and depth of penetration. Drainage must be considered to ensure pipeline does not impeded the overland flow.

If pipes are placed on pipe stands, base preparation will become very important to minimize movement of the pipe stands.

Covering the pipes with granular material in a berm would provide the greatest protection to the pipes from temperature and shifting forces, though would cost the highest amount. Depending on the selected route, berming of material over the pipelines should be considered.

4. Drainage Planning

Flash spring melting or high precipitation events are increasingly being observed. Future design must consider overall site drainage and changes in overland drainage patterns to minimize erosion and damage to infrastructure. This will involve careful consideration of engineered drainage pathways.

5. Source Integrity

The water sources considered in this study may be affected by changing permafrost conditions, such that potential for changes to basin or channel morphology will need to be considered in detailed design to mitigate for potential water loss. Changing permafrost conditions also have potential to affect water quality.

6. Alternate Water Sources

Climate extremes may be expressed with high and low temperatures and precipitation and potentially changes to local hydrology. The need to evaluate alternate water sources as a response

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to climate change over a longer planning horizon should be evaluated as the project is implemented.

Detailed designs of the water supply system (pumping infrastructure, pipeline, etc.) must consider a changing Arctic climate.

3.3 ACCESSIBILITY AND ROUTING

Accessibility of the source options will be described with respect to roads, power, pipeline, and pumping requirements. This section aims to describe possible scenarios for construction and operation access for SGR and UNL.

3.3.1 Roads

3.3.1.1 Road Access to Sylvia Grinnell River

As described in the conceptual report, the SGR scenario recommends an intake location at “Site B” and a pipeline route shown as the blue line in Figure 2.1. The pipeline route runs from Intake Site B south along the riverbank generally in a southeast direction, past and alongside the north side of the runway before heading generally east towards Lake Geraldine. A blue dashed line shows an additional pipeline route from LGHC to New Lake (per EXP 2020) anticipated to be required as part of the SGR supply option. See further discussion on this in Section 3.1.2.

The north side of the runway is accessible with existing roads used to access the Sylvia Grinnell Territorial Park. Additional access to the intake site would be required by extending and upgrading this access to permit maintenance at the intake site. The concept considers an instrumentation building adjacent to the existing trail that appears to be providing access to the Water Survey Canada station and informal all-terrain (ATV) access up the Sylvia Grinnell River. Conceptually, this access trail would be upgraded so the required operations and maintenance traffic can reach the intake and pumphouse in summer months, with room to maneuver to complete any maintenance or equipment replacement. A service road or trail will also be required between existing subdivision roads (North 40 and Plateau subdivisions) and from the intake site past the eastern side of the runway and as the pipeline approaches LGHC. Approximately 5.15 km of new road and trail could be required. The estimate of probable cost includes a rough cost for upgrading the required access trails. It should be noted that this cost will be refined as design advances.

While access is required for intake and pumping stations, it should be noted that a full access road is not required to run along the entire length of pipeline, however, trails would be required for maintenance.

3.3.1.2 Road Access to Unnamed Lake

A temporary trail was constructed between the Road to Nowhere (near the Iqaluit Shooting Range) and UNL as part of the 2019 Emergency Supplementary Pumping Program. Utilizing UNL as a permanent part of the City’s potable water supply system will require roads to be engineered, constructed, and maintained for potentially year-round operations. Pumping stations at stages along this pipeline route will not be

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required. As a result, a road or trail along the UNL pipelines would not be required for maintenance purposes.

The UNL pre-concept identifies two pipeline routes, as Options 1 and 2. Both options are shown on Figure 2.1 in green. The general route of the existing temporary road will suffice to support both options, with an additional portion of road required to reach the central portion of UNL where the intake is most likely to be located. The road requirements are approximately 3,200 m. Further analysis and design will be required to understand optimal routes for grading and drainage, with respect to topography.

3.3.2 Pumping Stations and Power Requirements

3.3.2.1 Sylvia Grinnell River Pumping Stations and Power Requirements

Nunami Stantec has selected the summer only open-water withdrawal rate of 233 L/s to provide adequate resupply of Lake Geraldine over a three-month period of July, August, and September.

An intake pumphouse will be required, as discussed within the concept report, with two pumps required for the selected pipeline route. Head and frictional losses contribute to a higher pressure within the system. It is good practice where possible that each additional booster pump be coupled with an atmospheric tank or drain to prevent unsafe conditions within the pipeline. An atmospheric tank, or a break pressure tank, is one possible solution to provide pressure relief in the pipe as water is pumped to a higher elevation. During the selection of pumps, a 63 m³ atmospheric tank could be used to release pressure at stages within the pipeline route. If this option is selected for detailed design, the number of required tanks would be one less than the required number of pumps. In a situation requiring only one pump, no atmospheric tank would be needed. The need for pressure release has also been included within the estimate of probable cost.

The SGR concept report has identified a 500 mm pipeline size (as will be discussed in the subsequent section), a required pressure of 1,792 kPA, two pumps, one atmospheric tank, and a design pump horsepower of 700 horsepower (hp), as two 320 hp pumps. While a larger pipe size is paired with a higher construction cost, it has lower pumping operational costs.

Power poles and an access road will need to be constructed at the intake site and along the pipeline for booster and pumping station operation and maintenance. These have been included in the estimate of probable cost. There is partial power access near the airport runway; however, upgrades are expected to be required.

3.3.2.2 Unnamed Lake Pumping Stations and Power Requirements

The UNL plan will not require interim pumping stations to lift the water to Lake Geraldine as there is a net elevation loss along the pipeline route. The only pumping requirements of the UNL to Lake Geraldine system for the continuous resupply scenario will be to pump the water out of UNL. The elevation loss (static head) from UNL to Lake Geraldine is -107 m. At an assumed flow rate of 59 L/s (937 USGPM), the total dynamic head (TDH), which considers the frictional loss and static head, is -105.3 m. Converting this to pressure, the TDH is -147.9 psi (1,019.7 kPA).

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The hydraulic power required to convey this water is -68.9 hp, with the negative sign indicates that power could be generated by the water flow downhill for this system. In theory, this system could continuously generate about 44.8 hp of electrical power with use of a micro hydro plant, assuming 65% efficiency, and result in about \$146,000 in annual power earnings. Feasibility of the installation of a micro hydro plant will need to be evaluated further at concept level, however, it is mentioned here to illustrate the potential optimal pumping dynamics of the UNL to Lake Geraldine system.

For the “continuous resupply” pre-conceptual resupply scenario (see Appendix A), the start up power requirements can be either fulfilled by use of a generator or direct grid connection with power poles. Since the pumping requirements for this concept are minimal, a generator located near the intake pump would likely be suitable.

As noted in the previous section the operation of the continuous flow pipeline could potentially produce more power than is needed for pumping out of the lake. Thus power could only be required on startup, making a generator or batteries a viable option rather than grid power.

For the “bulk resupply” pre-conceptual resupply scenario (see Appendix A), power requirements are much greater. A permanent grid power connection would be recommended, although a generator would also be possible.

To demonstrate the pumping requirements from UNL to Lake Geraldine, the following scenarios have been analyzed. Note that pumps types discussed here are for comparison purposes and not intended to be viewed as preliminary design equipment selection.

1. Year-round Resupply;

Resupply rate of 937 USGPM (59 L/s) applied

2. 5-Month Resupply

Resupply rate of 2,219 USGPM (140 L/s) applied

3. Summer-only Resupply.

Resupply rate of 3,698 USGPM (233 L/s) applied

Figure 3.1 compares pump curves for each of the resupply scenarios using different pumps and pipeline sizes 200 – 400 mm.

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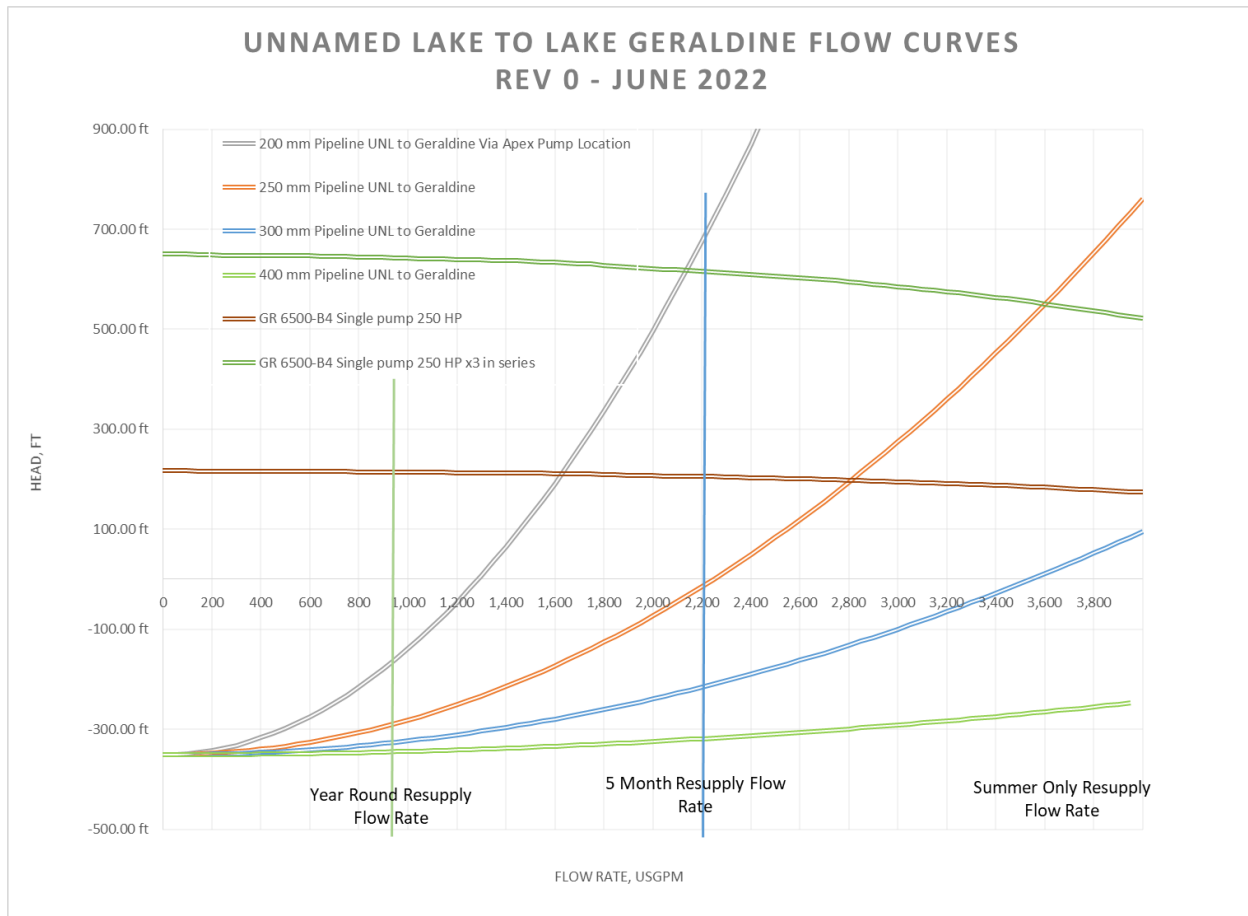


Figure 3.1 Hypothetical Pump Curve for UNL Operations

3.3.3 Pipeline

3.3.3.1 Sylvia Grinnell River Pipeline Route

A suitable pipeline design will run primarily above-ground from a pumping station at the selected intake location to the LGHC, with potential need to extend to a New Lake. As discussed in the previous sections, year-round withdrawal was not considered feasible, so the pipeline design considered only summer withdrawal. The pipe will consist of fused, uninsulated high-density polyethylene (HDPE) pipe. Buried sections will be required at road crossings and to avoid interference with existing infrastructure at the North 40 and Plateau subdivisions.

From the intake site, the pipeline route runs south past the east side of the runway and bordering the airport lands between the asphalt plant and the quarry. Where applicable, the pipeline has been offset from the river to accommodate the 30 m federal reserve on navigable waters.

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The 500 mm diameter pipeline will span a total length of 6,500 - 7,500 m across craggy terrain to the discharge at Lake Geraldine Headwater Creek (LGHC). Running north of the airport lands, this option is easily accessed through Kudlik yards and along access roads north of Federal Road. The pipeline continues along Qaqqamiut Street toward Upper Base and running behind the residential housing on the Plateau toward LGHC.

High and low points can be smoothed with a cut and fill plan during detailed design, however, not eliminated. As a result, staged pumping and drains will be required to ensure that adequate pressure and relief can be maintained. The elevation gain from the intake site to LGHC is about 125 m.

3.3.3.2 Unnamed Lake Pipeline Route

UNL is located approximately 3.5 km northeast of Lake Geraldine. The topography generally slopes down from UNL to Lake Geraldine, but the Apex River runs between these lakes, creating a topographic valley. In the limited analysis of routing options, a general approach to routing has been taken, which would require optimization with detailed topography prior to detailed design. In this approach, two conceptual routes from UNL to Lake Geraldine have been identified; one running from the intake location along the northwest side of UNL to directly into Lake Geraldine, and a second running from the intake location along the western side of UNL directly to Lake Geraldine. To compensate for future route optimization, 30% was added to the length of each of these pipelines in the costing analysis.

The assumed discharge locations are within Lake Geraldine and would be accessible by the Water Treatment Plant (WTP intake), as estimated from bathymetric data. This can be further confirmed during detailed design.

Option 1 for pipeline routing consists of a pipeline running from the intake location (central UNL) past the northwest side of UNL directly to Lake Geraldine at a location accessible by the current WTP intake. This discharge location would feed Lake Geraldine directly without requiring any modifications to the current WTP intake structure. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake Geraldine.

Option 2 for pipeline routing consists of a pipeline running from the intake in the central region of UNL past the western side of UNL to eastern side of Lake Geraldine. This discharge location would feed Lake Geraldine directly at a location that remains accessible by the current WTP intake as based upon bathymetric data. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake Geraldine. This route was selected as it generally aligns with the current pipeline route from the Apex Supplemental Pumping infrastructure, and would be intersected by the New Lake, if constructed at the location proposed by EXP (2020).

The pipeline length for Option 1 is about 4,700 m and 4,050 m for Option 2. For each of these, as mentioned, a 30% contingency onto the length has been added as an optimal route will be selected at a concept level design with detailed topography analysis. As such, this pre-concept report will consider the pipeline length for Option 1 as 6,100 m and 5,300 m for Option 2.

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With the continuous resupply scenario, a 300 mm insulated HDPE pipe was applied to the concept. The pipe can be placed either directly on the ground surface or buried in a bermed area. Heat tracing, while it could be included for recovery following emergency shut down periods, would not be required for normal operation under the continuous flow system. As mentioned, ideal routing would be selected using detailed topography during the subsequent design phases.

3.4 IMPLEMENTATION

3.4.1 Constructability

By identification of major construction activities, constructability is considered at this project phase as topics needed to be addressed to manage risks to the project during subsequent design phases. While this section does not address every detail, it is expected to form the basis of risk and constructability through detailed design. Road, trails, intake, and pipeline can be constructed in a single construction season; however, careful planning must be done to ensure the contractor is awarded the job with adequate time to get materials shipped on the first sealift. Materials and equipment have had a recent shift in lead times and may require pre-ordering up to or more than 90 days in advance of the first sealift delivery cut off, which is usually in early June. To avoid potential delays, one option might be that the contractor may be awarded the work a year before construction is expected to ensure the materials are waiting in Iqaluit for the following construction year or the City could choose to procure long lead items directly. This is not likely required for HDPE and granular materials, however, building materials and mechanical equipment may have a longer lead time requirement.

3.4.1.1 Sylvia Grinnell River Constructability

Intake construction will require a temporary cofferdam to isolate the workspace within the river channel. The isolation could comprise bulk bags wrapped in poly sheeting, rock and earth fill with riprap or other means of providing a sealed enclosure from behind which the workspace can be dewatered. Cofferdams should be installed and all instream work completed during low water periods to reduce risk of overtopping. The timing of cofferdam installation and removal would need to consider fisheries objectives and instream work windows.

Detailed topographic information is available for most parts along the SGR concept; however, detailed design will need to be completed to understand drainage and overall quantity and type of granular material required. As with any project, the quantity of materials should be specified to ensure stockpiles are ready at the time of construction. Given our current understanding of terrain conditions, substantial amounts of materials will be required. While some access exists to the north side of the runway, additional road will need to be constructed to the intake site. Trails for construction could be used as maintenance trails. Trails will need to be constructed to ensure access is available at booster pumping stations for maintenance.

As mentioned, the pipeline routing will be confirmed with detailed topographic information during detailed design. The optimal route would not require a permanent maintenance road; however, it will likely require a temporary construction path for installation. Insulated HDPE pipe is readily available; however, it does

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have a longer lead time and must be ordered in advance of the construction season. This material should be ordered such that it arrives to Iqaluit on the first sealift of the season. Construction trails can be prepared to ease access for installation. As was done for previous emergency resupply projects, contractors are able to fuse HDPE pipe and drag into location with equipment. Where this is not possible, temporary access trails can be constructed to allow for larger equipment to get to location. Fusing the pipe can be done in a central location and the fused segments dragged to location, or the fusing equipment can be moved relatively easily along the pipeline route. Any local contractor will understand the constructability challenges upon review of the designed site plan. Additional equipment and time may lead to an increase in cost.

Power requirements for operation can be in the form of a direct grid connection or from a diesel generator. The long-term road must be in place prior to installation of power poles if this option is selected. Adequate distance from SGR (minimum 30 m) and secondary containment will be required for placement of fuel storage or a generator. If a generator and fuel storage is chosen (including use for redundancy and backup), it is recommended to be ordered in advance of the first sea lift such that it arrives in Iqaluit in July. However, if grid power is chosen to power the system, backup diesel power systems are not recommended as this would substantially increase the cost of the system used only during summer months. Failure in the grid power line could be fixed during the summer season.

Sylvia Grinnell River will require some security to ensure this remains a protected water supply. The trail along the river is currently utilized by many community members, with cabins located north of the intake site. Development of a permanent road to the intake site will likely lead to increased activity in the area. It will not be possible to limit activities along the river, as it is an important cultural feature running through a territorial park. Signage and fencing may be required in various areas, as well as some potential limits to future use of the land.

The number of contractors expected to bid on this is limited, due to the remoteness of the site.

3.4.1.2 Unnamed Lake Constructability

The road to UNL will require detailed topographic information to delineate drainages courses to allow the installation of adequate drainage control. Also, the overall quantity and type of granular material should be specified to ensure stockpiles are ready at the time of construction. Given the current understanding of terrain conditions, substantial amounts of materials will be required. The temporary trail, built for the Lake Geraldine Resupply 2019 project, while in relatively good condition at this time, was not constructed using any detailed design for drainage or material quality and built mostly of locally sourced material. This trail is not suitable for long-term use and maintenance; however, the route generally meets the pre-conceptual design requirements and will be suitable to provide access during construction of the long-term road. In addition to that, the Road to Nowhere (RTN) bridge may be in poor condition with limitations to load weights and use of the bridge. If UNL is developed into detailed design, further review of RTN bridge will be required to determine if remedial action is required.

As mentioned, the pipeline routing will be confirmed with detailed topographic information during detailed design. The optimal route does not require a maintenance road; however, it will likely require a temporary

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construction path for installation. Once the route is selected, borrow sources for gravel can be considered. Construction of the long-term road is recommended before installation of the pipeline. Insulated HDPE pipe is readily available; however, it does have a longer lead time and must be ordered in advance of the construction season. This material should be ordered such that it arrives to Iqaluit on the first sealift of the season. Construction trails can be prepared to ease access for installation. As was the case with previous emergency resupply projects, contractors are able to fuse HDPE pipe and drag into location with equipment. Where this is not possible, temporary access trails can be constructed to allow for larger equipment to get to location. Fusing the pipe can be done in a central location and the fused segments dragged to location, or the fusing equipment can be moved relatively easily along the pipeline route. Any local contractor will understand the constructability challenges upon review of the designed site plan. Additional equipment and time may lead to an increase in cost.

To construct the intake at UNL, access to the central part of the lake will be required. The temporary road from 2019 does not run to this exact location so additional road construction will be required prior to installation of the intakes and supporting structures (i.e. generator room, site office). Construction would require a barge to lower pre-cast footings to the lake bottom and to pull the water line to the withdrawal location. Installation of the screen would then be done from the barge and all work would be coordinated using divers. The screen and its flange do not weigh too much and could be serviced using a smaller vessels with divers if necessary. There may be opportunity to use helicopters for the installation in place of a barge.

Power requirements for operation can be in the form of a direct grid connection or from a generator. The long-term road must be in place prior to installation of power poles if this option is selected. Adequate distance from UNL (minimum 30 m) and secondary containment will be required for placement of any diesel fuel storage or the generator. If a generator and fuel storage is required, it is recommended to be ordered in advance of the first sea lift such that it arrives in Iqaluit in July.

UNL will require some security to ensure this remains a protected water supply. As access to the area becomes easier by way of a road, so does community interest in recreational pursuits. The temporary 2019 road has already brought interest to UNL and an increase in activities (i.e. camping and ATV use) has been observed. Signage and fencing will likely be required in various areas.

3.4.2 Operation and Maintenance

3.4.2.1 Sylvia Grinnell River O&M Complexity

The SGR concept considered maintenance requirements related to screen clogging, sediment accumulation in the wet well, seasonal operation, and preliminary measures to protect against ice floes or jams that might occur at the intake site.

A potential disadvantage of the general arrangement of this concept is that the wet well approaches 6 m deep. Any sediment build-up in the wet well would likely need to be removed using a hydrovac truck. At this depth (6 m) it may be difficult for a hydrovac to remove the sediment. It is possible that the site could be

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graded down 1 to 2 m to create a shallower wet well. However, any lowering of the proposed infrastructure would have to be evaluated against potentially exposing the infrastructure to flood flows and/or ice and debris. A potential lowering of the wet well access for sediment removal using a hydrovac, should be further reviewed during preliminary design.

The screen face and trash racks could be designed with some provision for ice resistance but there would be residual risk of damage over winter. The City may wish to remove the screens at the end of the withdrawal season, prior to freeze-up and replace them with solid steel plates. Removing the screens would prevent them from being damaged by ice, and the steel plates would provide some protection to the structure and the intake chamber. The intake concept includes a removable davit for screen and trash rack removal. The davit also facilitates the removal of the screens for cleaning as part of regular maintenance. Regular cleaning of sediment, debris and biological fouling will help to maintain the flow rate across the screen and maintain overall system performance.

The general arrangement allows for access during spring break-up. Should the City wish to pursue beginning withdrawal during ice break-up, then consideration for leaving the screens in throughout winter should be included in preliminary engineering design.

The intake can be designed with an air bubbler or air scour system to reduce the likelihood of frazil ice build-up on the intake screens. Teflon coated screens and trash racks can also reduce frazil build-up. Because withdrawal is planned for the open water season, we have not included provision for frazil management in the concept, but mitigation measures like those mentioned above, could be further considered in preliminary engineering.

While effort to minimize low and high points within the pipeline during routing selection shall be made, low point drains and air releases will inevitably be required. The current semi-permanent pipeline from Apex River to Lake Geraldine currently requires walking the pipeline periodically during startup and shutdown, however, no engineered trail has been constructed for this and contractors complete this on foot. ATV trails could be considered along the pipeline route to provide ease of access for pipeline route inspection and low point drain operation. During any shut down when water is drained from the system low point drains may be operated. This is true during end of pumping season shutdown and for any other O&M purposes.

This pipeline does not need to be insulated nor does heat need to be added during operations as operation will only occur during the summer season.

This system requires large pumps and pipe to move water from the Sylvia Grinnell River to the new storage reservoir near Lake Geraldine. These pumps will need to be regularly maintained and annually serviced.

3.4.2.2 Unnamed Lake O&M Complexity

Operation and maintenance complexity is largely dependent on the selected resupply scenario. For Resupply Scenario 1, bulk period resupply periods, the line will be required to be drained after each use. If a generator is used to supply power, all fuel should be removed from site and the equipment during each shut down period. Roads must be maintained throughout the entire winter as late winter pumping may be

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required as demands increase. Any planned shutdowns must be timed adequately to ensure pipes with water do not freeze.

Resupply Scenario 2 of continuous supply will also require carefully timed shutdowns for maintenance and road maintenance. The site must be kept clear of snow as with any municipal building or infrastructure.

While effort to minimize low and high points within the pipeline during routing selection shall be made, low point drains and air releases will inevitably be required. The current semi-permanent pipeline from Apex River to Lake Geraldine currently requires walking the pipeline periodically during startup and shutdown, however, no engineered trail has been constructed for this and contractors complete this on foot. ATV trails could be considered along the pipeline route to provide ease of access for pipeline route inspection and low point drain operation.

During any shut down when water is drained from the system low point drains may be operated. This is true during end of pumping season shutdown and for any other O&M purposes, unless year-round operations are selected.

This pipeline does not need to be insulated nor does heat need to be added during operations if “summer-only” operation is selected. If 5-month or year-round operation is selected, the system will require an insulated pipe and heat injection into a recirculated water.

The UNL pipeline system will have minimal pumping requirements, largely only the low rate pumping required to fill the line before flow startup. These could be dealt with via small diesel or electric pump.

3.4.2.3 Automation & Security

Automatic controls should be in place, including alarms, so City operations can be alerted of any problems resulting from low flow conditions. Thermal analysis will be included during the detailed design to determine alarm setpoints. SCADA system design will certainly be part of detailed design.

Watershed protection must be carefully considered, which may include some trail gates and fencing where possible. In addition to that, security cameras within and around the pumping facilities can be considered.

3.5 COSTS

3.5.1 Capital Costs

Based on the identified site conditions, anticipated intake types, and pipeline options with associated infrastructure (i.e., access roads, power, pumping stations), Nunami Stantec has developed a Class 5 (AACE No.18R-97) estimate of probable infrastructure costs. This has been completed for both SGR and UNL options. To permit comparison, the unit prices have been normalized to match the 2019 estimate from SGR concept report. Construction costs are summarized in Table 3.2 and operations costs are summarized in Table 3.3.

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Table 3.2 Estimate of Probable Cost Summary

COST ITEM	SYLVIA GRINNELL RIVER CONCEPT	UNNAMED LAKE PRE-CONCEPT
	Route BA	All Resupply Scenarios
DESIGN, PERMITTING, CONSTRUCTION SUPERVISION	\$3M	\$1.5M
GENERAL REQUIREMENTS (MOB/DEMOB, ECO PLAN AND ENV. MONITORING, UTILITIES COORDINATION)	\$0.16M	\$0.16M
SITE PREPARATION	\$0.07M	\$0.07M
INTAKE (INCLUDING PUMPHOUSE AND EQUIP.)	\$3.7M	\$1M
BOOSTER PUMPS, PUMPHOUSES, AND TANKS	\$1M - \$1.8M	\$0.4M
POWER SUPPLY, ROAD, AND PIPE	\$11-20M	\$9-9.5M
SUB-TOTAL (NO CONTINGENCY)	\$25M	\$10.5-11.5M
TOTAL CONSTRUCTION COSTS (INCL. 30% CONTINGENCY)	\$32.5M	\$13.5-15M
COST OF ADDITIONAL STORAGE	+\$65M	\$0-\$65M

It should be noted that the SGR option requires additional storage to be constructed, though not all UNL options require this. The cost of additional storage (New Lake) has been added based on EXP (2020). The permitting cost does not include potential compensation or offsetting that may be required as a result of harmful alteration destruction or degradation (HADD) of fish habitat, which would be determined based on a review by Fisheries and Oceans Canada (DFO) of the final design of the selected options (see Section 3.6). This cost would apply to either option.

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3.5.2 Operational Cost

The operational cost estimated as part of this assignment estimates power consumption (or generation), annually.

Table 3.3 O&M and Power Costs

ANNUAL POWER COST	SYLVIA GRINNELL RIVER CONCEPT	UNNAMED LAKE PRE- CONCEPT
POWER REQUIREMENTS	Power required = 700 hp Power consumed = 1,916,747 KWh Annual cost > \$1,000,000	Power required = -69.60 hp Generation potential = 45.24 hp Power generated = 295,245 KWh Annual <u>earnings</u> = \$148,000
O&M COSTS¹	\$300,000	\$150,000

1. A broad estimate to include pump maintenance, road clearing, etc. To be confirmed following design and selection of equipment.

3.6 ENVIRONMENTAL & SOCIO-CULTURAL

This criterion reflects the considerations associated with advancing an option within the biophysical and socio-cultural environment and includes consideration of environmental regulatory approvals that may be required.

3.6.1 Biophysical Environment

3.6.1.1 Fish and Fish Habitat

Both the SGR and UNL options have potential to impact fish and fish habitat (HADD). The SGR is known to be a recreational and Indigenous fishery, with Arctic char being the primary harvested species. As reported in Nunami Stantec (2018), Arctic char use the SGR throughout the year for migration, overwintering, spawning, and rearing. The intake site is unlikely to provide overwintering habitat but may have some desirable habitat during certain times of year. Winter withdrawal from the SGR has been deemed not feasible due to low flow conditions (Nunami Stantec 2018). To remain protective of fish, withdrawals during the open water season (June to September) are limited to 10% of the instantaneous flow when flows are above 30% of the mean annual discharge in accordance with DFO (2013). Using this limitation, the design withdrawal rate of 0.233 m³/s would take no more than 2% of the expected flows during July to September, as based on historical data, and therefore have low risk of effects to fish. There

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would be some habitat loss associated with the construction of intakes at both sites, with the SGR option leading to greater potential of a HADD and Fisheries Authorization being required.

The UNL option has considerations for fish and fish habitat as based on the need to install a new intake, and to withdraw water during winter when the lake is ice-covered. The available under-ice volume in UNL is estimated between 4.2 and 4.7 million m³ (Appendix A and Tetra Tech 2019). For protection of fish, DFO applies a protocol to limit under-ice withdrawal to 10% of the available volume. In summer, withdrawals should meet the ecological flow needs of connected waterbodies. A proposed winter withdrawal of up to 1.2 million m³ may exceed the 10% under-ice withdrawal that is protective of fish, triggering the need for additional study and authorization when withdrawals approach this volume. In any season, water withdrawal from UNL will reduce or eliminate outflows from UNL to the downstream Apex River. The reduction in flows is not immediately quantifiable but may exceed 10% of the total flow of the Apex River from time to time, triggering the need for additional study and/or authorization by DFO.

Of note is that this report does not discuss ongoing or complementary supplementation from the Apex River at its current location during the open water season, which is upstream of the confluence of the UNL outflow with Apex River. Taking water from the Apex River when available may mitigate potential effects to fish in UNL by reducing the withdrawal amounts needed in winter.

3.6.1.2 Terrain, Soils and Permafrost

The conceptual overland pipeline routes traverse hilly and rocky terrain with consideration of several wetlands and drainage areas. The SGR option may require some cut and fill sections. Both routes will require construction of a new road or upgrade to existing roads. Both options are located in an area of continuous permafrost. Granular material requirements and considerations of constructing and operating in permafrost will need to be considered in design. Granular (and rock) material is generally understood to be available within the City municipal boundaries.

3.6.1.3 Wildlife and Species at Risk

Both options require development in new areas, which has potential to disturb habitats for migratory birds, game birds and large and small mammals. Both options have potential to impact species at risk, including rare plants. Both options are currently considered comparable in terms of their potential impacts to wildlife and species at risk. Further study of potentially impacted habitats of species at risk should be completed as project planning advances for a selected option.

3.6.2 Socio-cultural Environment

3.6.2.1 Traditional and Recreational Land Use

The SGR option is located adjacent to the Sylvia Grinnell River, which is a popular area for seasonal and year-round camping by Iqalummiut, including Inuit families. Use of the area is currently unregulated. The placement of a new intake and pipeline in the river may locally impact traditional and recreational land use. The UNL area is not used commonly for recreational activities and is not believed to be used for traditional

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activities. The routing of pipelines for both options may impede access to traditional or recreational land use areas or create safety or security risks in certain areas. The potential impacts to, and mitigations for impacts to traditional and recreational land use should be considered as planning advances for a selected option and should be informed by consultation and engagement activities.

3.6.2.2 Heritage Resources

A portion of the UNL option was previously assessed for heritage resources during the 2019 emergency supplementation project. This included assessment and recording of heritage resources along the access road from Apex River to UNL, borrow sources and semi-permanent pipeline from Apex River to Lake Geraldine. Additional heritage resources assessment would need to be completed at all areas proposed to be disturbed by either option. This report makes no comment on heritage resources potential of either option, though potential may be correlated with traditional land use. Generally, impacts to heritage resources are mitigable and can be considered in later stages of planning, as further informed by field studies and consultation and engagement.

3.6.3 Community Engagement

The following stakeholders may have interest in one or both of the supply options being considered:

- Amaruq Hunters and Trappers Association
- Qikiqtani Inuit Association – Community Lands and Resources Committee
- Residents of the City of Iqaluit
- Iqaluit Joint Planning and Management Committee

The City of Iqaluit (supported by Nunami Stantec) has held several engagement meetings with stakeholders on water supply options, including the Sylvia Grinnell River, Apex River and Unnamed Lake since 2018. A summary of engagement meetings is provided in Table 3.4.

Table 3.4 Summary of Engagement Meetings on Water Supply Options

Date	Stakeholder	Type of Engagement	Topics Discussed
September 6, 2018	Amaruq HTA	Board Meeting	Sylvia Grinnell source and intake options
February 7, 2019	Amaruq HTA	Board Meeting	Update on water supplementation studies; short-term water licence amendment to withdraw water from Apex River
July 4, 2019	Amaruq HTA	Letter	Ongoing planned studies of Unnamed Lake
July 30, 2019	QIA	Individual Meeting	Information about ongoing and planned projects to be sent to QIA for information
May 16, 2022	Amaruq HTA	Board Meeting	Update on evaluation of UNL and SGR water supply options
May 17, 2022	Nunavut Parks representative of NJMPC	In-person Meeting	SGR supply option

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Date	Stakeholder	Type of Engagement	Topics Discussed
May 23, 2022	QIA Planning representative	MS Teams Meeting	Update on evaluation of UNL and SGR water supply options
June 9, 2022	QIA Lands Administration and CLARC Coordinator	MS Teams Meeting	Overview of supply options being considered; discussion on further need to engage QIA and CLARC

3.6.3.1 What We Heard

During engagements since 2018, the Amaruq HTA has been firmly and consistently opposed to installing permanent infrastructure for water withdrawal within the Sylvia Grinnell River. They have raised concerns about potential effects to fish and fish habitat from installing water intakes and from pumping operations. These are not concerns related to the amount of water to be taken. They are concerns rooted deeply in the culture and traditional practices of Inuit who use the river and the surrounding area.

By contrast, the Amaruq HTA has encouraged the City to evaluate Unnamed Lake as a potential source, as well as other lakes further upstream in the Apex River (referred to as Crazy Lake and Long Lake) so as not to take all the water from any single lake. The small fish [*nutiblik*] present in the Apex River are not harvested by Inuit. The Amaruq HTA raised the need to maintain access to snowmobile trails and that pipelines need to be clearly marked.

QIA has responsibility for administering Inuit-owned lands. As the project does not directly impact IOL, QIA has asked to remain informed of the project. QIA would need to be further consulted if there were to be impacts to Inuit rights, such as impacts to hunting, fishing or trapping. This could potentially be a confounding consideration for the SGR supply option.

There were generally no concerns raised around potential impacts to Sylvia Grinnell Park from creating new access or pipeline for the SGR option.

3.6.4 Regulatory Engagement and Approvals

Supplementation from either the SGR or UNL will require approval and/or authorizations from the Nunavut Water Board, GN Department of Health and Fisheries and Oceans Canada. Other organizations that may have an interest include Crown-Indigenous Relations and Northern Affairs Canada – Water Resources Division, Government of Nunavut –Department of Environment and Department of Culture and Heritage.

A screening by the Nunavut Impact Review Board will be required as per the Nunavut Planning and Project Assessment Act. To support applications for approval, the City will need to engage with Amaruq Hunters and Trappers Association (HTA), Qikiqtani Inuit Association, Parks Management Committee (SGR Option) and residents of Iqaluit.

To support applications for approval, the City will need to engage with Amaruq Hunters and Trappers Association, Qikiqtani Inuit Association, and residents of Iqaluit. As both supply options (UNL and SGR)

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are within the municipal boundaries of the City of Iqaluit, community consultation is expected to be a key aspect of the regulatory review process. Some consultation has already occurred with the HTA for the SGR option. We understand that the HTA's current preference is to not utilize SGR as a long-term water supply, but to consider UNL.

The construction and operation of a new intake site, pipeline and associated infrastructure for water withdrawal and conveyance is anticipated to require review, approvals and/or authorizations from:

- Nunavut Planning Commission (NPC) and Nunavut Impact Review Board (NIRB) (Screening)
- Fisheries and Oceans Canada (Request for Review / Fisheries Act Authorization)
- Nunavut Water Board (amendment to municipal type A water licence)
- Government of Nunavut Department of Health (source water quality)
- Government of Nunavut Economic Development and Transportation – Iqaluit International Airport Division (for SGR option)
- NAV Canada (land use application), for SGR option
- Nunavut Department of Culture and Heritage – approval of Archaeological Assessment

Neither option encroaches upon the Sylvia Grinnell Territorial Park.

The City of Iqaluit will need to consider amending the Zoning by-law to add watershed protection to the UNL watershed, and to potentially extend existing protection of the Apex River watershed to beyond the municipal boundary, if the Apex River additional supply is considered further (beyond the scope of this report). Figure 3.1 shows the extend of current watershed protection areas within the municipal boundary and the full extent of the Apex River watershed, including the Unnamed Lake sub-watershed.

Additional fields studies that may be required to support regulatory approvals include:

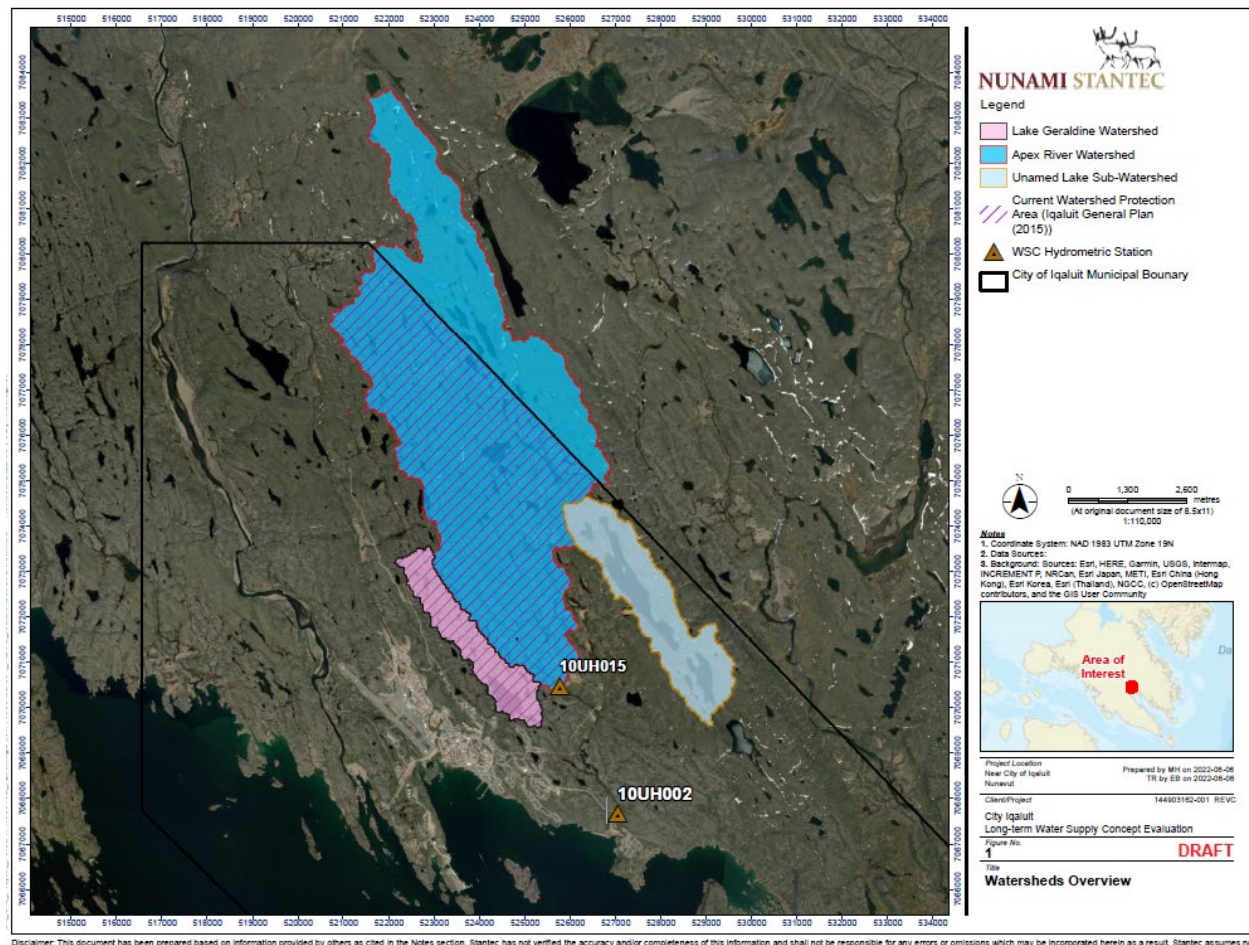
- Further validation of the water balance model for UNL
- Water quality profile including sediment quality in UNL
- Fisheries study (gill netting) of UNL
- Archaeological assessment of the road and pipeline route
- Evaluation of presence of species at risk

A key aspect of the regulatory review process for UNL is expected to be the water balance, to confirm the sustainability of the supply.

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Figure 3.2 Watersheds and Existing Watershed Protection Areas



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3.6.4.1 NPC/NIRB Screening

The requirements to obtain an authorization from one or more regulators or agencies of the federal or territorial government for the project triggers the requirement for a NIRB screening of the proposed project under the provisions of the Nunavut Agreement and Nunavut Planning and Project Assessment Act. This process requires submission of a project proposal to the NPC first, then a more detailed project proposal to NIRB, including a description of the project works and activities, evidence of engagement with affected communities, and a preliminary assessment of impacts of the project on the environment. The outcome of this public screening is a determination by the NIRB whether the project can proceed to permitting, or whether additional review is required. The NPC/NIRB screening for this project should be expected to take approximately 4 months and is coordinated with the Nunavut Water Board's process.

3.6.4.2 Amendment to City of Iqaluit Water Licence

The City of Iqaluit currently holds a type "A" water licence issued by the Nunavut Water Board (NWB). The licence permits water withdrawal from specified sources and up to specified amounts. The withdrawal of more than 300 m³ water per day from a new source – the SGR or UNL and diversion to Lake Geraldine, requires approval by the NWB and an amendment to the licence in accordance with the Nunavut Waters Regulations. An application for such amendment requires that the application supporting documents include detailed design drawings accompanied by updates to the compliance monitoring program and environmental protection plans as applicable. The NWB's process to amend a type A water licence begins after a NIRB screening process concludes the project proposal can proceed to licensing. The NWB's process to amend a type A water licence includes a public technical review and requires a public hearing to be held. The NWB review process should be expected to take approximately 12 months.

3.6.4.3 Fisheries Act Authorization

For the SGR option, a Fisheries Act Authorization may be required due to instream works related to the proposed water intake structure and local importance of the Sylvia Grinnell River fishery. A Fisheries Act Authorization may be required for the UNL option due to the potential for water withdrawal to exceed 10% of the under-ice volume of UNL and for withdrawals to affect downstream flow. To initiate this process, a Request for Review is submitted to DFO to start a file number, and to confirm whether an Authorization will be required. A Request for Review by DFO typically takes 6-8 weeks for a decision whether an Authorization is required. If an Authorization is required under Section 35(2) of the Fisheries Act an application for Authorization is required to be submitted to DFO. The application also requires the submission of an Offsetting Plan and letter of credit. DFO prefers that offsetting be completed prior to construction of a project, however this sometimes can be waived and the offsetting can be conducted at the same time as project construction. DFO has 60 days to respond whether the application is complete. Once DFO considers the application to be complete they have 90 days to decide on whether the Authorization is approved or denied. Depending on the circumstances (generally information requirements) the timelines can be stopped and restarted. Both the Authorization and Offsetting Plan require engagement with affected communities

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and Indigenous groups to identify potential offsetting measures and then to confirm the offsetting measured to be used. DFO participates in this process to confirm the identified offsetting options area suitable. The amount of offsetting would be based on the degree of serious harm that is likely to occur and is usually transformed into square meters of habitat. Offsetting would require an engineered design which would require a field survey of the area to be offset to inform the engineering design. Preparing and obtaining an Authorization should be expected to take approximately 6 –12 months.

3.6.4.4 Department of Health

As both source options are new raw potable water sources, water quality testing must be conducted to confirm the water is suitable as a raw water supply. The Territorial Medical Health Officer issues approval to use a source as a raw water supply based on a review of results of water quality analyses. Based on experience from the 2019 supplementation from UNL, it is a suitable potable water source based on surface water samples. Additional water testing should be completed along a depth profile, and testing of mercury in sediment should be completed and compared against applicable guidelines at the time. No data is available for Sylvia Grinnell River.

3.6.4.5 Airports and NAV Canada Approval

The City of Iqaluit Airport Authority has jurisdiction over developments conducted on airport lands, and Transport Canada has authority to approve certain types of developments within Airport Zoning Regulations (4,000 m radius of airport). A review of the proposed development against these authorities' requirements is completed by the Airports Division and by NAV Canada. Drawings showing the location and all dimensions of infrastructure are required to be provided.

3.7 SCHEDULE

Table 3.5 provides a high level conceptual schedule from design to in-service of supply options, which can be applied to both options. The schedule does not reflect timelines associated with modifications to alter storage.

Table 3.5 Conceptual Schedule for In-service of Supply Options

Development Stage	2023	2024	2025	2026	2027
Field Studies and Design					
Engagement					
Permitting					
Financing					
Tender					
Equipment Orders and Staging					
Construction					
In Service					

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4.0 EVALUATION SUMMARY

Table 4.1 summarizes the evaluation discussion into quantitative and qualitative results for ranking. No weighting has been applied to the criteria. This could be factored in during future evaluation as combined with storage options.

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Table 4.1 Evaluation Summary

Evaluation Criteria			Comparative Comment	
			Sylvia Grinnell River	Unnamed Lake
Technical	Capacity	Open-water	Yes; additional storage required	Yes; no additional storage required for year-round. Additional storage required for 3 – or 5-month resupply scenarios.
		Winter	No	Yes
	Supply	Required in 2050	Yes	Yes, if considering Apex River as supplemental. But to population of 17,000, annual recharge rate to be confirmed
		Required in 2026	Yes	Yes
		Addresses Climate Change Resilience	Yes	Yes
	Accessibility	New Roads Required	5,000 m	3,200 m
		Power & Pumping	Intake + Two Booster Power Requirement = 700 HP	Intake Only Power Requirement = -69.60 HP
		Pipeline Required	500 mm 6,500 m	200-400 mm, depending on resupply scenario 5,000 – 6,000m
	Implementation	Constructability	Generally the same constructability as UNL, however, there are more pumping stations required.	Generally the same constructability as SGR, however, less pumping infrastructure.
		O&M Complexity	Sylvia Grinnell will require more pumping stations and therefore, more maintenance	Less maintenance is required due to less pumping infrastructure. Reheat and recirculation required for year-round operations.
Economic	Costs	Capital	\$32.5M (+\$65M for options with additional storage requirements)	\$13.5M - \$15M (+\$65M for options with additional storage requirements)
		Operational	Annual power cost = \$1,100,000 - \$1,500,000 Annual O&M = \$300,000	Annual earnings (from power generation) = \$148,000 Annual O&M Costs =
Environmental	Environmental / Socio-cultural	Biophysical Environment	Potential impacts to fish and fish habitat; summer only	Potential impacts to overwintering fish as approaching high withdrawal volumes
		Socio-cultural	Area of traditional and recreational land use; not supported by HTA	Limited recreational or traditional land use value; supported by HTA
		Regulatory Approvals	No special considerations; FAA will be required	No special considerations; FAA may be required

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Evaluation Criteria			Comparative Comment	
			Sylvia Grinnell River	Unnamed Lake
		Land Use Planning	Watershed protection and site security needed	Watershed protection exists; site security needed
	Community Preference	Consultation Results	Not favoured (HTA consultation)	Preferred (HTA consultation)

5.0 CONCLUSIONS & RECOMMENDATIONS

In accordance with the background data provided, Nunami Stantec has completed an evaluation of the SGR long-term supplementation of Lake Geraldine conceptual level report and the pre-conceptual level design from UNL. Within this document, we describe the information extracted from the background documents and determined that, according to projections:

3. SGR could be a sustainable supply for a population of 24,000, however, it would require an additional storage reservoir as it can only be used during open-water season.
4. UNL by itself could be a sustainable supply up to a population of 17,000 (with additional supply potential from Apex River). UNL does not require an additional reservoir as it, in itself, is a functioning reservoir.

The pumping scenario reviewed for SGR indicates that a three-month pumping regime would be used during open water. Because of the elevation increase from SGR to Lake Geraldine, this is paired with additional pumping requirements. The additional pumping requirements add cost and O&M requirements.

We consider that the optimal pumping scenario for UNL is to continuously resupply Lake Geraldine from UNL. That recommendation will require further analysis during detailed design to optimize pumping and other operational details. Required equipment and controls will also be determined later in design. UNL has minimal pumping requirements and could potentially generate power. While continuous pumping is optimal for the UNL system and would not require an additional reservoir (\$65M), winter operations may present risk to the City. As such, it has been requested to move forward with three-month, summer operation of the UNL system and additional reservoir.

SGR optimal concept indicates that intake Site B with a pipeline route towards the airport runway then overland be selected. For UNL, at the pre-conceptual level, considering the minor differences in cost between Options 1 and 2, we suggest that both pipeline routing options remain considered for UNL until detailed topography is evaluated during design.

Following our analysis, we have created a list of information that would provide valuable information to confirm feasibility of UNL and move this project into further design stages.

- Construct a metering station comprising a weir and data logger in the downstream channel of UNL to measure outflow and compare the results with modeled outflow (Golder 2021) and the assumptions used in developing this pre-concept.
 - This is in addition to the existing transducer that is in UNL.
 - This data can be used to develop a relationship between flows recorded at UNL and those on the Apex River. This relationship could potentially be used to construct a synthetic dataset for UNL that extends back as far as records on the Apex River (1973).
- Assess the effect of drawdown on the abandonment of sub-basin to confirm total under ice water volumes used in this pre-concept.

- Re-assess the quality of bathymetric survey data to confirm stage-storage relationships that formed the basis of this assessments.
- Conduct a more detailed assessment of lake response to proposed withdrawals, particularly in drought years, including back-to-back occurrences, and under future climate scenarios.
- Ensure detailed topography is attained and used to optimize pipeline routes.
- Complete a drainage assessment of the area prior to road design.
- Consider the feasibility of complementary supplementation from the Apex River

Capital and operational cost of SGR, considering the requirement to construct an additional reservoir for storage, is much higher than UNL.

Community consultation will play a major role in selection of the source. We understand that UNL is currently the preferred option, however, this will be understood more at the subsequent project phases.

Understanding the available water and recharge rate of UNL is critical before selection of this as the long-term supplemental source and at least two years of data should be collected to confirm the hydrology of UNL and the effects on the downstream Apex River.

6.0 REFERENCES

- DFO (Fisheries and Oceans Canada). 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada. Canadian Science Advisory Secretariat Science Advisory Report 2013/017.
- EXP. 2020. Iqaluit Water Storage Pre-Feasibility Study. Report to the City of Iqaluit dated October 16, 2020.
- Golder Associates Ltd. 2021. Water Balance Assessment for Unnamed Lake. Report to the City of Iqaluit dated March 2021
- Nunami Stantec Limited. 2018. Options Evaluation for Raw Water Supplementation from the Sylvia Grinnell River. Report to the City of Iqaluit, April 2018.
- Nunami Stantec Limited. 2019a. Conceptual Design Advancement for Raw Water Supplementation from the Sylvia Grinnell River. Report to the City of Iqaluit, April 2019.
- Nunami Stantec Limited. 2019b. Lake Geraldine Reservoir Storage – Desktop Review and Assessment. Memorandum to the City of Iqaluit, January 2019.
- Tetra Tech Canada Inc. Iqaluit DFO Bathymetric Lake Surveys. Memorandum to the City of Iqaluit, July 2019.
- WSP. 2021. Unnamed Lake Fish and Fish Habitat Assessment Technical Report. Report to the City of Iqaluit, February 2021.

APPENDIX A
UNNAMED LAKE PRE-CONCEPT MEMORANDUM

To: Amy Elgersma, CAO
City of Iqaluit
File: 144903162

From: Erica Bonhomme
Nunami Stantec Ltd.
Date: October 4, 2021

Reference: Unnamed Lake Pre-concept Memorandum

1 INTRODUCTION

The purpose of this memo is to describe and develop the Unnamed Lake (UNL) pumping and conveyance option to be used as a basis for the comparative evaluation between Sylvia Grinnell River (SGR) and UNL as supplementary sources of potable water for the City of Iqaluit.

On June 18, 2021, as the first step of the evaluation, Nunami Stantec Ltd (Nunami Stantec) submitted a draft evaluation criteria and summary of gaps analysis. Upon completion of this review, we identified that additional definition of the UNL option would be required to proceed with an overall evaluation of the two sources. As such, the City of Iqaluit (City) and Colliers Project Leaders (Colliers) decided to include a pre-concept study of the UNL option to address the identified information gaps.

This memo assumes that UNL provides the necessary amount of supplementation capacity for long-term requirements of the City (Golder 2021) and provides some validation to this assumption through the selection of the design basis for the withdrawal infrastructure and its operational regime. This work then provides a pre-concept design for an intake at UNL and two options for pipeline routing and conveyance from source to storage. The memo contains level-appropriate discussion on intake and discharge locations, conveyance direction and distance, infrastructure requirements (road, power, pipeline, pumping stations), operability and constraints, and an estimate of probable cost to construct and operate the system.

2 BACKGROUND DOCUMENT REVIEW

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 24,000 people by 2050. Based on a raw water consumption rate to be 400 Lpcd, future demands are estimated to be 9,600 m³/d. This is important data when considering the concept of UNL as a potential future water source. Based on this projected daily demand, the pre-concept described herein considers an annual raw water demand requirement of 3,500,000 m³ by 2050.

Lake Geraldine currently has a capacity of 1,680,500 m³ (4,600 m³/d), of which 1,100,000 m³ is accessible during winter months due to ice formation and only when the reservoir is full prior to freeze up. The calculations for winter months, considered conservatively to be from October to May, do not consider any inflows from precipitation or runoff (Nunami Stantec, 2019). Between October and May, or 8 months (242 days), the predicted 2050 demand equates to a required raw water demand of 2,323,200 m³ during this period. This means that Lake Geraldine will have a shortfall of about 1,223,200 m³ by 2050 (or population of 24,000) during winter months. Considering the projected annual demand, the required amount of water from UNL to supplement future needs of Iqaluit would be about 1,820,000 m³, or 4,990 m³/d (915 USGPM).

Reference: Unnamed Lake Pre-concept Memorandum

2.1 UNNAMED LAKE SUPPLY CAPACITY

A water balance assessment of Unnamed Lake was prepared in March 2021 (Golder, 2021). That study assumed a system that tops up lake Geraldine over a four-week period prior to freeze-up and found that “under current climate conditions, the Unnamed Lake supplementation has the potential to be a feasible additional water supply for the City of Iqaluit.”

According to Golder (2021), the average annual outflows from UNL are estimated to be 1,591,928 m³ (4,361 m³/d) and the average annual outflows from Lake Geraldine are estimated to be 829,754 m³ (2,273 m³/d). For the purposes of this pre-concept we assumed that all of the outflow from UNL as estimated by Golder (2021) is available for use. While this amount would not reflect the available volumes on an annual basis, it is an approximation of potentially available water once other lake variables are accounted for (for example, lake evaporation). Nunami Stantec acknowledges that additional work is required to provide additional confidence to the hydrology of Unnamed Lake, however, the volumes presented in Golder (2021) will be used throughout this report as the amount of available water for use, annually, from UNL and Lake Geraldine.

To summarize, the following will be used as sustainable amounts that can be withdrawn from both UNL and Lake Geraldine.

- Annual regeneration from UNL: 1,591,928 m³ (4,361 m³/d)
- Annual regeneration from Lake Geraldine: 829,754 m³ (2,273 m³/d)

The UNL water balance study (Golder 2021) assumed that UNL’s outlet channel invert elevation is at 202.1 m. Stage-storage curves for each of UNL’s three sub-basins were provided in that study and suggest that there is a total volume of 5,534,000 m³ in UNL during open water, and at the point where no outflow occurs from the lake (e.g at freeze-up or at ‘full supply level’). Golder assumed that ice thicknesses on UNL ranges between 1.3 m and 1.8 m under current climate. For the purposes of this pre-concept, Nunami Stantec conservatively used an ice thickness of 1.8 m and this translates to an under-ice elevation of 200.3 m. Referring to the stage-storage curves provided in Golder 2021, and summing them to capture total volume, but omitting abandonment of sub-basins from the drawdown, results in a total minimum under ice volume of 4,252,000 m³ in the Unnamed Lake. This is nearly four times the volume of water available in winter than can be stored in Lake Geraldine.

2.2 FUTURE POPULATION OF IQALUIT & WATER DEMAND PROJECTION

As discussed in the Iqaluit Water Storage Pre-Feasibility Study (EXP, 2020), using the high growth rate for population projections, the City of Iqaluit is expected to have a population of 24,000 by year 2050.

Table 2-1 indicates future needs based on population projections and average annual outflows of UNL and Lake Geraldine. Average annual outflows, as discussed in the water balance report by (Golder, 2021), are described in Section 2.1.

Reference: Unnamed Lake Pre-concept Memorandum

Table 2-1 Population Projection and Future Water Demands

YEAR	POPULATION HIGH GROWTH (3.38%)	DAILY DEMAND (M ³ /D) (POPULATION X 400 LPCD)	UNL SUPPLEMENTATION REQUIREMENT (M ³ /D)
2020	8,839	3,536	1,263
2025	10,440	4,176	1,903
2035	14,566	5,826	3,553
2040	17,204	6,882	4,609* Deficiency = 248
2045	20,321	8,128	5,855* Deficiency = 1,491
2050	24,002	9,600	7,327* Deficiency = 2,966

With this in mind, we see that based on the current information and assumptions, UNL is suitable as a stand-alone supplementation source to a population of 17,000, or about 2040 under the high growth rate scenario used by EXP (2020).

Some inaccuracies in the assumptions should be noted here. We see that the average consumption estimated here for 2020 is about 3,536 m³/d. Based on the Iqaluit Systems Flows, the current average daily consumption is about 2,850 m³/d (July 2021). Based on the current population information, the high population growth rate may overestimate population growth. Nunami Stantec recommends the City and City planning department reconsider lower growth rate scenarios as part of the long-term water supply feasibility analysis so as to not discount viable sources into 2050. For the purposes of this assignment, we will consider the values presented in Table 2-1 and count UNL as a viable source to a population of 17,000 people, as opposed to projected demand to 2050.

3 RESUPPLY SCENARIOS AND DESIGN PUMPING REGIME

The mandate of this pre-concept design was to utilize information gathered from the UNL water balance (Golder, 2021). That study also determined that under a high consumption scenario of 115,000 m³/month (or 3,780 m³/d), the average pumping rates required from Unnamed Lake in the simulations were between 36 L/s and

Reference: Unnamed Lake Pre-concept Memorandum

540 L/s in the years simulated. Golder recommended a design pumping rate of 50% greater than 584 l/s for a system that tops up Lake Geraldine prior to winter. This flow rate was the maximum instantaneous required pumping rate observed in the results of their simulation and with the factor of safety equates to a design pumping rate of 867 l/s.

While this allows for recharge of Lake Geraldine prior to winter months, it does not address the winter month deficiency at Lake Geraldine resulting from increased future demands and inaccessible frozen water, as described by EXP (2020). The available capacity of water in Lake Geraldine in winter is 1,100,000 m³ resulting in a deficit of 1,223,200 m³. Either a winter recharge or the construction of additional reservoir capacity would therefore be required as demands grow in the future.

The high consumption rate of 115,000 m³/month is defined as the entire demand for the City of Iqaluit, as opposed to an available amount from UNL. The high consumption rate does provide an increase from the City's current demand; however, it does not account for the predicted future growth to 2050 (population of 24,000), which has been estimated to be as large as 9,600 m³/d (EXP, 2020). A system of such capacity as that recommended by Golder (2021) is possible, but the system will likely not be able to meet demand projections made by EXP (2020) demand for 2050 during the winter totals 2,323,200 m³. These projections are what served as the basis of design for other options being evaluated alongside this pre-concept for UNL. Should those projections be realized by the time a population of 17,000 is observed, then the winter demand may exceed the 1,100,000 m³ of water available under the ice in Lake Geraldine and would require additional pumping in mid-winter from UNL to replenish the supply. A more flexible system would be one that is designed to be able to draw from UNL continuously throughout the winter to top up Lake Geraldine. Continuous operation of a raw water pipeline will provide a more desirable operation of the system, preserving the available water in Lake Geraldine throughout the winter months, regardless of the water demand, without requiring the construction of additional winter storage capacity or reservoir.

Nunami Stantec is of the opinion that a continuous re-supply is a more suitable candidate for the long-term solution than an intermittent recharge program. By providing a continuous, lower rate flow of water, pumping requirements are much more reasonable as compared to intermittent pumping. As is used by the current utilidor system, maintaining flow within a pipe prevents freeze up. Understanding the Lake Geraldine storage capacity and future winter recharge requirements, continuous resupply will provide the necessary resiliency for operation and capacity as populations and demand grows. The reported outflows from the Lake Geraldine and UNL indicate that UNL can be used to supplement demands in Lake Geraldine until the population reaches 17,000.

If UNL is used as a supplement to meet the projected demand to 17,000 people, the system would need to provide 4,361 m³/d (0.05 m³/s, or 50 lps). UNL's total under ice volume of 4,252,000 m³ (described in Section 2.1) exceeds this winter demand suggesting there is sufficient supply. Comparing this to the lake's total annual outflow of 1,591,928 m³ suggests that there is potentially sufficient volume of throughflow in UNL to replenish its lake levels each year from such a drawdown. This still indicates that minimal pumping requirements are necessary to complete the action. This will be the daily flowrate throughout the year.

To summarize the operating scenario for this pre-concept memo:

- A pumping rate of 0.05 m³/s (50 l/s) will be used
- UNL will be drawn down over the winter below 202.1 m elevation, sufficient to allow the full recovery of spring freshet with minimal or no overflow and discharge from UNL in the spring

Reference: Unnamed Lake Pre-concept Memorandum

4 INTAKE AT THE UNNAMED LAKE

The intake at Unnamed Lake would be comprised of a pump house on the west shore and a raw water line extending out into the lake and running along the lake bed to the withdrawal location. At the withdrawal location, the pipe would be screened with an orb type screen(s) with the pipe and screen affixed to an anchor block or pile footing to keep it in place and above the lake bed. The screening must be sized in accordance with Fisheries and Oceans Canada's (DFO) code of practice for end of pipe fish screening. eDNA samples taken from the lake (WSP 2021) identified the presence of arctic char, but no other fish, though Ninespine stickleback have potential to be present. Arctic char and Ninespine stickleback both have a subcarangiform mode of swimming and under the code of practice a withdrawal rate of 50 l/s would require a screen area of 0.51 m² to prevent entrainment and impingement. This screen area can be accommodated with a single drum type orb screen with openings no larger than 2.54 mm, in accordance with the code. The screens would also be fitted with an air scour that is operated by an airline running in parallel with the raw water line and connected to a compressor at the pump house. The air scour can be run continuously in winter to mitigate frazil or in bursts to control biofouling.

The withdrawal should occur in an area of the lake that is deep enough to accommodate the screens without risk of entrainment of lake sediment from being too close to the bottom; or damage from ice, or the entrainment of frazil from being too near the surface. The screens contemplated in this pre-concept and should be placed no less than 2 m from the lake bed. The screens should have at least a minimum of 2 m of water above them to accommodate ice thickness however Stantec recommends a minimum of 4 m for this pre-concept. Totalling these assumed values suggests the intake should be in a minimum of 8 m of water. Bathymetry of the lake bottom (Tetratech, 2019) suggests the maximum depth in Unnamed Lake is 22 m and there are a considerable number of areas in unnamed lake where this depth is exceeded. Based on desktop review of the bathymetry Stantec recommends that the intake withdraw from the deeper portions of the lake around 7072500N 527400E z19. The pump house would be located on shore near this location. This assumption served the basis for pipeline and access road routing for the pre-concept.

5 PIPELINE ROUTING OPTIONS

UNL is located approximately 3.5 km northeast of Lake Geraldine. It is located approximately 200 m asl, with Lake Geraldine located at about 95 m asl, with topography generally sloping down. The Apex River runs between these lakes, creating a topographic valley. In our limited analysis of routing options, we've taken a general approach to routing, which would require optimization with detailed topography prior to detailed design. In this approach, we've identified two routes from UNL to Lake Geraldine, one running from the intake location along the northwest side of UNL to directly into Lake Geraldine and a second running from the intake location along the western side of UNL directly to Lake Geraldine. To compensate for future route optimization, we will be adding 30% to the length of each of these pipelines in the costing analysis.

The assumed discharge locations are to locations within Lake Geraldine that are accessible by the Water Treatment Plant (WTP intake), as estimated from bathymetric data. This can be further confirmed during detailed design.

5.1 PRE-CONCEPT PIPELINE ROUTING, OPTION 1

Option 1 for pipeline routing consists of a pipeline running from the intake location (central UNL) past the northwest side of UNL directly to Lake Geraldine at a location accessible by the current WTP intake. This discharge location would feed Lake Geraldine directly without requiring any modifications to the current WTP

Reference: Unnamed Lake Pre-concept Memorandum

intake structure. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake Geraldine.

This route is shown in Figure 2-1.

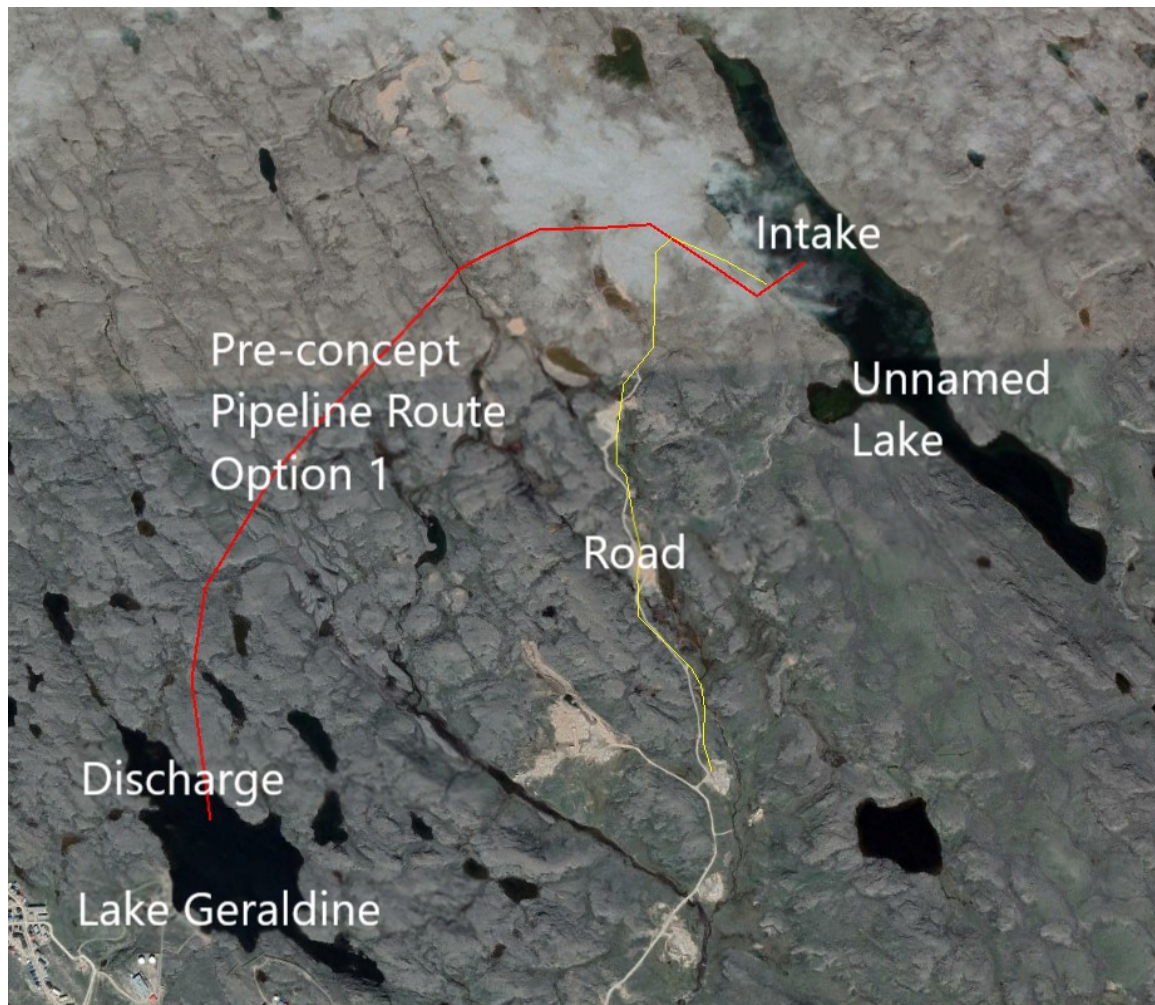


Figure 2-1 Pre-concept Pipeline Route Option 1

5.2 PRE-CONCEPT PIPELINE ROUTING, OPTION 2

Option 2 for pipeline routing consists of a pipeline running from the intake in the central region of UNL past the western side of UNL to eastern side of Lake Geraldine. This discharge location would feed Lake Geraldine directly at a location that remains accessible by the current WTP intake as based upon bathymetric data. Following this path, the pipeline would generally flow down from 202 m asl at UNL to about 95 m asl at Lake

Reference: Unnamed Lake Pre-concept Memorandum

Geraldine. This route was selected as it generally aligns with the current pipeline route from the Apex Supplemental Pumping infrastructure.

This route is shown in Figure 2-2.

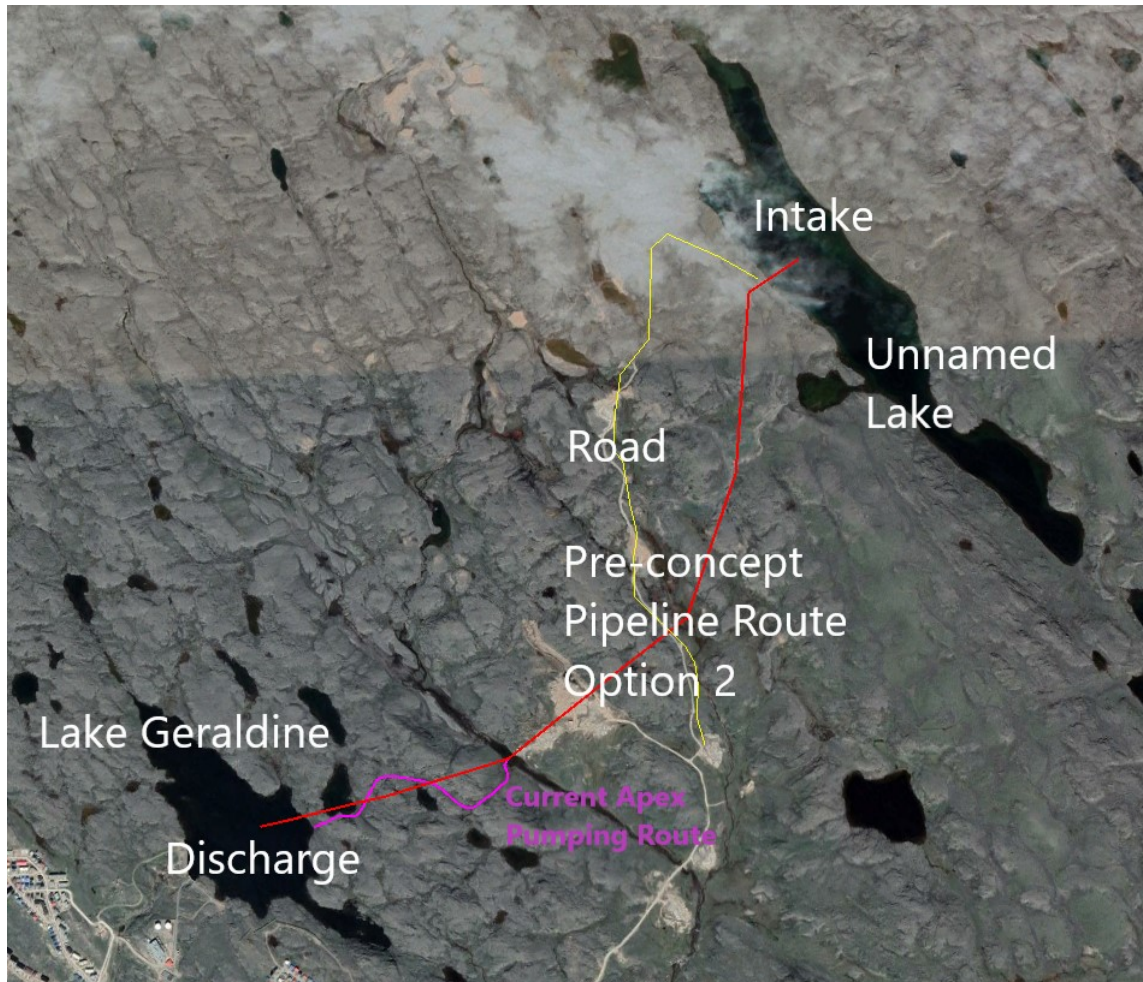


Figure 2-2 Pre-concept Pipeline Route Option 2

6 EVALUATION CRITERIA DISCUSSION

The criteria that will be used in the SGR and UNL evaluation will be described in the following sections.

Reference: **Unnamed Lake Pre-concept Memorandum**

6.1 ACCESSIBILITY

6.1.1 Roads

Though a temporary road was constructed for the 2019 Lake Geraldine Emergency Supplementation program, utilizing UNL as a permanent part of the Iqaluit potable water supply will require roads to be engineered, constructed, and maintained. Pumping stations at stages along the pipeline will not be required. As a result, a road or trail along the UNL pipelines will not be required for maintenance purposes.

For both routing Options 1 & 2, upgrading the existing road from Road to Nowhere (just past the Iqaluit Shooting Range) to the northwest side of UNL will be required. The general path of the existing temporary road will suffice for this analysis, with an additional path required to reach the central portion of UNL where we estimate will be the intake location. The road requirements are approximately 3,200 m in length. Further analysis and design will be required to understand optimal routes for grading and drainage, with respect to topography.

6.1.2 Pipeline

The pipeline for Option 1 has is shown as about 4,700 m and 4,050 m for Option 2. For each of these, as mentioned, we will be adding a 30% contingency onto the length as an optimal route will be selected at a concept level design with detailed topography analysis. As such, this pre-concept report will consider the pipeline length for Option 1 as 6,100 m and 5,300 m for Option 2.

With the continuous resupply scenario, we've selected a 300 mm insulated HDPE pipe. The pipe can be placed either directly on the ground surface or buried in a bermed area. Heat tracing, while may be included for recovery following emergency shut down periods, will not be required to function for normal operation under the continuous flow system. As mentioned, ideal routing will be selected using detailed topography during the subsequent design phases.

6.1.3 Pumping Stations and Power Requirements

The UNL plant will not require interim pumping stations to lift the water to Lake Geraldine as there is a net elevation loss along the route. The only pumping requirements of the UNL to Lake Geraldine system for the continuous resupply scenario will be to pump the water out of the reservoir. The elevation fall (static head) from UNL to Lake Geraldine is -107 m. We assume a flow rate of 50.47 lps (800 USGPM). The total dynamic head (TDH), which considers the frictional loss and static head, is -105.31 m. Converting this to pressure, the TDH is equal to -147.90 psi.

The hydraulic power required to convey this water is -68.93 HP. In theory, this system could generate about 44.80 HP of electrical, assuming 65% efficiency, and result in about \$146,000 in annual power earnings with use of a micro hydro plant. Feasibility of the installation of a micro hydro plant will need to be evaluated further at concept level, however, it is mentioned here to illustrate the potential optimal pumping dynamics of the UNL to Lake Geraldine system.

6.1.4 Power

For the "continuous resupply" pre-conceptual resupply scenario, power requirements can be either fulfilled by use of a diesel generator or direct grid connection with power poles. Since the pumping requirements for this concept are minimal, a generator near the intake pump would likely be suitable.

Reference: **Unnamed Lake Pre-concept Memorandum**

As noted in the previous section the operation of the continuous flow pipeline could potentially produce more power than is need for pumping out of the lake. Thus power could only be required on startup, making a generator or batteries a viable option rather than grid power.

For the “bulk resupply” pre-conceptual resupply scenario, power requirements are much greater. A permanent grid power connection would be recommended, although a generator would also be possible.

6.2 IMPLEMENTATION

6.2.1 Constructability

By identification of major construction activities, constructability is considered at this project phase to being discussions on risk management for the project during subsequent design phases. While this section does not address every detail, it is expected to form the basis of risk and constructability through detailed design.

The road to UNL will require detailed topographic information to ensure adequate drainage is delineated to prevent washout. Also, the overall quantity and type of granular material should be specified to ensure stockpiles are ready at the time of construction. Given our current understanding of terrain conditions, substantial amounts of materials will be required. The temporary road built for the Lake Geraldine Resupply 2019 project, while in relatively good condition at this time, was not constructed using any detailed design for drainage or material quality and built mostly of locally sourced material. This road is not suitable for long-term use and maintenance; however, it has mapped out the general location of the pre-conceptual design requirements. It will also provide access during construction of the long-term road.

As mentioned, the pipeline routing will be confirmed with detailed topographic information during detailed design. The optimal route does not require a maintenance road; however, it will likely require a temporary construction path for installation. Once the route is selected, borrow sources for gravel can be considered. Construction of the long-term road is recommended before installation of the pipeline. Insulated HDPE pipe is readily available; however, it does have a longer lead time and must be ordered in advance of the construction season. This material should be ordered such that it arrives to Iqaluit on the first sealift of the season.

The intake at UNL will require access to the central part of the lake. The temporary road from 2019 does not run to this exact location so additional road construction will be required prior to installation of the intakes and supporting structures (i.e. generator room, site office).

Power requirements for operation can be in the form of a direct grid connection or from a diesel generator. The long-term road must be in place prior to installation of power poles, if this option is selected. Adequate distance from UNL (minimum 30 m) and secondary containment will be required for placement of any diesel fuel storage or the generator. If a generator and fuel storage is required, it is recommended to be ordered in advance of the first sea lift such that it arrives in Iqaluit in July.

UNL will require some security to ensure this remains a protected water supply. As access to the area increases, so does community interest. The temporary 2019 road has already brought interest to UNL and an increase in activities (i.e. camping and ATV use) has been observed. Signage and fencing will likely be required in various areas.

Supplementation from UNL will require approval and authorizations from the Nunavut Water Board, GN Department of Health and Fisheries and Oceans Canada. A screening by the Nunavut Impact Review Board will be required. To support applications for approval, the City will need to engage with Amaruq Hunters and

Reference: Unnamed Lake Pre-concept Memorandum

Trappers Association, Qikiqtani Inuit Association, and residents of Iqaluit. Additional studies that may be required include:

- Further validation of the water balance model,
- Water quality profile, and
- Archaeology of the road and pipeline route and species at risk.

A key aspect of the regulatory review process is expected to be the water balance.

The number of contractors expected to bid on this is limited, due to the remoteness of the site.

6.2.2 Operation & Maintenance Complexity

Operation and maintenance complexity is largely dependent on the selected resupply scenario. For Resupply Scenario 1, bulk period resupply periods, the line will be required to be drained after each use. If a generator is used to supply power, all fuel should be removed from site and the equipment during each shut down period. Roads must be maintained throughout the entire winter as demands increase as winter pumping will be required. Any planned shutdowns must be timed adequately to ensure pipes with water do not freeze. Resupply Scenario 2 will also require carefully timed shutdowns for maintenance and road maintenance. The site must be kept clear of snow as with any municipal building or infrastructure.

Automatic controls should be in place, including alarms, so City operations can be alerted of any problems resulting from low flow conditions. Thermal analysis will be included during the detailed design to determine alarm setpoints.

6.3 ESTIMATE OF PROBABLE COST

6.3.1 Capital Cost

Based on the identified site conditions, anticipated intake types, and pipeline options with associated infrastructure (i.e., access roads, power, pumping stations), Nunami Stantec has developed an (AACE No.18R-97) Class 5 estimate of probable infrastructure costs. This has been completed for both Sylvia Grinnell River and Unnamed Lake options. So as to make a comparison, the unit prices have been normalized to match the 2019 estimate from Sylvia Grinnell River concept report. Costs are summarized in Table 6-1.

Reference: Unnamed Lake Pre-concept Memorandum

Table 6-1 Estimate of Probable Cost Summary

COST ITEM	UNNAMED LAKE PRE-CONCEPT	
	Option 1	Option 2
GENERAL REQUIREMENTS (MOB/DEMOB, ECO PLAN AND ENV. MONITORING, UTILITIES COORDINATION)	\$160,000	\$160,000
SITE PREPARATION	\$70,000	\$70,000
INTAKE (INCLUDING PUMPHOUSE AND EQUIP.)	\$1,582,000	\$1,582,000
POWER SUPPLY, ROAD, AND PIPE	\$6,695,000	\$6,335,000
SUB-TOTAL (NO CONTINGENCY)	\$8,507,000	\$8,147,000
TOTAL CONSTRUCTION COSTS (INCL. 30% CONTINGENCY)	\$11,059,100	\$10,591,100

6.3.2 Power Cost

Table 6-2 Power Cost

ANNUAL POWER COST	UNNAMED LAKE PRE-CONCEPT
POWER REQUIREMENTS	Power required = -69.60 HP Generation potential = 45.24 HP Annual earnings = \$148,000

Reference: Unnamed Lake Pre-concept Memorandum

7 CONCLUSIONS AND RECOMMENDATIONS

In accordance with the background data provided, Nunami Stantec has completed a pre-conceptual level design of long-term supplementation of Lake Geraldine from Unnamed Lake. Within this document, we describe the information extracted from the background documents and determined that, according to projections, UNL could be a sustainable supply up to a population of 17,000.

We believe that the optimal pumping scenario is to continuously resupply Lake Geraldine from UNL. That recommendation will require further analysis during detailed design to optimize pumping details. Required equipment and controls will also be determined later in design.

At the pre-conceptual level, considering the minor differences in cost between Options 1 and 2, we suggest that both pipeline routing options remain considered until detailed topography is considered.

Following our analysis, we have created a list of information that would provide valuable information to confirm feasibility and move this project into further design stages.

- Construct a metering station comprising a weir and data logger in the downstream channel of Unnamed Lake to measure outflow and compare the results with modeled outflow (Golder 2021) and the assumptions used in developing this pre-concept.
 - This is in addition to the existing transducer that is in Unnamed Lake.
 - This data can be used to develop a relationship between flows recorded at UNL and those on the Apex River. This relationship could potentially be used to construct a synthetic dataset for UNL that extends back as far as records on the Apex River (1973).
- Assess the effect of drawdown on the abandonment of sub-basin to confirm total under ice water volumes used in this pre-concept.
- Re-assess the quality of bathymetric survey data to confirm stage-storage relationships that formed the basis of this assessments.
- Conduct a more detailed assessment of lake response to proposed withdrawals, particularly in drought years, including back-to-back occurrences, and under future climate scenarios.
- Ensure detailed topography is attained and used to optimize pipeline routes.
- Complete a drainage assessment of the area prior to road design.

The content of this memo has been prepared and reviewed by professional engineers and geoscientists licensed to practice in Nunavut, including: Matthew Follet, P.Eng., Walter Orr, P.Eng., Matt Wood, P.Eng., and Dr. David Luzi, Ph.D.

Nunami Stantec Ltd.

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APPENDIX B
NIAQUNGUK (APEX) RIVER WATER WITHDRAWAL
ANALYSIS MEMORANDUM



To:	Erica Bonhomme Yellowknife, NT	From:	Mike Soloducha, David Luzi Victoria, BC
Project/File:	144903162	Date:	May 29, 2022

Reference: Niaqunguk (Apex) River Water Withdrawal Analysis

Introduction

The City of Iqaluit (City) obtains and distributes potable water from Lake Geraldine, an engineered reservoir located north of the city. Due to prevalent supply shortages in the reservoir, the city applied for and received an amendment (Amendment #4) to its type A water license 3AM-IQA1626 to permit supplementation from the Niaqunguk (Apex) River on an annual basis if required.

As part of a study on long term water sourcing options, a review of water availability was completed for the Apex River based on available data from the Water Survey of Canada (WSC) station Apex River at Apex [10UH002]. This work updates earlier work presented by exp (2014) and Nunami (2017), expanding the period of analysis until 2021.

This technical memorandum summarizes the results of the review of water availability at the supplemental pumping location (SPL) located on the Apex River, approximately 1 kilometre upstream of the bridge on the Road to Nowhere, under several scenarios based on pumping capacity and observed streamflow. The SPL receives flows from the Apex River watershed upstream of the SPL, and excludes outflows from Unnamed Lake.

Methods

Long term flow data for Apex River was obtained from the WSC hydrometric station *Apex River at Apex* (Station ID 10UH002). There are 37 years of streamflow data available for this station for the period between 1973 and 2021 (data was not available in 1984 and 1996-2005). The station is only operational during the open water season, and the observed period of record (i.e. number of days with measurements) is not consistent between years and thus the results presented here may not be reflective of actual streamflow available. To convert the streamflow record of Apex River to the SPL, a scaling factor of 0.73 was applied to the mean daily discharge recorded at the Apex River station to account for differences in streamflow at the point of diversion (Apex River 1Km Above Bridge to Nowhere [WSC Station 10UH015]) and the monitored station location (10UH002 *Apex River at Apex*). The period of record at the Apex River 1km Above Bridge to Nowhere station has only been active since 2019 and streamflow has not been reliably produced by WSC for the station as of yet and the period of record is too short to use for planning purposes.

Volumetric outflow was computed for each year in which streamflow data was available to determine the maximum amount of water that would have been available for supplementation at the SPL. Note that this result differs from exp (2014) and Nunami (2017) which only looked at withdrawals from July to September of each year and for a location further downstream of our assessment point. Also note that the results are not intended to be used to forecast, as it is based on historical observations. This study considered all recorded daily streamflow over the period of record. Additionally, this analysis did not consider any restrictions related to minimum flow requirements for riverine ecosystems (DFO 2013).

Reference: Contract Change Order Request #3 (CCO-03) to SC00248 – Draft Evaluation Report Additions and Presentation to Engineering Committee – Rev3

In addition to assessing volumetric outflow, which considers availability of water under a variable, and unrestricted pumping scenario, three fixed rate pumping scenarios were evaluated for comparative purposes. The three pumping scenarios were 50 L/s, 100 L/s and 200 L/s. For each pumping rate, pumping was assumed to be operated at a fixed rate and therefore observed streamflow must be either equal to or greater than the specified pump rate for withdrawals to occur. For example, if the daily average streamflow was 150 L/s (0.15 m³/s), 150 L/s would be available for pumping and withdrawal could occur with the 50 L/s and 100 L/s pump scenario but not for the 200 L/s scenario on that day. Under the unrestricted pumping scenario, 150 L/s would be available for withdrawal.

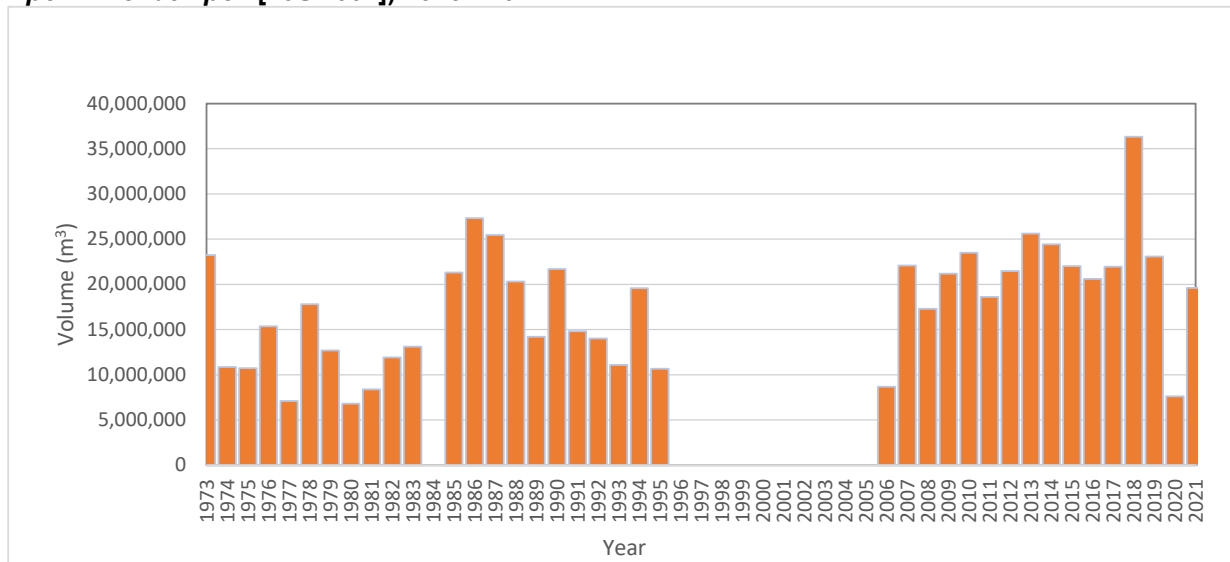
Results and Discussion

Water availability was assessed for the four scenarios outlined above, volumetric outflow (i.e. the unrestricted scenario), 50 L/s, 100 L/s and 200 L/s. Summary results for pumping volumes using each scenario are included in Table A.1 and Figure A.1.

Table A.1 Summary of Water Availability at the Supplemental Pumping Location (scaled based on Apex River at Apex [10UH002]) 1973 - 2021

Statistics	Period of Record (days)	Annual Volumetric Outflow (m ³) – Unrestricted Scenario	Pumping Scenario-50 L/s (m ³)	Pumping Scenario-100 L/s (m ³)	Pumping Scenario-200 L/s (m ³)
Average	141	17,697,765	543,183	1,054,989	2,005,389
Minimum	64	6,800,371	276,480	552,960	1,088,640
Maximum	225	36,333,915	747,360	1,451,520	2,782,080

Figure A.1 Annual Volumetric Outflow (m³) Supplemental Pumping Location (scaled based on Apex River at Apex [10UH002]) 1973 - 2021



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The average annual volume available (volumetric outflow) from the Apex River at the SPL, if there are no ecological flow requirements, is over 17.5 million m³, 2018 the volume exceeded 36 million m³, in 1978 the annual volume was only 6.8 million m³. The low volume year in 1978 was likely due to streamflow observations starting after freshet, so only a partial hydrograph was available for that year. The three fixed pump rate scenarios result in substantially lower volumes of water withdrawn. On average the 200 L/s pump rate results in 2,005,389 m³, which is greater than the other two pump rates, both minimum and maximum flows are greater in the 200 L/s scenario.

Table A.2 presents the annual summary of available volumes at the SPL for the period of record.

Table A.2 Annual Water Availability at the Supplemental Pumping Location (scaled based on Apex River at Apex [10UH002]) 1973 - 2021

Year	Period of Record (days)	Annual Volumetric Outflow (m ³) – Unrestricted Scenario	Pumping Scenario-50 L/s (m ³)	Pumping Scenario-100 L/s (m ³)	Pumping Scenario-200 L/s (m ³)
1973	122	23,232,442	527,040	1,054,080	2,073,600
1974	105	10,862,035	453,600	907,200	1,814,400
1975	105	10,732,262	453,600	907,200	1,814,400
1976	107	15,367,536	462,240	924,480	1,848,960
1977	92	7,101,130	397,440	794,880	1,589,760
1978	64	17,796,326	276,480	552,960	1,105,920
1979	92	12,697,430	397,440	794,880	1,589,760
1980	99	6,800,371	427,680	855,360	1,710,720
1981	87	8,385,379	375,840	751,680	1,503,360
1982	153	11,927,434	509,760	984,960	1,866,240
1983	116	13,124,765	488,160	881,280	1,088,640
1984					
1985	156	21,321,274	630,720	1,209,600	2,332,800
1986	136	27,338,170	540,000	1,054,080	2,056,320
1987	121	25,446,442	518,400	1,036,800	2,056,320
1988	158	20,297,261	630,720	1,209,600	2,280,960
1989	146	14,198,890	479,520	924,480	1,762,560
1990	145	21,694,522	583,200	1,114,560	2,108,160
1991	161	14,800,493	604,800	1,157,760	2,211,840
1992	145	14,026,522	548,640	1,036,800	1,952,640
1993	131	11,096,179	522,720	1,010,880	1,935,360
1994	190	19,563,552	699,840	1,365,120	2,592,000
1995	124	10,650,269	522,720	1,019,520	1,952,640
1996 to 2005					
2006	75	8,676,720	302,400	587,520	1,140,480
2007	184	22,075,114	561,600	1,054,080	1,987,200
2008	174	17,281,210	630,720	1,226,880	2,384,640
2009	160	21,196,166	557,280	1,071,360	2,039,040
2010	217	23,512,118	747,360	1,451,520	2,782,080
2011	144	18,603,475	578,880	1,114,560	2,211,840
2012	160	21,469,882	673,920	1,304,640	2,522,880
2013	159	25,611,984	648,000	1,261,440	2,436,480
2014	181	24,443,942	721,440	1,365,120	2,505,600
2015	151	22,013,285	609,120	1,157,760	2,177,280

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2016	214	20,598,811	617,760	1,192,320	2,246,400
2017	225	21,941,225	678,240	1,278,720	2,401,920
2018	143	36,333,915	617,760	1,200,960	2,332,800
2019	170	23,077,115	730,080	1,451,520	2,401,920
2020	146	7,606,676	475,200	941,760	1,624,320
2021	102	19,612,755	440,640	881,280	1,762,560
AVG	141	17,697,765	543,183	1,054,989	2,005,389
MIN	64	6,800,371	276,480	552,960	1,088,640
MAX	225	36,333,915	747,360	1,451,520	2,782,080

Limitations

The analysis presented above did not account for the potential effects of climate change on the volume available from the Apex River and thus this should not be considered as a predictive tool. Additionally, no consideration, beyond the selected pumping rates, was given to any engineering limitations with regards to the engineering design or operations of the pumping program. Lastly, the requirements related to regulatory approvals was not considered.

Closing

The analysis conducted here illustrates that under a scenario of no environmental flow requirements, the Apex River would on average be able to provide over 17.5 million m³ of water a year as based on the historical record. Over the period of record annual volumes ranged between 6.8 million m³ and 36.3 million m³, this would potentially be available for an unrestricted withdrawal scenario. Three additional withdrawal scenarios were examined at fixed pumping rates of 50 L/s, 100 L/s and 200 L/s. Of the three fixed rate pumping scenarios assessed the 200 L/s rate resulted in the largest volumes.

Nunami recommends that additional work be undertaken to determine an optimal pump rate that incorporates future peak water demand, historic streamflow record, pump size and pipeline diameter in determining the pump configuration scenario to support long term supplementation. This additional work could also incorporate a consideration of ecological flow requirements, that may not meet the DFO (2013) guidance, but could still maintain ecosystem needs.

Regards,

Nunami Stantec Limited

Nunami Stantec Limited

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References

DFO (Fisheries and Oceans Canada). 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/017.

exp. 2014. City of Iqaluit Supplementary Water Supply Study. Prepared for the City of Iqaluit, 31 pp.

Nunami (Nunami Stantec Ltd.). 2017. Fish and Fish Habitat Assessment of the Niaqunguk (Apex) River, Lake Geraldine, and the Lake Geraldine Drainage Channel. Prepared for the City of Iqaluit, 72 pp.