

**VILLAGE OF HAINES JUNCTION
GEOTHERMAL DISTRICT HEATING
DEMAND SIDE ASSESSMENT**

Submitted to:

**The Energy Solution Centre
and the Village of Haines
Junction Joint Venture**

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Demand Side Assessment

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GLOSSARY

AADD	Average annual daily demand
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
CBD	Central Business District
CDWQG	Canadian Drinking Water Quality Guidelines
CSA	Canadian Standards Association
DCW	Domestic cold water
DHW	Domestic hot water
DHWH	Domestic hot water heater
DW:	Domestic Water
EBA	EBA Engineering Consultants Ltd.
ELT	Entering Load Temperature
ESC	Energy Solutions Centre
EST	Entering Source Temperature
EWT	Entering Water Temperature
FM	Factory Mutual
HVAC	Heating Ventilation and Air Conditioning
HW	Heating water
HWR	Heating water return
HWS	Heating Water supply
kW	Kilowatt
l/c/d	Litres per capita per day
l/s	litres per second
LLT	Leaving Load Temperature
LMP	Lessoway Moir Partners
LST	Leaving Source Temperature
LWT	Leaving Water Temperature
m	metre
m ³	Cubic metre
NBCC	National Building Code of Canada
NFPA	National Fire Protection Association
Pa	Pascal
Pa/m	Pascal per metre
Usgpm	US gallons per minute
VHJ	Village of Haines Junction
MUA	Make Up Air
API	American Petroleum Institute

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1 **Executive Summary**

In September 2002, the Village of Haines Junction (VHJ) constructed a new water well to meet its average daily and future domestic water requirements. The well flows under artesian pressure and provides relatively warm water. VHJ recognized the potential for using the well water as an alternate energy heat source and commissioned a study to review the potential of the well to provide geothermal district heating.

A Resource Assessment was completed in late August 2003 to confirm the quality, reliability and long term capacity of the well to deliver water. The results indicated that the water is of high quality, the water temperature 16.6°C and the long term yield in the order of 25.6 litres per second confirming the well's suitability as a geothermal source of heat.

Following the Resource assessment, the Demand Side Study confirms that the use of well water for heat extraction and distribution to Village building heating for systems may be implemented in a practical manner using geothermal heat pumps. Additionally, heat extraction may be done without adversely affecting the temperature and quality of the village domestic supply water.

Application of geothermal heating to the entire Village of Haines Junction is possible due to the volume of well water available however provision of heat for the entire Village will require re-injection of the well water to the aquifer as the water volume for heating will exceed the domestic consumption. A second well for re-injection or alternate means of water disposal will be required with added pumping requirements and a system for the de-chlorination of the water returned to the aquifer. Application of geothermal heating to the entire Village is an appealing opportunity as it will result in a reduction of the current use of fossil fuel by approximately 90% and a similar reduction in the emission of green house gases.

It is recommended that the VHJ approach the application of Geothermal Heating within the Village in stages. The initial stage includes the core Village buildings interconnected by a recirculation system utilizing the existing water distribution system to exchange and transfer heat energy. This distribution system will include the Arena, Convention Centre,

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and School. The proposed model is based on 55 kW of heat available from the geothermal source.

The initial stage will permit the Village to match the volume of heating water required to the current rate of domestic consumption delaying the need for the re-injection well. The injection well will be required for the application of the geothermal heating system to the remainder of the Village. This staged approach will reduce the risk to the Village in providing an opportunity to install a system on a smaller scale. Through the operation and monitoring of the performance of the initial installation the Village will gain valuable information to support the extension of geothermal heating to the remainder of the Village.

Subject to the results of the Business Case Study it is believed that energy savings involved in this approach will be significant and will result in a considerable reduction in the use of fossil fuels and the resulting green house gas emissions.

Acknowledgement:

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2 Introduction

In September 2002, the Village of Haines Junction (VHJ) constructed water well No. 5 and installed a 150mm insulated waterline from well No. 5 to the existing pumphouse No. 2. Post construction evaluation indicated that the well flows under artesian pressure, produces a water volume capable of meeting the average daily water demand requirements of the Village, meets the Canadian Drinking water Quality Guidelines (CDWQG) and has an average temperature of 16°C.

The Village of Haines Junction recognized the potential for using the well water as an alternate energy heat source and through a joint venture with the Energy Solutions Centre (ECS) in Whitehorse initiated a study to determine the heat recovery potential of the ground water.

ESC and VHJ retained Lessoway Moir Partners (LMP) in June 2003 and their team of specialists including EBA Engineering Consultants (hydrologist), Quest Engineering Group (Civil engineering), Dorward Engineering Services Ltd. (Electrical Engineering), Luigi Zanasi Economist (economist), Access Consulting (regulatory and permitting issues) to review and study the potential of well No. 5 to provide geothermal district heating. The Firm of Lessoway Moir Partners is the prime consultant and the mechanical engineering consultant.

The study is divided into distinct phases including;

- Resource assessment;
- Water Distribution System and Demand Side Assessment;
- Business Case; and
- Preliminary Design and Design Brief Preparation.

The Resource Assessment was completed in late August 2003. The results indicated that the water quality was of high quality, the water temperature 16.6°C and the long term yield in the order of 25.6 l/s.

This report presents the findings of the Demand Side Assessment and the Water Distribution System Assessment.

3 Background

3.1 History of Well No. 5

Although located adjacent to the Dezadeash River, the Village uses groundwater as its potable water source. Reasons include higher quality water, uniform temperature throughout the year and reliability of flow volumes. The Village drilled four shallow wells prior to well No. 5 and No. 3 is the only remaining active well. The other wells which previously provided water have been abandoned for a variety of reasons including silting and inadequate flow.

Well No. 5 was drilled in September 2002 to provide an alternate water supply for the VHJ. The well was drilled to a depth of 362 metres. EBA Engineering completed the resource assessment in late August and the results of the assessment indicated that well No. 5 is capable of producing drinking quality water at a sustained flow of 25.6 l/s.

Currently, well No. 5 flows under artesian pressure with a water temperature of 16.6°C.

3.2 Population Data:

Population data for Haines Junction was collected from the Yukon Vital Statistics office which was compiled from 2 sources; Yukon Health records and Statistics Canada census data.

Health records information show an increase in the total population for the Haines Junction area from 621 in 1991, to 801 in June of 2003. This represents an average annual growth of approximately 2.0%.

Census data for the years 1987 to 2001 indicates an increase in population from 493 in 1987, to 531 in 2001. Census data represents the population living within the Village boundaries.

The difference between Health records and Census data has remained relatively constant, at approximately 240, which would represent the surrounding area population, outside of the Village boundaries.

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Based on 2% population growth over 20 years, the Village population may increase to approximately 950 with the total area growth increasing to 1190.

Figure 1 represents projected population growth for the Village of Haines Junction.

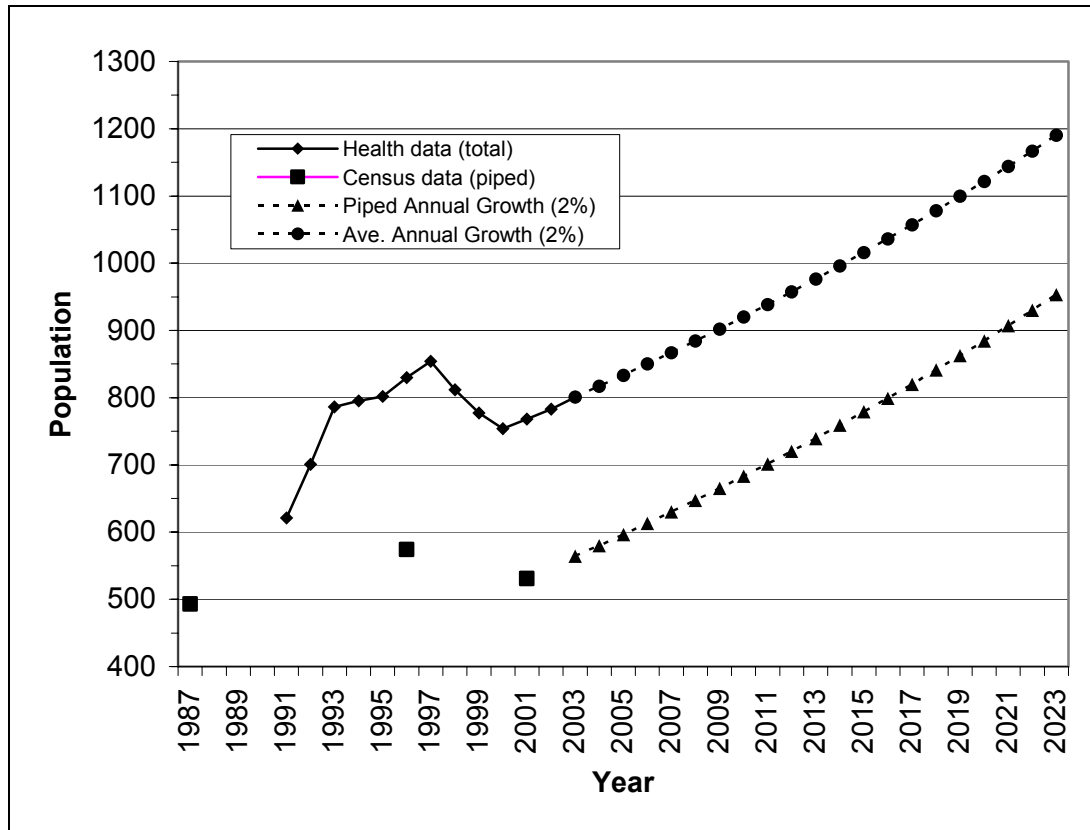


Figure 1 – Village Population Projection

3.3 Water Consumption Data

Water consumption records for years 2001, 2002 and a portion of 2003 were obtained from the Village of Haines Junction. Refer to figure 2. The data illustrates that the Average Annual Daily Demand (AADD) is approximately 325 m³/d, or 575 litres per capita per day (l/c/d), assuming a piped system population of 550 persons. Previous usage had been established at 568 l/c/d in 1979 by Stantec, and 584 l/c/d by UMA in 1988. The current estimate of 575 l/c/d appears to be reasonable. The demand of 575 l/c/d equates to approximately 3.55 l/s at the current population.

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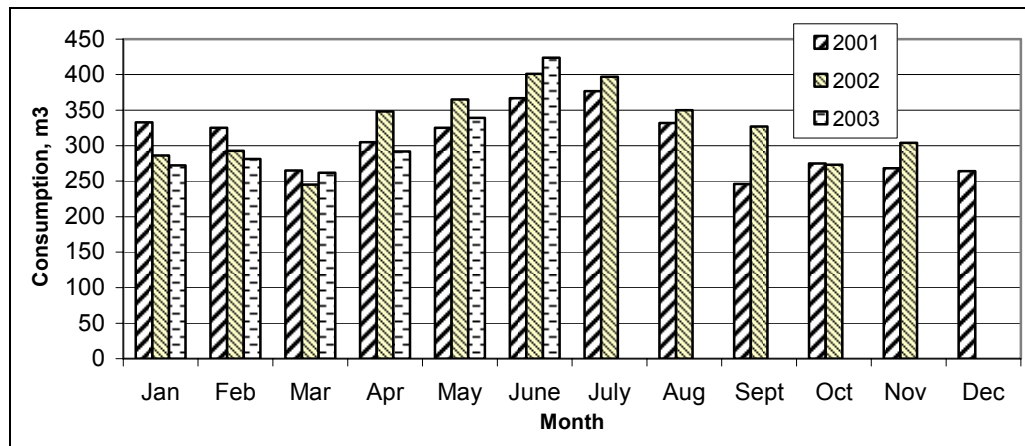


Figure 2 – Village Monthly Water Consumption Data

Maximum day demand occurs in July with a maximum day factor of approximately 2 times AADD. This demand factor appears reasonable, and is consistent with anticipated demand. Maximum daily demands of 550 to 650 m³/d were recorded.

Minimum daily demands occur in December averaging 280 m³/d between October and April, equating to an average 3.24 l/s water consumption.

In the long term, water consumption is expected to increase to 6.3 l/s, based on the projected population increase over the next 20 years.

There are no hourly consumption or flow-rate figures available for the Village. The following assumptions were used to model the operation and performance of the Village water storage tank;

- The distribution system is in good condition and does not leak.
- The only demand during the off hour periods are end-of-line bleeders. Assumed flow = 0.5 l/s
- Consumption peaks @ 3 times AADD in the morning and evening.
- Demand during the day between 0900 and 1130 operates @ approximately 4 l/s
- Demands between 1400 and 1700hrs operates @ approximately 3.5 l/s

Based on these assumptions, the estimated water consumption during a typical winter day is illustrated in *figure 3*.

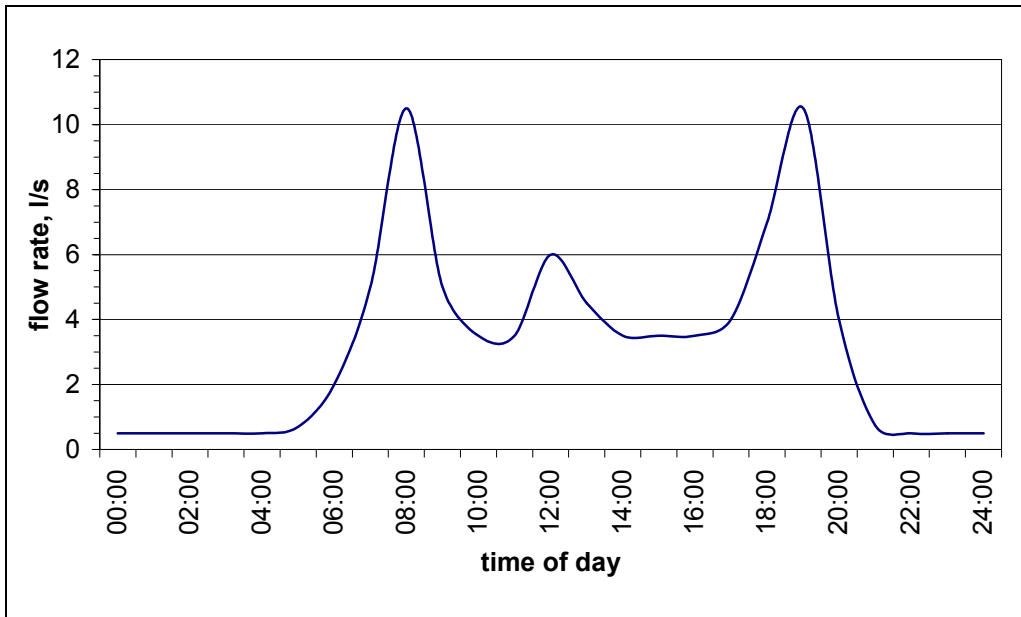


Figure 3 – Estimated Village Hourly Water Consumption - Winter

3.4 Existing Water Distribution System

Figure 4 (appendix A 1.1) is a single line schematic of the Village water distribution system. The existing water delivery system in the Village of Haines Junction includes two active water supply wells; Well No. 3 near the Dezadeash River, and Well No. 5 in the northwest quadrant of the town site; a 700,000 liter capacity elevated water storage tower; a heating and treatment pumphouse near the water tower; a treatment building near Well No. 3; and a piped distribution network of buried, insulated HDPE and PVC water mains, varying in size from 150 mm to 250 mm in diameter.

Well No. 3 produces relative warm ground water, at 7°C and has a long term production yield of approximately 8 l/s.

Well No. 5 was recently drilled and is producing warm ground water at approximately 16.6°C with an estimated long term production yield of approximately 25.6 l/s. Well No. 5 currently flows under artesian conditions which can produce a flow rate of approximately 4.0 l/s to the water tower.

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The existing piped system is configured as two separate pressure zones. The lower zone includes the Village water distribution system. The upper zone feeds the Champagne Aishihik lands to the east of the tower.

The upper zone is isolated from the lower zone at the water tower pumphouse. The upper zone pressure is boosted and controlled at the tower pumphouse maintaining operating pressures of approximately 415 kPa (60 psi). The upper Champagne Aishihik zone is a looped circulating system consisting of 200mm diameter and 150mm diameter mains. The flow is recirculated to prevent freeze-up.

The lower zone is gravity fed from the existing water tower, with pressures dictated by the elevation differences between the tower height and the natural ground levels. Pressures vary between 275 kPa (40 psi) at the upper end of the zone, to approximately 690 kPa (100 psi) at the lower end of the zone.

The lower zone is a grid layout with looped segments and dead-end radial mains requiring bleeding to prevent freezing.

Well No. 3 pumps directly into the lower zone water system near the south end of the Village. The water is chlorinated then passed through retention tanks to increase the chlorine contact time prior to entering the distribution system.

Well No. 5 is connected to the tower pumphouse with a new 150mm diameter supply main. The water is chlorinated before passing into the water tower.

The total length of each of the water mains has been scaled from the Overall Plan as follows:

Distribution Zone	Pipe Diameter	Length of Pipe
Supply main from Well No. 5 to Pumphouse No. 2	150mm	1564 m
Zone 1: distribution mains	150mm	6682 m
	200mm	1800 m
	250mm	670 m
Zone 2: distribution mains	150mm	1520 m
	200mm	1400 m

Table 1 – Water Distribution System

4 Water Distribution System Assessment

4.1 Existing Water Distribution System Heat Loss Assessment

Heat losses in the existing water system occur primarily at the exposed water tower and through the piped water system to the ground. The rate of heat loss is a function of air temperature, ground temperature, water temperature and insulation value.

The ambient air temperature is a function of atmospheric environmental conditions and may vary from +30°C to -50°C annually. Average annual winter temperature is estimated to be -25°C.

The ambient ground temperature is a function of total degree days, soil type, soil moisture content and snow cover. Ambient ground temperatures increase with depth of soil. The average winter ambient ground temperature is estimated to be between -3°C and -5°C at 2.0 m soil depth (average burial depth of the water mains).

Due to the nature of heat transfer, the total heat loss in the distribution system increases as differential temperature between the system operating temperature and the ground and air temperature increases.

For the purpose of this study system heat losses have been calculated for the water tower and the piped water system for various system operating temperatures, and ambient ground temperatures.

Heat loss from the water tower varies from 9.6 kW at 1°C to 12.3 kW at 15°C, average operating temperatures.

Heat loss from the piped network varies from 16 kW at 1°C; to 72 kW at 15°C, average operating temperature, and -3°C ground temperature, the average anticipated winter ground temperature. If ground temperatures cooled to -5°C, the heat loss would rise to 24 kW at 1°C, and 79 kW at 15°C, average operating temperatures. Operating with the water at higher average temperatures result in increased heat losses from the system.

The minimum recommended average operating temperature is 2°C, to provide a reasonable safety factor in consideration of variations in pipe insulation, depth of cover, rates of flow, etc.

To ensure a minimum operating temperature of 2°C during the winter the system is required to operate at an average temperature of 4°C based on a water demand rate of 3.24 l/s. The minimum water temperature of the water leaving the tower should be set at 5°C. The heat available through the daily consumption of 3.24 l/s of 16°C water (assuming 0.6°C temperature drop between well No. 5 and the water tower) will offset the water distribution system heat losses. The total distribution system heat loss at 4°C average operating temperature is estimated to be 38 kW. The total heat available at 3.24 l/s flow rate and 16°C temperature is 244 kW resulting in approximately 200 kW of heat energy available in the water for heating purposes.

4.2 **Assessment of Existing Piped Network as a Heat Supply Source**

The existing piped water distribution network was assessed to determine its suitability as a heating water supply source.

Water distribution pipe sizes throughout the network are adequate to carry the maximum anticipated flow rate of 25.6 l/s. Velocities of approximately 1.5 m/s would be created in the 150 mm pipes, which are considered acceptable. Flow rates above 1.5 m/s result in high head losses increasing pumping costs considerably.

The existing supply line and distribution system was modeled using computer simulation to confirm that the artesian flow (without pumping requirements) from Well #5 to the tower is approximately 5.5 l/s. This is more than 100% of the average winter demand. Well No. 3 would not have to be operated in the winter heating season other than for the purpose of preventing the supply line from freezing. An option to maintain heat supply levels could include returning flow to Well #3 to prevent line freeze-up and also to provide some re-injection to take advantage of the available heat in the excess supply from Well No. 5.

Installation of an in-line booster pump on the well supply line at the water tower pumphouse was reviewed however the suction side pressure would be negative for much of the supply line length with flow rates greater than 6 l/s. Negative pressures could result in collapse of the supply line. Alternately locating an in-line pump closer to Well No. 5 may be possible, but would be limited to the available power supply.

A submersible pump in Well No. 5 would be the ideal pumping option if higher flow rates to the tower are required.

Installation of a primary recirculation pump at the water tower pumphouse to provide circulation flow in the lower water system was also considered. The distribution system is configured such that circulation is possible. However, the flow must be balanced to ensure flow in the areas of high heat loads with balancing valves. The single supply line from Well #3 cannot be made to circulate in the present configuration. If Well No. 3 is operated at the same time as the primary circulation pump, it may create back pressure for the primary circulation pump. The circulation pump would have to be controlled to avoid backpressure when Well No. 3 was operating.

The existing distribution system may be used as a heating water supply source requiring some upgrades to ensure an efficient and effective operating system.

4.3 Comments on Using Existing District Water Distribution System

4.3.1 Advantages

1. All connected users would have access to the heated water source.
2. Water distribution system is in place and would not require a large capital cost to make it functional as a heat source.

4.3.2 Constraints

1. The existing water distribution system is a gravity flow system. Consequently heat is extracted from the distribution system (heated water source) and is not replenished by means of a recirculated flow.

2. Based on the available well yield, there is sufficient heat energy to heat only a portion of the Village.
3. Well No. 5 has an available yield rate of approximately 25.6 l/s. The current Village winter average annual daily demand is approximately 3.24 l/s. In order to make use of all the available heat energy in well No. 5, disposal of excess well water to meet the heat load is a major consideration.
4. Well No. 5 is a flowing artesian well with approximately 580 kPa (84 psig) at the surface. Re-injection into the same aquifer would require a sizable pump. Preliminary calculations indicate that the injection pump would be in the order of 37 kW (50 HP) based on 22.4 l/s @ 600 kPa TDH, 90% motor efficiency, 50% pump efficiency. In addition to the operational costs of the pump, the new injection well and the wellhead are prohibitively costly.

4.4 Re-Injection Sites

1. Potential re-injection points include existing well No. 4 near the existing water tower and well No. 3 near the Dezadeash River and pumphouse No. 1. A detailed investigation of the existing wells would be required to determine if either well could be upgraded to an injection well.
2. Potential discharge points include the Dezadeash River and the existing sewage lagoon.
3. The existing sewage lagoon has a design capacity for a population of 1000 people, and can receive approximately 7 l/s average annual effluent generation. Discharging water to the lagoon would result in additional pumping costs through the existing lift station, and flow rates above 7 l/s would require upgrading of the lift station pumps.

5 Alternate Heating Technology

Heating systems in the northern areas of Canada use fossil fuels and are inefficient relative to newer alternate heating technologies now available. Conventional heating equipment includes oil or propane fired hydronic boilers, oil or propane fired forced air furnaces and wood fired furnaces.

Heat pumps are an alternate heating (and cooling) technology that can provide an efficient alternative to traditional heating technology. This section provides a brief description and overview of heat pump technology.

5.1 Heat Pump Basics

Heat pumps deliver 3 to 5 times more heating or cooling per unit of consumed energy than conventional systems. Heat pumps extract heat from the earth, from water or from the air to heat buildings. Heat pumps provide cooling through a reversal in operation, cooling buildings while rejecting heat to the earth.

The technology is highly effective in extracting heat from low grade heat sources such as the ground or waste heat sources such as cooling towers. Current heat pump technology is not restricted to or fully dependant on high grade heat sources such as geothermal heat available from high temperature hot springs or hot rock areas in the earth, a more limited application.

The principals of the heat pump are:

1. Heat flows from a warm surface to a cold surface.
2. Heat pumps use a refrigerant - a liquid that boils at very low temperature, far below 100°C (boiling temperature of water).
3. When the refrigerant boils and becomes a vapour, it absorbs heat.
4. When it changes back to a liquid, it gives up the heat.

The steps in a typical heat pump operation are:

1. The refrigerant flows to an evaporator. During heating mode, the refrigerant absorbs heat and flashes to a low pressure gas.
2. The gas is pumped into a compressor where it is compressed into a high pressure, high temperature vapour.

3. The high pressure gas flows to a condenser where the heat energy is released and the refrigerant condenses back to a liquid thereby releasing its heat energy.
4. During the cooling mode, the process is reversed and heat is withdrawn from the condenser (building side or arena ice plant) and then released into the evaporator.

5.1.1 Advantages

1. Heat pumps are less costly to operate than conventional heating systems, i.e. hydronic, forced air or wood fireplaces.
2. Heat pumps can supply both heating and cooling and require only one distribution system for both.
3. Heat pumps are clean and environmentally safe.
4. Heat pumps have a long life with lower maintenance and operating costs than conventional systems.
5. Installation of multiple heat pumps on a common piping loop can provide heating at one unit and cooling at another unit. It is possible to have a zero input energy system where the heat rejected from the cooling unit into the shared piping loop transfers heat energy to a heat pump unit operating on a heating cycle.

5.1.2 Disadvantages

1. The initial capital cost of a heat pump system may be from 25 to 50% greater than oil fired heating system. The capital cost difference is less if air conditioning is considered for both systems.
2. Equipment noise levels must be considered requiring careful selection and placement.
3. Existing hydronic systems are typically sized based on 82°C entering water temperature (EWT) and 71°C leaving water temperature (LWT). Heat pumps can only produce a maximum LWT of 54°C, consequently, existing heating equipment including finned tube radiation, hydronic reheat coils and air

handling unit heating coils requiring an 82°C heating water source may be undersized and require upgrade.

4. A close evaluation of equipment specifications is required to ensure that the equipment's components and efficiencies meet the requirements for dependability, equipment life and operating costs suitable for the application.

5.2 Heat Sources

5.2.1 Air Source Heat Pumps

An air source heat pump uses heat energy from the outdoor air. The efficiency is proportional to the outdoor air temperature, as temperature decreases, efficiency decreases. At outdoor air temperatures below approximately -20°C, an alternate heating system is required, e.g. fossil fuel fired furnace or electric resistance heaters.

5.2.2 Water Source Heat Pumps

A water source heat pump extracts heat from water. Sources include well water, river or lake. Water source heat pumps have a major advantage over air source heat pumps in that water temperatures are typically constant over the year making it ideal as a heat source and a heat storage sink during the cooling cycle.

5.3 Heat Pump Combinations

5.3.1 Air to Air Heat Pumps

Air to air heat pumps typically use outdoor air as a heat source. During heating season and when the air temperature is greater than -20°C, heat is extracted from the outdoor air and transferred to the building condenser via the refrigerant where it is distributed through the building via a forced air heating system.

5.3.2 Water to Air Heat Pumps

A water to air heat pump is similar in operation to an air-to-air heat pump except that the heat source is water - typically a well, lake, river or a boiler. During heating season heat is extracted from the water source and transferred to the

building condenser via the refrigerant where it is distributed through the building via a forced air heating system.

5.3.3 Water to Water Heat Pumps

The heat source is typically water from a well, lake, river, or hot water boiler. Heat is extracted from the water source and transferred to the condenser via the refrigerant. The refrigerant releases its heat to the condenser where it is transferred to water. The water is then used to heat a building or domestic water.

6 **Demand Side Assessment**

The demand side assessment involved a survey of buildings in the Village of Haines Junction to determine an approach to community heating. Primary factors include the heating requirements for each building, the potential heat contribution of each building, relative location of the buildings and configuration of the water distribution systems serving the buildings.

To establish feasible community heating options information was collected on the various municipal, commercial, and territorial buildings in The Village of Haines Junction including; (See Appendix A 1.3.6, A 1.3.7,A 1.3.8)

- Building plans. Where no plans existed, the building area and footprint was measured,
- Building envelope. Where possible, building envelope details were determined from plans. Where no plans existed, assumptions were made based on typical construction. In either case the results of the heat loss calculations were reconciled with actual utility records to confirm accuracy,
- Building dimensions were determined from plans or measured,
- Heating plant details, e.g. type and capacity,
- Type of fuel used; wood, propane or fuel oil,
- Unique process loads, e.g. gymnasium showers, pool make-up water, Zamboni hot water production, ice making,
- Utility records including fuel oil consumption, propane consumption, electrical consumption, electrical demand, and
- Location relative to pumphouse No. 2 water tower.

Background information was collected on existing building systems in two phases. During Phase 1, information was collected on 14 key municipal and territorial buildings. When the results of the Resource Assessment Study concluded that the well No. 5 could provide a long term heating source and initial demand assessment calculations indicated that there was sufficient heating potential in well No 5 raw water to heat additional buildings, 16 additional

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buildings were added to the demand side assessment. These buildings are identified as Phase 2 buildings.

Subsequent analysis indicated that although there may be sufficient heating capacity in well No. 5 to heat both the Phase 1 and Phase 2 buildings. However, additional infrastructure may be costly and provide a lower the return on investment.

Implementation of a geothermal district heating system in The Village would be best approached through staged development. This approach provides an opportunity to control and reduce risk while establishing an operating geothermal heating system at a reasonable cost and effective payback. Future development of geothermal systems in the Village will benefit through monitoring the operation of the initially installed system.

The Phase 1 buildings are listed in the following table.

Building	Agency	Building	Agency
School	Territorial	Arena Zamboni Room	Municipal
Pool	Municipal	Convention Centre	Municipal
Curling Rink Lounge	Municipal	Village Public Works shop	Municipal
Community Hall	Municipal	Pumphouse No. 1	Municipal
Arena Change Room	Municipal	Pumphouse No. 2	Municipal
Arena Mezzanine	Municipal	Sewage Lift Station	Municipal
Arena Chiller Plant Room	Municipal	Village Fire Hall	Municipal

Table 2 – List of Phase 1 Buildings

The building information collected was used to prepare heat load estimates for each building, and to establish each building's suitability for distributed heating.

Figure 5 (appendix A 1.2) indicates a Village site plan with approximate Phase 1 building locations.

Detailed heat loss calculations, modified degree day energy consumption estimation and mechanical system descriptions for each phase 1 building is presented in appendix B.

6.1 Detailed Calculations.

Heating loads of the Phase 1 buildings were developed to establish geothermal heated water flow requirements for each building. Calculations were standardized with the following criteria;

6.1.1 Peak Winter Design Temperatures

The National Building Code of Canada (NBCC) does not define winter design temperatures for the Village of Haines Junction. For this study, climactic weather data for Whitehorse was used as a reasonable representation of the weather in Haines Junction.

The NBCC lists the 1% and 2.5% winter design temperatures for Whitehorse as -43°C and -41°C respectively. A 1% design temperature is defined as the temperature at which 1% of the time, in a typical winter, it is that temperature or colder.

These temperatures were checked using historical data for the years from 1971 to 2000. By calculating the degree-days on average below a nominal indoor temperature of 18°C it was determined that a more representative 1% design temperature to use for historical conditions would be -40°C . This is the temperature that was used as the basis for theoretical peak heating load calculations for Phase 1 buildings (reference equation 1 and 2).

6.1.2 Typical Monthly Heating Design Temperatures

The NBCC winter design temperature defines a peak winter design temperature for peak heating block load estimating. NBCC does not define a design temperature for each month. Based on the Canadian Climatic Normals for years 1971 – 2000, typical monthly heating design temperatures were estimated using the average of the extreme minimum and the daily minimum temperatures.

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Table 3 indicates the typical monthly heating design temperatures.

Month	Extreme Minimum	Daily Minimum	Mean Monthly Temp.	Month	Extreme Minimum	Daily Minimum	Mean Monthly Temp
Jan	-52.2 °C	-22.0 °C	-37.1 C	July	-0.5 °C	7.7 °C	3.6 °C
Feb	-51.2 °C	-18.7 °C	-35.0 C	Aug	-4.4 °C	6.3 °C	1.0 °C
Mar	-40.6 °C	-12.3 °C	-26.5 C	Sep	-19.4 °C	2.0 °C	-8.7 °C
Apr	-29.4 °C	-4.6 °C	-17.0 C	Oct	-31.1 °C	-3.1 °C	-17.1 °C
May	-11.7 °C	0.7 °C	-5.5 C	Nov	-40.6 °C	-13.0 °C	-26.8 °C
Jun	-2.8 °C	5.1 °C	1.2 C	Dec	-47.8 °C	-19.1 °C	-33.5 °C

Table 3 – Typical Monthly Heating Design Temperatures

6.1.3 Heat Loss

Peak heat loss calculations based on the estimated 1% design outdoor temperature and an assumed indoor temperature of 22°C were then carried out on individual buildings. Construction drawings of each building were used where possible as a basis for the calculations and actual building construction was verified by site visits carried out by LMP staff.

The heat loss through building envelope components were calculated as recommended in the ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) Fundamentals Handbook, 2001. The calculations also took into account estimates of infiltration and ventilation.

Infiltration and Ventilation are combined in calculation eq. 02

Calculations used:

$$\text{Skin Loss: } Q_{sl} = U \times A \times (IAT - OAT) \quad \text{eq. 01}$$

$$\text{Infiltration, Ventilation: } Q_{oa} = M_a \times C_{pa} (IAT - OAT) \quad \text{eq. 02}$$

where;

Q_{sl} = Heat Transfer Rate across building envelope skin component

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U = Heat Transfer Coefficient for envelop skin component

A = Area of envelope skin component

IAT = Indoor Air Temperature

OAT = Outdoor design Air Temperature

Q_{oa} = Heat transfer rate to warm outside air to room temperature

M_a = Mass transfer rate of outside air into the building

C_{pa} = Specific heat capacity of outside air by unit mass

6.1.4 Peak Monthly Heating Load

To verify the accuracy of the peak heating load calculations, fuel oil consumption data for each building was collected for the years 1999 to 2002. An estimate of design outside air temperatures was established for each month of the values shown in *table 4*.

These monthly design temperatures were used to estimate the heating energy consumed in a typical year on a month-to-month basis for each building. The values were then converted to litres of fuel oil and the total yearly consumption estimate was checked against actual fuel oil delivery records for each building.

The method used to estimate heating energy consumed was based on ASHRAE's MDD (Modified Degree Day) method. This method assumes that on a long-term average, solar and internal gains tend to offset heat loss when the mean daily outdoor temperature is 18°C or warmer. Therefore fuel consumption is proportional to the difference between the mean daily outside temperature and 18°C.

The equation for fuel consumption follows.

$$E = C_D \frac{86.4 Q_L DD}{K(IAT-OAT)} \quad \text{eq. 03}$$

where;

E = fuel or energy consumption for the period, kJ

C_D = empirical correction factor for heating effect versus 18 Kelvin days

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- Q_L = design heat loss for the period based on 22°C indoor temperature, W
- DD = number of 18 Kelvin days for the estimate period
- K = an empirical correction factor that allows for the effects of rated full load efficiency, part load performance, over sizing and energy conservation devices

Statistically C_D factors range from a low of 0.6 at 3000 DD to a high of approximately 0.7 at 7000 DD with a standard deviation +/- 0.2. Calculations included a factor of 0.65.

Energy consumption was then converted to litres of fuel oil using the heat capacity of No 2 diesel fuel based on the lower API heating value, i.e. 38.2 MJ/L.

6.1.5 Heat Pump Source Water Flow Requirement

The next step in the calculation process was to estimate the source (heated water) flow rate required to generate the peak heating requirements for each building using heat pump technology. The calculations determined that the peak heating load occurs during the month of January (*table 5*). The heat pump source flow requirements were therefore calculated only for the coldest month.

In order to estimate the source flow rate requirements, the following assumptions were used,

- a) Heat pumps are 5 ton water to water units. This provides a conservative average profile, as larger heat pumps are generally more efficient. During detailed design, the size and number of units may be optimized for improved performance.
- b) Heat pump capacities were based on WaterFurnace® catalogue no. WF1556 dated 05/03, model P056W.
- c) Heat pump performance is based on following operating conditions:
 - Heating Entering Load Temp (ELT) = 48.8°C (120°F),
 - Heating Leaving Load Temp (LLT) = 45.1°C (129.4°F)
 - Cooling Entering Load Temp (ELT) = 10°C (50°F)

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- Cooling Leaving Temp (LLT) = 5.4°C (41.7°F)
- Heating Entering Source Temp (EST) = 10°C (50°F)
- Heating Leaving Source Temp (LST) = 6.4° C (43.5°F)
- Cooling Entering Source Temp (EST) = 10°C (50°F)
- Cooling Leaving Source Temp (LST) = 15.5° C (59.9°F)
- Source flow rate = 0.69 l/s (11 usgpm)
- Load flow rate = 0.69 l/s (11 usgpm)

d) At the conditions above, the WaterFurnace® Heat Pump literature indicates the following performance characteristics;

- Total Heating Capacity (HC) = 14.74 kW (50.3 MBH)
- Heat of Extraction (HE) = 10.14 kW (34.6 MBH)
- Total Cooling Capacity (TC) = 13.00 kW (44.3 MBH)
- Heat Rejected (HR) = 15.47 kW (52.8 MBH)

1. The number of 5 ton water to water heat pumps required was estimated by dividing the peak heating load for each building by the total heating capacity or total cooling capacity as required. The figures were rounded up to the nearest integer.

Example: School

- Peak load = 309.7 kW, Heat Pump HC = 14.7 kW
- Number of 5 ton heat pumps = $309.7 / 14.7 = 22$ units.

2. The theoretical total heat of extraction was then calculated using the number of water to water heat pumps times the heat of extraction (for heating) or the heat rejected (for cooling).

Example: School

- Number of units = 22, HE = 10.13 kW.
- Total heat of extraction = $22 \times 10.13 \text{ kW} = 223.0 \text{ kW}$.

3. The total source flow rate (heating water) was determined by multiplying the number of 5 ton heat pump units by the individual source flow.

Example: School

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- Number of units = 22, source flow = 0.69 l/s
- Total source flow rate = 22 x 0.69 l/s =15.2 l/s.

6.2 Results

6.2.1 Heat Loss & Fuel Oil Consumption

Table 4 indicates the estimated peak heating loads for each building based on the peak winter design 1% temperature, (i.e. -40°C)

Building	floor area, m2	skin loss, kW	infiltr, kW	heat load, kW	est. occup, persons	Est. O/A load, kW	Add'l process load	peak heat load, kW	Avg heat load kW/sm
School	3,148.0	138.7	202.5	341.2	382	220.9	(2)	359.6	0.11
Convention Centre	1,241.0	94.1	72.0	166.1	156	90.2		184.3	0.15
Community Hall	279.0	20.5	15.0	35.5	150	86.7		122.2	0.44
Village maint shop	459.2	33.0	50.0	83.0	3	1.7		84.7	0.18
Fire hall	434.9	26.8	17.0	43.8	0	0.0		43.8	0.10
Arena Mezzanine	356.4	12.0	13.4	25.4	30	17.3		42.7	0.12
Arena - change rooms	356.4	5.3	14.3	19.6	20	11.6	(4)	31.2	0.09
Curling rink lounge	116.2	8.8	5.0	13.8	30	17.3		31.1	0.27
Swimming pool	524.8	7.3	7.0	14.3	50	11.3	(6)	25.6	0.05
Pumphouse # 2	129.2	7.1	3.0	10.1	1	0.6		10.7	0.08
Zamboni room	62.5	5.5	2.0	7.5	1	0.6	(5)	8.1	0.13
Pumphouse # 1	47.8	5.0	2.0	7.0	1	0.6		7.6	0.16
Arena Chiller plant	45.5	4.0	2.0	6.0	1	0.6		6.6	0.14
Sewage lift station	46.8	3.7	1.0	4.7	1	0.6		5.3	0.11
Arena (cooling load)				0.0		0.0	(3)	0.0	

Table 4 – Phase 1 Buildings –Estimated Peak Heating Loads

Notes for *table 4*:

1. Occupancy was estimated based on ASHRAE occupant loading (persons/100 m²) in order to determine peak heating load.
2. DHW demand from school showers is not included in the heating load calculation.
3. The arena ice surface is a consistent cooling load. For this study, the cooling load was estimated at 210 kW (60 tons) using -9.4°C (-15°F) ice.
4. DHW production for the Arena change room showers is not included in heating load calculations.
5. DHW production for Zamboni operation is not included in heating load calculations.
6. The pool is not operated during the winter. The heat loss shown is based on maintaining the temperature in the pool enclosure above freezing at 1°C.

The values in *table 4* were calculated assuming a peak winter design outdoor temperature of -40°C representing the peak heating load that can be expected during 1% of the winter. This is the capacity of a stand-alone heating plant.

Figure 6 indicates the peak heating load, skin loss and infiltration load per square meter of building footprint for each Phase 1 building.

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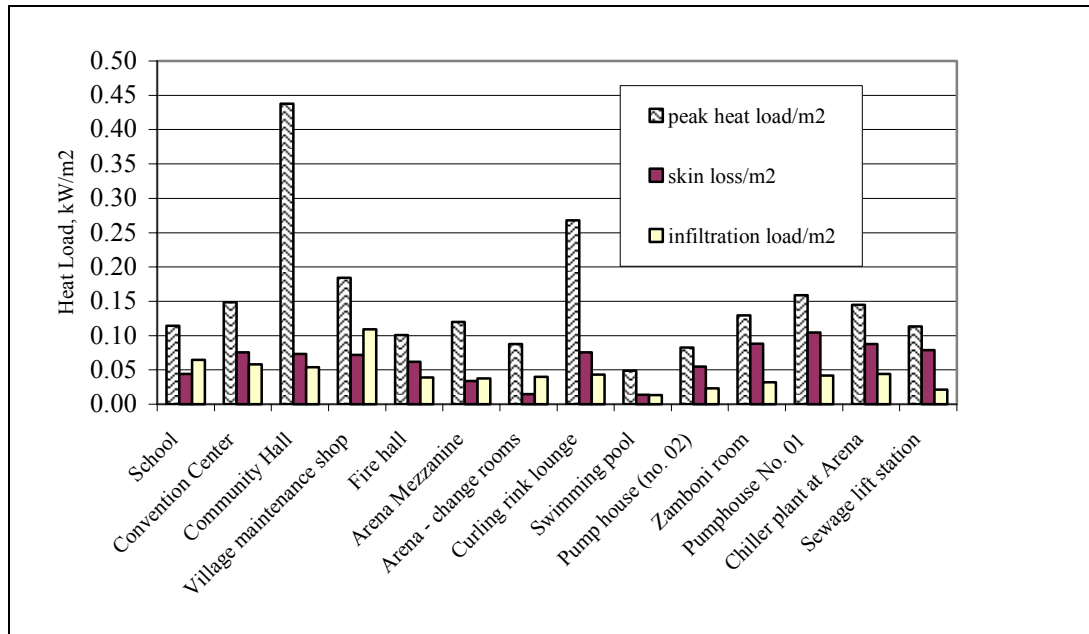


Figure 6 – Phase 1 Buildings – Heating load per sq meter per building

Figure 6 indicates that most of the buildings are operating at less than 0.15 kW/m². The heating loads were estimated based on peak occupant loading and peak ventilation (outdoor air) load and represent the heating load required if the building was designed to current ASHRAE standards. Several buildings are likely not operating at these peak design conditions.

Table 5 (Appendix A 1.3) indicates the estimated monthly peak heating loads for Phase 1 buildings based on typical winter temperatures (reference table 3).

Table 6 (Appendix A 1.4) summarizes the estimated annual fuel consumption versus actual annual averages over the years 1999 to 2002. The fuel consumption rates are based on estimated infiltration rates and heat losses of commercial buildings of “standard” construction. They do not account for additional loads not determined such as heat required for Zamboni hot water requirements etc. Comments are included where appropriate.

Factors that could affect the variance between estimated and actual fuel consumption rates are:

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- Higher than estimated infiltration rates of outside air.
- Differences in system efficiencies of the estimated heating systems.
- Loads such as domestic hot water heating that were not included in the heating calculations.

Infiltration can be reduced by revising the fire hall overhead door operating procedures or by the use of auto controls to reduce temperatures based on occupancy and overhead door usage.

It is assumed that the largest variance would be the infiltration rate estimates and system effectiveness. Domestic water heating contributions to peak load requirements should not be significant with the possible exception of the Zamboni room of the arena that has a large domestic hot water heating load.

In general, *Table 6* indicates that the estimates of fuel consumption, based on calculated peak heating loads and historical degree day energy consumption calculations are within reasonable accuracy for several of the larger buildings including the Convention Centre, the Public Works Maintenance Shop and the Swimming Pool.

In the “larger” buildings with significantly higher actual fuel consumption than estimated, several factors may account for the discrepancy. The Arena, Fire hall, Community Hall and Curling Rink were generally noted to have inferior construction compared to the better performing buildings noted above. This could result in higher building envelope losses but more significantly, a higher leakage or infiltration rate of outside air.

The smaller buildings such as the pumphouses and the sewage lift stations can be expected to have higher infiltration rates due to a higher envelope to floor area ratio and less stringent construction procedures than the larger commercial style buildings.

The infiltration rate used in estimating heating loads was taken as a constant 0.35 ACH (Air Changes per Hour). This is a generally accepted average value for commercial buildings of standard construction quality throughout North

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America. Typical housing construction can range from a low of below 0.11 ACH in special construction R2000 homes to as high as greater than 10 ACH in older homes. (ASHRAE Fundamentals Handbook 2001, study of 1024 European and 473 Canadian single family homes).

If the smaller buildings are compared to typical housing leakage/infiltration rates of 1.5 ACH or higher the estimated fuel consumption rates for these buildings become more in line with actual fuel consumption figures.

6.2.2 Heat Pump Source Water Flow Requirements

Source water flow rates for the Phase 1 buildings are presented in table 7.

(appendix A 1.5)

7 District Heating Options

Options for the application of a geothermal heat distribution in the Village were based on the most practical approach to the implementation of heat transfer systems and equipment in the Village. These options are described below.

7.1 OPTION 1 Existing Water Distribution System.

Water is pumped from well No. 5 to pumphouse No. 2 where it is chemically treated and then distributed through the existing buried water system. The distribution system will require modifications to operate as a recirculation system.

7.2 OPTION 2A Raw Water Loop Upstream of Water Tower.

Water flows under artesian pressure from well No. 5 to the water tower. A water bypass loop installed on the raw water line will permit the flow of raw water to specific Village buildings then back to the water main. This option is designed to initially heat select Village buildings only, not the entire Village. (See Appendix A 1.3.3)

7.3 OPTION 2B Heat Exchanger Upstream Of Water Tower.

This option is similar to option 2A with the exception that a heat exchanger is installed on the raw water supply line in lieu of supply pipes directly to the primary Village buildings. The raw water flows through the heat exchanger and transfers heat to the cold side. The cold side is a buried distribution loop that moves tempered glycol from the heat exchanger to the designated primary Village buildings. This option is designed to initially heat select Village buildings only, not the entire Village. (See Appendix A 1.3.4)

7.4 OPTION 3 Dedicated Raw Water Branch Line.

Provide a dedicated raw water branch line for the primary Village buildings heating including an injection well to dispose of excess raw water once heat is extracted from new raw water branch line. This option is designed to initially heat select Village buildings only, not the entire Village. (See Appendix A 1.3.5)

7.5 **OPTION 4 Heat Exchanger on Treated Water Main.**

Recommended Option

Install a heat exchanger on the Village treated water supply line and modify the existing Village water distribution system into a recirculation system. At the pumphouse the treated water from the water tower will be directed to flow through a heat exchanger transferring heat to the demand side. The demand side of the heat exchanger consists of a buried piping loop that moves tempered antifreeze from the heat exchanger to the selected primary Village buildings.

Details of the distribution system are illustrated in Figure 10 (Appendix A 1.6)

Figure 24 (Appendix A 1.7) is a spread sheet that allows for the dynamic modeling of flows and temperatures to establish and evaluate the characteristics of distribution system.

System Details Include:

1. Raw water flows from well No. 5 to pumphouse No. 2 via the existing buried 150mm Ø water line and into the water tower. Raw water flow rate is matched as close as possible to Village AADD.
2. Chlorine is injected into the raw water as required and treated water flows into the water storage tank.
3. A double walled heat exchanger installed on the treated water line transfers heat to the demand side or buildings. This heat exchanger is designated as the primary heat exchanger.
4. Two new insulated buried raw water lines are installed from the heat exchanger to selected Village buildings including the School, Village Office and the Arena. One line delivers heated glycol supply and the second line returns the cooled glycol back to the main line. This loop is designated as the secondary heating loop.

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5. The heated glycol is piped into each building and heat extracted via the heat pumps. Cool glycol is returned via a common return line back to the primary heat exchanger.
6. The existing Village water distribution system is modified to operate as a recirculation system. Recirculation is required to ensure flow through the heat exchanger so that the maximum amount of heat can be extracted. Work includes elimination of end-of-line bleeders. Controls are included that limit the minimum water storage tank temperature to 5°C.

7.5.1 Advantages:

- .1 The district heating system is on a separate loop and the chlorine consumption is not affected. Operation requires minimal additional chlorination and/or de-chlorination.
- .2 Use of a heat exchanger provides a physical separation between the heating system and potable water system reducing the risk of potable water contamination.
- .3 Modifying the Village water distribution system into a recirculation system allows the flow rate on the heat source side of the heat exchanger to be greater than Village AADD resulting in a greater heat transfer through the heat exchanger for the secondary loop system.
- .4 Converting the Village water distribution system into a recirculation system will improve system performance and reduce maintenance due to freeze-up.
- .5 Provision of a separate heating loop allows waste heat from the arena artificial ice plant to be transferred into the heating loop for use by other buildings on the same loop.
- .6 Heat is extracted from the treated water thereby reducing the Village water supply temperature to within recommended CDWQ guidelines.
- .7 The original design of pumphouse No. 2 includes an allowance for a future Village recirculation pump and associated pipe. Modifications in the pumphouse will be relatively straightforward.

- .8 Modifications to the existing water distribution system will be relatively simple as the existing lines are new and modifications required are not extensive.
- .9 Heat recovery on the Village side of the water tank and provision of a water distribution system recirculation loop allows for a variable flow rate through the heat exchanger to suit demand or minimum flow requirements. For example; at 10.5 l/s (3 times AADD – reference *figure 3*) and assuming 15.6°C EWT, 7°C LWT, 95% heat exchanger efficiency, the available heat is approximately 375 kW. The recirculation loop flow rate will vary from 10 l/s during the night to 0 l/s during peak periods. Increasing the heat source side flow rate to 15 l/s, and assuming 15.6°C EWT, 7°C LWT, 95% heat exchanger efficiency, the available heat is approximately 536 kW. In this scenario, recirculation flow rate varies from 14.5 l/s during the night to 4.5 l/s during peak periods.
- .10 Provision of a heat exchanger and glycol secondary loop permits shut-down during the winter without risk of freeze-up.
- .11 Provision of the loop allows for the use of auxiliary input from a boiler to adjust for peak loading capacity of the water supply.

7.5.2 Disadvantages:

- .1 Heat exchangers are marginally inefficient resulting in a reduced heat transfer;
- .2 Construction of the recirculation system is costly resulting in a longer payback time.
- .3 Additional pumps are required including primary and secondary side recirculation pumps;
- .4 The thermal performance of the water storage tank will require continuous monitoring. If the flow rate through the heat exchanger is too high, extracting too much heat, the water storage tank temperature could fall below the minimum recommended temperature of 5°C. Controls will be necessary to permit bypassing the heat exchanger until the tank temperature rises.

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.5 A discharge of some water may be required at minimum flow times to maintain heat levels. This can be minimized by balancing the load sharing requirements of the buildings.

7.6 Comparison of District Heating Options

Table 8 below is a summary of the district heating and the justification for Option 4.

Description	Option 1	Option 2A	Option 2B	Option 3	Option 4
Raw Water submersible pump required for district heating based on current AADD?	Yes	No	No	Yes	No
Village recirculation required for district heating?	Yes	No	No	No	Yes
Injection Well Required for district heating?	Yes	No	No	Yes	No
Chlorine volume	High	Low	Low	Low	Low
De-chlorination required for district heating?	Yes	No	No	No	No
Heat Exchanger required for district heating?	No	No	Yes	No	Yes
Approximate available heat at yr 2003 winter ave. day demand (3.5 l/s)	126 kW	126 kW	95 kW	N/A	237 kW (1)
Approximate available heat at well No. 5 production = 25.6 l/s		920 kW	685 kW	853 kW (2)	N/A (3)
Opportunity to use waste heat off artificial ice plant?	No	No	Yes	No	Yes
Freeze protection required if well no. 5 shutdown?	N/A (4)	Yea	No	Yes	No

Table 8 – Comparison of District Heating Options

Notes:

1. Based on 3.5 l/s raw water flow, 10.5 l/s treated water flow. At 3.5 l/s average winter daily demand, average return water to tower = 7.0 l/s
2. Based on 15 l/s, EWT = 15.6°C, LWT = 2°C
3. Well No. 5 production does not affect operation since heat is extracted off treated water. Will affect heat recovery time of water storage tank.
4. Assumes that if well No. 5 is shut down, well No. 3 will provide water.

8 District Heating System

8.1 Recommended District Heating Option.

Option 4 - Heat recovery from treated water is recommended for the following reasons:

- .1 An injection well and injection pump is not required.
- .2 Chlorine consumption is based on Village domestic water demand and is not affected by geothermal heating.
- .3 In the event that geothermal heat is not available (e.g. well No. 5 is shut down or water storage tank temperature is too low), the secondary loop can be shut down without risk of freeze up.
- .4 Provides the highest heat recovery potential of the options reviewed.
- .5 Allows the waste heat from the arena ice plant to be transferred to the secondary heating loop for use by other buildings on the same loop and thereby increasing the overall secondary heating loop performance.
- .6 Allows for auxiliary heat for supplementing a low flow condition or peak load conditions.

8.2 Buildings To Be Heated Using Geothermal District Heating.

Assuming the implementation of district heating Option 4, a number of the Phase 1 buildings remotely relative to the water tower requiring installation of extended piping which is prohibitively expensive. These buildings include;

- Sewage lift station,
- Pumphouse No. 1,
- Fire hall, and
- Village of Haines Junction Public Works shop.

Several of the remaining Phase 1 buildings require further detailed review to confirm operation and heating load as the results of the demand assessment indicates that the building envelopes may not be energy efficient.

These buildings include;

- Community Hall,
- Curling Rink Lounge

The remaining Phase 1 buildings are located in close proximity to the water tower and are adaptable to geothermal district heat.

These buildings include;

- Territorial school,
- Village Pool,
- Arena Change Room,
- Arena Mezzanine,
- Arena Chiller plant room,
- Arena Zamboni Room,
- Convention Centre, and
- Pumphouse No. 2.

Recommended Phase 1 buildings to be district heating include;

- Territorial school,
- Arena Change Room,
- Arena Mezzanine,
- Arena Chiller plant room,
- Arena Zamboni Room,
- Convention Centre,

Geothermal heating of the village pool does not warrant the cost of the installation as the pool is required for summer use only. The pool however may be used the pool as a storage reservoir increasing the available heat capacity to meet peak demands on the system.

8.3 Geothermal District Heating performance

The secondary water distribution system performance has been evaluated based on various building combinations.

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Using the assumed heating water flow recirculation rate plus the continuous domestic consumption flow of 2.8 l/s the discharge rate for excess flow at certain hours varies inversely with the flow of domestic water. The highest excess flow discharge time of the day would be between 10 pm and 5 pm where the discharge rate is 2.3 l/s. This flow rate can be reduced by drawing the temperature down in the water tank. Under these conditions the tank temperature will drop to the minimum recommended temperature in 46.8 hrs. If the system is replenished each morning the tank temperature will recover in 14 hrs based on the daily consumption. If the water temperature is allowed to drop and the recovery time is not enough to handle the increase in temperature the boiler in the distribution loop may provide heat to avoid drooping the water temperature in the tank to critical levels. The system could be controlled to maintain a discharge rate of 0 l/s under ideal conditions.

Discharge Rate	
Hourly Period	Flow l/s
1 AM to 4 AM	2.3
5 AM	2.1
6 AM to 8 PM	0
9 PM	1.8
10 PM to 12 PM	2.3

Table 9 Hourly Discharge flow rate

School

The school heat pump recovery system was sized to handle 61% of the peak load which accounts for 94% of annual load. (See Appendix A 1.2.4)

The existing school system would remain in place and would operate as an auxiliary backup system to help handle the peak loads in conjunction with the operation of the heat pump system reducing the run time significantly on the conventional system. (See Appendix A 1.2.3,1.2.5)

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A piping system would be required from the secondary loop (between buildings) in the crawl space to each of the small forced air heat pumps located in crawl space, the heat pump consoles in the library and entry areas, and the heat pump water to water units in the mechanical room. (See Appendix A 1.2.2)

The secondary loop transfers the heat from the heat exchanger (in the school) from the domestic water system to the piping system in the crawl space to the heat pumps.

The heat pumps operate on any call for heat; the auxiliary system (conventional) will operate on a predetermined temperature drop on either the air temperature, water temperature, or the secondary loop temperature.

Coils will be added to the MUA system for low temperature operation from the heat pump and the units will operate as a first stage, second stage operation allowing the heat pumps to take the brunt of the load.

Building cooling may also be achieved with the heat pump system.

Convention Centre

The convention central heat pump recovery system was sized to handle 62% of the peak load which accounts for 94% of annual load. (See Appendix A 1.2.7)

The existing convention centre system would remain in place and would operate as an auxiliary system to help handle the peak loads along with the operation of the heat pump system reducing the run time significantly on the conventional system. (See Appendix A 1.2.6, 1.2.8)

A piping system would be added from the secondary loop (between buildings) in the crawl space to each of the forced air heat pumps located in crawl space, the heat pump consoles and entry areas, the heat pump water to direct expansion units in the mechanical room. (See Appendix A 1.2.2)

The secondary loop transfers the heat from the heat exchanger (located in the school) from the domestic water system to the piping system in the crawl space (in the convention centre) to the heat pumps and back.

The heat pumps operate on any call for heat; the auxiliary system (conventional) will operate on a predetermined temperature drop on either the air temperature, water temperature, or the secondary loop temperature.

Existing coils will be used to the MUA systems for low temperature operation from the heat pump and the units will operate as a first stage, second stage operation allowing the heat pumps to take the brunt of the load.

Cooling can also be done with this system.

Arena

The Arena heat pump recovery system was sized to handle 41% of the peak load which accounts for 83% of annual load. (See Appendix A 1.2.9)

The existing arena system would be replaced with force air heat pumps with the exception of the roof top unit which would remain and operate as an auxiliary system and would help handle the peak loads along with the operation of the heat pump system reducing the run time significantly on the conventional system. (See Appendix A 1.3.0, 1.3.1)

A piping system would be added from the secondary loop (between buildings) in the cooling plant room to each of the forced air heat pumps located in mechanical room. (See Appendix A 1.2.2)

The secondary loop transfers the heat from the heat exchanger (located in the arena) from the domestic water system to the piping system in the cooling plant (in the arena) to the heat pumps and back.

The heat pumps operate on any call for heat; the auxiliary system (conventional) will operate on a predetermined temperature drop on either the air temperature, water temperature, or the secondary loop temperature.

Cooling can also be done with this system.

Heat will also be captured off the existing ice plant through the existing heat exchanger to the secondary loop increasing the average loop temperature in the secondary loop, which in turn will increase the COP in each of the heat pumps in all buildings.

8.4 Discussion of Heating Options 4 System Alternatives.

Figures 11, 12 and 13 (Appendix A 1.8, 1.9, 1.2.1) show preliminary geothermal system performance for several building options as follows;

- **Alternative 1:** Geothermal heating system is provided to the school, convention centre and arena occupied space (mezzanine and change rooms). The artificial ice plant is not tied into the secondary heating loop. *Figure 11* (Appendix A 1.8) indicates that the geothermal heating system does not have sufficient capacity to heat the building at peak load. Approximately 157 kW of additional heat is required. This can be provided by the existing boiler plant in either the school or the convention centre.
- **Alternative 2. (Recommended)** Geothermal heating system is provided to the school, convention centre, arena occupied space (mezzanine and change rooms) and the artificial ice plant is tied into the secondary heating loop. *Figure 12* (Appendix A 1.9) indicates that the geothermal heating system has sufficient capacity to heat the building at peak load. This model indicates that there is approximately 55 kW surplus of heat available.
- **Alternative 3.** Similar to Alternative 2 with the exception that the Village recirculation flow rate is increased from 10.5 l/s to 15 l/s. *Figure 13* (Appendix's A 1.2.1) indicates that the geothermal heating system has sufficient capacity to heat the building at peak load. This model indicates that there is approximately 216 kW surplus of heat available.

8.5 System Information

Figure 14 indicates the estimated water volume of the water storage tank based on winter average day consumption shown in *figure 3*.

Village of Haines Junction Geothermal District Heating
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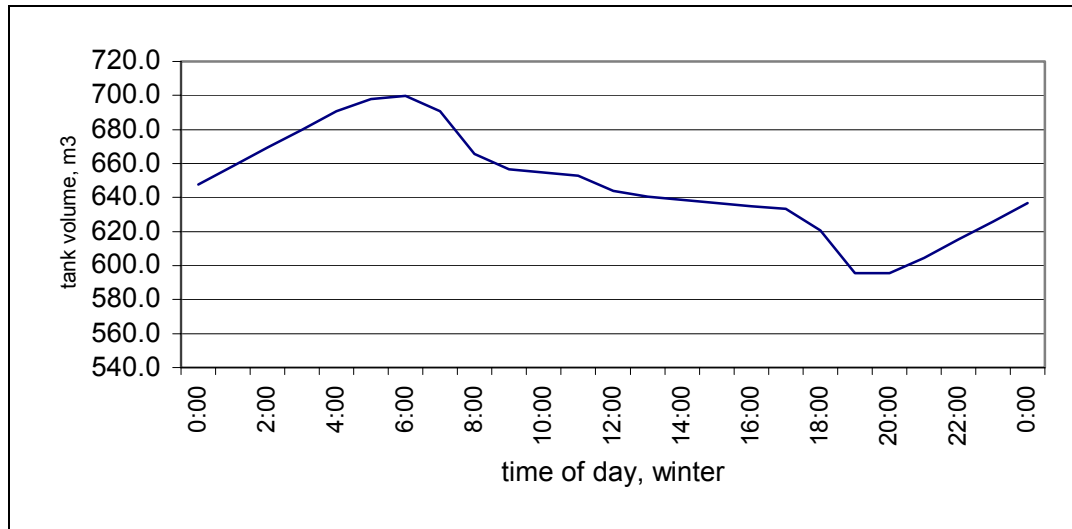


Figure 14 –Water Tank Volume During Typical Winter Day

9 Conclusions and Recommendations

- 9.1 The recommended approach to the application of Geothermal Heating for the Village of Haines Junction is the implementation of a recirculation system on the water distribution system to exchange and transfer heat energy between primary Village buildings. Option 4, Alternate 2 is designed to provide geothermal heating for the primary Village heating consumers including, the Arena, Convention Centre, and School. Figure 25, (Appendix A 1.2.2) represents the placement of the secondary loop system between the buildings.
- 9.2 The Demand Side Study illustrates that the use of water from well 5 for heat extraction implementing heat pump technology facilitates capture and distribution of heat in a practical manner. Additionally the heat extraction will not adversely affect the temperature and quality of the village supply water.
- 9.3 A secondary heating system consisting of looped supply/return piping with 2 pipes in a common trench is recommended. An ideal location for this system is along Backe Street extending south from Willow Acres road. Most of the heating loads occur along Backe St., within 1 block of the roadway.
- 9.4 Implementation of this option includes the installation of two heat exchangers in the secondary system with one in the School and another located in the Arena. The secondary loop pump would be located in the Arena.
- 9.5 It is recommended that a heat recovery system be installed in the Arena to capture heat from the arena ice plant to supplement the secondary loop heat capability and improve system performance.
- 9.6 The Village water distribution system will require modifications to include a recirculation piping loop with the pump located in pumphouse No 2.

Village of Haines Junction Geothermal District Heating
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- 9.7 The existing heating systems in each of the primary buildings with the exception of the Arena would be retained to provide supplemental heating for the peak heat loads.
- 9.8 The discharge of the water can also be controlled and monitored to minimize or eliminate the need for excess water discharge. An increased consumption of the well water for useful purposes such as commercial bottling will increase the available heat for the Village.
- 9.9 Subject to the results of the Business Case Study it is believed that energy saving involved in this approach will be significant with a considerable reduction in the use of fossil fuel and the resulting CO2 emissions.

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

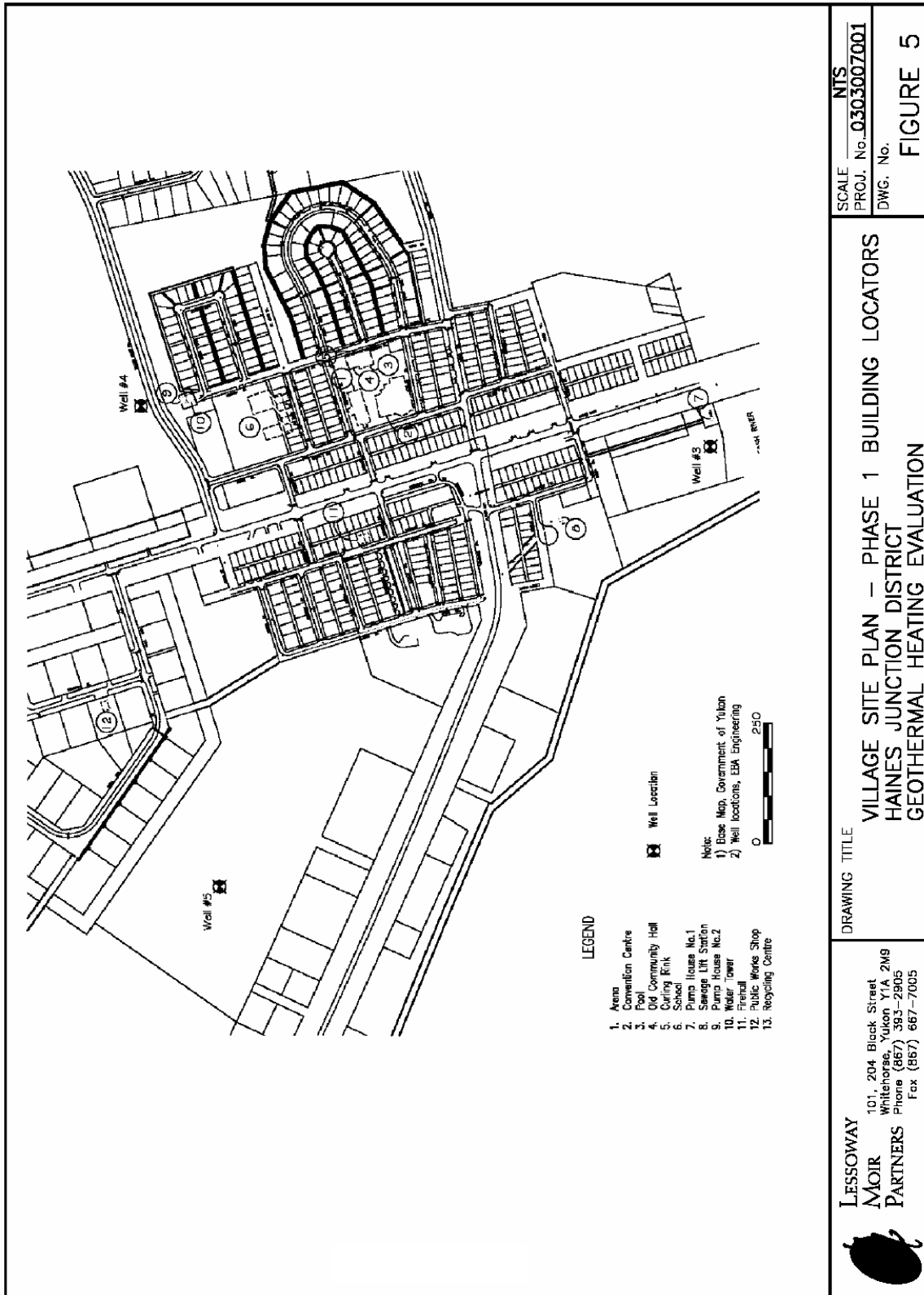
APPENDIX A

TABLES & FIGURES

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

Appendix A1.1	Existing Water Distribution System Schematic
Appendix A1.2	Village Site Plan
Appendix A 1.2.1	Primary Village building Heating model No. 3
Appendix A 1.2.2	Secondary Loop Location 3D Sketch
Appendix A 1.2.3	School Heat pump Layout
Appendix A 1.2.4	School Load Chart
Appendix A 1.2.5	School Heat Pump List
Appendix A 1.2.6	Convention Centre Heat pump Layout
Appendix A 1.2.7	Convention Centre Load Chart
Appendix A 1.2.8	Convention Centre Heat Pump List
Appendix A 1.2.9	Arena Heat load Chart
Appendix A 1.3	Estimated Monthly Heating Design Peak Loads
Appendix A 1.3.1	Arena Heat Pump List
Appendix A 1.3.2	Arena Heat pump Layout
Appendix A 1.3.3	District Heating Schematic Option 2a
Appendix A 1.3.4	District Heating Schematic Option 2b
Appendix A 1.3.5	District Heating Schematic Option 3
Appendix A 1.3.6	Existing Arena Equipment Plan
Appendix A 1.3.7	Existing School Equipment Plan
Appendix A 1.3.8	Existing Convention Centre Equipment Plan
Appendix A 1.4	Estimated Fuel consumption & Historical Fuel Consumption
Appendix A 1.5	Phase 1 Buildings - Heat Pump Flow Requirements
Appendix A 1.6	Proposed District Heating Schematic – Option 4
Appendix A 1.7	Interactive Spreadsheet System Layout
Appendix A 1.8	Primary Village building Heating model No. 1
Appendix A 1.9	Primary Village building Heating model No. 2

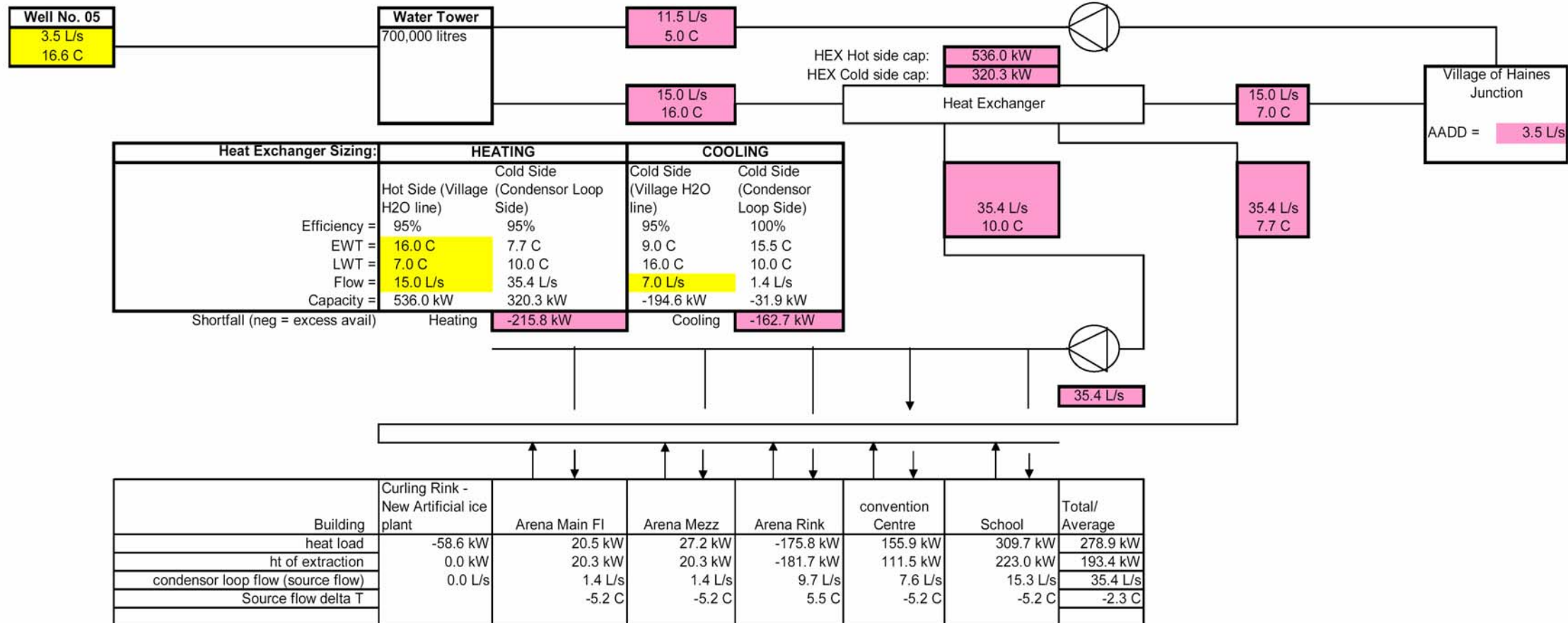
Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Appendix A1.2 – Village Site Plan

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

Include in Geo Loop? (Y/N)	Building	Winter				Summer			
		Heat Load	Theoretical Ht of Extraction	ΔT, °C	condensor loop flow	Cooling Load	Theoretical Ht of extraction	ΔT, °C	condensor loop flow
y	school	309.7 kW	223.0 kW	-5.2 C	15.3 L/s	0.0 kW	0.0 kW		0.0 L/s
y	convention center/town office	155.9 kW	111.5 kW	-5.2 C	7.6 L/s	-15.6 kW	-30.9 kW	5.5 C	1.4 L/s
y	arena ice plant	-175.8 kW	-181.7 kW	5.5 C	9.7 L/s	0.0 kW	0.0 kW		0.0 L/s
y	Arena lower floor - change rooms	20.5 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
y	Arena Mezzanine	27.2 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Zamboni room @ arena	7.2 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Chiller plant at Arena	5.9 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Fire hall	39.1 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Main pump house (no. 02)	9.5 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	public works maintenance shop	75.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	swimming pool	20.0 kW	0.0 kW		0.0 L/s	80.0 kW	0.0 kW		0.0 L/s
n	Community Hall	31.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	curling rink lounge	12.3 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	sewage lift station	4.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	pumphouse No. 01 (by River)	6.8 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	curling rink (new artificial ice plant)	-58.6 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
	TOTAL	491.8 kW	193.4 kW	-2.3 C	35.4 L/s	64.4 kW	-30.9 kW	5.5 C	1.4 L/s



Appendix A1.2.1 – Primary Village Building Heating Model No. 3

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

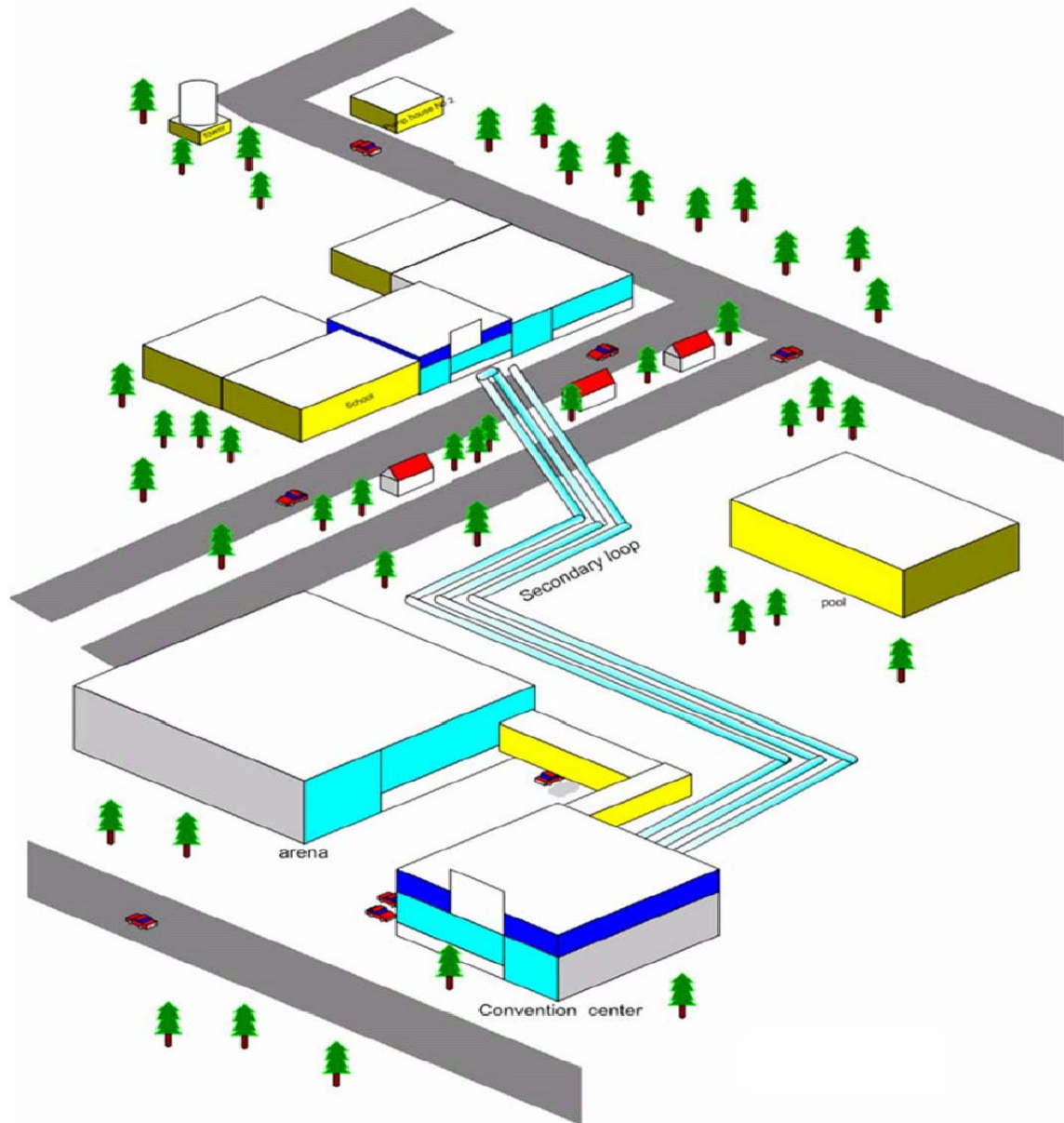


Figure 25 3d Closed Loop Piping Location

Appendix A1.2.2 – Secondary Loop Location 3D Sketch

Village of Haines Junction Geothermal District Heating Demand Side Assessment

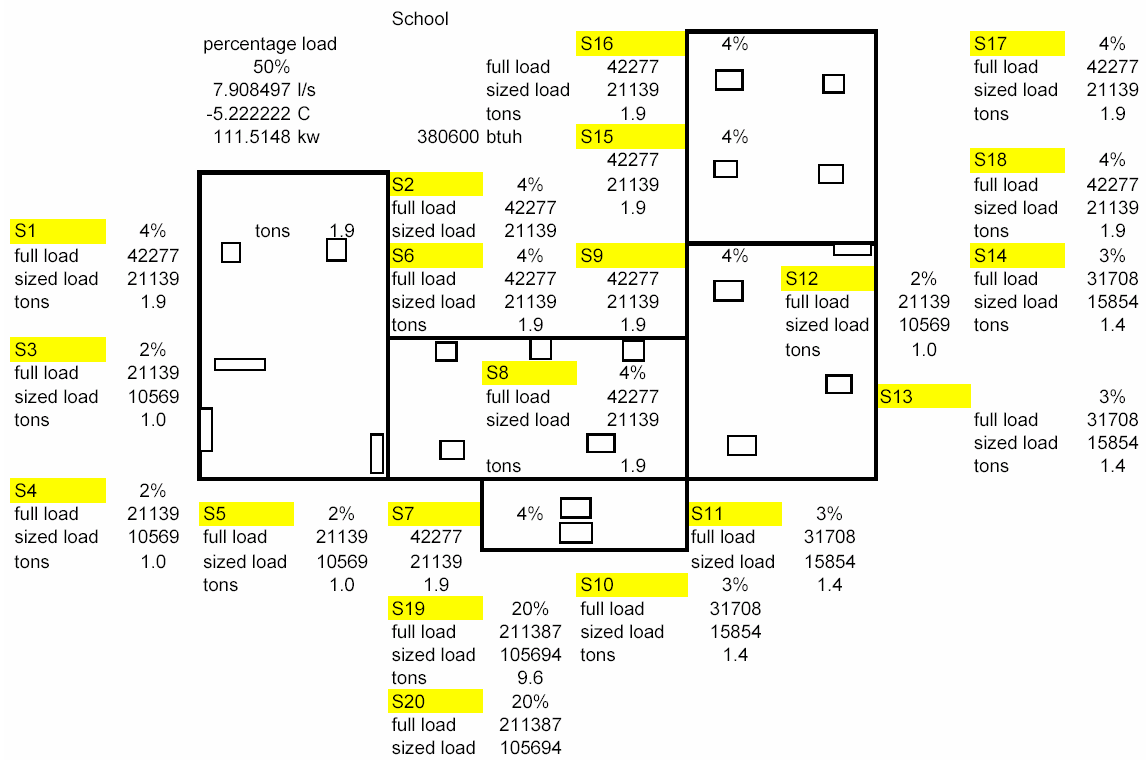
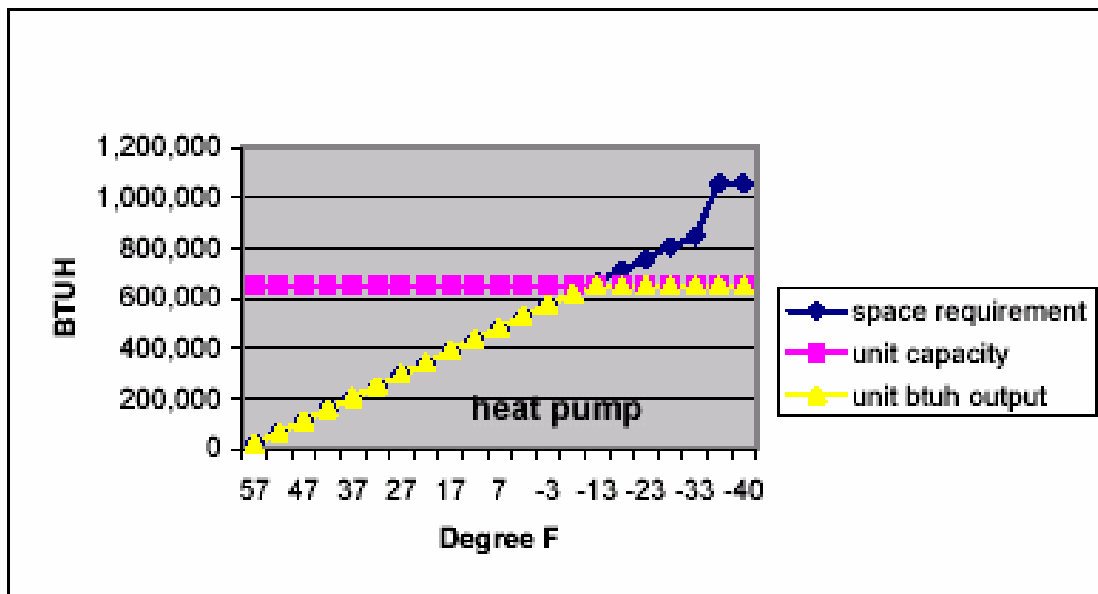


Figure 21--- School Heatpump Equipment Location

Appendix A1.2.3 – School Heat Pump Layout

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



covering 94.12 % of annual load
covering 61.29 % of peak @ outdoor temp of -40F

The heatpump is sized for 61.29% of the peak load and provides for 94.12% of the annual load @ outdoor temp of -40F

School space heating output versus peak demand

Chart for table10

Appendix A1.2.4 – School Load Chart

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

unit #	%f/load	full load	partial load	tons	unit	nit output@5f	gpm	cop	he	electrical options				type	location		
										fla	fla	fla	fla				
										208/230/1	208/230/3	575/3	460/3				
S1	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S2	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S3	2%	21139	10569	1.0	cw012	12691.0	3.0	4.4	9.8	5.2	0.0	0.0	0.0	console	library		
S4	2%	21139	10569	1.0	cw012	12691.0	3.0	4.4	9.8	5.2	0.0	0.0	0.0	console	library		
S5	2%	21139	10569	1.0	cw012	12691.0	3.0	4.4	9.8	5.2	0.0	0.0	0.0	console	front entry		
S6	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S7	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S8	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S9	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S10	3%	31708	15854	1.4	vh018	19400.0	5.0	3.7	14.2	9.4	0.0	0.0	0.0	horiz versatec	crawl		
S11	3%	31708	15854	1.4	vh018	19400.0	5.0	3.7	14.2	9.4	0.0	0.0	0.0	horiz versatec	crawl		
S12	2%	21139	10569	1.0	cw012	12691.0	3.0	4.4	9.8	5.2	0.0	0.0	0.0	console	side entry		
S13	3%	31708	15854	1.4	vh018	19400.0	5.0	3.7	14.2	9.4	0.0	0.0	0.0	horiz versatec	crawl		
S14	3%	31708	15854	1.4	vh018	19400.0	5.0	3.7	14.2	9.4	0.0	0.0	0.0	horiz versatec	crawl		
S15	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S16	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S17	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S18	4%	42277	21139	1.9	vh024	26100.0	6.0	3.5	18.0	11.0	0.0	0.0	0.0	horiz versatec	crawl		
S19	20%	211387	105694	9.6	vw120	129200.0	28.0	3.8	92.3	0.0	30.1	15.1	19.4	w/w	mech room		
S20	20%	211387	105694	9.6	vw120	129200.0	28.0	3.8	92.3	0.0	30.1	15.1	19.4	w/w	mech room		
						647,764				460.6	btuh						
						148400	61%			134.9	kw						
						48.0											

Appendix A1.2.5 – School Heat Pump List

Village of Haines Junction Geothermal District Heating Demand Side Assessment

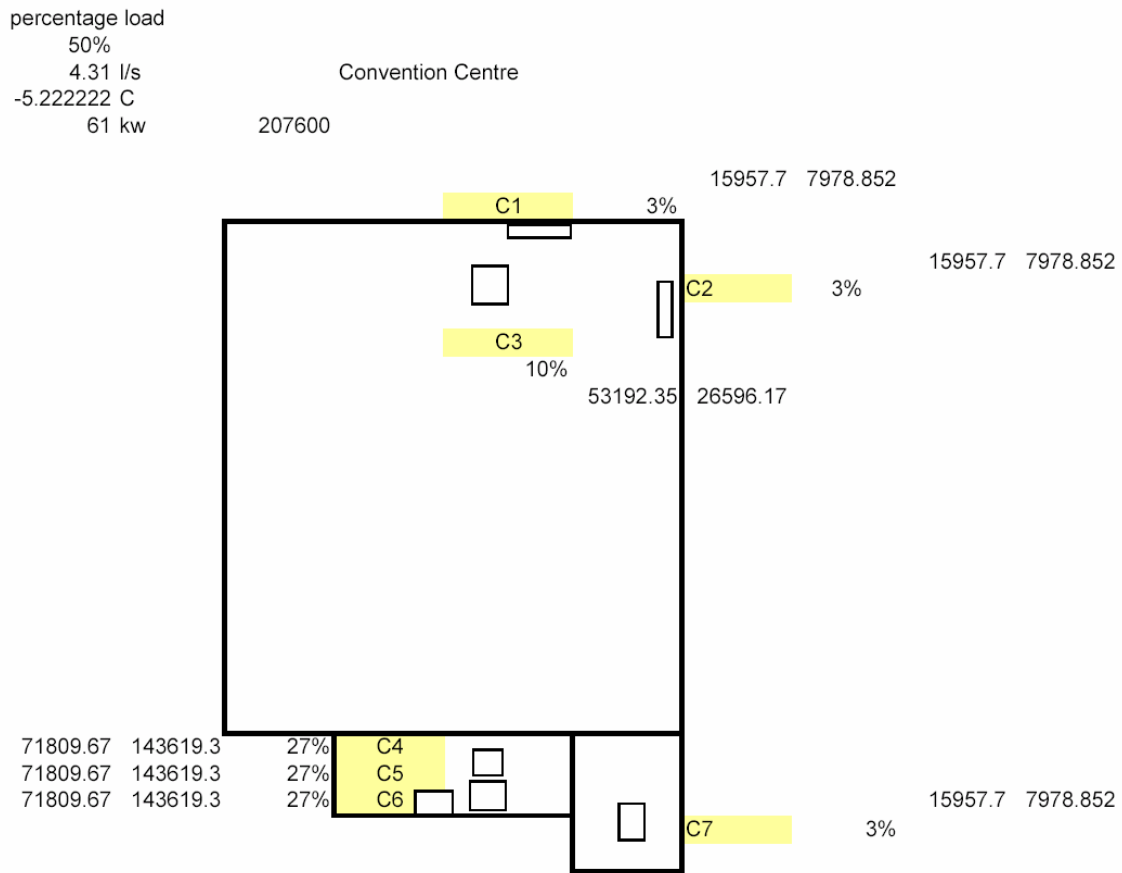
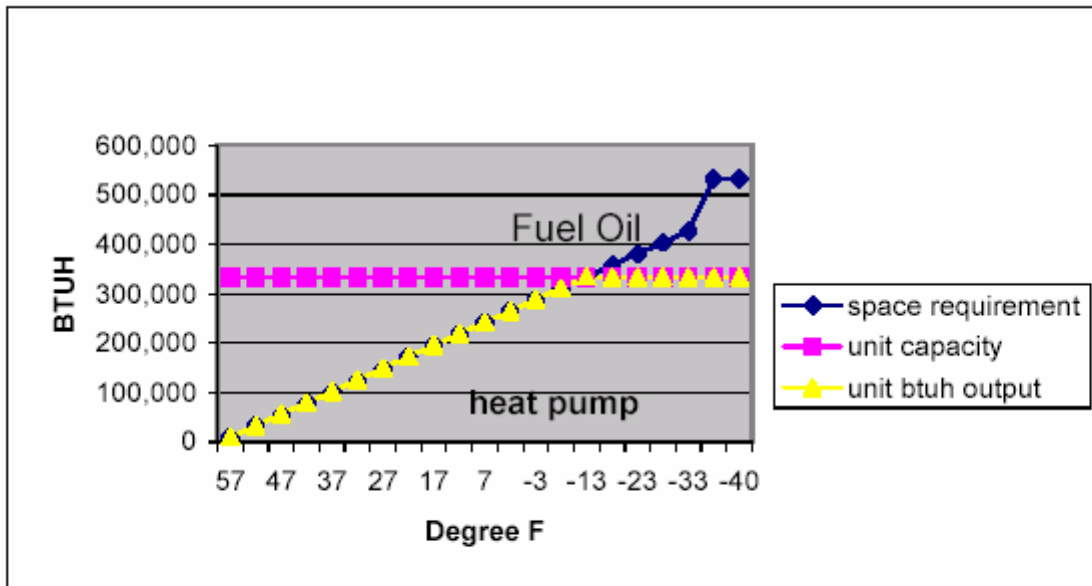


Figure 20--- Convention Centre Heatpump Equipment Location

Appendix A1.2.6 – Convention Centre Heat Pump Layout

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



covering 94.12 % of annual load
covering 62.56 % of peak @ outdoor temp of -40F

The heatpump is sized for 61.56% of the peak load and provides for 94.12% of the annual load @ outdoor temp of -40F

Community Center space heating output versus peak demand

Chart for table 11

Appendix A1.2.7 – Convention Centre Load Chart

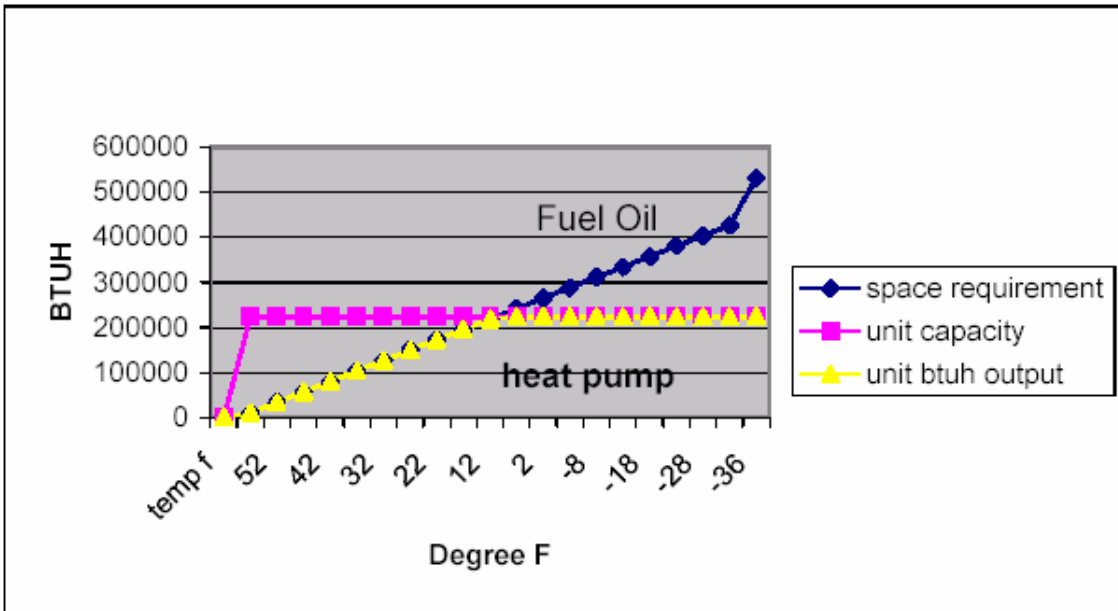
Village of Haines Junction Geothermal District Heating
Demand Side Assessment

unit #	%f/load	full load	partial load	tons	unit	nit output@5	gpm	cop	he	electrical options				type	location
										fla	fla	fla	fla		
										208/230/1	208/230/3	575/3	460/3		
C1	3%	15958	7979	0.7	cw009	10068.0	2.5	4.4	7.8	4.8	0.0	0.0	0.0	console	lobby
C2	3%	15958	7979	0.7	cw009	10068.0	2.5	4.4	7.8	4.8	0.0	0.0	0.0	console	lobby
C3	10%	53192	26596	2.4	vh036	34800.0	9.0	3.8	25.6	16.3	10.4	0.0	5.2	horiz versatec	crawl
C4	27%	143619	71810	6.5	vw120	129200.0	28.0	3.8	92.3	0.0	30.1	15.1	19.4	w/w	mech room
C5	27%	143619	71810	6.5	vw120	129200.0	28.0	3.8	92.3	0.0	30.1	15.1	19.4	w/w	mech room
C6	27%	143619	71810	6.5	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	w/w	mech room
C7	3%	15958	7979	0.7	vh018	19400.0	5.0	3.7	14.2	9.4	0.0	0.0	0.0	horiz versatec	crawl
8		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
9		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
10		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
11		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
12		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
13		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
14		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
15		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
16		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
17		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
18		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
19		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
20		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

332,736
148400 63%
24.2
239.9 btuh
70.3 kw

Appendix A1.2.8 – Convention Centre Heat Pump List

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



covering 83.25 % of annual load
covering 41.97 % of peak @ outdoor temp of -40F

The heatpump is sized for 41.97% of the peak load and provides for 83.25% of the annual load @ outdoor temp of -40F

Arena space heating output versus peak demand

Chart for table 12

Appendix A1.2.9 – Arena Heat Load Chart

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

building	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
school	309.7 kW	287.4 kW	207.3 kW	133.7 kW	65.7 kW	37.3 kW	28.9 kW	38.1 kW	82.2 kW	134.4 kW	210.4 kW	272.3 kW
convention center/town office	155.9 kW	144.7 kW	104.7 kW	67.9 kW	33.7 kW	19.4 kW	15.1 kW	19.8 kW	42.1 kW	68.2 kW	106.3 kW	137.2 kW
arena (will be negative for ice making)												
Arena lower floor - change rooms	20.5 kW	19.0 kW	13.7 kW	8.9 kW	4.4 kW	2.5 kW	1.9 kW	2.5 kW	5.4 kW	8.9 kW	13.9 kW	18.0 kW
Arena Mezzanine	27.2 kW	25.2 kW	18.2 kW	11.7 kW	5.8 kW	3.3 kW	2.5 kW	3.3 kW	7.2 kW	11.8 kW	18.5 kW	23.9 kW
Zamboni room @ arena	7.2 kW	6.7 kW	4.8 kW	3.1 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW	1.9 kW	3.1 kW	4.9 kW	6.3 kW
Chiller plant at Arena	5.9 kW	5.5 kW	3.9 kW	2.5 kW	1.2 kW	0.7 kW	0.5 kW	0.7 kW	1.6 kW	2.5 kW	4.0 kW	5.2 kW
Fire hall	39.1 kW	36.3 kW	26.2 kW	16.9 kW	8.3 kW	4.7 kW	3.6 kW	4.8 kW	10.4 kW	17.0 kW	26.6 kW	34.4 kW
Main pump house (no. 02)	9.5 kW	8.9 kW	6.4 kW	4.1 kW	2.0 kW	1.1 kW	0.9 kW	1.2 kW	2.5 kW	4.1 kW	6.5 kW	8.4 kW
public works maintenance shop	75.7 kW	70.2 kW	50.7 kW	32.7 kW	16.1 kW	9.1 kW	7.1 kW	9.3 kW	20.1 kW	32.8 kW	51.4 kW	66.6 kW
swimming pool	0.0 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW	2.3 kW	1.7 kW	2.3 kW	0.0 kW	0.0 kW	0.0 kW	0.0 kW
Community Hall	31.7 kW	29.4 kW	21.2 kW	13.7 kW	6.7 kW	3.8 kW	3.0 kW	3.9 kW	8.4 kW	13.8 kW	21.5 kW	27.9 kW
curling rink lounge	12.3 kW	11.4 kW	8.3 kW	5.3 kW	2.6 kW	1.5 kW	1.1 kW	1.5 kW	3.3 kW	5.3 kW	8.4 kW	10.8 kW
sewage lift station	4.7 kW	4.4 kW	3.2 kW	2.0 kW	1.0 kW	0.6 kW	0.4 kW	0.6 kW	1.3 kW	2.0 kW	3.2 kW	4.1 kW
pumphouse No. 01 (by River)	6.8 kW	6.3 kW	4.5 kW	2.9 kW	1.4 kW	0.8 kW	0.6 kW	0.8 kW	1.8 kW	2.9 kW	4.6 kW	6.0 kW
TOTAL	706.2 kW	655.5 kW	473.2 kW	305.4 kW	149.0 kW	87.1 kW	67.5 kW	88.8 kW	188.2 kW	307.0 kW	480.2 kW	621.1 kW

Table 5- Estimated Monthly Heating Design Peak Loads
Highlighted building are the target loads

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

unit #	%f/load	full load	partial load	tons	unit	nit output@5l	gpm	cop	he	electrical options				type	location
										208/230/1	208/230/3	575/3	460/3		
A1	25%	132981	66490	6.0	vh058	55800.0	14.0	3.6	44.3	26.4	22.2	0.0	10.7	horiz versatec	mech room
A2	25%	132981	66490	6.0	vh058	55800.0	14.0	3.6	44.3	26.4	22.2	0.0	10.7	horiz versatec	mech room
A3	25%	132981	66490	6.0	vh058	55800.0	14.0	3.6	44.3	26.4	22.2	0.0	10.7	horiz versatec	upper floor
A4	25%	132981	66490	6.0	vh058	55800.0	14.0	3.6	44.3	26.4	22.2	0.0	10.7	horiz versatec	upper floor
5		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
7		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
8		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
9		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
10		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
11		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
12		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
13		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
14		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
15		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
16		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
17		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
18		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
19		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
20		0	0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

24.2
148400
223,200
42%
177.2 btuh
51.9 kw

Appendix A1.3.1 – Arena Heat Pump List



Village of Haines Junction Geothermal District Heating
Demand Side Assessment

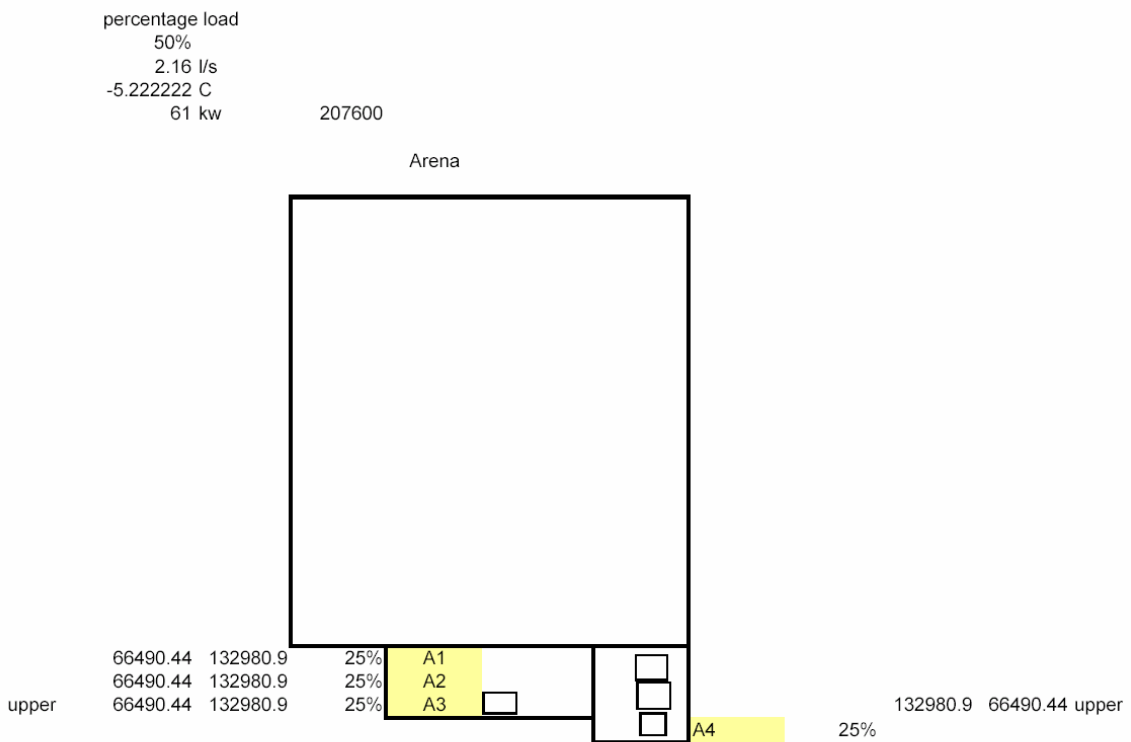
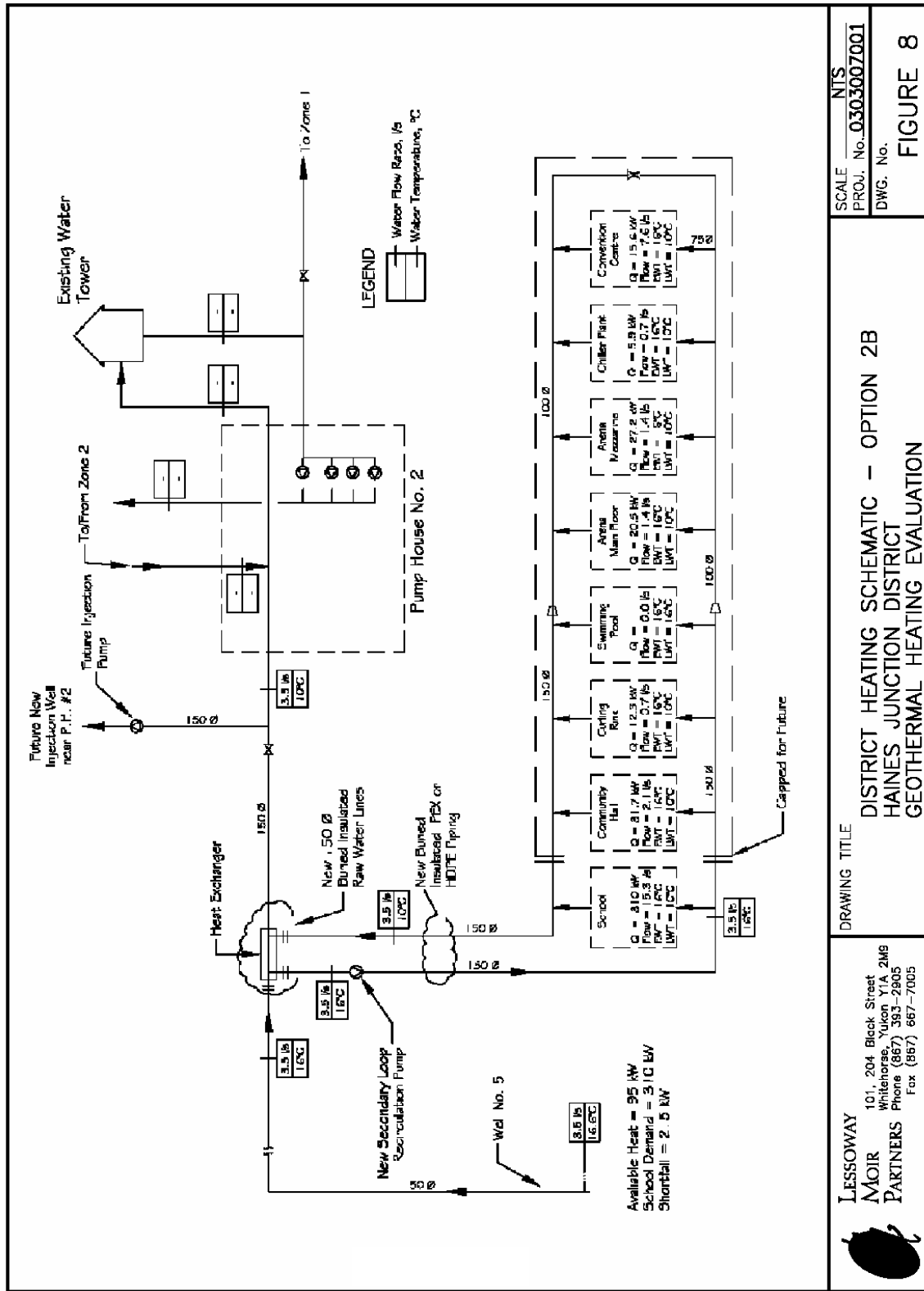


Figure 22--- Arena Heatpump Equipment Location

Appendix A1.3.2 – Arena Heat Pump Layout

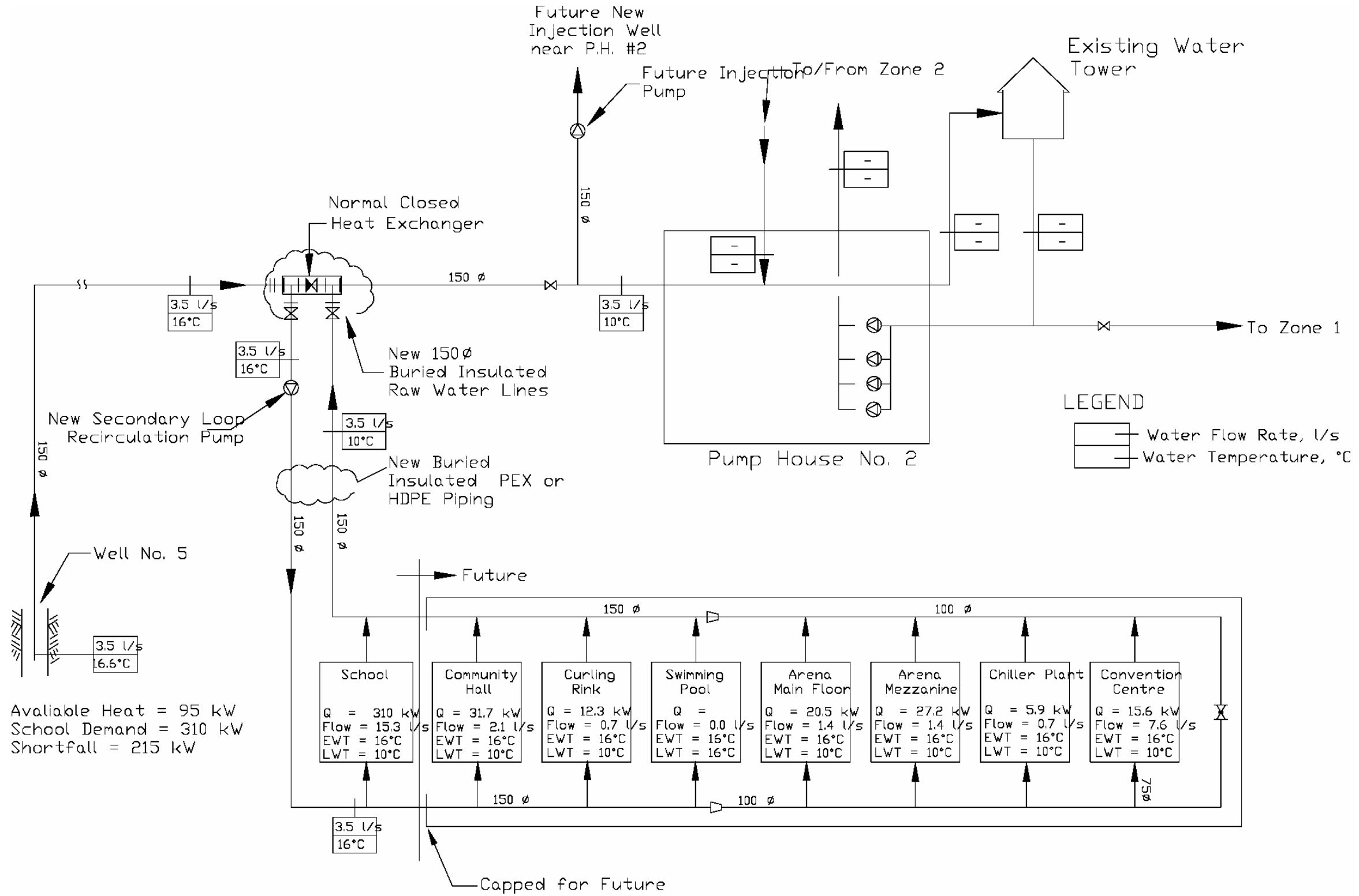
Village of Haines Junction Geothermal District Heating
Demand Side Assessment



	LESSOWAY MOIR PARTNERS 101, 204 Black Street Whitehorse, Yukon Y1A 2M8 Phone (867) 393-2905 Fax (867) 667-7005	DRAWING TITLE DISTRICT HEATING SCHEMATIC – OPTION 2B HAINES JUNCTION DISTRICT GEOTHERMAL HEATING EVALUATION	SCALE PROJ. No. 0303007001 DWG. No.
	FIGURE 8		NTS No. 0303007001

Appendix A1.3.3 – District Heating Schematic Option 2a

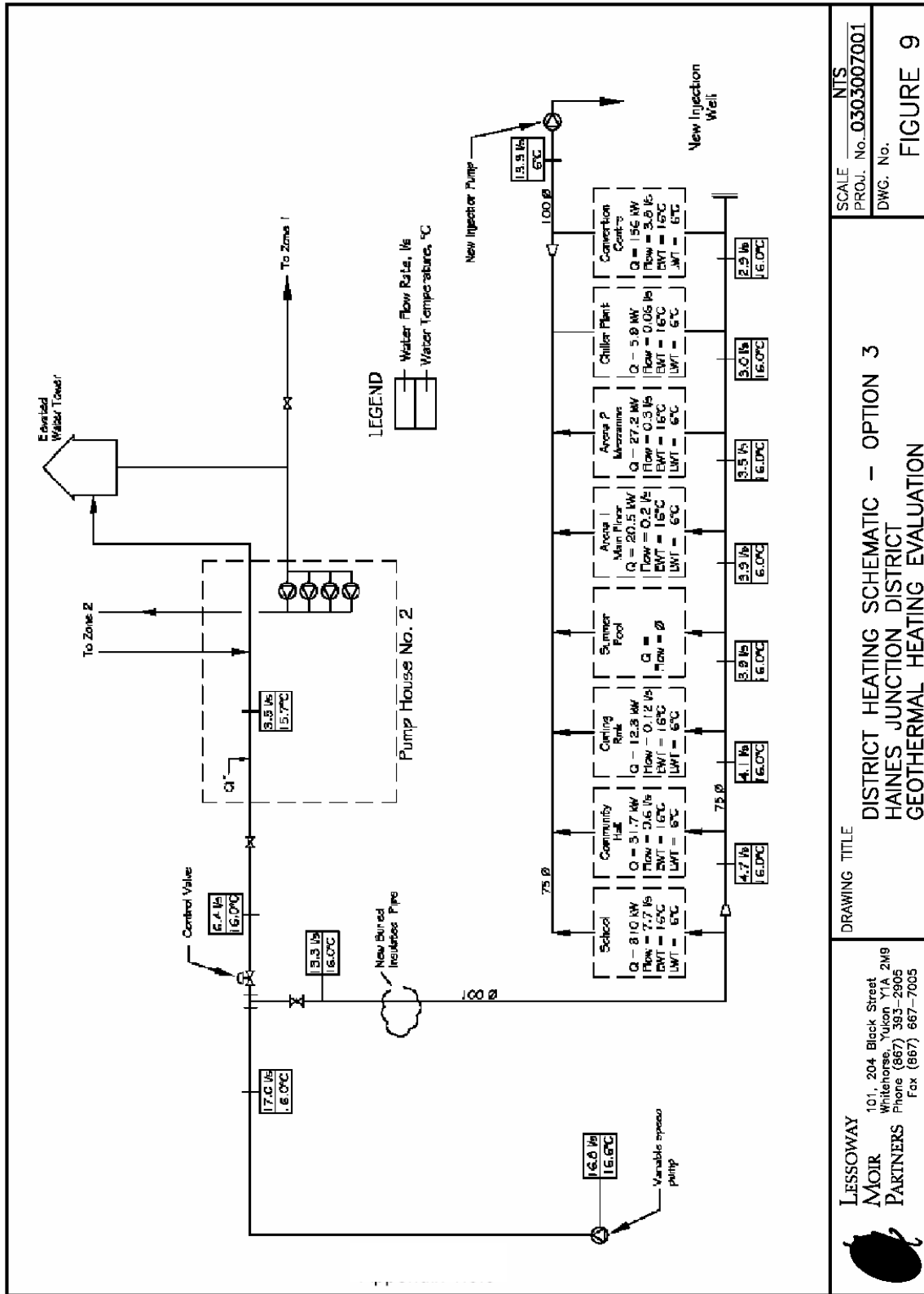
Village of Haines Junction Geothermal District Heating
Demand Side Assessment



(Not to Scale)

Appendix A1.3.4 – District Heating Schematic Option 2b

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



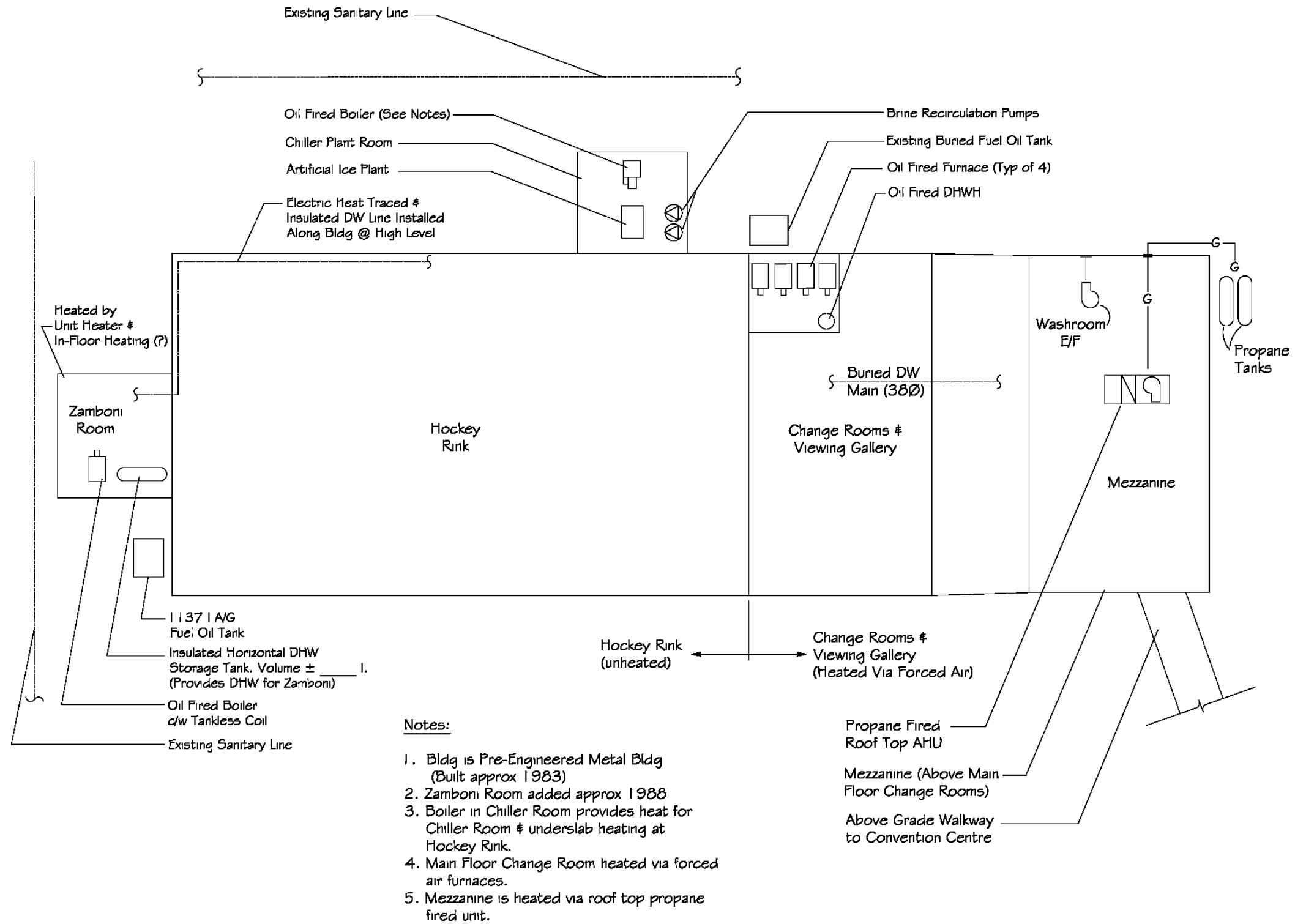
LESSOWAY MOIR PARTNERS
 101, 204 Black Street
 Whitehorse, Yukon Y1A 2M9
 Phone (867) 393-2905
 Fax (867) 667-7005

DRAWING TITLE
 DISTRICT HEATING SCHEMATIC – OPTION 3
 HAINES JUNCTION DISTRICT
 GEOTHERMAL HEATING EVALUATION

SCALE NTS
 PROJ. No. 0303007001
 DWG. No. **FIGURE 9**

Appendix A1.3.5 – District Heating Schematic Option 3

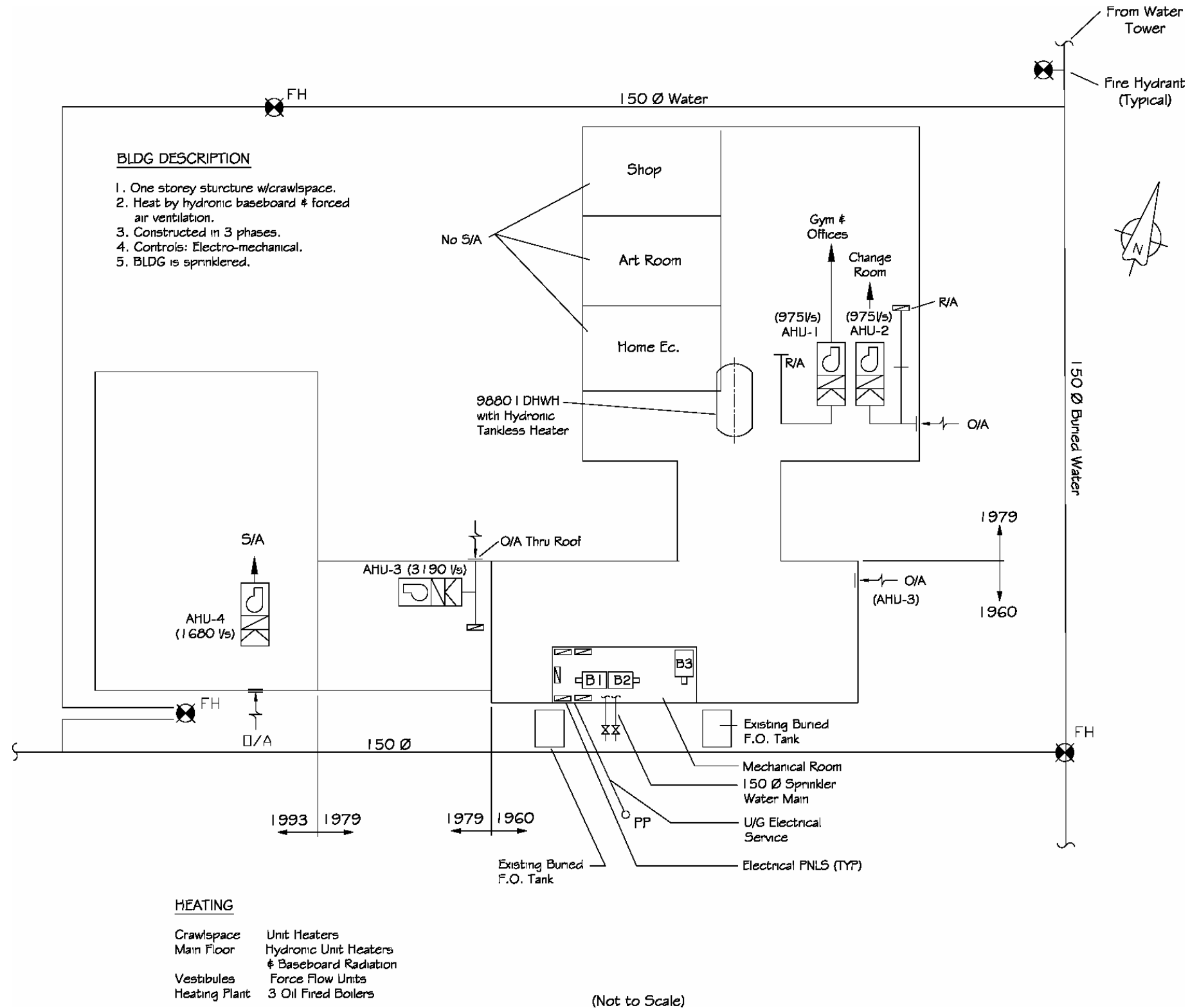
Village of Haines Junction Geothermal District Heating
Demand Side Assessment



ARENA
(Not to Scale)

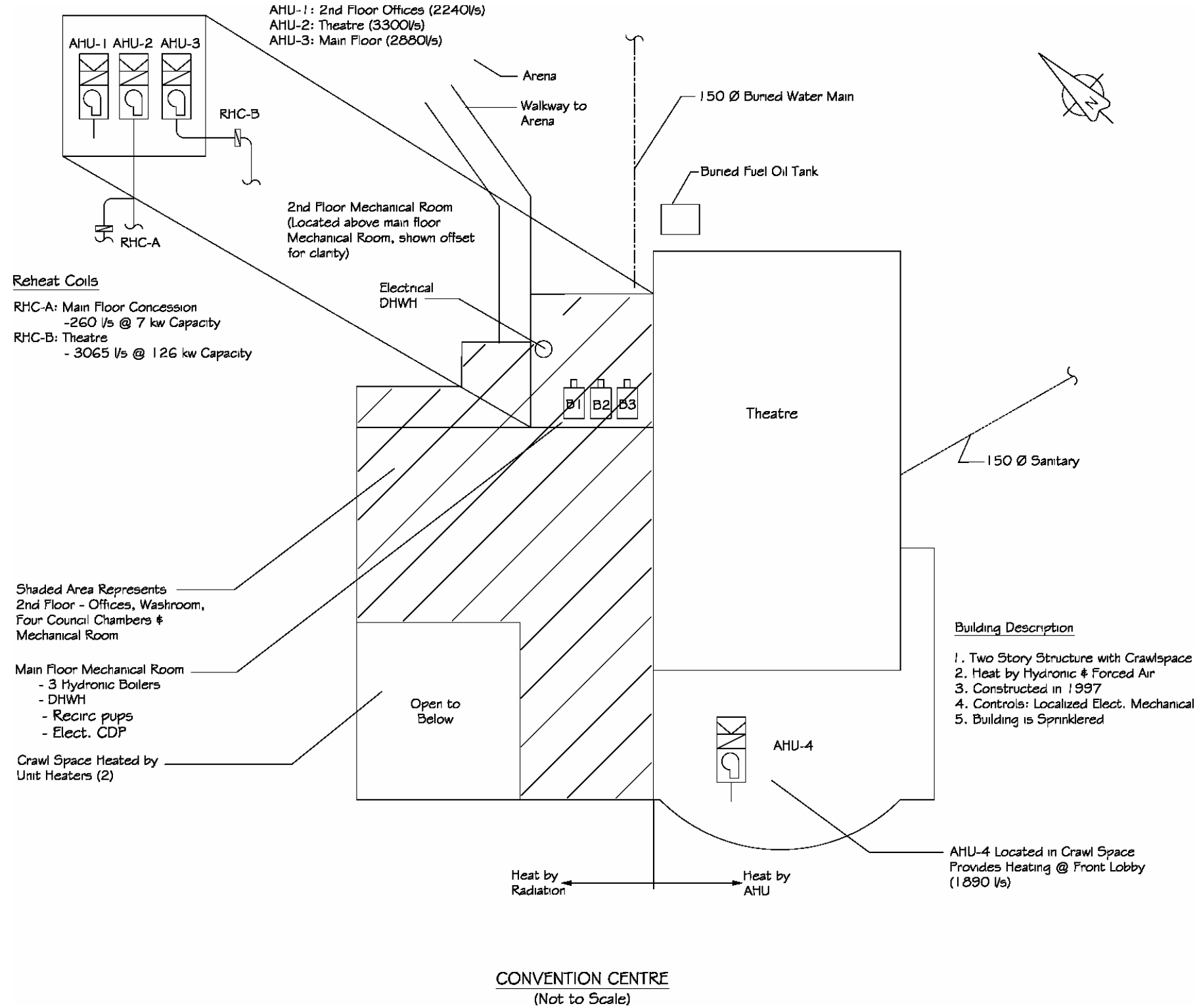
Appendix A1.3.6 – Existing Arena Equipment Plan

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Appendix A1.3.7 – Existing School Equipment Plan

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Appendix A1.3.8 – Existing Convention Centre Equipment Plan

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

Building	Est. Consumption Litres	Avg Consumption Litres	Remarks
School	65,322	65,884 over last 3 yrs	Building may be tighter than modelled resulting in reduced infiltration. Also, ventilation (Outdoor Air) load may be lower than modelled. 75, 336 lts avg. over 5 yrs . the drop may be due to a new roof membrane.
Convention Centre	32,318	32,772	Model compares well to actual.
Arena Lower Floor	4,329	14,147	The Difference may be due to the outside doors being open for long periods of time while the staff service the building and / or public moving in and out of the arena and change room area.
Arena Mezzanine	8,666	15,768	Heat and ventilation is provided by 100% out door air using a propane fired roof top unit
Zamboni Room	1,522	5,538	Actual consumption relatively high versus estimated. Possibly higher infiltration rates than allowed for. Also, estimated rates did not allow for domestic hot water heating that could be significant and are not included in the calculations.
Arena Chiller Plant	1,239	4,375	Actual consumption relatively high versus estimated. Possibly higher infiltration rates than allowed for, also an oil fired boiler also heats up under the ice slab which is not included in the calculations
Fire Hall	8,253	15,073	Actual consumption relatively high versus estimated. Possibly higher infiltration rates than allowed for. The difference would also be due to the operation of the building. ie/ overhead doors being left open for extended periods of time, and the users sometimes turn the space
Main Pump House No. 2	2,077		Actual consumption levels not available
Public Works Maintenance Shop	15,966	11,558	Within reasonable range of accuracy
Swimming Pool	10,206	14,370	Within reasonable range of accuracy.
Community Hall	6,689	14,006	Actual consumption relatively high versus estimated. Possibly higher infiltration rates than allowed for.
Curling Rink	2,600	5,749	Actual consumption relatively high versus estimated. Possibly higher infiltration rates than allowed for.
Sewage Lift Station	995	6,502	Infiltration could be higher than accounted for due to size of building and construction.
Pumphouse No 1 (by River)	2,077	7,305	Infiltration of outside air may be higher than estimated. Also, water storage tanks uninsulated in building could double heat loss from that calculated.

*Table 6 - Comparison of Estimated Fuel consumption
Versus Historical Fuel Consumption*

Appendix A1.4 – Estimated Fuel Consumption & Historical Fuel Consumption

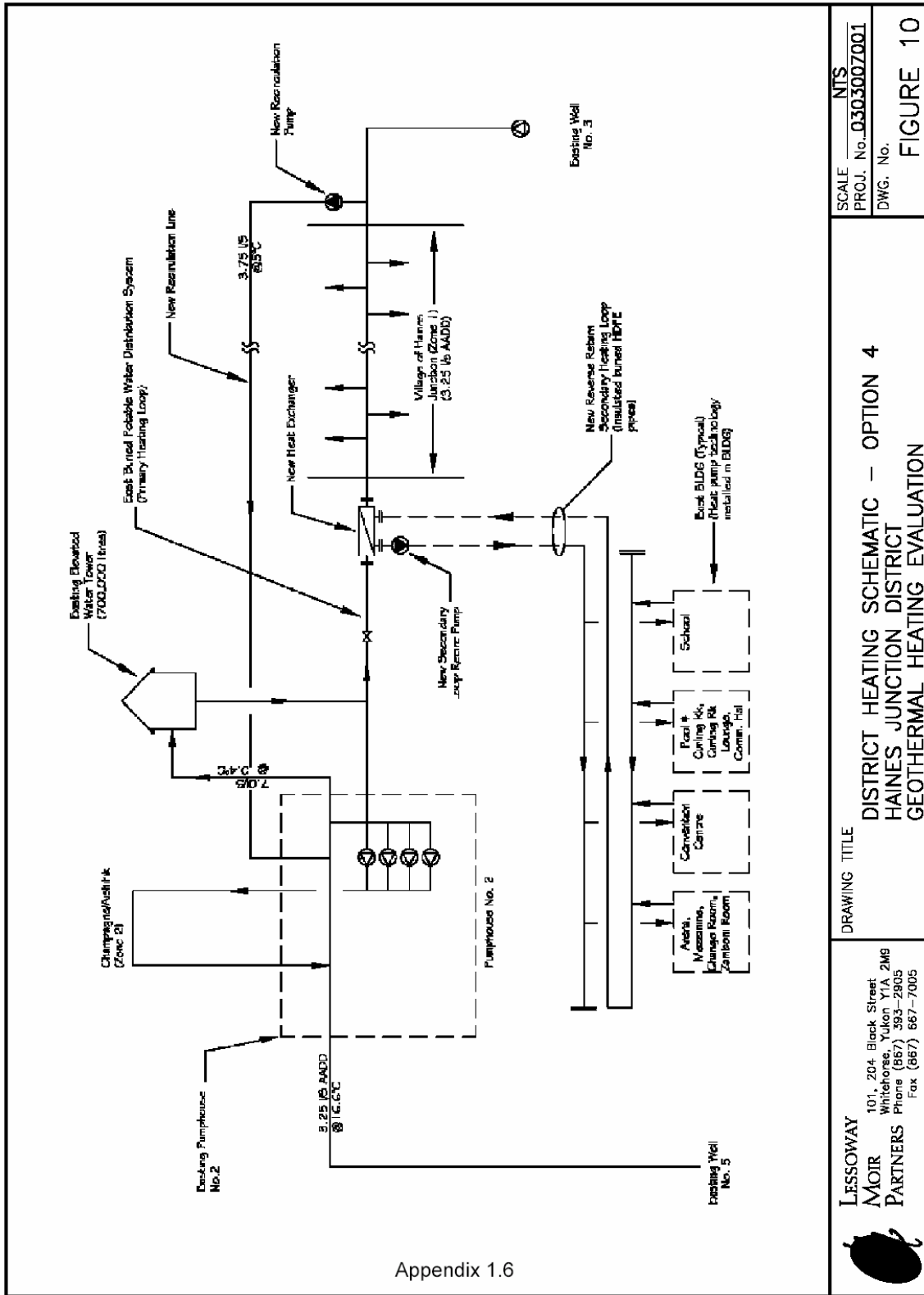
Village of Haines Junction Geothermal District Heating
Demand Side Assessment

Table 7 – Phase 1 Buildings – Heat Pump Flow Requirements


Building	Winter				Summer			
	Heat Load	Total HE	$\Delta T, ^\circ C$	Source flow rate	Cooling Load	Total HE/HR	$\Delta T, ^\circ C$	Source flow rate
<i>school</i>	309.7 kW	223.0 kW	-5.2 C	15.3 L/s	0.0 kW	0.0 kW		0.0 L/s
<i>convention centre/town office</i>	155.9 kW	111.5 kW	-5.2 C	7.6 L/s	-15.6 kW	-30.9 kW	5.5 C	1.4 L/s
<i>arena ice plant</i>	-175.8 kW	-181.7 kW	5.5 C	9.7 L/s	0.0 kW	0.0 kW		0.0 L/s
<i>Arena lower floor - change rooms</i>	20.5 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
<i>Arena Mezzanine</i>	27.2 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
<i>Zamboni room @ arena</i>	7.2 kW	10.1 kW	-5.2 C	0.7 L/s	0.0 kW	0.0 kW		0.0 L/s
<i>Chiller plant at Arena</i>	5.9 kW	10.1 kW	-5.2 C	0.7 L/s	0.0 kW	0.0 kW		0.0 L/s
Fire hall	39.1 kW	30.4 kW	-5.2 C	2.1 L/s	0.0 kW	0.0 kW		0.0 L/s
Main pumphouse (No. 2)	9.5 kW	10.1 kW	-5.2 C	0.7 L/s	0.0 kW	0.0 kW		0.0 L/s
public works maintenance shop	75.7 kW	60.8 kW	-5.2 C	4.2 L/s	0.0 kW	0.0 kW		0.0 L/s
swimming pool	20.0 kW	20.3 kW	-5.2 C	1.4 L/s	80.0 kW	108.3 kW	-4.6 C	4.9 L/s
Community Hall	31.7 kW	30.4 kW	-5.2 C	2.1 L/s	0.0 kW	0.0 kW		0.0 L/s
curling rink lounge	12.3 kW	10.1 kW	-5.2 C	0.7 L/s	0.0 kW	0.0 kW		0.0 L/s
sewage lift station	4.7 kW	10.1 kW	-5.2 C	0.7 L/s	0.0 kW	0.0 kW		0.0 L/s
pumphouse No. 1 (by River)	6.8 kW	10.1 kW	-5.2 C	0.7 L/s	0.0 kW	0.0 kW		0.0 L/s
curling rink (assumes new artificial ice plant)	-58.6 kW	-64.9 kW	5.5 C	3.5 L/s	0.0 kW	0.0 kW		0.0 L/s
TOTAL	491.8 kW	331.2 kW	-2.5 C	52.7 L/s	64.4 kW	77.4 kW	0.4 C	6.2 L/s

Appendix A1.5 – Phase 1 Buildings – Heat Pump Flow Requirements

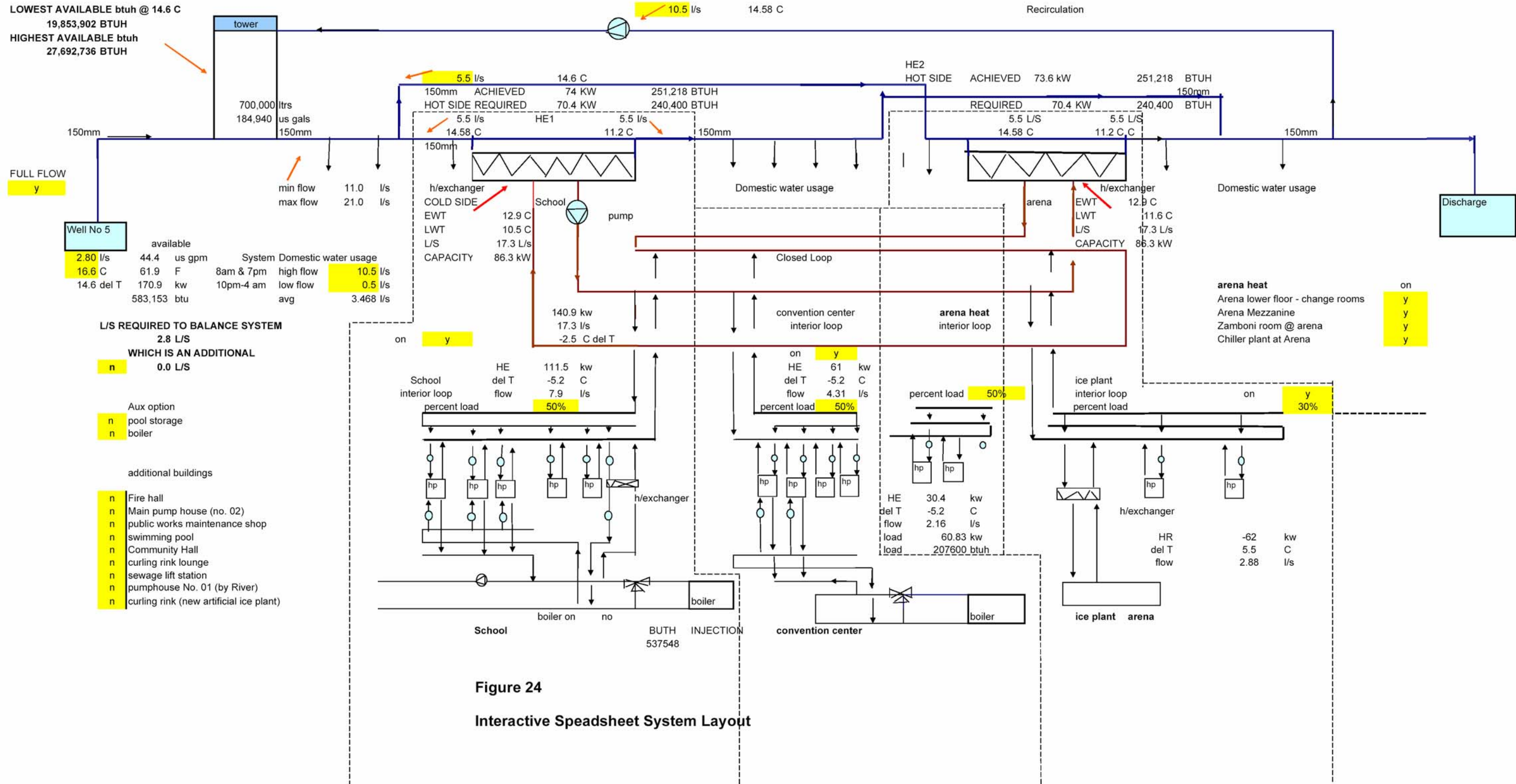
Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Appendix A1.6 – Proposed District Heating Schematic – Option 4

<p>LESSOWAY MOIR PARTNERS 101, 204 Black Street Whitehorse, Yukon Y1A 2M6 Phone (867) 393-2905 Fax (867) 667-7005</p> 	<p>DRAWING TITLE DISTRICT HEATING SCHEMATIC – OPTION 4 HAINES JUNCTION DISTRICT GEOTHERMAL HEATING EVALUATION</p>	<p>SCALE NTS PROJ. No. 0303007001 DWG. No.</p>
		<p>FIGURE 10</p>

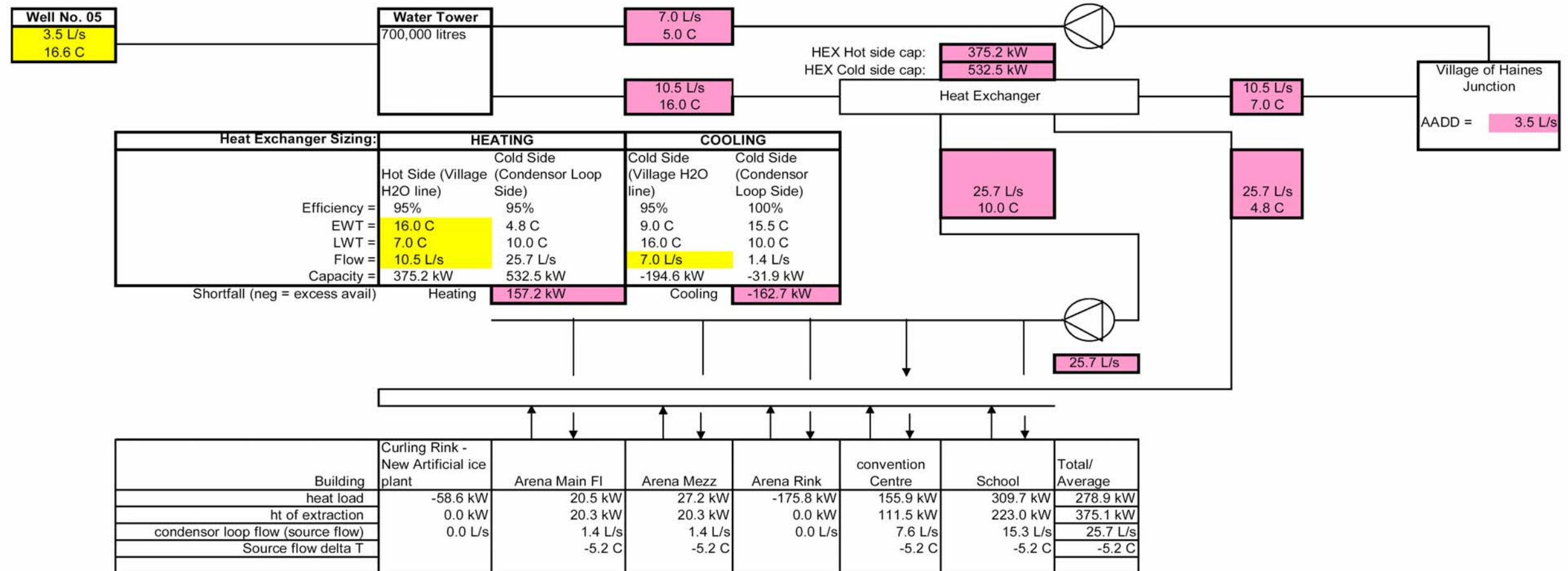
Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Appendix A1.7 – Interactive Spreadsheet System Layout

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

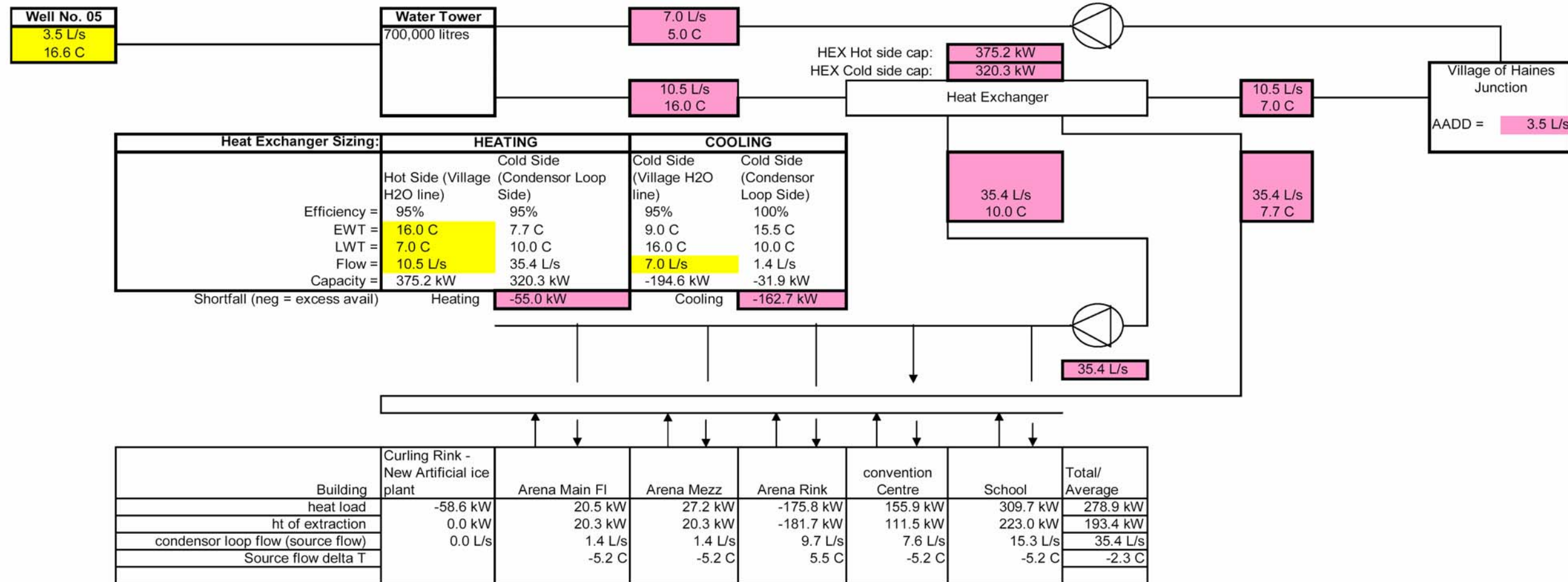
Include in Geo Loop? (Y/N)	Building	Winter				Summer			
		Heat Load	Theoretical Ht of Extraction	ΔT, °C	condensor loop flow	Cooling Load	Theoretical Ht of extraction	ΔT, °C	condensor loop flow
y	school	309.7 kW	223.0 kW	-5.2 C	15.3 L/s	0.0 kW	0.0 kW		0.0 L/s
y	convention center/town office	155.9 kW	111.5 kW	-5.2 C	7.6 L/s	-15.6 kW	-30.9 kW	5.5 C	1.4 L/s
n	arena ice plant	-175.8 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
y	Arena lower floor - change rooms	20.5 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
y	Arena Mezzanine	27.2 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Zamboni room @ arena	7.2 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Chiller plant at Arena	5.9 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Fire hall	39.1 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Main pump house (no. 02)	9.5 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	public works maintenance shop	75.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	swimming pool	20.0 kW	0.0 kW		0.0 L/s	80.0 kW	0.0 kW		0.0 L/s
n	Community Hall	31.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	curling rink lounge	12.3 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	sewage lift station	4.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	pumphouse No. 01 (by River)	6.8 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	curling rink (new artificial ice plant)	-58.6 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
TOTAL		491.8 kW	375.1 kW	-5.2 C	25.7 L/s	64.4 kW	-30.9 kW	5.5 C	1.4 L/s



Appendix A1.8 – Primary Village Building Heating Model No. 1

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

Include in Geo Loop? (Y/N)	Building	Winter				Summer			
		Heat Load	Theoretical Ht of Extraction	ΔT, °C	condensator loop flow	Cooling Load	Theoretical Ht of extraction	ΔT, °C	condensator loop flow
y	school	309.7 kW	223.0 kW	-5.2 C	15.3 L/s	0.0 kW	0.0 kW		0.0 L/s
y	convention center/town office	155.9 kW	111.5 kW	-5.2 C	7.6 L/s	-15.6 kW	-30.9 kW	5.5 C	1.4 L/s
y	arena ice plant	-175.8 kW	-181.7 kW	5.5 C	9.7 L/s	0.0 kW	0.0 kW		0.0 L/s
y	Arena lower floor - change rooms	20.5 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
y	Arena Mezzanine	27.2 kW	20.3 kW	-5.2 C	1.4 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Zamboni room @ arena	7.2 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Chiller plant at Arena	5.9 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Fire hall	39.1 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	Main pump house (no. 02)	9.5 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	public works maintenance shop	75.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	swimming pool	20.0 kW	0.0 kW		0.0 L/s	80.0 kW	0.0 kW		0.0 L/s
n	Community Hall	31.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	curling rink lounge	12.3 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	sewage lift station	4.7 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	pumphouse No. 01 (by River)	6.8 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
n	curling rink (new artificial ice plant)	-58.6 kW	0.0 kW		0.0 L/s	0.0 kW	0.0 kW		0.0 L/s
	TOTAL	491.8 kW	193.4 kW	-2.3 C	35.4 L/s	64.4 kW	-30.9 kW	5.5 C	1.4 L/s



Appendix A1.9 – Primary Village Building Heating Model No. 2

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

APPENDIX B

EXISTING ENERGY CONSUMPTION RECORDS

Appendix A1.9 – Primary Village Building Heating Model No. 2

Village of Haines Junction Geothermal District Heating Demand Side Assessment

Project: **Haines Junction District Heating**
 Date Prepared: 4-Sep-03
 Prepared by: Lee Fleming
 location: **School**
 IP Project Number: 0303007001

ASSUMPTIONS:

- 1 $E = CD*(86.4*Qls*DD)/(k*DT)$
 ref: ASHRAE Fundamentals handbook, 1989, SI ver, pg F28.2
 where:
 E= fuel or energy consumption for estaimte period, kJ
 CD = correction factor for heating effect vs. kelvin degree days
 Qls = design heat loss incl. infiltration and ventilation, W
 DD= Kelvin degree days, C
 k = correction factor for heating system
 DT = design temperature difference, C
- 2 Use degree day data for Whitehorse, Yk
- 3 fuel oil consumption = E/fuel oil heating value
- 4 Day loss assume ventilation system off at night
- 5 fuel oil = # 2 diesel fuel oil
- 6 assume operation = 10hr/d, 5d/wk, average = $10*5/7=7.14$ hrs/ave day
- 7 design temperatures based on Canada Climatic data (1971-2000), average of daily mean and extreme
- 8 mth pk heating based on Canada Climatic design temperatures not NBCC 2.5% design temperature.

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada Climatic Norms

Jan DD	1105	July DD	124	0.65	Correction factor CD:
Feb DD	894.5	Aug DD	175.2	359,623 W	heat loss day
Mar DD	761.8	Sep DD	325.9	341,200 W	heat loss night
Apr DD	512.7	Oct DD	540.1	7 hrs	ave occupied hours
May DD	344.7	Nov DD	822.3	17 hrs	ave unoccupied hours
Jun DD	185.8	Dec DD	1019	0.65	correction factor k:
		Total DD:	6811	62 C	NBCC Delta Temp
				38.2 mJ/L	Fuel Oil heating Value, mJ/L

Design Temperatures

Jan	-37.1 C	Jul	3.6 C	$E = CD*(86.4*Qls*DD)/(k*DT)$ $Qls = E*k*DT/CD*86.4*DD$
Feb	-35.0 C	Aug	1.0 C	
Mar	-26.5 C	Sep	-8.7 C	
Apr	-17.0 C	Oct	-17.1 C	
May	-5.5 C	Nov	-26.8 C	
Jun	1.2 C	Dec	-33.5 C	

OUTPUT: Monthly Fuel oil Consumption & Peak kW

Month	Mth Fuel	Mth Pk ht	Month	Mth Fuel	Mth Pk ht
Jan	13,321 L	309,680 W	July	465 L	28,875 W
Feb	10,391 L	287,371 W	Aug	752 L	38,064 W
Mar	7,529 L	207,338 W	Sep	2,041 L	82,233 W
Apr	4,079 L	133,659 W	Oct	4,308 L	134,354 W
May	1,934 L	65,725 W	Nov	8,186 L	210,376 W
Jun	790 L	37,326 W	Dec	11,526 L	272,301 W

Total Annual Fuel consumption 65,322 L

Actual consumption not available.

Village of Haines Junction Geothermal District Heating Demand Side Assessment

Project: **Haines Junction District Heating**
 Date Prepared: 4-Sep-03
 Prepared by: Lee Fleming
 location: **Arena Mezzanine (top floor)**
 IP Project Number: 0303007001

ASSUMPTIONS:

- 1 $E = CD * (86.4 * Q_{ls} * DD) / (k * DT)$
 ref: ASHRAE Fundamentals handbook, 1989, SI ver, pg F28.2
 where:
 E= fuel or energy consumption for estaimte period, kJ
 CD = correction factor for heating effect vs. kelvin degree days
 Q_{ls} = design heat loss incl. infiltration and ventilation, W
 DD= Kelvin degree days, C
 k = correction factor for heating system
 DT = design temperature difference, C
- 2 Use degree day data for Whitehorse, Yk
- 3 fuel oil consumption = E/fuel oil heating value
- 4 Day loss assume ventilation system off at night
- 5 fuel oil = propane
- 6 assume typical operation = 5pm-12pm, 7 days per week, O/A via E/F.
- 7 design temperatures based on Canada Climatic data (1971-2000), average of daily mean and extreme
- 8 mth pk heating based on Canada Climatic design temperatures not NBCC 2.5% design temperature.

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada Climatic Norms

Jan DD	1105	July DD	124	0.65	Correction factor CD: heat loss day heat loss night ave occupied hours ave unoccupied hours correction factor k: NBCC Delta Temp Fuel Oil heating Value, mJ/L
Feb DD	894.5	Aug DD	175.2	42,750 W	
Mar DD	761.8	Sep DD	325.9	25,400 W	
Apr DD	512.7	Oct DD	540.1	7 hrs	
May DD	344.7	Nov DD	822.3	17 hrs	
Jun DD	185.8	Dec DD	1019	0.65	
		Total DD:	6811	62 C	
				25.3 mJ/L	

Design Temperatures

Jan	-37.1 C	Jul	3.6 C	$E = CD * (86.4 * Q_{ls} * DD) / (k * DT)$ $Q_{ls} = E * k * DT / CD * 86.4 * DD$
Feb	-35.0 C	Aug	1.0 C	
Mar	-26.5 C	Sep	-8.7 C	
Apr	-17.0 C	Oct	-17.1 C	
May	-5.5 C	Nov	-26.8 C	
Jun	1.2 C	Dec	-33.5 C	

OUTPUT: Monthly Fuel oil Consumption & Peak kW

Month	Mth Fuel	Mth Pk ht	Month	Mth Fuel	Mth Pk ht
Jan	1,767 L	27,209 W	July	62 L	2,537 W
Feb	1,379 L	25,249 W	Aug	100 L	3,344 W
Mar	999 L	18,217 W	Sep	271 L	7,225 W
Apr	541 L	11,744 W	Oct	571 L	11,805 W
May	257 L	5,775 W	Nov	1,086 L	18,484 W
Jun	105 L	3,280 W	Dec	1,529 L	23,925 W

Total Annual Fuel consumption 8,666 L

Actual average propane consumption 15,768 L

Village of Haines Junction Geothermal District Heating Demand Side Assessment

Project: **Haines Junction District Heating**
 Date Prepared: 4-Sep-03
 Prepared by: Lee Fleming
 location: **Arena veiwing gallery & change rooms (lower floor)**
 IP Project Number: 0303007001

ASSUMPTIONS:

- 1 $E = CD \cdot (86.4 \cdot Q_{ls} \cdot DD) / (k \cdot DT)$
 ref: ASHRAE Fundamentals handbook, 1989, SI ver, pg F28.2
 where:
 E= fuel or energy consumption for estaimte period, kJ
 CD = correction factor for heating effect vs. kelvin degree days
 Q_{ls} = design heat loss incl. infiltration and ventilation, W
 DD= Kelvin degree days, C
 k = correction factor for heating system
 DT = design temperature difference, C
- 2 Use degree day data for Whitehorse, Yk
- 3 fuel oil consumption = E/fuel oil heating value
- 4 Day loss assume ventilation system off at night
- 5 fuel oil = propane
- 6 assume typical operation = 5pm-12pm, 7 days per week, O/A via E/F.
- 7 design temperatures based on Canada Climatic data (1971-2000), average of daily mean and extreme
- 8 mth pk heating based on Canada Climatic design temperatures not NBCC 2.5% design temperature.

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada Climatic Norms

Jan DD	1105	July DD	124	0.65	Correction factor CD: heat loss day
Feb DD	894.5	Aug DD	175.2	31,167 W	
Mar DD	761.8	Sep DD	325.9	19,600 W	heat loss night
Apr DD	512.7	Oct DD	540.1	7 hrs	ave occupied hours
May DD	344.7	Nov DD	822.3	17 hrs	ave unoccupied hours
Jun DD	185.8	Dec DD	1019	0.65	correction factor k:
		Total DD:	6811	62 C	NBCC Delta Temp
				38.2 mJ/L	Fuel Oil heating Value, mJ/L

Design Temperatures

Jan	-37.1 C	Jul	3.6 C	$E = CD \cdot (86.4 \cdot Q_{ls} \cdot DD) / (k \cdot DT)$ $Q_{ls} = E \cdot k \cdot DT / CD \cdot 86.4 \cdot DD$
Feb	-35.0 C	Aug	1.0 C	
Mar	-26.5 C	Sep	-8.7 C	
Apr	-17.0 C	Oct	-17.1 C	
May	-5.5 C	Nov	-26.8 C	
Jun	1.2 C	Dec	-33.5 C	

OUTPUT: Monthly Fuel oil Consumption & Peak kW

Month	Mth Fuel	Mth Pk ht	Month	Mth Fuel	Mth Pk ht
Jan	883 L	20,522 W	July	31 L	1,913 W
Feb	689 L	19,043 W	Aug	50 L	2,522 W
Mar	499 L	13,740 W	Sep	135 L	5,449 W
Apr	270 L	8,857 W	Oct	285 L	8,903 W
May	128 L	4,355 W	Nov	542 L	13,941 W
Jun	52 L	2,474 W	Dec	764 L	18,045 W

Total Annual Fuel consumption 4,329 L

Actual fuel consumption avearge 14,147L

Village of Haines Junction Geothermal District Heating Demand Side Assessment

Project: **Haines Junction District Heating**
 Date Prepared: 4-Sep-03
 Prepared by: Lee Fleming
 location: **zamboni room**
 IP Project Number: 0303007001

ASSUMPTIONS:

- 1 $E = CD * (86.4 * Qls * DD) / (k * DT)$
 ref: ASHRAE Fundamentals handbook, 1989, SI ver, pg F28.2
 where:
 E= fuel or energy consumption for estaimte period, kJ
 CD = correction factor for heating effect vs. kelvin degree days
 Qls = design heat loss incl. infiltration and ventilation, W
 DD= Kelvin degree days, C
 k = correction factor for heating system
 DT = design temperature difference, C
- 2 Use degree day data for Whitehorse, Yk
- 3 fuel oil consumption = E/fuel oil heating value
- 4 Day loss assume ventilation system off at night
- 5 fuel oil = #2 Diesel
- 6 Heating & DW production, 24/7, winter only
- 7 design temperatures based on Canada Climatic data (1971-2000), average of daily mean and extreme
- 8 mth pk heating based on Canada Climatic design temperatures not NBCC 2.5% design temperature.

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada Climatic Norms

Jan DD	1105	July DD	124	0.65	Correction factor CD: heat loss day heat loss night ave occupied hours ave unoccupied hours correction factor k: NBCC Delta Temp Fuel Oil heating Value, mJ/L
Feb DD	894.5	Aug DD	175.2	8,078 W	
Mar DD	761.8	Sep DD	325.9	0 W	
Apr DD	512.7	Oct DD	540.1	24 hrs	
May DD	344.7	Nov DD	822.3	0 hrs	
Jun DD	185.8	Dec DD	1019	0.65	
		Total DD:	6811	62 C	
				38.2 mJ/L	

Design Temperatures

Jan	-37.1 C	Jul	3.6 C	$E = CD * (86.4 * Qls * DD) / (k * DT)$ $Qls = E * k * DT / CD * 86.4 * DD$
Feb	-35.0 C	Aug	1.0 C	
Mar	-26.5 C	Sep	-8.7 C	
Apr	-17.0 C	Oct	-17.1 C	
May	-5.5 C	Nov	-26.8 C	
Jun	1.2 C	Dec	-33.5 C	

OUTPUT: Monthly Fuel oil Consumption & Peak kW

Month	Mth Fuel	Mth Pk ht	Month	Mth Fuel	Mth Pk ht
Jan	310 L	7,216 W	July	11 L	673 W
Feb	242 L	6,696 W	Aug	18 L	887 W
Mar	175 L	4,831 W	Sep	48 L	1,916 W
Apr	95 L	3,114 W	Oct	100 L	3,131 W
May	45 L	1,531 W	Nov	191 L	4,902 W
Jun	18 L	870 W	Dec	269 L	6,345 W

Total Annual Fuel consumption 1,522 L

Actual average fuel consumption 5,538 L

DHW for Zamboni

Village of Haines Junction Geothermal District Heating Demand Side Assessment

Project: **Haines Junction District Heating**
 Date Prepared: 4-Sep-03
 Prepared by: Lee Fleming
 location: **chiller plant rm**
 IP Project Number: 0303007001

ASSUMPTIONS:

- 1 $E = CD * (86.4 * Qls * DD) / (k * DT)$
 ref: ASHRAE Fundamentals handbook, 1989, SI ver, pg F28.2
 where:
 E= fuel or energy consumption for estaimte period, kJ
 CD = correction factor for heating effect vs. kelvin degree days
 Qls = design heat loss incl. infiltration and ventilation, W
 DD= Kelvin degree days, C
 k = correction factor for heating system
 DT = design temperature difference, C
- 2 Use degree day data for Whitehorse, Yk
- 3 fuel oil consumption = E/fuel oil heating value
- 4 Day loss assume ventilation system off at night
- 5 fuel oil = #2 Diesel
- 6 24/7, winter only
- 7 design temperatures based on Canada Climatic data (1971-2000), average of daily mean and extreme
- 8 mth pk heating based on Canada Climatic design temperatures not NBCC 2.5% design temperature.

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada Climatic Norms

Jan DD	1105	July DD	124	0.65	Correction factor CD: heat loss day heat loss night ave occupied hours ave unoccupied hours correction factor k: NBCC Delta Temp Fuel Oil heating Value, mJ/L
Feb DD	894.5	Aug DD	175.2	6,578 W	
Mar DD	761.8	Sep DD	325.9	0 W	
Apr DD	512.7	Oct DD	540.1	24 hrs	
May DD	344.7	Nov DD	822.3	0 hrs	
Jun DD	185.8	Dec DD	1019	0.65	
		Total DD:	6811	62 C	
				38.2 mJ/L	

Design Temperatures

Jan	-37.1 C	Jul	3.6 C	$E = CD * (86.4 * Qls * DD) / (k * DT)$ $Qls = E * k * DT / CD * 86.4 * DD$
Feb	-35.0 C	Aug	1.0 C	
Mar	-26.5 C	Sep	-8.7 C	
Apr	-17.0 C	Oct	-17.1 C	
May	-5.5 C	Nov	-26.8 C	
Jun	1.2 C	Dec	-33.5 C	

OUTPUT: Monthly Fuel oil Consumption & Peak kW

Month	Mth Fuel	Mth Pk ht	Month	Mth Fuel	Mth Pk ht
Jan	253 L	5,876 W	July	9 L	548 W
Feb	197 L	5,453 W	Aug	14 L	722 W
Mar	143 L	3,934 W	Sep	39 L	1,560 W
Apr	77 L	2,536 W	Oct	82 L	2,549 W
May	37 L	1,247 W	Nov	155 L	3,992 W
Jun	15 L	708 W	Dec	219 L	5,167 W

Total Annual Fuel consumption 1,239 L

Actual Annual Average consumption 4,375

Village of Haines Junction Geothermal District Heating Demand Side Assessment

Project: **Haines Junction District Heating**
 Date Prepared: 4-Sep-03
 Prepared by: Lee Fleming
 location: **Community Hall**
 IP Project Number: 0303007001

ASSUMPTIONS:

- 1 $E = CD \cdot (86.4 \cdot Q_{ls} \cdot DD) / (k \cdot DT)$
 ref: ASHRAE Fundamentals handbook, 1989, SI ver, pg F28.2
 where:
 E= fuel or energy consumption for estaimte period, kJ
 CD = correction factor for heating effect vs. kelvin degree days
 Q_{ls} = design heat loss incl. infiltration and ventilation, W
 DD= Kelvin degree days, C
 k = correction factor for heating system
 DT = design temperature difference, C
- 2 Use degree day data for Whitehorse, Yk
- 3 fuel oil consumption = E/fuel oil heating value
- 4 Day loss assume ventilation system off at night
- 5 fuel oil = #2 Diesel
- 6 assume operation = 24/7, i.e. no night setback, no O/A ventiltion or control thereof
- 7 design temperatures based on Canada Climatic data (1971-2000), average of daily mean and extreme
- 8 mth pk heating based on Canada Climatic design temperatures not NBCC 2.5% design temperature.

INPUT DATA: (input yellow)

Heating Degree days - Environment Canada Climatic Norms

Jan DD	1105	July DD	124	0.65	Correction factor CD: heat loss day heat loss night ave occupied hours ave unoccupied hours correction factor k: NBCC Delta Temp Fuel Oil heating Value, mJ/L
Feb DD	894.5	Aug DD	175.2	35,500 W	
Mar DD	761.8	Sep DD	325.9	14,300 W	
Apr DD	512.7	Oct DD	540.1	24 hrs	
May DD	344.7	Nov DD	822.3	0 hrs	
Jun DD	185.8	Dec DD	1019	0.65	
		Total DD:	6811	62 C	
				38.2 mJ/L	

Design Temperatures

Jan	-37.1 C	Jul	3.6 C	$E = CD \cdot (86.4 \cdot Q_{ls} \cdot DD) / (k \cdot DT)$ $Q_{ls} = E \cdot k \cdot DT / CD \cdot 86.4 \cdot DD$
Feb	-35.0 C	Aug	1.0 C	
Mar	-26.5 C	Sep	-8.7 C	
Apr	-17.0 C	Oct	-17.1 C	
May	-5.5 C	Nov	-26.8 C	
Jun	1.2 C	Dec	-33.5 C	

OUTPUT: Monthly Fuel oil Consumption & Peak kW

Month	Mth Fuel	Mth Pk ht	Month	Mth Fuel	Mth Pk ht
Jan	1,364 L	31,711 W	July	48 L	2,957 W
Feb	1,064 L	29,427 W	Aug	77 L	3,898 W
Mar	771 L	21,231 W	Sep	209 L	8,421 W
Apr	418 L	13,687 W	Oct	441 L	13,758 W
May	198 L	6,730 W	Nov	838 L	21,542 W
Jun	81 L	3,822 W	Dec	1,180 L	27,883 W

Total Annual Fuel consumption 6,689 L

Actual average fuel consumption 14,006 L

Village of Haines Junction Geothermal District Heating
Demand Side Assessment

APPENDIX C

PHOTOS

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Convention Centre Haines Junction

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Arena Upper Floor Hall

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Arena Mechanical Room

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Arena Ice Plant

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Arena Cooling Towers

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Arena Oil Tank

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Arena Propane Tanks

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Back of the Arena and Convention Centre

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



School Mechanical Room

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Convention Centre Mechanical Room

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Convention Centre Oil Tank

Village of Haines Junction Geothermal District Heating
Demand Side Assessment



Front of Convention Centre and Arena

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