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PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
EUREKA CIVIL CONSULTING SERVICES
PROJECT NO.: R.015466.001

Eureka Civil Consulting Services

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Any questions concerning the information or its interpretation should be directed to Carlos Cancino or Philip Songhurst-Thonet.

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1. INTRODUCTION

1.1 General

WorleyParsons has been retained by Public Works and Government Services Canada (PWGSC) to carry out a conceptual engineering study to assess potential upgrades to the water reservoir, sewage lagoon, airstrip and fuel storage facilities at the Eureka Weather Station (the Station) located in Nunavut, Canada.

Eureka, Nunavut is a small outpost located on Slidre Fjord, midway up Ellesmere Island in the Canadian High Arctic (Figure 3 through Figure 12). The Station has been continuously occupied since 1946 and it is the second most northerly permanently inhabited site on the globe. Mainly in use as part of Environment Canada's High Arctic Weather Station (HAWS) network. The site also currently supports ongoing atmospheric research as well as Canadian Forces activities. The primary facilities at the site include the main weather station complex, a water reservoir, sewage lagoon and airstrip.

1.2 Project Objectives

The primary project goal of this project was to complete a study to define the scope and price associated with several of infrastructure upgrades to the Eureka Weather Station. This includes looking at technologies and options to mitigate issues associated with source water for human consumption, water supply and treatment system, fuel storage containment and runway surface degradation. As a result, in addition to the engineering studies associated with this work, a comprehensive geotechnical survey and hydrological program were completed in parallel to provide the necessary input into the design parameters.

1.3 Scope of Work

The proposed scope of work for this project was outlined in PWGSC Terms of Reference R. 015446.001 (ET025-110131) and WorleyParsons' proposal No: CPR 10-039, dated July 21, 2010. The scope of work was divided into the following major components

- Water Supply and Distribution Study
- Wastewater Treatment Options Review Study
- Fuel Drum Storage Area Study
- Geotechnical Investigation Report
- Digital Topographic Survey

1.4 Site Reconnaissance

During the week of August 16, 2010, WorleyParsons conducted an inspection of the Station and surrounding area. Activities completed during the site visit are summarized below:

- a review of topographical, soil, and hydrological information for the area;
- a review of the water storage and distribution system, including sampling for water quality;
- a review of the waste water disposal system, including the waste water lagoon;
- a review of historical information, including available third party information, for the area;
- an evaluation of potential sources of drinking water, including water quality analysis:
  - potential sources included Station Creek, Black Top Creek, and the Slidre Fiord.
- completion of 16 Test Pits (TP) using a backhoe-loader;
- an evaluation of potential sources of suitable sand and gravel;
- an interview with the Station Program Manager (André Bouchard 2010) about the history of the Station; and
- a field survey of the Station and surrounding area

2. WATER SUPPLY AND DISTRIBUTION STUDY

The purpose of this study is to evaluate all aspects of the water supply for the Station, including the existing water source, storage, treatment, and distribution, and develop and assess various options for meeting the potential future water demand of increased station occupancy for the next 15 years. Available information related to water sources, storage, treatment, and distribution was assessed in order to determine the best option for the Eureka Station for the next 15 years. The engineering study was conducted following the Canadian drinking water guidelines requirements (Health Canada 2008).

2.1 Scope of work

The scope of work of this study included completing the following assessments for the Station:

- Station Water demand assessment
- Station Creek assessment
- Alternate water source assessment
- Reservoir assessment
- Water treatment assessment
- Development and evaluation of feasible options
- Water distribution system assessment

2.2 Main Findings

The following are the main findings of the Water Supply and Distribution Study. The complete study can be found in Appendix 1.

The Station has capacity for 60 persons. Future water supply options have been developed to provide a water system that meets the demand of this population (design demand). The average daily demand for the Station was estimated to be 335 L/person/day.

The existing water supply system was reviewed to determine if it could meet the potential future demand. The reservoir has an over winter capacity for about 17 persons and is therefore undersized to meet the design demand. The water treatment system is able to supply up to 170 L/day of drinking water and is undersized to meet the design demand.

Three alternative water sources were reviewed (Station Creek, Black Top Creek and seawater from the Slidre Fiord). It was concluded that Station Creek is the preferred water source for the Station based on

a quantitative and qualitative analysis of following parameters: water quantity, water quality, potential for contamination, storage requirements and intake pump house and pipeline concerns.

Options for provision of a traditional earthen reservoir were developed and assessed. These options included modifying the existing reservoir and constructing a new reservoir. It was determined that modifying the existing reservoir would not provide the full design capacity, but would provide increased stability of the reservoir and add some additional capacity.

Three options of constructing a new full capacity reservoir were developed for a comparative analysis. The construction cost estimates for the options were in the range of $12,500,000. The ranking of each option in the comparative analysis was sufficiently close to warrant further investigation and refinement of this analysis.

Table A summarizes the construction cost for all the options considered to upgrade the Station reservoir.

Table A Reservoir Options Construction Cost Estimate

Reservoir Option	Estimated Construction Cost
Option 1 – Increase Stability of Existing Reservoir	$2,165,072
Option 2 – Raise Existing Reservoir Berms	$8,991,211
Option 3 – Construct New Reservoir North of Existing Reservoir	$12,779,794
Option 4 – Construct New Reservoir West of Station Creek	$12,582,757
Option 5 – Construct New Reservoir East of the Station	$12,482,731

Water treatment systems were evaluated to meet the design demand by treating surface water or saline water. The assessment concluded that treating surface water (i.e. Station Creek as the water source) in conjunction to the current practice at the station in which only the drinking water portion of the demand (i.e. 2 m^3/day) is to be treated to obtain drinking water quality and non-potable utility water to be used after softening and multimedia filtration (i.e. 18 m^3/day) was the preferred option.

The cost of treating water is considerably less than the construction cost of a new earthen reservoir. Therefore, further consideration of treating sea water is warranted. In order to use sea water a permanent year round intake structure and pipeline would need to be constructed. If such a structure is not practical, then some form of water storage would still need to be provided during the winter months and surface water (Station Creek) would, again be the preferred source.

3. WASTEWATER TREATMENT OPTIONS REVIEW STUDY

The purpose of this study is to provide engineering for the evaluation of options for the ultimate selection of the most viable wastewater treatment system for implementation at the Station over the next 15 years.

3.1 Scope of Work

The primary task is to review Golder Associates' report (Golder 2009) on Wastewater Treatment System Options and confirm the constructability at the proposed sites. This will include an analysis of all potential challenges related to sighting, technology, operations and maintenance.

The second task is to conduct an analysis to determine size and capacity of force main, pumps and other components of the wastewater treatment systems that will meet the future demands.

3.2 Main Findings

The following are the main findings of the Wastewater Treatment Options Review Study. The complete study can be found in Appendix B.

The Golder Associates' report (Golder 2009) evaluates several wastewater treatment options and ranks them based on treatment performance, ease of operation, upset risk/impact, mechanical failure risk/impact, energy consumption, solids handing requirements and capital cost. The resulting short-listed treatment technologies recommended are two kinds of attached growth systems (media-based trickling filters or submerged fixed film bioreactors) or a new facultative pond lagoon.

Since secondary quality effluent is not required at this site and sludge/solids handling is expected to be difficult at this location, mechanical type systems including attached growth systems are not recommended for this facility. Lagoons have several advantages over the other two recommended systems. In northern climates, lagoons offer a reliable and easy-to-operate process. The recommendation to proceed with lagoon treatment is based on the assumption that past performance of the existing lagoon meets the current and future Nunavut Water Board (NWB) licence effluent requirements, and also meets the Station's operational and performance. Based on this selection, preliminary design information and recommendations are presented for the preferred option for the proposed wastewater facility.

The next phase of the design includes confirmation of the design data including flows and loads to the wastewater system, followed by system component selection and sizing, and finally detailed design of the wastewater treatment system.

4. FUEL DRUM STORAGE AREA STUDY

The purpose of this study was to complete a design basis which outlines the key design aspects of the proposed fuel drum storage area at the Station, including preliminary engineering drawings and addressing the technical challenges of construction in the arctic.

This design basis memorandum includes a review of existing information and a summary of the field work and the design basis.

4.1 Scope of Work

The scope of work for the fuel drum storage area study includes the following:

- a review of any existing background information;
- coordinate with and support of the geotechnical and topographic investigations for the proposed footprint area;
- review of geotechnical and topographical survey results, as it pertains to the fuel drum storage area; and
- preparation of a design basis.

4.2 Main Findings

The following are the main findings of the Fuel Drum storage area study. The complete study can be found in Appendix 3.

The geometric design basis of the fuel drum storage was to maximize the fuel drum storage capacity while minimizing the area footprint. The proposed layout inside the fuel drum storage area is "U-shaped". This allows the front-end loader the maximum amount of manoeuvrability while maintaining the smallest footprint. This layout can be modified going forward, for operational reasons, if necessary. However, the proposed footprint of the fuel drum storage area is based on this arrangement.

The proposed secondary containment structure is to be constructed on a pad of granular fill with a minimum thickness of 1,000 mm (WorleyParsons 2010). The crushed gravel fill should be placed near the end of the summer season when the annual depth of thaw has been achieved. Constructing a stable crushed gravel fill during the poorest annual subgrade conditions should ensure stable crushed gravel fill in all seasons. To protect the linear low density polyethylene liner, two layers of sand will be used. One sand layer will be placed under the liner and the other sand layer will be placed on top of the liner. Two layers of woven geotextile will be used as separation barriers to prevent the sand mixing with

the gravel. The first woven geotextile will be placed on top of the gravel fill, with the sand placed on top of the geotextile. The second woven geotextile will be placed on top of the upper sand layer with the gravel surface placed on top. For a trafficable surface, crushed gravel will be placed on the fuel drum storage footprint. The fuel drum storage footprint includes the area the drums are stored in and the area required for the front-end loader to manoeuvre.

Two locations were identified as potential sites for the fuel drum storage area (Drawing 12). One site, Location Option 1, was identified in the Terms of Reference (PWGSC 2010) and the second site, Location Option 2, was identified by WorleyParsons geotechnical engineers. The location of the fuel drum storage area is proposed to the north of the existing bulk fuel storage site at the airfield (Location Option 1). Location Option 1 was deemed less desirable by the WorleyParsons' field team due to its proximity to the Rose Rock Creek slope and an alternative location (Option 2) has been suggested. Location Option 2 is situated slightly south and east of Option 1 moving it away from the potentially unstable slope of Rose Rock Creek. The soil conditions in the area of Option 1 consist of relatively undisturbed tundra (silty clay till) with permafrost located approximately 0.5 meters (m) below grade. The soil conditions in Option 2 are presumed to be equivalent to Option 1.

In terms of the proposed construction schedule, the compacted crushed gravel fill would ideally be placed and left in place over a full winter season (WorleyParsons 2010). The following summer, the crushed gravel fill can be re-graded as needed and the subsequent secondary containment structure be placed. However, if necessary, the entire structure can be placed in one construction season.

5. GEOTECHNICAL INVESTIGATION REPORT

The objective of this report was to conduct a geotechnical investigation at the Station to support the overall conceptual engineering study. This investigation comprised a site reconnaissance, a subsurface investigation at the existing airstrip and in the proposed sewage lagoon sites and a granular material borrow source search. In addition, the geotechnical investigation included reviewing the Stantec report prepared for the proposed fuel drum storage area and the Golder report on the proposed sewage lagoons.

5.1 Scope of Work

The scope of work of the geotechnical investigation report includes:

- a review of the available geotechnical and geological information for the Eureka area;
- a geotechnical investigation, including site reconnaissance, test pitting and sampling of potential granular material borrow sources;
- laboratory testing of selected soil samples recovered from the site; and
- preparation of a geotechnical report, which summarizes the results of the study and provides suitable comments and recommendations.

5.2 Main Findings

The following are the main findings of the Geotechnical investigation report. The complete report can be found in Appendix 4.

The existing runway at Eureka consists of a thin layer (approx 150 mm) of granular material directly overlying native silty clay till with permafrost located at an approximate depth of 1.0 m to 1.4 m below existing grade. The runway is poorly drained in some areas and placement of gravel fill is proposed to promote adequate drainage and improve the structural strength.

A new fuel drum storage area is proposed to the north of the Canadian Forces bulk fuel storage site at the airfield. This site was deemed unsuitable by WorleyParsons field team due to its proximity to the Rose Rock Creek slope and an alternative location has been suggested. Soil conditions in the area consist of relatively undisturbed tundra (silty clay till) with permafrost located approximately 0.5 m below grade. The fuel drum storage area should be constructed on a thick gravel pad placed directly on the tundra. The pad should be placed near to the time of maximum thaw depth, to replicate worst-case conditions, and constructed to sufficient thickness to adequately support a loader even when the underlying till is in a partially thawed state.

Two new sewage lagoon locations have been proposed by Golder Associates. Soil conditions in these locations consists of various depths of granular fill overlying silty clay colluvium with permafrost at a depth of approximately 1.0 m below grade. Based on the site topography, the southern location (Option 1) is deemed more suitable for construction of the lagoon.

The existing water reservoir is understood to be undersized for the potential station population. As well, during the site reconnaissance, signs of instability were noted in the existing reservoir berms. Several options were examined for upgrading or expanding the existing reservoir and for construction of a new reservoir. Any new reservoir should have a geosynthetic liner with an underdrain system to prevent uncontrolled seepage during the thaw season and influxes of contaminated and/or brackish groundwater. Any new reservoirs should also have appropriately graded side slopes; slopes of 3H:1V for berms formed out of good quality granular fill and slopes of 4H:1V for berms formed out of the native fine grained soils.

Sources of suitable sand and gravel to serve as feedstock for a screening and crushing operation to procure good quality granular material were identified along the Station Creek, Blacktop Creek and Remus Creek watercourses. Of the three, Blacktop Creek was identified as the most practical location to site a screening and crushing plant.

It should be noted that this report presents the results only of a site reconnaissance and shallow test pitting investigation conducted using the available equipment on site. Prior to the detailed design of the sewage lagoon or water reservoir, a detailed geotechnical investigation using suitable drilling equipment should be conducted.

6. DIGITAL TOPOGRAPHIC SURVEY

WorleyParsons engaged Inukshuk Nunasi Geomatics (ING) to complete a topographic survey of the Station during the site reconnaissance. The topographic survey of the Station and surrounding areas included the airstrip, the water reservoir, the proposed lagoon locations and buildings, as required by WorleyParsons Canada Services Ltd (refer to Figure 1 and Figure 2). The purpose of the survey was to derive elevations of the existing surfaces.

The topographic survey was performed with Real Time Kinematic (RTK) GPS using Leica 1200 Systems; Total Station survey using Lieca Robotic TPS 1201; and scanning using Lieca C10 3D Scanner.

Surveyed co-ordinates and elevations were based on published values for GSD Monument 749167A and confirmed by means of check ties to NRCan Geodetic Survey Division (GSD) Monument 749167 along with post process to Canadian Active Control System (CACS) Station M059000 as well as using the NRCan Precise Point Positioning (PPP) Web site. A complete Topographic survey report can be found in Appendix 5. All files provided by ING are included in a CD attached to this document.

7. RECOMMENDATIONS

The following additional assessments and analysis are recommended to ensure a safe and reliable execution of the proposed infrastructure upgrades to the Station.

7.1 Water Supply and Distribution

- refine the design basis water demand by determining future population projections and water use;
- consider implementing water conserving practices at the Station to reduce water demand and storage requirements;
- recommend to the Water Survey of Canada (Environment Canada) that they provide a hydrometric gauging station at Station Creek to confirm available flow estimates and track the changes to flow in the future due to climate change;
- implement interim reservoir rehabilitation Option 1 to increase reliability of existing reservoir;
- refine the reservoir option analysis including:
  - additional geotechnical assessment to confirm the subsurface materials;
  - assessment of conflicts with existing and potential Station infrastructure;
  - additional topographic survey (Option 4 only);
  - study defining how to manage the contamination located immediately west;
  - provision of new pump house and pipeline routes and feasibility of trucking water or providing a pipeline to convey water from the reservoir to the treatment plant;
  - assess impacts of snow drift formation around the Station; and
  - investigate potential of intentionally accumulating snow above reservoir to limit ice formation and increase active storage depths.
- although not considered in this study, it appears that it might be feasible to replace the earthen reservoir with above ground, heated, and insulated water tanks. The tanks could be assembled onsite with minimal equipment and man-power. Further assessment of that option is required;
- perform a feasibility study and cost estimate for the provision of a permanent sea water intake that could operate throughout the winter. Re-evaluate the analysis presented in this Study;
- if desalination is further pursued as potential treatment option, a detailed assessment will be required to determine how to supply power to the treatment system; and

- during the next design phase, consideration should be given to relocating the chlorine dosing point to downstream of the treatment process. Current operation of the facility includes pre-chlorination, which can lead to the formation of disinfection by-products (DBP) such as halo acetic acids (HAA) and trihalomethanes (THM) in the treated water.

7.2 Wastewater Treatment Options Review

- complete the technology selection between the two kinds of attached growth systems and wastewater lagoons options such that further design refinement can be completed, including:
  - selection and sizing of key components of the system including the new wastewater transfer pipeline and pumps, wastewater treatment system and effluent discharge; and
- it is recommended that major components of the design be modeled to determine sizing and predict performance.

7.3 Fuel Drum Storage Area

It is recommended that the fuel drum storage area be altered from the original proposed location (Option 1) to the area east of the bulk fuel storage on the east end of the north apron (Option 2).

7.4 Geotechnical Investigation Report

- it should be noted that the geotechnical investigation report presents the results only of a site reconnaissance and shallow test pitting investigation conducted using the available equipment on site. Prior to the detailed design of the sewage lagoon or water reservoir, a detailed geotechnical investigation using suitable drilling equipment should be conducted;
- conduct an airport feasibility study to rehabilitate the existing runway and apron granular surfaces and to upgrade the runway shoulder areas to provide proper drainage; and
- complete a high level construction cost estimate of the proposed upgrades to the runway and the apron.

8. CLOSURE

We trust that this report satisfies your current requirements and provides suitable documentation for your records. If you have any questions or require further details, please contact the undersigned at any time.

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