# MUNICIPAL & COMMUNITY AFFAIRS
# GOVERNMENT OF NWT
# PLANNING STUDY - TRUCKFILL STATION
# CLYDE RIVER, N.W.T.
# DRAFT

Clyde River
Nunavut District



M.M. DILLON LIMITED
CONSULTING ENGINEERS,
PLANNERS, AND ENVIRONMENTAL
SCIENTISTS

94-2214-01
January 1995

DILLON
Consulting Engineers • Planners
Environmental Scientists

Our File: 94-2214-01
Your File: #SC 320524

January 19, 1995

Municipal & Community Affairs
Government of the N.W.T.
P.O. Box 1000
Iqaluit, N.W.T.
XOA OHO

Attention: Rick Armstrong,
Capital Programs Officer

**Clyde River Truckfill Station**
**Planning Study**

Dear Mr. Armstrong;

Dillon is pleased to forward three (3) copies of the draft report for the above project. By copy of this letter, we have also forwarded one copy to:

- Mr. Al Shevkenek, Manager
  Program Delivery and Standards

- Mr. Gordon Wray, Chairman
  NWT Water Board

At the request of Mr. Al Shevkenek, we have not forwarded a copy to the Community. We will send their copy after you have had an opportunity to review this document.

We trust this meets with your approval.

Yours truly,

M.M. DILLON LIMITED

Gary Strong, P.Eng.
Project Manager

GS:vw
Encls.

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APPENDICES

# 1.0 INTRODUCTION

## 1.1 General

The Department of Municipal and Community Affairs (MACA) is mandated to plan and develop water supply systems for the non tax based communities across the Northwest Territories. In accordance with this mandate, MACA has undertaken to plan a water supply system for the Community of Clyde River.

Several studies have been completed on the water supply system for this community. These studies and their findings are as follows:

- "Report on Water Supplies and Waste Disposal, Clyde River, N.W.T." J.W. Grainge, 1974. The recommendations from this report with respect to water supply were:

    - "The community should be planned for piped water and sewage..."

- "Predesign Report/Information on a community water supply system for Clyde River, N.W.T." Department Public Works, 1979 - internal document only. This report reviewed the use and capacity of the water supply lake. The results of this study suggest:

    - that the water supply lake had sufficient volume and recharge capacity to meet the needs of the community for the 20-year planning horizon (to 2009) based on a trucked system,

    - that the supply lake could not meet the system needs based on a piped system.

- "Clyde River Water Supply Analysis, Clyde River, N.W.T." Reinders Northern Limited, 1989. This report analyzed the capacity of the water supply lake, similar to the above report, however, this report based the analysis on bathometric survey data and a dynamic draw-down analysis, which were not available at the time of the previous study. This report concluded that the current water supply lake will provide sufficient water to meet the community's needs for the 20-year planning horizon (to 2012).

Based on the above reports, MACA is planning the construction of a truckfill station for the community. Prior to completing this work, MACA has identified two main issues that are to be addressed, namely:

- The requirement for an analysis of the winter storage and recharge capacity of the water supply lake to meet the community's needs beyond the 20-year horizon (to the 40-year planning horizon).

- The requirement for an analysis to compare a fully trucked system to a gravity pipeline with an in-town storage tank and truckfill system.

To complete the above assessments and complete a general planning study for the water supply system, MACA retained M.M. Dillon Limited in July of 1994.

## 1.2 Terms of Reference

The following are the specific Terms of Reference for this project reproduced from the project's Call for Proposal.

- "Visit the site before August 15, 1995. Meet with the Hamlet foreman and Senior Administration Officer to discuss the water source and future truckfill station. Solicit any information that will be useful on the subject.

- Undertake a decision analysis to select the most favourable site for a truckfill station at the water lake considering economic feasibility.

- Review the site selected in terms of:

  - Vehicle access, road and station requirements,

  - Drainage around the site, seasonal run-off, snowdrifting,

  - The geotechnical suitability of the site; consider access roads, turn-around at the truckfill station and intake (single line),

  - Location of the fill line with regard to available bathometric data, ice conditions and a dynamic draw down analysis. The depth and location of the intake are to be recommended.

    - Proximity to granular sources that may be required for access road construction or truckfill pad construction.

- Prepare a Class 'C' cost estimate of project cost for the following:

    - A truckfill station, access road, truck turn-around and site drainage.

    - Truckfill station powered using pole line service and a station using a motor-generator set with a back-up supply. (Note MACA Standards and Criteria). The cost of the installation of pole line service compared to station operating costs using on-site generator power over a 20-year period is to be studied.

    - Heat traced intake (single line) as per MACA Standards and Criteria Guidelines.

- Prepare a preliminary site plan showing the location of the proposed access road, truckfill station, truck turn-around, fill line and site drainage. A profile of the proposed intake line is to be provided.

- Study the water quality and water temperature at two meter intervals from the bottom of the deepest section of the water lake. Water quality tests must include dissolved oxygen, and all parameters used in compliance testing for potable water. Any deviation of results from "Guidelines for Canadian Drinking Water" are to be highlighted. Sampling should be conducted from the ice surface in June, if possible.

- It is anticipated in the 20 - 40 year range that the outlet structure on the water supply will need to be raised to increase the water supplies capacity. The consultant is to complete a cost/benefit analysis of raising the outlet structure.

  The recharge of the water supply from another source may be necessary. The consultant would propose the method and location of recharge if the outlet structure were raised.

- The consultant is to do a cost comparison of a fully trucked water system using a truckfill station and a gravity pipeline system with an in-town storage tank a truckfill station. Compare the cost effectiveness of the two methods using MACA study guidelines.

- Determine whether fluoridation of the water source is practical. What method would be recommended to fluoridate the water? What initial cost would be associated with fluoridation; is it feasible?

- Review the site chosen with respect to any concerns that regulatory agencies may have. Regulatory agencies that may have concerns are:

  - NWT Water Board

  - Baffin Regional Health Board

  - Department of Indian and Northern Affairs

  - Department of Fisheries and Oceans

  - Department of Renewable Resources"

## 1.3 Cost Analysis

Throughout this document, there are cost analyses of various options. The analyses have been carried out as outlined by the Government of Northwest Territories' (GNWT's) General Terms of Reference as outlined below.

*Capital Cost* - Cost of construction for a facility.

*Annual Operation and Maintenance Costs* - The cost of operation, which may include manpower, energy requirements, fuel, general maintenance (light bulbs, paint), and equipment replacement.

*Life Cycle Costs* - The calculation of the total facility cost over a 20 Year period. This includes the capital and operation and maintenance costs. The life cycle value is shown as a present value which is calculated at an 8% discount rate.

# 2.0 COMMUNITY INFORMATION

## 2.1 General

### *Location*

Clyde River is situated on the eastern shore of Baffin Island, near the outlet of the Clyde River into Patricia Bay. Located at 70° 28' North and 68° 36' West, it is approximately 740 air miles (1,180 km) north of Iqaluit.

### *Climate*

The climate in Clyde River is typical of areas north of the Arctic Circle. The winters are long and cold, and the summers are short and cool. Precipitation is low throughout the year, with 46 mm of rainfall and 1,689 mm of snowfall, which results in a total of 206 mm of precipitation. The following is the climatic data for the community.

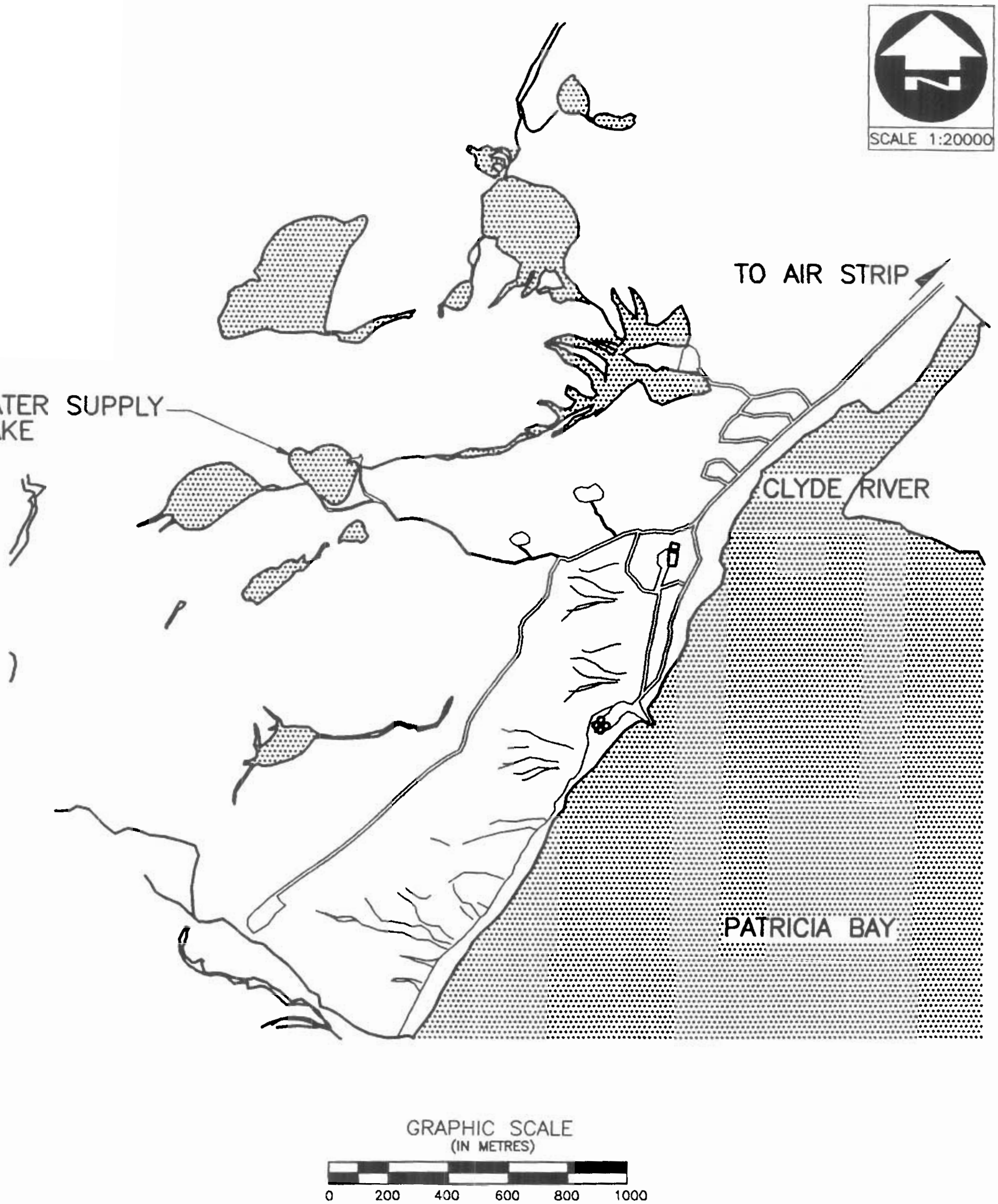
| | **Mean High Temp** | **Mean Low Temp** |
|---|---|---|
| January | - 22.5°C | - 30.3°C |
| July | + 7.8°C | + 0.4°C |

## 2.2 Site Investigation

The community currently uses a small lake located approximately 1.0 kilometres west of the community as the potable water source. **Figure 2.1** illustrates the location of the lake, the access road, and the location of the community. There are two accesses to the lake, described as follows:

- The south access was used in the past, however; as reported by the community, snowdrifting problems along the south side of the lake made access difficult in the winter.

- The access on the east side of the lake is near the outflow of the lake. This area does not have a reported snowdrifting problem, and is the only access currently used.

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TRUCKFILL STATION PLANNING STUDY
CLYDE RIVER, NWT

PROJECT NUMBER
94–2214

TITLE
SITE LOCATION

FIGURE NUMBER
2.1

On July 26 and 27th, 1994, a site investigation was completed. During the site investigation, the following activities were undertaken.

- Interview with the Hamlet representatives were completed.
- Site survey data was recorded.
- Water samples were recovered for later laboratory testing.
- Complete a geotechnical review of the potential sites.

A meeting was held with representatives of the Hamlet. In this meeting, the following information with respect to the existing water supply system was provided by the Hamlet's representatives.

- The existing water lake is a natural lake.
- Only the right side (east) draw-off location is now used. The left side draw-off has had snowdrifting problems.
- The prevailing winds are from the northwest.
- The community, in general, has a snowdrifting problem. A snow fence project is scheduled for the 1995/96 fiscal year.
- Several times per year, the road between the community and the water lake is blocked due to snowdrifting.
- The community residents are satisfied with the quality of the lake water (i.e. no reported taste problems).
- Disinfection of the water is provided by the addition of Javex bleach to each truck load of water.
- The following is a list of equipment available to the Hamlet:
    - Two (2) bulldozers,

- Two (2) water trucks - 2,000 gal (9,000 l),
  - 1,500 gal (6,800 l),

- Two (2) dump trucks,

- Two (2) sewage trucks.

- Twenty to thirty (20-30) minutes is required for a water truck to leave the community, refill at the lake, and return to the community. In-town delivery times vary.

- Only one water truck is currently operated for water supply. It runs from 8 a.m. to 11 p.m. 6 days/week to meet the community needs.

- Current population is slightly over 600 people.

- In the past, residents used the water lake water shed area for recreation and hunting. Through discussion and education, the Hamlet has stopped these activities in the water shed area to protect the potable water source.

## Site Survey

In 1989 a bathometric survey of the water lake was undertaken by the Department of Public Works. This data was compiled and a contour plan produced by Reinders in their 1989 report. During the site investigation in July, 1994, supplementary survey data was collected to aid in the definition of the catchment area of the water lake. This data is discussed in a later section.

## Geotechnical Investigation

The sites were reviewed for geotechnical suitability by Agra Earth and Environmental. The findings of the review are contained in their report dated December 21, 1994 (appended). A summary of the results is provided below:

- Three (3) test pits were excavated in the vicinity of the existing draw-off location. Frozen ground was experienced at approximately 1.0 m below grade.

- The soils encountered at the site generally consisted of a fine to course grained, loose, brown sand overlying a brown, frozen silt.

- There are several potential borrow sources for granular material that are available for construction. Two of these are shown on Figure 1.2 of Agra's report.

- The foundation for a truckfill station, located at the water lake, is recommended to be constructed of 1.0 m thick granular material. This will allow the active layer to remain within the granular pad.

- Intake line protection can be provided by installing large diameter rocks (armour, rip rap) along the intake pipe.

- The existing roadway is subject to some instability, as evidenced by cracks paralleling the roadway along the slope to the lake. Boulders are to be installed along the shoreline to stabilize the road.

Generally, the geotechnical review indicates that the draw-off location can support a truckfill station.

## 2.3 Water Consumption and Population

The following table illustrates the historical and present water consumption and populations.

| Year | Population | Growth Rate | Water Consumption (L.C.D.) |
|---|---|---|---|
| 1974 | 350 | 4.6% | |
| 1979 | 439 | 4.5% | 20.6 |
| 1981 | 443 | 1.2% | |
| 1986 | 471 | 3.7% | |
| 1989 | 500 | | 49.2 |
| 1991 | 565 | 2.4% | 49.9 |
| 1993 | 592 | 1.5% | 480 |
| 1994 | 601 | | |

MACA's guidelines identify the following water consumption for a community below 2,000 people serviced by a truckfill system.

*Residential Consumption = 90 lcd*

*Commercial Component = 90 x 0.00023 x population*

The Bureau of Statistics for the Northwest Territories provides population projections for all communities in the Northwest Territories with populations of over 100 people. These projections for Clyde River are shown below.

| Year | Population | Annual Rate of Increase |
|---|---|---|
| 1996 | 639 | 2.36% |
| 2001 | 718 | 2.69% |
| 2006 | 820 | |

Using the above data, **Table 2.1** shows the projected population and water consumption for the 20 and 40 Year planning horizon and this data is graphically illustrated in **Figure 2.2**. Current consumption rates have been assumed to increase to MACA's guidelines over a five year period.

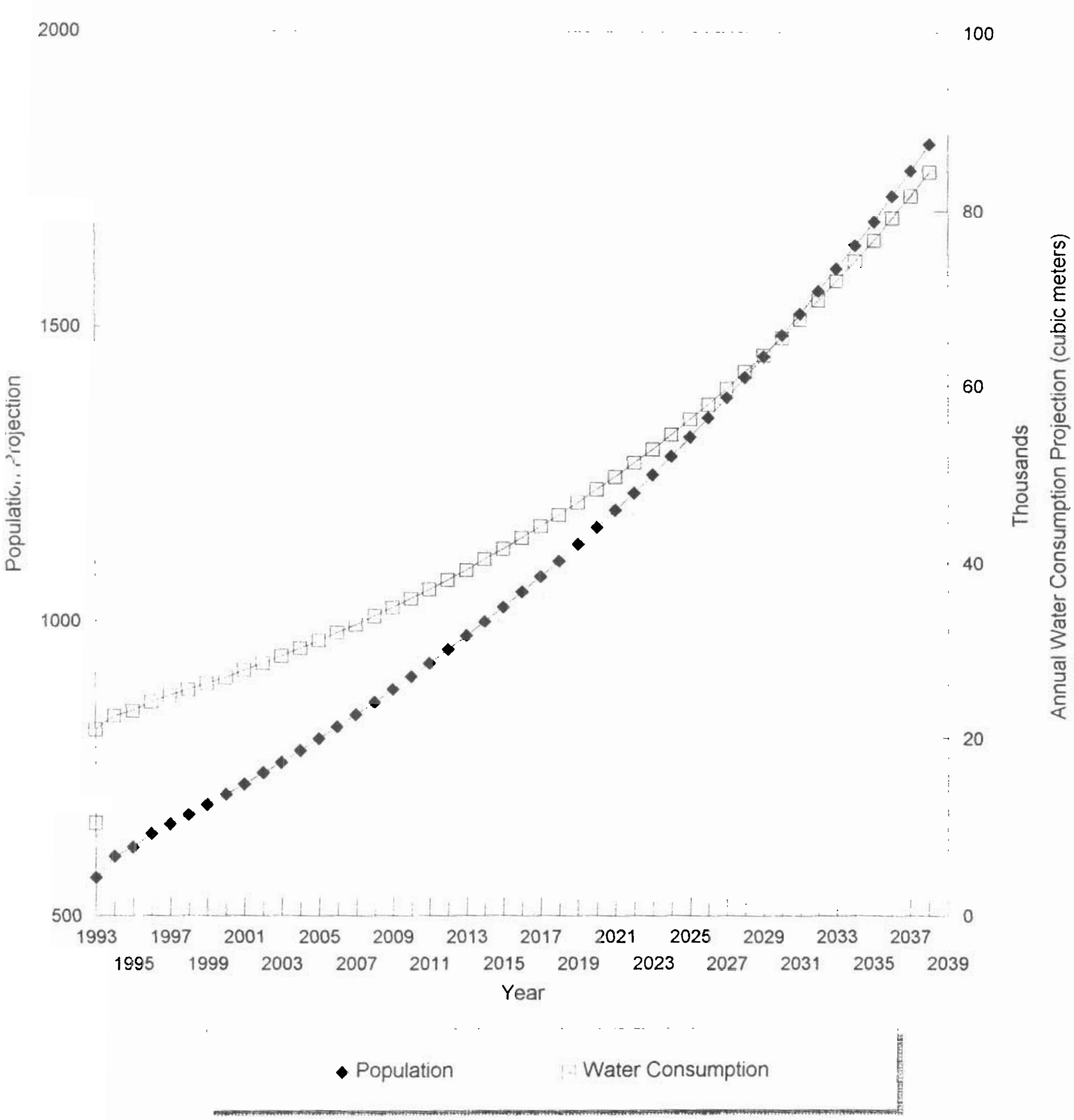
| Year | Notes | Population | Liters per Capita per Day (lcd) | Consumption Daily (l/day) | Annual (cubic m/year) |
|---|---|---|---|---|---|
| 1993 | | 565 | 51 | 28,691 | 10,472 |
| 1993 | | 565 | 102 | 57,500 | 21,000 |
| 1994 | | 601 | 102 | 61,600 | 22,500 |
| 1995 | | 616 | 103 | 63,300 | 23,100 |
| 1996 | | 639 | 103 | 66,000 | 24,100 |
| 1997 | | 655 | 104 | 67,800 | 24,800 |
| 1998 | Year 0 | 672 | 104 | 69,800 | 25,500 |
| 1999 | | 688 | 104 | 71,800 | 26,200 |
| 2000 | | 706 | 105 | 73,800 | 26,900 |
| 2001 | | 723 | 105 | 75,900 | 27,700 |
| 2002 | | 742 | 105 | 78,100 | 28,500 |
| 2003 | | 760 | 106 | 80,400 | 29,300 |
| 2004 | | 779 | 106 | 82,700 | 30,200 |
| 2005 | | 799 | 107 | 85,100 | 31,100 |
| 2006 | | 819 | 107 | 87,600 | 32,000 |
| 2007 | | 840 | 107 | 90,200 | 32,900 |
| 2008 | | 861 | 108 | 92,800 | 33,900 |
| 2009 | | 882 | 108 | 95,500 | 34,900 |
| 2010 | | 905 | 109 | 98,400 | 35,900 |
| 2011 | | 927 | 109 | 101,300 | 37,000 |
| 2012 | | 951 | 110 | 104,300 | 38,100 |
| 2013 | | 975 | 110 | 107,400 | 39,200 |
| 2014 | | 999 | 111 | 110,600 | 40,400 |
| 2015 | | 1024 | 111 | 113,900 | 41,600 |
| 2016 | | 1050 | 112 | 117,300 | 42,800 |
| 2017 | | 1076 | 112 | 120,900 | 44,100 |
| 2018 | Year 20 | 1103 | 113 | 124,500 | 45,400 |
| 2019 | | 1131 | 113 | 128,300 | 46,800 |
| 2020 | | 1160 | 114 | 132,200 | 48,300 |
| 2021 | | 1189 | 115 | 136,200 | 49,700 |
| 2022 | | 1219 | 115 | 140,400 | 51,300 |
| 2023 | | 1249 | 116 | 144,700 | 52,800 |
| 2024 | | 1281 | 117 | 149,200 | 54,500 |
| 2025 | | 1313 | 117 | 153,800 | 56,200 |
| 2026 | | 1346 | 118 | 158,600 | 57,900 |
| 2027 | | 1380 | 119 | 163,600 | 59,700 |
| 2028 | | 1414 | 119 | 168,700 | 61,600 |
| 2029 | | 1450 | 120 | 174,000 | 63,500 |
| 2030 | | 1487 | 121 | 179,500 | 65,500 |
| 2031 | | 1524 | 122 | 185,200 | 67,600 |
| 2032 | | 1562 | 122 | 191,100 | 69,800 |
| 2033 | | 1601 | 123 | 197,200 | 72,000 |
| 2034 | | 1642 | 124 | 203,600 | 74,300 |
| 2035 | | 1683 | 125 | 210,100 | 76,700 |
| 2036 | | 1725 | 126 | 216,900 | 79,200 |
| 2037 | | 1769 | 127 | 223,900 | 81,700 |
| 2038 | Year 40 | 1813 | 128 | 231,200 | 84,400 |

**Table 2.1 Projected Population and Water Consumption**
**Truckfill Station Planning Study, Clyde River, NWT**

Municipal and Community Affairs
M.M. Dillon Limited

# Figure 2.2 Population and Water Consumption Projections

Truckfill Station Planning Study, Clyde River, NWT



# 3.0 WATER SUPPLY

## 3.1 General

The current water supply lake provides water of acceptable taste to the residents, is the closest possible water source, and is outside the future development areas for the community. For these reasons, MACA has identified the existing source as the potential long term water supply. The lake is assessed to verify that:

- The water meets the Guidelines for Canadian Drinking Water Quality.
- There is sufficient under-ice winter storage within the lake to meet the long term needs of the community.
- There is sufficient annual recharge for the long term needs of the community.

The following sections discuss each of the above analyses.

## 3.2 Water Quality

Water sampling and testing of the water lake has been completed over several years by various government agencies, including; Department of Health, Department of Indian and Northern Affairs (DIAND), and the Department of Public Works and Services. During the site investigation on July 26, 1994, additional water samples were taken. All water previous to 1994 had been sampled from the surface water at the lake's edge. Samples taken in 1994 were recovered from approximately 40 m offshore and at varying water depths. The purpose of sampling at the various depths was to ascertain if the water quality of the lake varies with depth. The results of all water sampling is shown in **Table 3.1**.

In general, the water is of good quality and suitable for a potable water source. Areas where the water quality exceeds the guidelines are highlighted in the Table and discussed below.

The water pH was recorded to be below the aesthetic objectives on two samples. The remaining samples would suggest that the water pH is generally in the low range of acceptable pH levels. A low pH indicates that the water may be aggressive towards corrosion of metallic piping and plumbing fixtures. No reported problems exist with the current plumbing systems in the houses. This should be monitored by the GNWT, and if corrosion becomes a concern, the addition of a buffering agent to the water should be considered.

The water data indicates that turbidity ranged from 1.0 to 15.0 with an average of 3.0 over the testing period. The water quality was over the aesthetic objective on three of the sixteen test samples, over a 12 year period. There was no concern with the appearance of the water from the residents. Therefore, it would appear that the aesthetics of the water are acceptable to the community. The maximum acceptable concentration for turbidity is 1.0, unless it can be shown that the increased level of turbidity does not affect the disinfection of the water. The community has used the water source for many years, with no reported illness related to the water supply. It can be suggested that the increased level of turbidity is acceptable for this water source.

The Terms of Reference for this project indicated that dissolved oxygen (DO) was to be sampled at the end of the under-ice storage period. Experience in the Northwest Territories indicates that water reservoirs that are drawn down over the winter months can have a taste that deteriorates in the late winter and early spring. Ideally, dissolved oxygen should be sampled in late May, just prior to the ice melting off the lake. Unfortunately, due to the contract award date, the site visit could not be undertaken until late July. There was no ice on the lake and, therefore, the under-ice water quality could not be assessed. Dissolved oxygen readings were not taken, as the results would not provide useful information with respect to the under-ice water quality.

The community does not have a concern with the taste of the water in the late winter. This anecdotal information suggests that the dissolved oxygen and other parameters do not deteriorate the quality of the water in the late winter.

Sampling of the under-ice water quality could be completed next spring to ascertain the dissolved oxygen level.

## 3.3 Winter Storage

In 1989, Public Works and Services completed a bathometric survey of the water lake. Based on this survey data, the volume of water stored in the lake is approximately 120,000 $m^3$. The elevations provided in this report are related to the benchmark elevations of 100.000 m found on the base map in the Reinder's Report. This benchmark is arbitrary and has not been related to geodetic data elevation. Volumetric calculations are based on the survey data and mapping provided by the GNWT and plotted as part of the Reinder's Report.

The GNWT has identified a concern that there may be insufficient under-ice storage available for the winter consumption needs of the community. To analyze the available under-ice storage, two methods were used.

1) Static storage model. The model assumes that the ice will form to the maximum ice depth at the top of the lake. This model has been shown to be conservative.

2) Dynamic draw down model. This model accounts for the incremental ice growth over the freezing season and the draw down effect caused by water consumption over the freezing season. This is a less conservative model than the static storage model.

To complete the under-ice storage calculations, the following data was used:

- The population and water consumption projections described in Section 2.
- The monthly average degree days as provided by Atmospheric Environmental Services, Environment Canada (AES).
- The bathometric survey data provided by the Department of Public Works and Services.

The detailed calculations for each model shown in Appendix 2 of this report and the results are summarized in **Table 3.2** below.

**TABLE 3.2**

| | | Planning Year 2018 | | | Planning Year 2038 | | |
|---|---|---|---|---|---|---|---|
| **Method of Analysis** | **Start Lake Level** | **Ice Volume ($m^3$)** | **Consumption ($m^3$)** | **Final Lake Level** | **Ice Volume ($m^3$)** | **Consumption ($m^3$)** | **Final Lake Level** |
| Static Storage | 89.15 | 37,883 | 45,400 | 82.733 | 37,883 | 94,400 | N/A |
| Dynamic Draw Down | 89.15 | 28,832 | 45,400 | 84.521 | 19,888 | 84,400 | 80.143 |

The above table shows that there is sufficient water storage for the 20 Year design horizon for both the static and dynamic draw down models.

In the 40 Year horizon, the static model calculates that there is insufficient water available for consumption. The dynamic model calculates that there is sufficient water for the 40 Year planning horizon. The GNWT has indicated that the dynamic model provides a good estimate of the winter storage capacity of water reservoirs. Therefore, the data shows there is sufficient storage to meet the community needs on the 40 Year horizon.

At the 40 Year planning year, approximately 7,000 $m^3$ of water remains available after the expected consumption requirements. This represents about 8% of the annual consumption. It can be expected that the water basin will provide sufficient storage to approximately year 45 of the planning horizon.

Based on these projections, a cost benefit analysis of raising the water level in the lake to meet the 40 Year horizon, as outlined in the Terms of Reference, is not required. It is suggested that within the 20 to 40 Year planning period, an additional study be completed, to assess the need to raise the outlet of the lake.

The Reinder's Report suggested a water intake elevation of 77.00 m. This is consistent with the above calculations and it is recommended that this be the intake elevation for the water supply system.

## 3.4 Lake Recharge

During the site investigation of July 1994, additional survey data was collected to define the drainage catchment area for the water lake. The drainage area is shown on **Figure 3.1** and is approximately 40.0 ha, of which 3.0 ha is the surface area from the water lake, and 4.6 ha is the surface area of the lake immediately upstream of the water lake.

The data climate from AES is shown in Section 2.1. Total water equivalent precipitation is 206 mm. To calculate the volume of water that flows through the water lake, a water budget/water balance analysis is required. Key components of this calculation would include:

- Annual precipitation
- Evaporation rates
- Wind velocities
- Daily temperatures

The Cold Climate Manual indicates the field testing for evaporation rates is required to develop useful estimates of the water balance. AES does not have evaporation rates for the Clyde River weather station, and the scope of work for this assignment precludes compiling this data by field work.

The Department of Indian and Northern Affairs is currently completing a field program for the evaporation from the tailings ponds in Nanisivik. These ponds are shallow (approximately 2.0 m in depth) and as a result, the data is not completely transferable to the water lake at Clyde River. The evaporation rates from Nanisivik are:

| | |
|---|---|
| 1993 | 254 mm/year |
| 1994 | 219 mm/year |

These values represent evaporation from the water surface only. No work has been completed for the evaporation from no water surfaces (i.e. tundra).

The following table indicates the water available for consumption at various evaporation rates, over the 20 and 40 Year planning periods.

| Evaporation from Tundra | Evaporation from Lakes | Total Available | Net Available | Year of No Water |
|---|---|---|---|---|
| 0% | 250 mm | 82,400 | 63,400 | 2029 |
| 0 m³ | 19,000 | | | |
| 5% | 250 mm | 82,400 | 60,200 | 2027 |
| 3,200 m³ | 19,000 | | | |
| 10% | 250 mm | 82,400 | 57,000 | 2026 |
| 6,400 m³ | 19,000 | | | |
| 15% | 250 mm | 82,400 | 53,900 | 2024 |
| 9,500 m³ | 19,000 | | | |
| 20% | 250 mm | 82,400 | 50.400 | 2022 |
| 13,000 m³ | 19,000 | | | |
| 25% | 250 mm | | 46,400 | 2019 |
| 17,000 m³ | 19,000 | | | |
| 0 | 150 mm | 82,400 | 71,000 | 2037 |
| 0 m³ | 11,000 m³ | | | |
| 5% | 150 mm | 82,400 | 68,000 | 2032 |
| 3,200 m³ | 11,000 | | | |
| 10% | 110 mm | 82,400 | 65,000 | 2031 |
| 6,440 m³ | 11,000 | | | |
| 15% | 150 mm | 82,400 | 62,000 | 2029 |
| 9,500 m³ | 11,000 | | | |
| 20% | 150 mm | 82,400 | 58,000 | 2027 |
| 13,000 m³ | 11,000 | | | |
| 25% | 150 mm | 82,400 | 54,000 | 2024 |
| 17,000 m³ | 11,000 | | | |

| Evaporation from Tundra | Evaporation from Lakes | Total Available | Net Available | Year of No Water |
|---|---|---|---|---|
| 0 | 50 mm | 84,400 | 80,000 | 2036 |
| 0 $m^3$ | 4,000 $m^3$ | | | |
| 5% | 50 mm | 84,400 | 77,000 | 2035 |
| 3,200 $m^3$ | 4,000 $m^3$ | | | |
| 10% | 50 mm | 84,400 | 74,000 | 2034 |
| 6,400 $m^3$ | 4,000 $m^3$ | | | |
| 15% | 50 mm | 84,400 | 71,000 | 2032 |
| 9,500 $m^3$ | 4,000 $m^3$ | | | |
| 20% | 50 mm | 84,400 | 67,000 | 2031 |
| 13,000 $m^3$ | 4,000 $m^3$ | | | |
| 25% | 50 mm | 84,400 | 64,000 | 2029 |
| 17,000 $m^3$ | 4,000 $m^3$ | | | |

The above table indicates that the recharge capacity of the water shed for the water lake will meet the water demand over the 20 Year planning horizon and will not meet the needs for the 40 Year demand.

It is expected that the evaporation loss from the lake surface will be less than the value recorded by DIAND. The water temperatures for the water lake will be lower than the shallow tailings pond, and this will result in a lower evaporation value.

Evaporation rates for tundra have not been field verified, however, others (Reinders) have used a value of 15%. Based on this value and a reduced lake evaporation of 150 mm, the recharge capacity will meet the needs of year 2029 (or planning year 31).

To increase the recharge of the water lake to meet the 20 to 40 Year needs, two methods are possible:

- Install a snow fence within the water shed to increase the collection of precipitation (reference Cold Regions Design Manual).

- Install a pipeline to seasonally fill the water lake from a lake or river outside the water shed (used elsewhere in the Northwest Territories).

Potential water sources exist in the form of lakes to the northwest and to the east of the water lake. Pipeline distances to these lakes are approximately 950 m and 400 m. No water quality data exists for these lakes, so the suitability as a potable water source is not known.

A cost estimate for the snow fence and pipeline options is shown below.

| Option | Capital | Annual Costs | Life Cycle Costs |
|---|---|---|---|
| Snow Fence | $ 250,000 | $ 5,000 | $ 300,000 |
| Lake to Northwest | | | |
| • Pipeline | $ 200,000 | $ 5,000 | $ 250,000 |
| • Pumps | 10,000 | 1,000 | 20,000 |
| • Road | 270,000 | 27,000 | 540,000 |
| | | TOTAL | $ 810,000 |
| Lake to East | | | |
| • Pipeline | $ 80,000 | $ 3,000 | $ 110,000 |
| • Pumps | 10,000 | 1,000 | 20,000 |
| • Roads | 120,000 | 12,000 | 240,000 |
| | | TOTAL | $ 370,000 |

The most economical option based on preliminary estimates, is the use of a snow fence. The viability of this option should be assessed with respect to:

- Natural terrain features that may affect snow collection.
- Wind directions and velocity.
- Deviation in wind directions and annual snow fall which may affect the minimum annual recharge capacity.

It is suggested that within the 20 to 40 Year planning period, the water quality of the lake to the east be assessed for use as a potable water source and a recharge source. The use of a snow fence should be investigated further.

# 4.0 WATER SUPPLY SYSTEM

## *Systems*

The following water supply systems are identified by the GNWT for analysis.

Option A - A truckfill station at the current draw-off location on the water lake.

Option B - A truckfill station at the old draw-off location on the water lake.

Option C - A gravity feed pipeline from the water lake to a storage tank in town and a truckfill station adjacent to the storage tank.

Each of the above systems are shown in **Figure 4.1**. The various system components are described below.

## *Prime Power and Back-Up Power Supply*

The electrical power required for a truckfill station at the water lake can be supplied by either a power line from the community or on-site power generation. Back-up supply can be in one of two forms, either a standby generator or a uninterrupted power supply (UPS) system. Typically, the standby generator is located within the truckfill station if prime power is supplied by a power line. For on-site generation, a standby unit is stored in the Hamlet garage. A UPS system is a battery bank that permits monitoring and control functions to be maintained while the prime power is unavailable. The cost analysis of these alternatives is shown below.

| Option | Capital Cost | Annual Cost | Life Cycle Cost |
|---|---|---|---|
| Power line c/w standby generator | $ 300,000 | $ 30,000 | $ 500,000 |
| Power line c/w UPS | 250,000 | 20,000 | 420,000 |
| On Site generation c/w standby generator | 130,000 | 40,000 | 520,000 |
| On Site generator c/w UPS | 120,000 | 30,000 | 420,000 |

| Date S | | Aug 26/83 | Mar 13/84 | Oct 24/84 | Sept 10/85 | Sept 11/85 | Dec 1/87 | July 26/94 | | | | | | GCDWQ [illegible]NES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Depth (m): | | 0 | 0 | 0 | 0 | 0 | 0 | | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 | 12.0 | | | |
| PARAMETER | NOTES | | | | | | | | | | | | | Maximum Acceptable Concentrations | Interim Maximum Acceptable Concentrations | Aesthetic Objectives (Max. Conc.) |
| Ammonia | | | | | | | | | 0.0250 | 0.0090 | 0.0030 | 0.0030 | 0.0110 | 0.0005 | | | |
| Arsenic | | 0.0010 | 0.0010 | | | <0.5 | | <0.005 | 0.0003 | <0.003 | 0.0003 | <0.0003 | 0.0003 | 0.0003 | 0.05 | 0.025 | |
| Cadmium | | <0.05 | 0.0013 | | | | | <0.0002 | | | | | | | 0.005 | | |
| Calcium | | <0.10 | 0.50 | 0.20 | 1.20 | <1.0 | 1.70 | <1.0 | 0.67 | 0.62 | 0.62 | 0.59 | 0.62 | 0.62 | | | |
| Chloride | | 2.00 | 4.50 | 3.80 | 3.20 | 3.30 | 4.10 | 3.90 | 2.42 | 2.34 | 2.30 | 2.29 | 2.31 | 2.28 | | | 250 |
| Chromium | | 0.0080 | 0.0045 | | | | | 0.0030 | | | | | | | 0.05 | | |
| Color (TCU) | 2 | <5.0 | <5.0 | 10.0 | 15.0 | 10.0 | 10.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | | | 15 |
| Conductivity (μmho/cm) | | 18.0 | 36.0 | 29.0 | 28.9 | 9.0 | 46.1 | 22.5 | 23.2 | 22.5 | 22.3 | 22.2 | 22.6 | 22.3 | | | |
| Copper | | | | | | | | 0.003 | | | | | | | | | 1.0 |
| Iron | | 0.0555 | 0.0400 | 0.2300 | 0.2300 | | 0.0200 | 0.0055 | | | | | | | | | 0.3 |
| Lead | | | 0.0057 | | | | | <0.001 | | | | | | | 0.01 | | |
| Magnesium | | 0.53 | 0.80 | 0.60 | 0.20 | 0.54 | 0.80 | 0.60 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.60 | | | |
| Manganese | | | | 0.006 | 0.005 | | <0.01 | | | | | | | | | | 0.05 |
| Mercury | | 0.00010 | 0.00006 | | | | | | 0.00022 | 0.00002 | | | 0.00030 | | 0.001 | | |
| Nickel | | | 0.001 | | | | | 0.001 | | | | | | | | | |
| Ortho Phosphate | 3 | | | | | | | | <0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | | | |
| pH (unitless) | | 6.50 | 6.60 | 6.90 | 7.43 | 4.10 | 6.90 | 6.76 | 6.48 | 6.53 | 6.59 | 6.58 | 6.58 | 6.60 | | | 6.5 - 8.5 |
| Potassium | | 0.35 | 0.70 | 0.70 | 0.60 | 0.60 | 0.60 | 0.50 | 0.58 | 0.41 | 0.41 | 0.41 | 0.42 | 0.42 | | | |
| Silica | | | | | | | | | 0.061 | 0.135 | | | | | | | |
| Sodium | | 1.80 | 3.60 | 2.70 | 3.60 | 2.35 | 2.70 | 2.50 | 2.13 | 1.90 | 1.92 | 1.89 | 1.91 | 1.90 | | | 200 |
| Sulphate | | <1.0 | 1.5 | 2.0 | 2.0 | 2.0 | <1.0 | <2.0 | <3.0 | <3.0 | <3.0 | <3.0 | <3.0 | <3.0 | | | 500 |
| Suspended Solids | | <5 | <5 | | | | | <3 | <3 | <3 | <3 | <3 | <3 | <3 | | | |
| Total Alkalinity | 4 | 3.1 | 5.8 | 8.2 | 8.4 | Note 1. | 7.5 | 4.0 | 3.1 | 3.1 | 3.1 | 3.0 | 3.1 | 3.0 | | | |
| Total Dissolved Solids | | | | | | | | 19.0 | 17.0 | <10.0 | 13.0 | 10.0 | 10.0 | 11.0 | | | 500 |
| Total Hardness | 4 | 2.36 | 4.50 | 3.00 | 3.80 | 4.20 | 7.40 | 5.00 | 3.70 | 3.60 | 3.60 | 3.50 | 3.60 | 4.00 | 500.00 | | 100 |
| Total Kjeldahl N | 5 | | | | | | | | <0.008 | <0.008 | | | | | | | |
| Total Nitrates | 6 | | | 0.050 | 0.050 | | <0.05 | <0.04 | <0.008 | <0.008 | 0.011 | 0.011 | 0.038 | 0.012 | 45.0 | | |
| Total Nitrites | 6 | | | 0.005 | 0.003 | | <0.05 | | | | 0.011 | 0.011 | 0.038 | 0.012 | 3.2 | | |
| Total Phosphorus | 3 | | | | | | | <0.005 | <0.002 | 0.008 | 0.007 | 0.005 | 0.010 | 0.008 | | | |
| Turbidity (NTU) | 7 | 1.5 | 0.6 | 5.0 | 6.5 | 6.0 | 1.0 | 15.0 | 2.2 | 2.2 | 2.0 | 2.1 | 2.1 | 2.3 | 1 | | 5 |
| Zinc | | 0.0440 | 0.0052 | | | | | 0.0010 | | | | | | | | | 5 |

**Notes**

All Results are expressed in mg/L, unless indicated in brackets ( ).

Blank cells indicate that the sample was not tested for that parameter.

Shaded cells indicate that the sample exceeds the GCDWQ guidelines for the indicated parameter.

1. Sample was too acidic for alkalinity titration.
2. TCU - True Color Units
3. Ortho Phosphate, and Total Phosphorus are stated in terms of mg/L of P (phosphorus)
4. Total Hardness, and Total Alkalinity are stated in terms of mg/L of CaCO3 (calcium carbonate)
5. Total Kjeldal N is stated in terms of mg/L of N (Nitrogen)
6. Equivalent to 10.0 mg/L nitrate as nitrogen, where nitrate and nitrite are determined separately. Levels of nitrite should not exceed 3.2 mg/L
7. NTU - Neophelometric Turbidity Units

**Table 3.1 Water Quality Results**
**Truckfill Station Planning Study, Clyde River, NWT**

Municipal and Community Affairs
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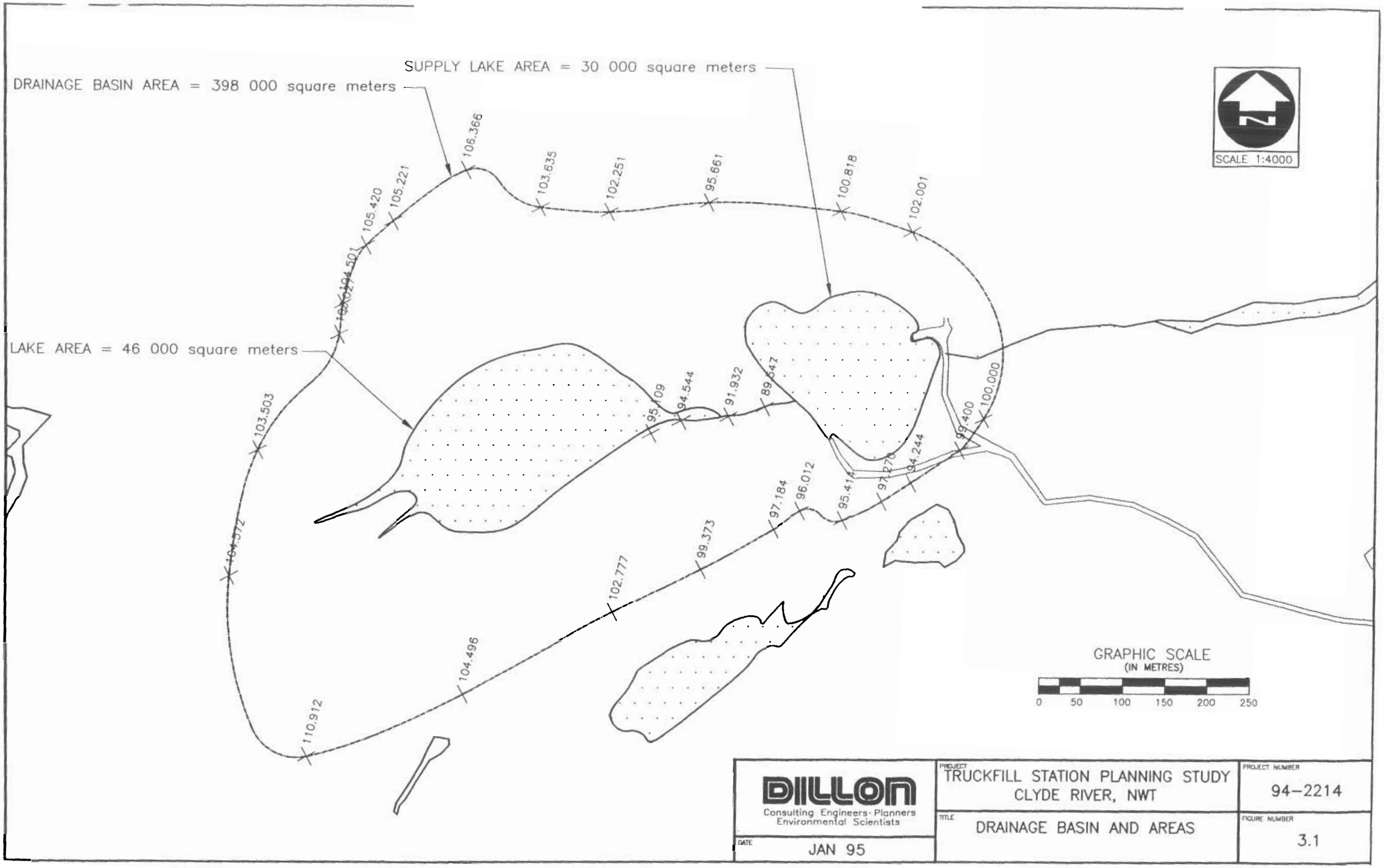
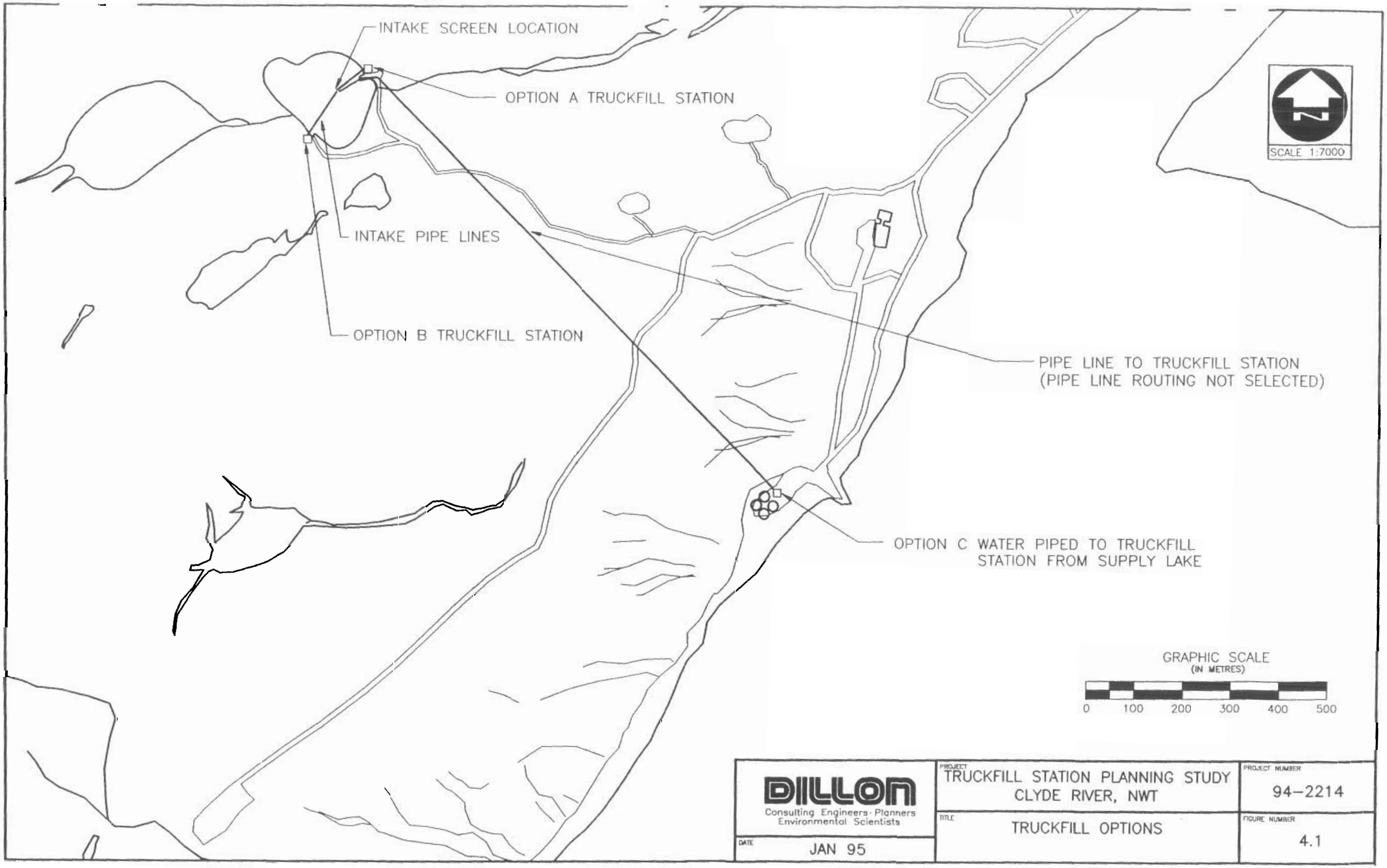


DRAINAGE BASIN AREA = 398 000 square meters
SUPPLY LAKE AREA = 30 000 square meters
LAKE AREA = 46 000 square meters
SCALE 1:4000
106.366
103.635
102.251
95.661
100.818
102.001
105.221
105.420
104.501
103.503
104.572
110.912
104.496
102.777
99.373
97.184
96.012
95.414
97.270
94.244
99.400
100.000
95.109
94.544
91.932
89.547
GRAPHIC SCALE
(IN METRES)
0 50 100 150 200 250
DILLON
Consulting Engineers · Planners
Environmental Scientists
DATE
JAN 95
PROJECT
TRUCKFILL STATION PLANNING STUDY
CLYDE RIVER, NWT
TITLE
DRAINAGE BASIN AND AREAS
PROJECT NUMBER
94-2214
FIGURE NUMBER
3.1


INTAKE SCREEN LOCATION
OPTION A TRUCKFILL STATION
INTAKE PIPE LINES
OPTION B TRUCKFILL STATION
PIPE LINE TO TRUCKFILL STATION
(PIPE LINE ROUTING NOT SELECTED)
OPTION C WATER PIPED TO TRUCKFILL
STATION FROM SUPPLY LAKE
SCALE 1:7000
GRAPHIC SCALE
(IN METRES)
0 100 200 300 400 500
DILLON
Consulting Engineers · Planners
Environmental Scientists
DATE
JAN 95
PROJECT
TRUCKFILL STATION PLANNING STUDY
CLYDE RIVER, NWT
TITLE
TRUCKFILL OPTIONS
PROJECT NUMBER
94–2214
FIGURE NUMBER
4.1

The use of a UPS system provides a cost benefit. However, the system cannot provide sufficient power to energize the water supply pumps to fill a truck during a power outage. This does not conform to the typical GNWT truckfill station concept. This concept is being implemented in smaller communities (Jean Marie River), where fire protection is provided by chemical fire fighting equipment. To meet the standard design of the GNWT and for the purposes of analysis, the on-site power generation with a standby generator located in the Hamlet garage, will be carried forth.

### *Intake*

The raw water intake for the truckfill stations is assumed to be the GNWT standard, which is comprised of:

- A screen with 0.15 mm openings.
- A 300 mm insulated high density polyethylene casing pipe.
- A 100 mm inclined shaft pump and discharge pipe with heat trace cables for freeze protection.
- An intake piping protection system such as armour rock.

The intake screen elevation has been selected in Section 3.0 as 77.00 m.

### *Truckfill Building*

A "stick built" building has been assumed for this analysis. The use of a "stick built" structure over a pre-engineered building allows for an increased level of involvement by the local residents over a pre-engineered/premanufactured structure. The use of a "stick built" structure for all options will not affect the comparative costs for the options.

### *Process System*

The truckfill station will have water treatment equipment as described in Section 3.2 (i.e. disinfection by sodium hypochlorite). Monitoring and metering of the water system will be by flow sensors and building totalizers. Alarm systems will be in accordance with GNWT standards.

## *Gravity Feed Pipeline and In-Town Storage*

The in-town storage volume requirements will vary with the supply rate from the gravity feed pipeline. The truckfill station is required to meet the fire flow demand of 910 l/min. If a pipeline is sized to meet this demand, then no storage component would be required. Conversely, if the pipeline is sized to supply the daily water consumption needs of the community in a 24 hour period, then the storage requirements would be equal to the peak day demand plus fire demand. For the purpose of analysis, three scenarios were analyzed for the storage/pipeline system.

| Option | Design Flow Rate | Pipe Size | Storage Component | Calculation of Storage Requirements |
|---|---|---|---|---|
| C1 | 910 l/min | 125 | 0 l | (910 l/min - 910 l/min) x 50 min = 0 |
| C2 | 500 l/min | 100 | 25,000 l | (910 l/min - 500 l/min) x 60 min = 25,000 l |
| C3 | 75 l/min | 50 | 145,000 l | (910 l/min - 75 l/min) x 60 + daily demand = 145,000 l |

The pipeline and water storage components will require a freeze protection/freeze recovery system. Water storage tanks of the size required in C2 and C3 above, can be economically housed in a building or in an underground reservoir located below the truckfill station. These types of installations have been used in the Northwest Territories previously (Fort Providence, Fort Liard, Wrigley).

To protect the pipeline from freezing, an insulated line that is continuously recirculated with hot water injection, is required. The return line can be a smaller diameter than the supply line. A small building at the water lake, to house a low lift pump and boiler for hot water injection, is required. This type of system is used in various locations in the Northwest Territories (Rankin Inlet, Edzo).

The selection of the best storage/flow rate alternative is not completed at this stage. Capital and life cycle costs for each option are similar, and in the event that this option is selected as the best alternative, then further analysis on the selection of the pipe and tank sizes will be completed.

# 5.0 EVALUATION

## 5.1 Process of Evaluation

To evaluate the alternatives described in Section 4.0, the Kepner Tregoe (K & T) analysis process is used. This process is a tool used to select the best alternative when there are several parameters that govern the alternative selection. It is a procedure that guides the systematic identification, analysis, and weighting of information leading to a final decision which, in this case, is the selection of a new water supply system.

There are both mandatory ("must") criteria and desirable ("want") criteria in the selection of the best alternative. All alternatives are compared against the "must" criteria. Any alternative that does not meet the "must" criteria is rejected and not carried forth to the next selection stage of analysis involving the "want" criteria.

Each "want" criteria is ranked for its importance in the selection process relative to other criteria. A ranking of 10 represents a highest priority and a ranking of 0 represents the lowest priority.

A comparative analysis of each alternative is completed for each criteria. The best alternative receives a score of 10. The product of the "want" criteria priority and the alternative rating give weighted scores. The sum of the weighted scores for each alternative results in the total weighted score for that alternative. The alternative with the highest total weighted score generally becomes the tentative choice, which can often graduate to the final choice after being assessed for potential risks.

## 5.2 Detail Analysis of Alternatives

The "must" criteria for analysis are:

1) The water must be able to be treated to meet the Guidelines for Canadian Drinking Water Quality with respect to maximum acceptable concentrations (MAC).

2) The water supply system must be able to supply 910 l/min for 60 minutes.

The "want" criteria and the weighting given to these criteria are listed below. The criteria are divided into technical and non-technical categories. The assessment for potential risks is carried at the end of the table.

1) The system is to have the lowest the lowest capital cost. This has a weighting of 10.

2) The system is to have the lowest cost effectiveness when analyzed for life cycle costs. This has a weighting of 10.

3) The system is to be the least complex for maintenance and operation. This has a weighting of 10.

4) The system is to minimize significant detrimental environmental impacts. This has a weighting of 5.

5) The system is to be acceptable to the Community. This has a weighting of 5.

6) The system is to minimize the risk of failure. This has a weighting of 8.

A summary of the individual ranking is illustrated in **Figure 5.1** and a detailed description is shown in **Figure 5.2**.

Capital costs and life cycle costings for each alternative meeting the "must" criteria are calculated and shown in **Table 5.1**. The cost estimates are based on:

- Historic construction costs of similar projects completed by the GNWT.

- Operation and maintenance costs are calculated according to the following percentages of capital cost which is representative of actual O&M costs experienced by the GNWT.

  - Pumphouse 15%
  - Access Road 10%
  - Pipelines 1%
  - Power Supply 1%

- The comparative delivery costs (i.e. trucking) were analyzed, using existing data related to the delivery of water to the community. Based on the Hamlet's reported truck delivery times of 15 hours/day for 6 days per week, the total delivery hours is 4,680 hours/year. The current consumption of the community is 10,400,000 litres. This results in

***10,400,000 l/year/4,680 hours/year = 2,200 l/hour***

The Hamlet uses a 9,000 l truck which means that the truck makes one (1) trip in 4.1 hours (250 minutes). The truck requires a time of 20 minutes to leave the community, refill and return to the community. Of the 20 minutes, approximately 10 minutes is required to refill, which means the actual travel time to the lake and back is 10 mins. This represents 4% of the total delivery time.

Therefore, the time difference between the in-town truckfill station and the truckfill station at the lake, will be 4% of the total delivery time. At the level of detail for cost estimates at the Class "C" level of estimate required for this study, this difference is insignificant.

The trucking costs for all options are, therefore, shown to be equivalent and represent the current costs indicated by the Hamlet.

| JST CRITERIA | | | A | B | C |
| --- | --- | --- | --- | --- | --- |
| | | | **OPTIONS** | | |
| *Water to meet Guidelines for Drinking Water (MAC)* | | | YES | YES | YES |
| *Fire Flow Requirements* | | | YES | YES | YES |
| **WANT CRITERIA** | | | | | |
| 1 *Lowest Capital Cost* | | Cost $ | $58,400 | $661,000 | $148,400 |
| | WEIGHT 10 | Score | 10.0 | 8.8 | 3.9 |
| | | Weighted Score | 100 | 88 | 39 |
| 2 *Lowest Life Cycle Cost* | | Cost $ | $1,390,000 | $1,470,000 | $2,380,000 |
| | WEIGHT 10 | Score | 10.0 | 9.5 | 5.8 |
| | | Weighted Score | 100 | 95 | 58 |
| 3 *Least Complex Operation* | WEIGHT 10 | Score | 10 | 10 | 5 |
| | | Weighted Score | 100 | 100 | 50 |
| 4 *Minimize Environmental Impact* | WEIGHT 5 | Score | 10 | 10 | 8 |
| | | Weighted Score | 50 | 50 | 40 |
| tal Technical | | | 350 | 333 | 187 |
| *Maximize Community Acceptance* | WEIGHT 5 | Score | 10 | 2 | 5 |
| | | Weighted Score | 50 | 10 | 25 |
| Running Total | | | 400 | 343 | 212 |
| 6 *Minimize Risk of Failure* | WEIGHT 8 | Score | 10 | 7 | 2 |
| | | Weighted Score | 80 | 56 | 16 |
| Grand Total | | | 80 | 56 | 16 |
| | | **Total Score** | **480** | **399** | **228** |

**Figure 5.1** Summary of Option Analysis
Truckfill Station Planning Study, Clyde River, NWT

Municipal And Community Affairs
M.M. Dillon Limited

| WANT C... ERIA | | WEIGHT | A | B | C |
|---|---|---|---|---|---|
| 1 *LOWEST CAPITAL COST* | Score | 10 | 10.0 | 8.8 | 3 9 |
| | | The impact on the capital budget could prevent the project from proceeding. There is fiscal restraint currently, and minimizing capital cost is important. | $584,000 / 584,000 X 10 = 10 | $584,000 / 661,000 X 10 = 8 8 | $584,000 / 1,484,000 X 10 = 3 9 |
| 2 *LIFE CYCLE COSTS* | Score | 10 | 10.0 | 9 5 | 5 8 |
| Estimated life cycle costs based on the present value of the capital costs plus the present value of an estimate of the operating and maintenance costs over the project design life. | | The long term economics is important to the GNWT as it affects the ability to provide future programs. | $1,390,000 / 1,390,000 X 10 = 10 | $1,390,000 / 1,470,000 X 10 = 9 5 | $1,390,000 / 2,380,000 X 10 = 5 8 |
| 3 *LEAST COMPLEX* | Score | 10 | 10.0 | 10.0 | 5.0 |
| The operation of the system should be simple in the Arctic conditions, and intuitive in nature. The system should use known technologies. | | Ease of operation in the arctic environment is important to the success of the facility. | Standard Truckfill station similar to many in the North. Known technology common application, and minimal components. | Standard Truckfill station similar to many in the North. Known technology common application, and minimal components. | Larger system than the standard truckfill station. More components higher level of technology with boilers |
| 4 *MINIMIZE THE ENVIRONMENTAL IMPACT* | Score | 5 | 10 | 10 | 8 |
| An assessment of the potential impact that the development will have on the environment | | The impact to the environment is weighted less than other criteria due to the relative importance of supplying the water delivery service. | Small impact by the installation of the intake pipe. | Small impact by the installation of the intake pipe. | Pipeline will have a larger impact on the environment than the intake pipeline. |
| 5 *MAXIMUM ACCEPTANCE BY COMMUNITY* | Score | 5 | 10 | 2 | 5 |
| A measure of the acceptability of the water supply system to the community. | | The relative importance of community acceptance is less than the impact on the funding requirements. | The option the community expressed their desire for. | The community has rejected the use of this site. | The community was impartial to this concept |
| 6 *MINIMIZE RISK OF FAILURE* | Score | 8 | 10 | 7 | 2 |
| Failure mechanisms would include road blockage, and pipe freeze up. | | The risk of failure is assessed on the chance of a system failure, the significance of that failure, and the consequences of the failure. | Low risk of failure for both mechanisms, low consequence. | High risk of failure for road block ups, low risk for pipe intake, low consequences in both cases. | Moderate risk of failure for pipeline freeze up, high cost of repair, may have serious consequences. |

**Figure 5.2 Detailed Option Analysis**
**Truckfill Station Planning Study, Clyde River, NWT**

Municipal And Community Affairs
M.M. Dillon Limited

## Capital Costs

| Item | Components | Units | Unit Costs | Option A Quantities | Option A Unit Total | Option B Quantities | Option B Unit Total | Option C Quantities | Option C Unit Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Truck Turn Around Pad - 12.5 m Radius<br>Based on 1.0 m of fill over existing grade | cubic metres | $30 | 450 | $13,500 | 450 | $13,500 | 450 | $13,500 |
| 2 | Truckfill Station - includes<br>Building<br>Chlorination<br>Monitoring<br>Controls<br>Freeze Protection | lump sum | $325,000 | 1 | $325,000 | 1 | $325,000 | 1 | $325,000 |
| 3 | On Site Power Generation | Kilowatt | $3,500 | 30 | $105,000 | 30 | $105,000 | 30 | $105,000 |
| | Stand - By unit stored at Hamlet Garage | Kilowatt | $1,000 | 30 | $30,000 | 30 | $30,000 | 30 | $30,000 |
| 4 | Intake Pipeline - includes<br>Piping<br>Pumps<br>Freeze protection | linear metres | $1,700 | 65 | $110,500 | 110 | $187,000 | 65 | $110,500 |
| 5 | Piping System to Truckfill Station in Town - includes<br>125 mm Insulated Pipe to Station<br>25 mm Insulated Pipe for Hot Water Return<br>Boilers for Hot Water Return<br>Building to House Intake Pump | lump sum | $900,000 | 0 | $0 | 0 | $0 | 1 | $900,000 |
| | **Total Capital Costs** | | | | **$584,000** | | **$661,000** | | **$1,484,000** |

## Annual Operation & Maintenance Costs

| Item | Components | Units | Unit Costs | Option A Quantities | Option A Unit Total | Option B Quantities | Option B Unit Total | Option C Quantities | Option C Unit Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Truck Turn Around Pad - 10 % of Capital Costs | % | 10% | $13,500 | $1,350 | $13,500 | $1,350 | $13,500 | $1,350 |
| 2 | Truckfill Station - 15 % of Capital Cost | % | 15% | $325,000 | $48,750 | $325,000 | $48,750 | $325,000 | $48,750 |
| 3 | Power Supply - 10 % of Capital Cost | % | 10% | $105,000 | $10,500 | $105,000 | $10,500 | $105,000 | $10,500 |
| 4 | Intake Pipeline - 1 % of Capital Cost | % | 1% | $110,500 | $1,105 | $187,000 | $1,870 | $110,500 | $1,105 |
| 5 | Piping System to Truckfill Station - 1% of Capital Cost | % | 1% | $0 | $0 | $0 | $0 | $900,000 | $9,000 |
| | **Total Operation & Maintenance Costs** | | | | **$62,000** | | **$62,000** | | **$71,000** |

## Life Cycle Costs

| | Option A | Option B | Option C |
|---|---|---|---|
| Capital Costs | $584,000 | $661,000 | $1,484,000 |
| Operation And Maintenance Costs | $608,000 | $608,000 | $697,000 |
| Trucking Costs | $200,000 | $200,000 | $200,000 |
| **Based on a 20 year life and a 8 % discount rate** | **$1,390,000** | **$1,470,000** | **$2,380,000** |

**Table 5.1 Cost Analysis**
**Truckfill Station Planning Study, Clyde River, NWT**

Municipal And Community Affairs
M.M. Dillon Limited

## 5.3 Summary

The analysis completed in the previous section ranks the alternatives in the following order (best to worst).

| Technical Score | OPTION |
|---|---|
| 350 | Truckfill station at the current draw-off location. |
| 333 | Truckfill station at the old draw-off location. |
| 187 | Intake pipeline to in-town storage and truckfill station. |

The analysis indicates that the trucked water supply system is the better alternative as compared to a pipeline to the community, due mostly to the lower capital cost for the trucked system.

The existing draw-off location is technically better than the old location because of a shorter intake pipe and, therefore, lower capital costs.

Through the technical analysis, the highest rated option is the truckfill station at the existing draw-off location.

The community has identified the best technical option location as their preferred choice for a truckfill station.

The best technical option has the lowest potential risk of failure when compared to the other options.

Based on the criteria established to assess the water supply systems, the truckfill station constructed at the current draw-off location is the best option.

## 6.0 IMPLEMENTATION

The implementation of the program to provide a truckfill station at Clyde River has been established to reflect the current GNWT capital plan. The implementation schedule is described below.

| Activity | Dates | Funding |
|---|---|---|
| Proposal call for design consultant | March 1996 | |
| Predesign Phase | May to July, 1996 | $ 25,000 |
| Design and Tender | Sept to Dec, 1996 | $ 35,000 |
| Construction:<br>• Site Works<br>• Sea Lift Material<br>• Truckfill Facility | June to July, 1997<br>August 1997<br>Aug to Oct, 1997 | $ 600,000 |
| Warranty Inspection | October 1998 | $ 5,000 |

## 7.0 SUMMARY OF CONCLUSIONS

The water lake currently used by the Community of Clyde River, was assessed for long term water capacity. The assessment indicates that the lake:

- is of general good quality, with slightly elevated levels of turbidity. The levels of turbidity do not present a concern and does not require treatment. The water is to be disinfected by chlorination.

- has sufficient storage capacity to supply water on a year-round basis through the 20 and 40 Year planning horizons.

- has a recharge capacity to meet the 20 Year consumption rate. The lake will require additional recharge in the 20 to 40 Year planning period. Recharge may be facilitated from an adjacent lake with a seasonal pipeline and pump, or through the installation of a snow fence within the lake's catchment area, to increase the snow accumulation. Further work in the analysis of these options is required.

Three alternate water supply systems were developed and analyzed to determine the best options. The options included a:

- Truckfill station at the existing draw-off location.

- Truckfill station at the old draw-off location.

- Pipeline from the lake to an in-town storage/truckfill station.

An analysis of the alternatives was completed, using the Kepner & Tregoe analysis process. This process indicates that the best balanced choice is the truckfill station at the existing draw-off location. To implement this option, the following fiscal funding is required.

| Fiscal Year | Funding |
|---|---|
| 1996/97 | $ 60,000 |
| 1997/98 | 600,000 |
| 1998/99 | 5,000 |

# APPENDIX 1

## AGRA EARTH & ENVIRONMENTAL GEOTECHNICAL REPORT

AGRA
Earth & Environmental

AGRA Earth &
Environmental Limited
135 Enterprise Road
P.O. Box 2245
Yellowknife, N.W.T.
X1A 2P7
Tel (403) 920-4140
Fax (403) 920-4402

December 21, 1994

File No. YX00388

M. M. Dillon Limited
201-5102 51 Street
Yellowknife, N.W.T.
X1A 1S7

Attention: Mr. Gary Strong, P.Eng.
Manager

Dear Sir:

Re: Report on Geotechnical Conditions
Water Supply Improvements, Clyde River, N.W.T.
MMD Reference 94-2214, MMD-GNWT Ref. SC320524

This letter summarizes the results of a geotechnical investigation undertaken by AGRA Earth & Environmental Limited (AGRA E&E) at the site of the proposed Water Supply Improvements and Truckfill Station in Clyde River, N.W.T.

## 1.0 TERMS OF REFERENCE

The Terms of Reference for the investigation, as outlined in AGRA E&E's proposal to M. M. Dillon of June 7, 1994 were to include:

- review available geotechnical information and examine aerial photographs;
- conduct a field investigation consisting of test pits (with locally contracted equipment) in order to identify the soil and bedrock conditions at the proposed truckfill sites and turn around areas;
- provide recommendations for the design and construction of the foundation for the pumphouse/truckfill station, water intake line, and armour rock/rip rap, and any site improvements, if required; and,

- provide comments as to the availability of suitable granular sources in the community.

## 2.0 PROJECT BACKGROUND

The hamlet of Clyde River receives its potable water from a lake which is approximately 1.6 kilometres northwest of the community. The lake has been chosen to fulfill the potable water supply needs of the community for the next 20 years. As such, a single, all-weather truckfill/pumphouse facility is required.

The truckfill station is understood to comprise the following:

- a pumphouse building of wooden construction with dimensions that are approximately 3.5m x 7.5m; it will be heated to +10°C;
- 300mm nominal diameter HDPE intake pipe will extend from the pumphouse to a depth in the order of 2 metres (design ice thickness); and,
- the intake line will be equipped with a heat trace line to reduce the potential for freezing; it will also be covered with 50mm of rigid foam insulation.

## 3.0 FIELD INVESTIGATION

The field investigation was conducted under the direct supervision of Mr. James Anklewich, P.Eng., of AGRA E&E's Yellowknife Office. Mr. Gary Strong, P.Eng., of M. M. Dillon's (MMD) Yellowknife Office was also present during the field investigation. The field program, which was conducted on July 26, 1994, included a visual reconnaissance of the site, excavation of test pits in the vicinity of the proposed pumphouse/truckfill station, and inspections of potential granular borrow sources.

The field program also included assisting MMD during the topographic and bathometric surveys, the results of which are reported by M. M. Dillon separately.

## 4.0 SITE CONDITIONS

### 4.1 PHYSICAL FEATURES

The subject lake is located in a natural depression with an elevation difference between lake level and the surrounding ridges being in the order of 7 to 10 metres. A second lake, which is located some 100 metres to the east, is approximately 6 metres higher in elevation and as such, drains into the subject lake. Based on the results of the topographic survey (reported by M. M. Dillon), the total area of the water shed affecting the subject lake is in the order of 50 hectares.

At the time of the field reconnaissance, the subject lake was clear of ice; however, the second lake still had a considerable amount of ice on the surface. A multibead thermoprobe was lowered into the water of the subject lake during the bathometric survey in order to establish the water temperature and confirm the presence of a thermocline. The thermoprobe data showed that the water was at a temperature of approximately +5°C (+/- 0.5°C) over the entire depth.

A nominal 3 metre wide and 75 metre long access road lies adjacent to portions of the south and east sides of the lake. The alignment of the road at this location is in an approximately north-south direction. At the approach to the lake, the top of the road is about 5.5 metres above the lake and gently slopes down to the location of the proposed new truckfill location, where the road surface is approximately 1 metre above the lake. The west bank of this access road (adjacent to the lake) has a slope angle of approximately 2.5H:1V. Although the bank appeared to be relatively stable at present, small cracks were observed in the road surface and were oriented parallel to the alignment of the road at a location where the top of the road is about 3 to 4 metres above the lake level. These cracks are indicative of movements of the active layer beneath the slope toward the water's edge (shoreline). These slope instabilities are likely attributed to saturated conditions of the active layer during prolonged rainfall whereby the unfrozen soil moves downwards over top of the frozen soil towards the shoreline.

At the most easterly edge of the lake, a 400mm diameter CMP culvert provides (outflow) drainage from the lake to the lower elevations to the east. Both inverts of the culvert, particularly the eastern invert, were noted to be damaged as a result of repeated vehicle traffic since minimal soil cover was observed on the culvert crowns. At the time of the site reconnaissance, the flow rate through the culvert was such that little to no sediment was being transported; however, several erosion scours were observed within 50 metres of the downstream invert of the culvert. These scours suggest that relatively high flow rates have occurred in the past, perhaps during peak runoff at spring thaw, or during prolonged rainfall.

## 4.2 SUBSURFACE CONDITIONS

A total of three test pits were excavated in the vicinity of the access road and truckfill location using a rubber-tired loader provided by the Hamlet of Clyde River. The test pits locations are shown on the attached Site Plan. The test pits were advanced to a depth of approximately 1 metre below existing grade whereupon frozen ground was encountered. Seepage from the active layer immediately above the permafrost table was observed in all of the test pits. The test pits were terminated at this depth and backfilled immediately.

The soils encountered at the test pit locations generally consisted of a fine to coarse grained, loose, brown sand overlying a brown, frozen silt. Thin beds of low plastic, brown silt were noted within the sand as well. Based on our experience elsewhere in the community, the deposit of silt observed at the 1 metre depth is expected to be ice rich and potentially unstable if allowed to thaw.

## 5.0 GRANULAR RESOURCES

AGRA Earth & Environmental previously reported on the availability of suitable granular materials in the community of Clyde River. The information was summarized in our June 11, 1993 letter to M. M. Dillon Ltd.

Based on a review of recent aerial photographs and available geotechnical data, several potential borrow deposits in the community were identified. All of the potential borrow sources identified, which are located in the vicinity of the existing airstrip, were reported to be poorly graded gravelly sands with a variable fines content (material passing 0.075mm/#200 sieve screen). These information is summarized in a letter to M. M. Dillon Ltd., dated June 11, 1993.

Sieve analyses were conducted on samples of granular materials, which were obtained by MMD field personnel and delivered to our Yellowknife laboratory. The results of these tests confirm that the samples are poorly graded, gravelly sands with a fines content varying from 10 percent to 22 percent. These results were reported in a letter dated July 26, 1993. The June 11, 1993 and July 26, 1993 letters are appended.

Other potential granular borrow sources exist in the immediate vicinity of the proposed truckfill station; however, the quantity remaining in these sources is not confirmed, nor has the quality of the material been identified. Moreover, it is uncertain whether the hamlet prefers to use the sources located near the airstrip or those located near the truckfill station. Regardless of which granular borrow source is chosen, samples of the materials should be shipped to our laboratories prior to construction in order to determine the specific construction criteria (standard Proctor density, grain size distribution).

## 6.0 RECOMMENDATIONS

### 6.1 PUMPHOUSE FOUNDATION

Based on AGRA E&E's past experience, it is envisaged that the pumphouse for the truckfill station will consist of an insulated building of wood construction that is mounted on skids and supported on a compacted granular pad. Such a foundation is considered to be feasible for the present truckfill site. It is not likely that other foundation types, such as piles (adfreeze or bedrock grouted) or spread footings would be necessary or economical.

It is likely that the new pumphouse building would be located in the immediate vicinity of the existing truckfill location. In such a case, the granular pad should be placed directly on the existing surface. The granular pad should be a minimum of 1 metre thick such that the summer depth of thaw is maintained within the granular pad and not the native soils.

Backfill for pad construction should be a well graded gravel that is free of organics and compressible material. Ideally, the backfill should contain less than 5% fines (particles passing the 0.075mm/#200 screen) to reduce the potential for frost heave. The maximum particle size is dependent on the compactive equipment available for construction; however, in the absence of a specified value, a maximum size of 75mm is recommended.

As the existing truckfill location and approach pad have been in use for several years, the surficial soils at this location are expected to be relatively dense due to the daily vehicular traffic; however, there may still exist localized "soft" spots, or zones of weaker material. As such, preparation of the existing surface should include proof-rolling with heavily loaded trucks. Where appreciable deflections are observed beneath the truck tires, the soils at this location should be subexcavated for a depth of at least 300mm and recompacted to a minimum of 95 percent of standard Proctor density.

All fill for the granular pad should be placed in lifts not exceeding 200 mm in loose thickness and should be compacted to not less than 95% of standard Proctor density. The compacted fill pad should be placed a minimum of 2 metres beyond the perimeter of the building. The bearing capacity of a well compacted pad may be taken as 150 kPa.

Long term settlement of the fill structure, if constructed according to the above guidelines, may be expected to be in the order of 1 to 2 percent of the fill thickness. However, if the granular pad is saturated prior to freezing, some heave can be expected during freezeback. For the minimum fill thickness specified above, potential heave in the order of 30mm to 40mm can be expected. Monitoring of the construction of the granular pad would verify that high quality construction is maintained and would reduce the potential for differential settlement.

## 6.2 WATER INTAKE LINE AND EROSION PROTECTION

At the time of the field reconnaissance, strong southerly winds were noted. During the spring breakup, such winds could cause any large blocks of loose ice on the lake to be deposited onshore and could infringe on the pumphouse building. Hence, consideration should be given to selecting the final locations for the pumphouse intake facility.

The need for a protective berm is envisaged near the shoreline for the water intake line. It is anticipated that sufficient quantities of the larger diameter rocks (boulders) which are required for the armour rock are available in a neighboring borrow source in the near proximity of the proposed pumphouse location. Recommendations with respect to the extent of erosion protection and rip rap size can be provided on request, when the design profile details have been established.

## 6.3 STABILITY OF ROAD EMBANKMENT

As noted in Section 4.1 above, small cracks were observed in the surface of the road adjacent to the lake and were oriented parallel to the alignment of the road. These cracks are likely due to slope instabilities caused by displacement of the soil in the active layer downslope. The concern is that this portion of the road could continue to move and become increasingly unstable. Saturated soil conditions resulting from extended rainfall events, combined with strong winds and wave action on the toe of the slope, could result in undermining the road embankment and failure of a portion of the access road. Periodic regrading of the road and slope will be required as future instabilities and slope movements occur.

Consideration could be given to improving the stability conditions of this slope. The most feasible mitigating measure includes placing large diameter rocks (cobble and boulder sizes) along the shoreline, particularly at the toe of the road embankment. These large diameter rocks would effectively act as a toe berm and serve to provide restraint against any potential slope movements. Additionally, a suitable geotextile (filter fabric) could be placed between the existing soils on the slope and the overlying rip rap so that the potential for migration and washing of the soils from wave action is reduced.

## 6.0 CLOSURE

We trust the foregoing is sufficient for your present purposes. Should any questions arise, please contact the undersigned at your convenience.

Yours truly,

**AGRA Earth and Environmental Limited**

REGISTERED PROFESSIONAL ENGINEER
J. L. ANKLEWICH
N.W.T.

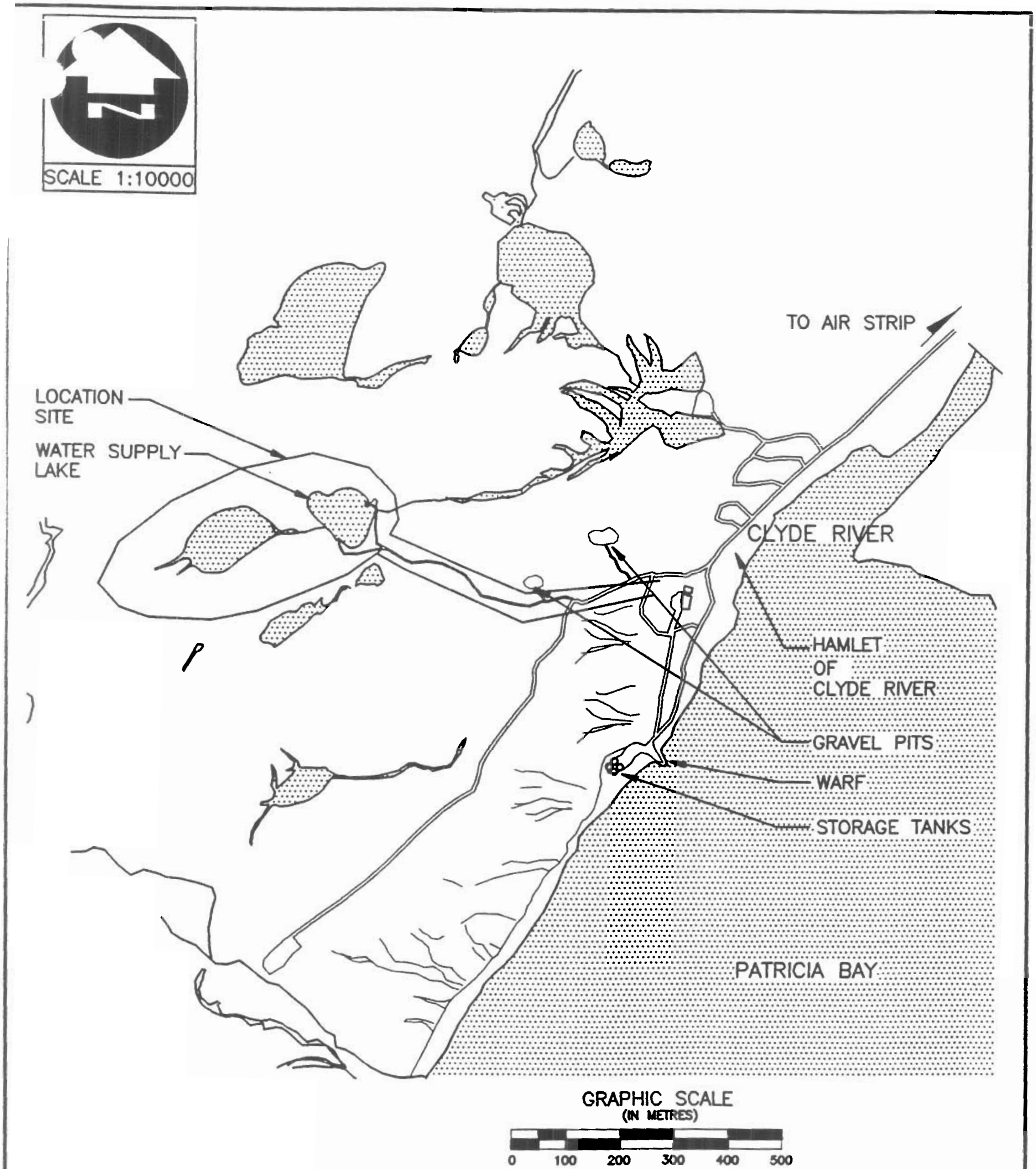
THE ASSOCIATION OF
PROFESSIONAL ENGINEERS,
GEOLOGISTS and GEOPHYSICISTS
OF THE NORTHWEST TERRITORIES
PERMIT NUMBER
P 047
AGRA Earth &
Environmental Limited

James L. Anklewich
Manager, Yellowknife Office

Reviewed by:

Marv J. Cherniawski, P.Eng.(Alberta)
Senior Project Engineer

YX00388.REP

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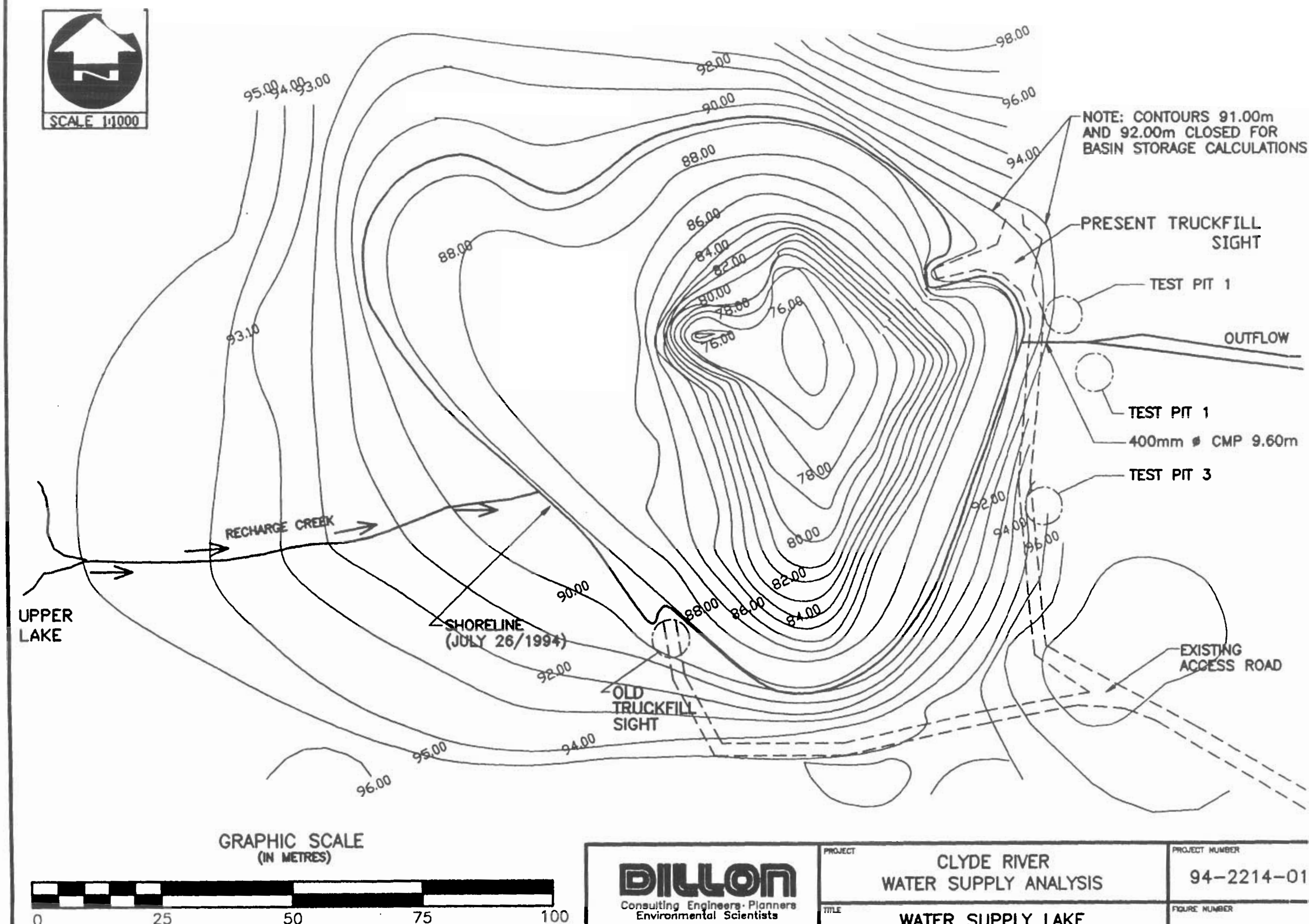
|---|---|---|
| DILLON Consulting Engineers · Planners Environmental Scientists | PROJECT PLANNING STUDY | PROJECT NUMBER 94–2214–01 |
| DATE AUG 94 | TITLE CLYDE RIVER TRUCKFILL STATION | FIGURE NUMBER 1.2 |

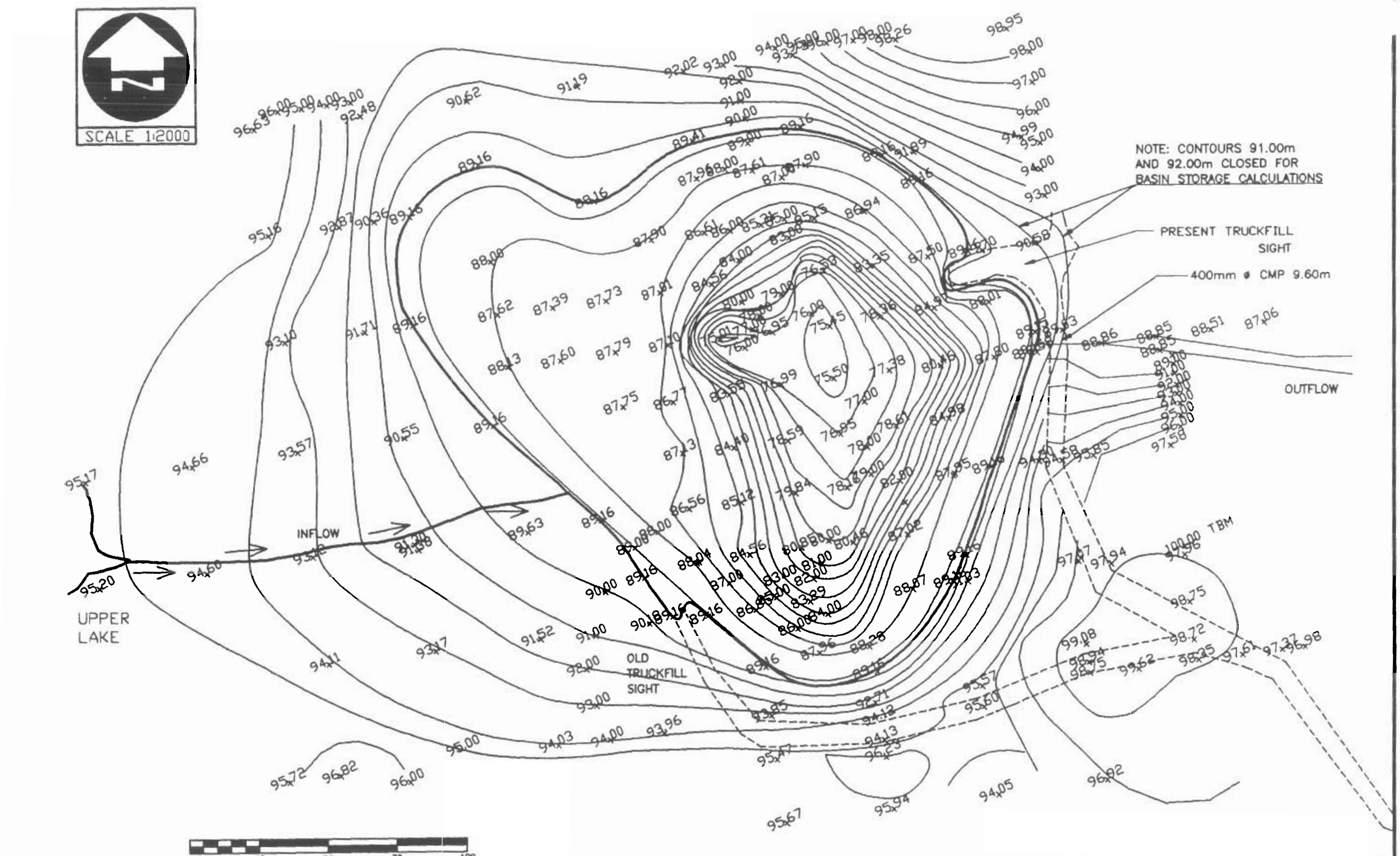



DILLON
Consulting Engineers · Planners
Environmental Scientists

| | |
|---|---|
| PROJECT | CLYDE RIVER WATER SUPPLY ANALYSIS |
| PROJECT NUMBER | 94-2214-01 |
| TITLE | WATER SUPPLY LAKE ELEVATIONS & CONTOURS |
| FIGURE NUMBER | 1.1 |
| DATE | AUG 94 |

# APPENDIX 2

# WATER DRAWDOWN CALCULATIONS




| | | |
|---|---|---|
| DILLON<br>Consulting Engineers · Planners<br>Environmental Scientists | PROJECT<br>TRUCKFILL STATION PLANNING STUDY<br>CLYDE RIVER, NWT | PROJECT NUMBER<br>94–2214 |
| DATE<br>JAN 95 | TITLE<br>WATER SUPPLY LAKE<br>ELEVATIONS & CONTOURS | FIGURE NUMBER<br>APPENDIX 2<br>FIG 1 |

| ELEVATION (m) | CONTOUR AREA (m^2) | INTERVAL AREA (m^2) | AREA PER UNIT DEPTH (m^2/mm) | INTERVAL VOLUME (m^3) | VOLUME PER UNIT DEPTH (m^3/m) | CUMULATIVE VOLUME (m^3) |
|---|---|---|---|---|---|---|
| 75 | 352.0 | | | | | |
| 77 | 1,629.6 | 1,277.6 | 0.6388 | 1,981.6 | 990.8 | 990.8 |
| 78 | 2,601.0 | 971.4 | 0.9714 | 2,115.3 | 2,115.3 | 3,106.1 |
| 79 | 3,663.4 | 1,062.4 | 1.0624 | 3,132.2 | 3,132.2 | 6,238.3 |
| 80 | 4,547.8 | 884.4 | 0.8844 | 4,105.6 | 4,105.6 | 10,343.9 |
| 81 | 5,600.3 | 1,052.5 | 1.0525 | 5,074.1 | 5,074.1 | 15,418.0 |
| 82 | 6,497.6 | 897.3 | 0.8973 | 6,049.0 | 6,049.0 | 21,466.9 |
| 83 | 7,452.2 | 954.6 | 0.9546 | 6,974.9 | 6,974.9 | 28,441.8 |
| 84 | 8,458.2 | 1,006.0 | 1.006 | 7,955.2 | 7,955.2 | 36,397.0 |
| 85 | 9,693.2 | 1,235.0 | 1.235 | 9,075.7 | 9,075.7 | 45,472.7 |
| 86 | 11,647.8 | 1,954.6 | 1.9546 | 10,670.5 | 10,670.5 | 56,143.2 |
| 87 | 13,882.2 | 2,234.4 | 2.2344 | 12,765.0 | 12,765.0 | 68,908.2 |
| 88 | 20,870.0 | 6,987.8 | 6.9878 | 17,376.1 | 17,376.1 | 86,284.3 |
| 89 | 27,845.6 | 6,975.6 | 6.9756 | 24,357.8 | 24,357.8 | 110,642.1 |
| 90 | 35,264.5 | 7,418.9 | 7.4189 | 31,555.1 | 31,555.1 | 142,197.2 |
| 91 | 42,282.5 | 7,018.0 | 7.018 | 38,773.5 | 38,773.5 | 180,970.7 |
| 92 | 48,982.7 | 6,700.2 | 6.7002 | 45,632.6 | 45,632.6 | 226,603.3 |
| 93 | CONTOUR NOT CLOSED | | | | | |

**Appendix 2 - Table 1- Basin Capacity Calculations**
**Truckfill Station Planning Study, Clyde River, NWT**

Municipal and Community Affairs
M.M. Dillon Limited

| MONTH | AVERAGE MONTHLY DEGREE-DAYS BELOW 0°C | CUMUL[illegible]E DEGREE-HOURS BELOW 0°C | TOTAL ICE THICKNESS (m) | INCREMENTAL ICE THICKNESS (m) |
|---|---|---|---|---|
| AUGUST | 0.3 | 7 | 0.013 | |
| SEPTEMBER | 39.1 | 946 | 0.149 | 0.136 |
| OCTOBER | 229.7 | 6,458 | 0.391 | 0.241 |
| NOVEMBER | 518 | 18,890 | 0.668 | 0.277 |
| DECEMBER | 748.2 | 36,847 | 0.933 | 0.265 |
| JANUARY | 835.3 | 56,894 | 1.159 | 0.226 |
| FEBRUARY | 791.3 | 75,886 | 1.339 | 0.180 |
| MARCH | 828.5 | 95,770 | 1.504 | 0.165 |
| APRIL | 571.7 | 109,490 | 1.608 | 0.104 |
| MAY | 255.6 | 115,625 | 1.653 | 0.044 |
| JUNE | 27.5 | 116,285 | 1.657 | 0.005 |
| JULY | 0.4 | 116,294 | 1.657 | 0.000 |

ICE THICKNESS FORMULA:

x=M(Ia)^(1/2)

x= depth of ice (m)

M= coefficient of proportionalaty (m/°C^(1/2)/h^(1/2))

typically for medium sized lakes= 4.86E-03

Ia= Degree hours below 0°C

annual average (AES Canada)= 138,000 °C h

**Appendix 2 - Table 2 - Incremental Ice Development**

**Truckfill Station Planning Study, Clyde River, NWT**

Municipal and Community Affairs

M.M. Dillon Limited

YEAR: 2018

CURRENT OUTLET ELEVATION

| MONTH | UNDERSIDE OF ICE AT START | SURFACE AREA AT START | HALF MONTHLY ICE DEVELOPMENT | UNDERSIDE OF ICE | WATER CONSUMPTION | DRAW DOWN FOR MONTH | HALF MONTHLY ICE DEVELOPMENT | UNDERSIDE OF ICE |
|---|---|---|---|---|---|---|---|---|
| | (m) | (m^2) | (m) | (m) | (m^3) | (m) | (m) | (m) |
| AUGUST | 89.150 | 28,958.4 | 0.007 | 89.143 | 3,856 | 0.133 | 0.007 | 89.004 |
| SEPTEMBER | 89.004 | 27,873.8 | 0.068 | 88.936 | 3,732 | 0.134 | 0.068 | 88.734 |
| OCTOBER | 88.734 | 25,986.8 | 0.121 | 88.613 | 3,856 | 0.148 | 0.121 | 88.344 |
| NOVEMBER | 88.344 | 23,269.8 | 0.139 | 88.205 | 3,732 | 0.160 | 0.139 | 87.906 |
| DECEMBER | 87.906 | 20,215.0 | 0.132 | 87.774 | 3,856 | 0.191 | 0.132 | 87.451 |
| JANUARY | 87.451 | 17,030.8 | 0.113 | 87.337 | 3,856 | 0.226 | 0.113 | 86.998 |
| FEBRUARY | 86.998 | 13,877.4 | 0.090 | 86.908 | 3,483 | 0.251 | 0.090 | 86.567 |
| MARCH | 86.567 | 12,915.4 | 0.083 | 86.485 | 3,856 | 0.299 | 0.083 | 86.104 |
| APRIL | 86.104 | 11,879.2 | 0.052 | 86.051 | 3,732 | 0.314 | 0.052 | 85.685 |
| MAY | 85.685 | 11,032.7 | 0.022 | 85.663 | 3,856 | 0.349 | 0.022 | 85.291 |
| JUNE | 85.291 | 10,262.7 | 0.002 | 85.289 | 3,732 | 0.364 | 0.002 | 84.923 |
| JULY | 84.923 | 9,598.2 | 0.000 | 84.923 | 3,856 | 0.402 | 0.000 | 84.521 |

**Appendix 2 - Table 3 - Dynamic Drawdown Calculations for 2018**
**Truckfill Station Planning Study, Clyde River, NWT**

YEAR: 2038 CURRENT OUTLET ELEVATION

| MONTH | UNDERSIDE OF ICE AT START | SURFACE AREA AT START | HALF MONTHLY ICE DEVELOPMENT | UNDERSIDE OF ICE | WATER CONSUMPTION | DRAW DOWN FOR MONTH | HALF MONTHLY ICE DEVELOPMENT | UNDERSIDE OF ICE |
|---|---|---|---|---|---|---|---|---|
| | (m) | (m^2) | (m) | (m) | (m^3) | (m) | (m) | (m) |
| AUGUST | 89.150 | 28,958.4 | 0.007 | 89.143 | 7,168 | 0.248 | 0.007 | 88.889 |
| SEPTEMBER | 88.889 | 27,074.3 | 0.068 | 88.821 | 6,937 | 0.256 | 0.068 | 88.497 |
| OCTOBER | 88.497 | 24,335.5 | 0.121 | 88.376 | 7,168 | 0.295 | 0.121 | 87.961 |
| NOVEMBER | 87.961 | 20,598.3 | 0.139 | 87.822 | 6,937 | 0.337 | 0.139 | 87.347 |
| DECEMBER | 87.347 | 16,306.6 | 0.132 | 87.214 | 7,168 | 0.440 | 0.132 | 86.642 |
| JANUARY | 86.642 | 13,083.2 | 0.113 | 86.529 | 7,168 | 0.548 | 0.113 | 85.868 |
| FEBRUARY | 85.868 | 11,390.2 | 0.090 | 85.778 | 6,475 | 0.568 | 0.090 | 85.120 |
| MARCH | 85.120 | 9,928.1 | 0.083 | 85.038 | 7,168 | 0.722 | 0.083 | 84.233 |
| APRIL | 84.233 | 8,745.9 | 0.052 | 84.181 | 6,937 | 0.793 | 0.052 | 83.336 |
| MAY | 83.336 | 7,789.9 | 0.022 | 83.313 | 7,168 | 0.920 | 0.022 | 82.371 |
| JUNE | 82.371 | 6,851.8 | 0.002 | 82.369 | 6,937 | 1.012 | 0.002 | 81.354 |
| JULY | 81.354 | 5,917.9 | 0.000 | 81.354 | 7,168 | 1.211 | 0.000 | 80.143 |

**Appendix 2 - Table 4 - Dynamic Drawdown Calculations for 2038**
**Truckfill Station Planning Study, Clyde River, NWT**

| Y.. | INITIAL LAKE LEVEL | TOTAL ICE DEPTH | WATER ELEV. AFTER ICE | ANNUAL CONSUMPTION | WATER DROP DUE TO CONSUMPTION | FINAL ELEVATION | MINIMUM INTAKE ELEVATION | WATER DEPTH ABOVE INTAKE | WATER REMAINING |
|---|---|---|---|---|---|---|---|---|---|
| | (m) | (m) | (m) | (cubic meters) | (m) | (m) | (m) | (m) | (cubic meters) |
| 2018 | 89.150 | 1.657 | 87.493 | 45,400 | 4.760 | 82.733 | 77.000 | 5.733 | 25,902 |
| 2038 | 89.150 | 1.657 | 87.493 | 84,400 | N/A | N/A | 77.000 | N/A | N/A |

**WATER DROP FOR 2018**

| ELEV | DROP(m) | VOL/m | CONSUMP (m^3) |
|---|---|---|---|
| 87+ | 0.493 | 12,765.0 | 6,288.6 |
| 86+ | 1.000 | 10,670.5 | 10,670.5 |
| 85+ | 1.000 | 9,075.7 | 9,075.7 |
| 84+ | 1.000 | 7,955.2 | 7,955.2 |
| 83+ | 1.000 | 6,974.9 | 6,974.9 |
| 82+ | 0.733 | 6,049.0 | 4,435.1 |
| | | | 45.400.0 |
| ELEVATION AFTER WATER DROP: | | | 82.733 |

**WATER DROP FOR 2038**

| ELEV | DROP(m) | VOL/m | CONSUMP (m^3) |
|---|---|---|---|
| 87+ | 0.493 | 12,765.0 | 6,288.6 |
| 86+ | 1.000 | 10,670.5 | 10,670.5 |
| 85+ | 1.000 | 9,075.7 | 9,075.7 |
| 84+ | 1.000 | 7,955.2 | 7,955.2 |
| 83+ | 1.000 | 6,974.9 | 6,974.9 |
| 82+ | 1.000 | 6,049.0 | 6,049.0 |
| 81+ | 1.000 | 5,074.1 | 5,074.1 |
| 80+ | 1.000 | 4,105.6 | 4,105.6 |
| 79+ | 1.000 | 3,132.2 | 3,132.2 |
| 78+ | 1.000 | 2,115.3 | 2,115.3 |
| 77+ | 1.000 | 990.8 | 990.8 |
| | | | 62,431.9 |

NOTE: CANNOT MEET CONSUMPTION

**Appendix 2 - Table 5 - Static Storage Calculations**
**Truckfill Station Planning Study, Clyde River, NWT**

Municipal and Community Affairs
M.M. Dillon Limited