CENTRAL HEATING PLANT

WOOD CHIP BOILER FEASIBILITY

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For:

Klondike Central Heating Ltd.

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1.0 INTRODUCTION

Authorization for this study was received from the Government of the Yukon, Department of Economic Development, Mines and Energy Branch. The purpose of the study is to evaluate the capital and operational costs and potential energy sales involved in the construction and operation of a wood-fired district heating system in downtown Whitehorse in order to determine its financial feasibility. Benefits and costs for the options are considered incrementally. Specifically, the study addresses a heating system proposed by Klondike Central Heating Ltd., to be located on Jarvis Street between 3rd and 4th Avenue.

District heating plants and central heating plants are not new technologies and are becoming more common in many large industrial and institutional installations. Central heating plants are in use and have been in use in the Whitehorse area for some time. The Whitehorse General Hospital, Nursing Residences, and National Health and Welfare complex, as well as the Public Works complex, residences, schools and office complex of DIAND on Range Road, are some examples.

The most common type of heat transfer medium in large installations is high pressure steam carried in insulated pipes, buried directly in the ground or within tunnels below ground. Hydronic systems are suitable where the distance from the loads to the central plant is short and the individual loads are not large with respect to many steam plant installations. It is this latter hydronic-type heating system that this feasibility report addresses.

The terms of reference identified six potential customers of the district heating plant: the Pulse North Building, the Yukon Business Services Building, Sheffield Hotel, Stratford Motel, the Polaris Building and the Law Centre. All six are of relatively close proximity to one another and the proposed heating plant. In addition, a seventh building, Whitehorse Performance Centre, was added to the scope of the study at a later date. Differing sets of data were provided for the Law Centre and their reliability is suspect. The Stratford Motel indicated that they were no longer interested in participating in the project and, as a result, data for analysis is not available.

The heating systems of the six potential customers, where possible, were examined in detail, and the findings are embodied in this report. A range of retrofit measures to accommodate connection to the central distribution system were assessed and recommended actions were identified.

The report takes the form of a case study of the type of plant proposed and deals primarily with the costs associated with setting up the system, and its operation and maintenance.

Lack of detailed records and the absence of all but the most elementary load calculations for two of the customers hampered the drawing of exact conclusions in some aspects. For the other customers, total energy consumption data was obtained from owners' monthly records where possible, as well as from energy audits which were made available for several of the buildings in question.

Other factors addressed in the report are the rated capacity of the District Heating Plant, the availability of the fuel source and the payback period on the capital investment. Environmental concerns are addressed peripherally where it is felt they will impact on the capital costs and the operations of the system.

2.0 ENVIRONMENTAL CONSIDERATIONS

In the plant proposed by Klondike Central Heating Ltd., flue gases will be drawn from the boiler through an induced draft fan and discharged to the chimney through two fly ash separator cyclones. This system should be reasonably good at removing most of the particulates from the flue gases; however, it is not capable of removing non-particulate products of combustion or odors associated with them.

Wood smoke odors have been identified around the system in Pelly Crossing * and can be expected to be noticeable around this plant. This factor will have to be taken into consideration, particularly because of the chimney's proximity to the Pulse North Building, the Yukon Business Services Building, the Law Centre, the Performance Centre and the Polaris Building. This proximity could contaminate these buildings when wood-smoke contaminated air is drawn in through their fresh air intakes. Consideration will be required to be given to removal of these odors either by activated carbon filters in the air systems or some similar mechanism. Should this be the case, additional costs can be expected to be incurred by the building owners in increased fan horsepowers and annual costs of reactivating the carbon filter or similar media.

These odors could also be expected to be evident at ground level for some distance from the plant during periods of temperature inversions, and would be considered nuisance odors.

* Reference: D. W. Thompson Consultants' report for Government of Yukon and Kein Engineering Report, Wood Chip Boiler Plant for the Administration Building, Government of Yukon.

3.0 PROPOSED DISTRICT HEATING PLANT

3.1 Boiler Plant Location

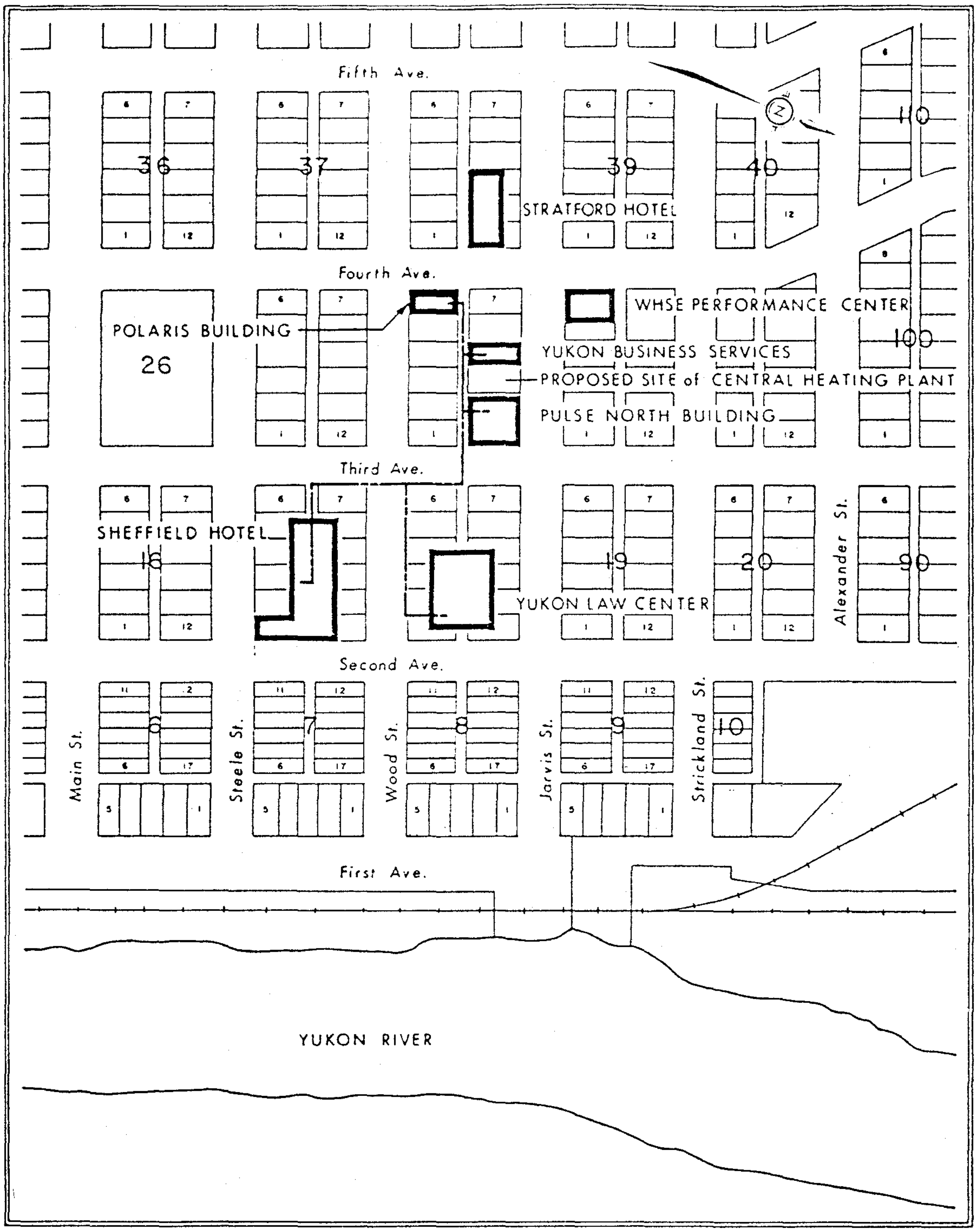
The District Heating Plant proposed by Klondike Central Heating Ltd. is to be located on Lot 10, Block 28 in central downtown Whitehorse. It is situated between the Pulse North Building and the Yukon Business Services Building. (See Figure 3.1).

3.2 Plant Description

The mechanical components of the plant are shown diagrammatically on Apsco Engineering appended drawings Nos. OC-84047-10/11/12/19. (See Appendix 'A'). The basic system consists of a single hot water boiler fired with wood chips. The wood chips are fed into the boiler by a live bottom system and a network of augers. Historically, this has been the weakest component of similar systems installed across Canada and, in particular, a similar unit installed in Pelly Crossing, Yukon Territory. However, experience from some twelve other installations across Canada has shown a continual improvement in the live bottom systems. This plant will have two independent live bottom systems which will be driven by a common hydraulic pump; should maintenance be required on one live bottom, the other will still be operative. The improvements made to the live bottom should reduce the risk of plant shut down caused by the feed system. The manufacturer proposes to use 8000 psi high pressure fittings to reduce leakage that was responsible for much of the previous problem.

3.3 Foundation and Structure

The location of the proposed Boiler Plant in relation to the adjacent buildings requires special care during construction. Both of the existing buildings are constructed on slab on grade foundations and are



PROPOSED FEED LINE LOCATION

Whitehorse, Yukon

Fig 3.1

built to the property line on both sides of the proposed Central Heating Plant lot. The Central Plant building requires a concrete basement which would act as a silo for wood chip storage. The main above-ground portion of the structure would consist of concrete block and steel frame with sheet metal roofing. Fire separations between both of these buildings will be required to meet the National Building Code.

Caution will also have to be exercised during excavation to prevent undermining neighbouring foundations.

3.4 Chimney

The wood chip boiler chimney must be extended and installed to an elevation higher than the roof line of the existing buildings. Special considerations for the final height of the chimney may be set during design or by the governing municipal building codes. Methods of securing and fastening of this stack should also be considered at that time.

3.5 Noise

From the data provided on the proposed boiler, high frequency noises are created by the cyclone (see Appendix 'B'). These noise levels should be determined and measures taken to insure that they are not detectable within the offices of the surrounding buildings. The building will be accessible from both Jarvis Street on the north and a fire lane to the south. Unloading of wood chips should not pose any hazard.

Any noise created by this operation should not be objectionable to nearby office workers.

3.6 Electrical Power Source

Electrical power for the plant is readily available from a back lane service by Yukon Electric. Electrical service load should not be a problem. The plant will require a 200-amp, 3-phase service.

3.7 Emergency Access

The proposed building location has direct access from both Jarvis Street to the north and a fire lane to the south. Access for emergency vehicles such as fire trucks, ambulance, police cars, etc. should not be any problem.

4.0 DEMAND AND ANNUAL FUEL CONSUMPTION

The technology and equipment for a wood chip fuel district heating plant is available. However, the unknown factor remains: can heat energy be produced at a cost and sold at a price and volume for an acceptable return on investment? If so, what are these costs and can they be kept low enough to encourage potential customers to purchase this energy rather than other forms?

Three factors affect the viability of this project: the capital cost, the operating cost, and the quantity of energy sold. Plant size influences all three factors. Plant size must be related to the customers' demand load and annual fuel consumption if the plant size is to be selected for best returns on the investment. Careful analysis of each customer is an essential part of this study.

4.1 Demand Load

Demand load is the rate at which the facility consumes energy. Because the individual customers each have existing heating plants, it is not essential that the central heating plant meet the total demand of all the customers. Their plants can make up any shortfall in the central plant's capacity during peak demand. Providing a plant that can meet maximum demands represents investment in plant capacity that will be seriously under-utilized most of the time and will increase the cost per unit of energy.

It may not seem essential to be concerned about demand, only energy consumption. We have some fuel consumption records of all the potential customers. The consumption total should represent the potential energy that could be sold. However, we have stated that it is not essential or desirable to provide a heating plant that can meet the maximum demand.

This will mean that there will be periods of time that the customers´ plants will be operating to make up the shortfall. It is essential to estimate this energy consumption during peak demands as it represents a portion of the annual energy consumption that cannot be sold by the Central Heating Plant.

Individual demand is also essential for conceptual designs and determination of capital costs. Not all the customers´ facilities will necessarily reach peak demand at the same time or for the same length of time. For maximum energy sales, the heat exchange units and piping at the individual customer´s site should equal either the maximum capacity of the plant or the maximum demand at the site, whichever is smallest. The system can be designed so that the output is automatically directed to those facilities with the greatest demand.

Table 4.1 shows the instantaneous demand of the potential customers. The figure for the Law Centre was provided by the mechanical consultant for that project, based on his design calculations. The demands for the other sites were based on information provided to us by the operators of the buildings. This consisted of the actual firing time and rates of the boilers under the worst conditions.

TABLE 4.1 **INSTANTANEOUS DEMAND LOAD (kW)**

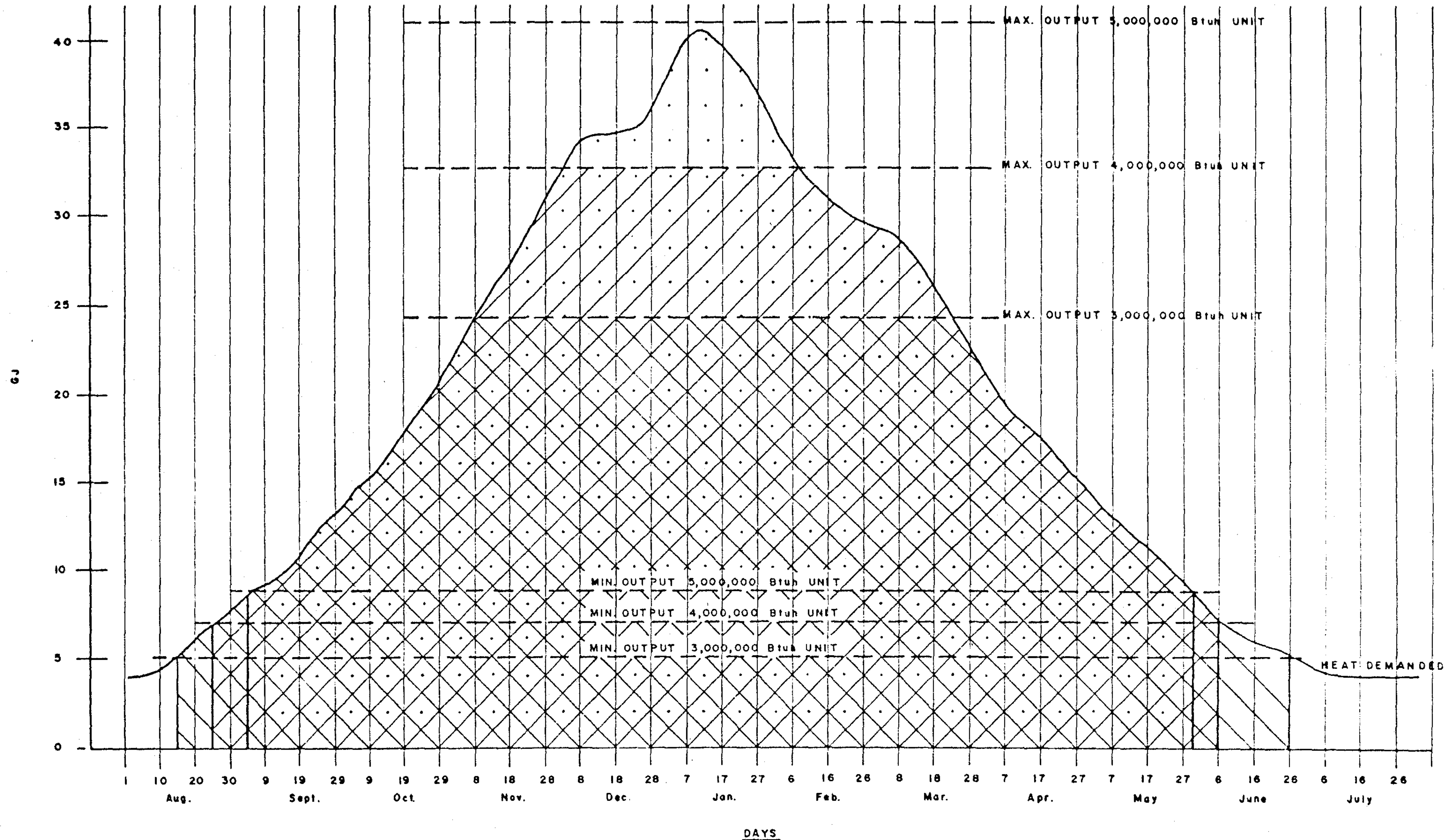
Sheffield Hotel	1194 kW
Yukon Business Services	181 kW
Pulse North	361 kW
Whitehorse Performance Centre	171 kW
Law Centre	1465 kW
Polaris Building	91 kW

4.2 Consumption

We have annual consumption figures and fuel purchase records that indicate approximately the monthly consumption for most of the potential customers. We do not know what percentage of this fuel consumption can be replaced by the central heating plant. There will be periods of time when the demand will exceed the capacity of the central plant and there will be periods of time when the consumption will be too low to justify operating the plant. The rate of consumption for heating load will closely follow degree days. Figures 4.2, 4.3, and 4.4 illustrate this for those buildings where fuel delivery records were available. The irregularity in the fuel consumption curve is due to the fact that the curve is based on delivery records. If the fuel tank capacity was small and fuel was delivered on a regular schedule, the curve would be less erratic. Special consideration must also be given to the Sheffield Hotel, since fuel consumed for heating domestic hot water does not relate to degree days.

In order to be able to properly predict the potential energy that could be sold, the known quantities had to be manipulated to project a total normalized energy load. To obtain this, the figures for the buildings with records were reduced to a fuel consumption per degree day, using actual degree days for the period of the fuel records. This was reduced further to fuel consumption per degree day per unit of area in order to help develop projections for the Law Centre and Whitehorse Performance Centre. The individual fuel consumptions per degree day were combined with average annual degree days to produce the projected load requirements in Figure 4.1. This allows determination of the potential energy that could be sold for various sizes of heating plants. The area below the curve represents the projected total energy requirements. The boiler sizes used in this study were 3 million, 4 million and 5 million Btu/hr.

The largest unit has enough output to meet the estimated peak demand; however, at 20% of full load, or 1 million Btu/hr, the plant ceases to be economical and must be shut down. The demand below that point must be met by the individual customers' heating systems. From the graph, it appears that the 4 million Btu/hr unit is the best compromise.



HEAT OUTPUT & DEMAND ESTIMATES

FIGURE 4.1

4.3 Pulse North Building

The Pulse North Building is located at 303 Jarvis Street, Whitehorse, Yukon. (See Fig. 3.1). The building contains about 1,400 square metres of floor space. It is a slab on grade building consisting of offices, restaurant, and commercial area. There are two 100% outdoor air ventilation air units which are not operated in winter. An air conditioning unit has been modified in the mechanical room to accommodate various building functional changes. The building is heated by five HydroTherm oil-fired boilers, of which four operate to provide heat to the building through perimeter baseboard radiation. Fuel consumption records were obtained for a five-year period and the analysis is provided for the years 1984 and 1985.

TABLE 4.2 **PULSE NORTH BUILDING - FUEL CONSUMPTION DATA - 1984**

Month (1984)	Fuel Consumption (L)	Btu	Btu/ Sq.Ft.	kWh/ Sq.Ft.	MJ/m^2
Jan	5,909	212,150,827	14,143.4	4.15	160.5
Feb	2,607	93,599,121	6,240	1.83	70.8
Mar	2,857	102,574,871	6,838	2.00	77.6
Apr	2,294	82,361,482	5,490	1.61	62.3
May	1,916	68,790,148	4,586	1.34	52.0
June	-	0	0	0	0
July	1,883	67,605,349	4,507	1.32	51.2
Aug	-	0	0	0	0
Sept	2,333	83,761,699	5,584	1.64	63.4
Oct	3,253	116,792,459	7,786	2.28	88.4
Nov	6,761	242,740,183	16,182.7	4.74	183.7
Dec	3,919	140,703,857	9,380.3	2.75	106.5
Totals	33,732	1,211,079,996	80,737.4	23.66	916.4

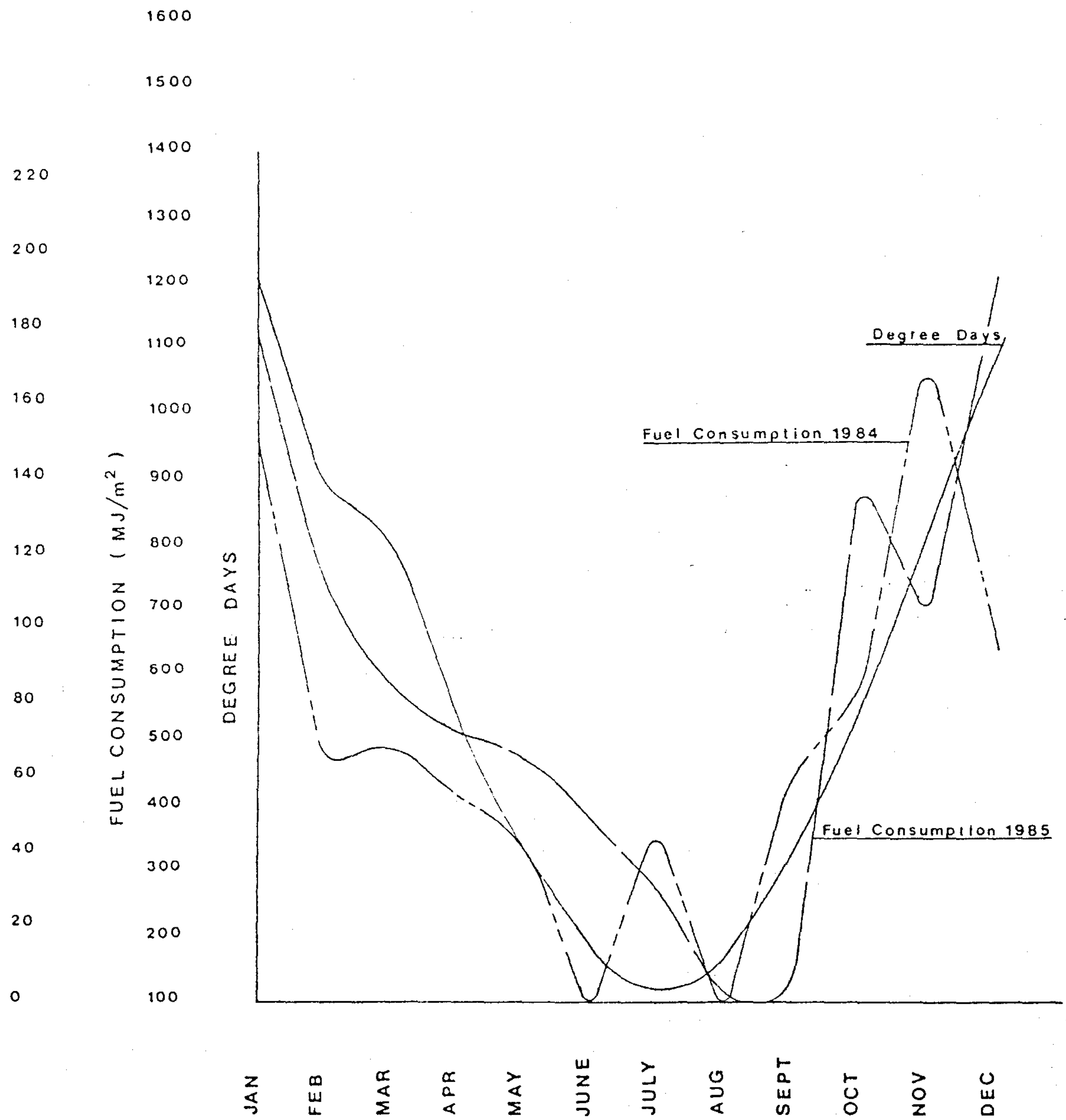
TABLE 4.3 **PULSE NORTH BUILDING - FUEL CONSUMPTION DATA - 1985**

Month (1985)	Fuel Consumption (L)	Btu	Btu/ Sq.Ft.	kWh/ Sq.Ft.	MJ/m^2
Jan	7,249	260,260,847	17,350	5.09	196.8
Feb	4,430	159,050,290	10,603	3.11	120.3
Mar	3,614	129,753,442	8,650	2.54	98.2
Apr	3,047	109,396,441	7,293	2.14	82.8
May	2,819	101,210,557	6,747	1.98	76.6
June	1,970	70,728,910	4,715	1.38	53.4
July	1,223	43,909,369	2,927	0.86	33.3
Aug	-	0	0	0	0
Sept	-	0	0	0	0
Oct	5,855	210,212,065	14,014	4.11	159.0
Nov	4,158	149,284,674	9,952	2.92	112.9
Dec	7,902	283,705,506	18,913	5.54	214.3
Totals	42,267	1,517,512,101	101,164	29.67	1,147.6

Fuel consumptions versus degree days are shown on Figure 4.2.

PULSE NORTH

FUEL CONSUMPTION AND DEGREE DAYS VS MONTH - YEAR



YEAR 1984-85

FIGURE 4.2

4.4 Yukon Business Services Building - (Davos Holdings)

Davos Holdings Limited owns and operates the Yukon Business Services Building located at 307 Jarvis Street, Whitehorse, Yukon. (See Figure 3.1.) The building contains two storeys of rental office space, having a total conditioned floor area of 664 square metres. The building consists of concrete foundation walls on strip footings, uninsulated. The east and west walls are concrete block while the main floor north and south are above grade framed walls. The building is heated by two oil-fired hot water boilers and the heat is distributed by perimeter baseboard radiation. Fuel consumption records for year mid-1984 to mid-1985 were provided and are illustrated in Table 4.4 and Figure 4.3 below.

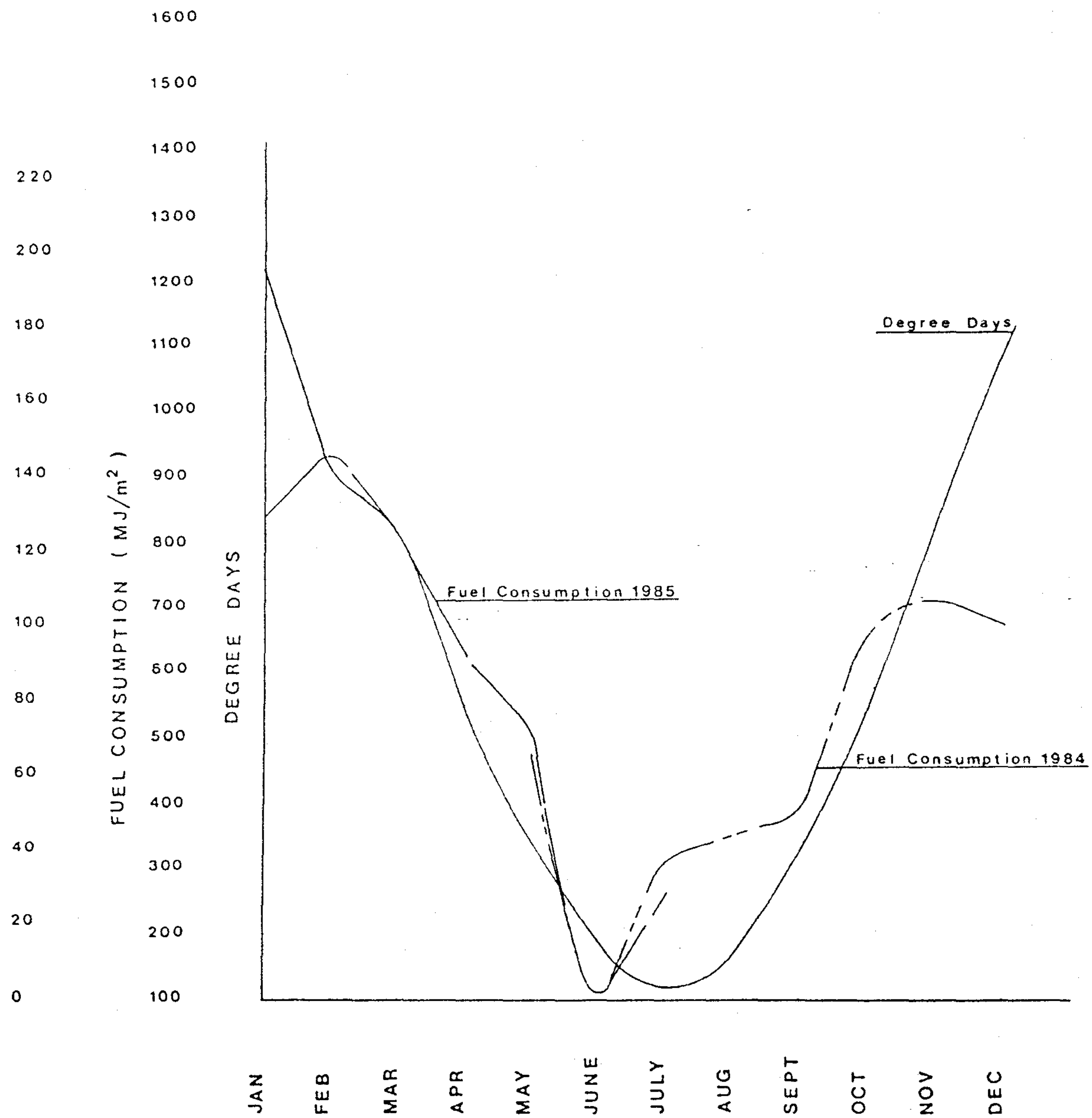
TABLE 4.4 **YUKON BUSINESS SERVICES - FUEL CONSUMPTION DATA - 1984-1985**

Month	Fuel Consumption (L)	Btu	Btu/ Sq.Ft.	kWh/ Sq.Ft.	MJ/m^2
May ('84)	1,244	44,663,332	6,289	1.84	71.4
June	0	0	0	0	0
July	710	25,491,130	3,589	1.05	40.7
Aug	842	30,230,326	4,257	1.25	48.3
Sept	948	34,036,044	4,792	1.40	54.4
Oct	1,880	67,497,640	9,504	2.79	107.9
Nov	2,013	72,272,739	10,176	2.98	115.5
Dec	1,872	67,210,416	9,464	2.77	107.4
Jan ('85)	2,420	86,885,260	12,233	3.59	138.8
Feb	2,779	99,774,437	14,048	4.12	159.4
Mar	2,347	84,264,341	11,865	3.48	134.7
Apr	1,705	61,214,615	8,619	2.53	97.8
May	1,439	51,664,417	7,275	2.13	82.6
July	564	20,249,292	2,851	0.84	32.4
Totals	20,763	745,453,989	104,962	30.77	1,191.3

A plot of fuel consumption versus degree days is shown in Figure 4.3.

YUKON BUSINESS SERVICES

FUEL CONSUMPTION AND DEGREE DAYS VS MONTH - YEAR



YEAR 1984-85

FIGURE 4.3

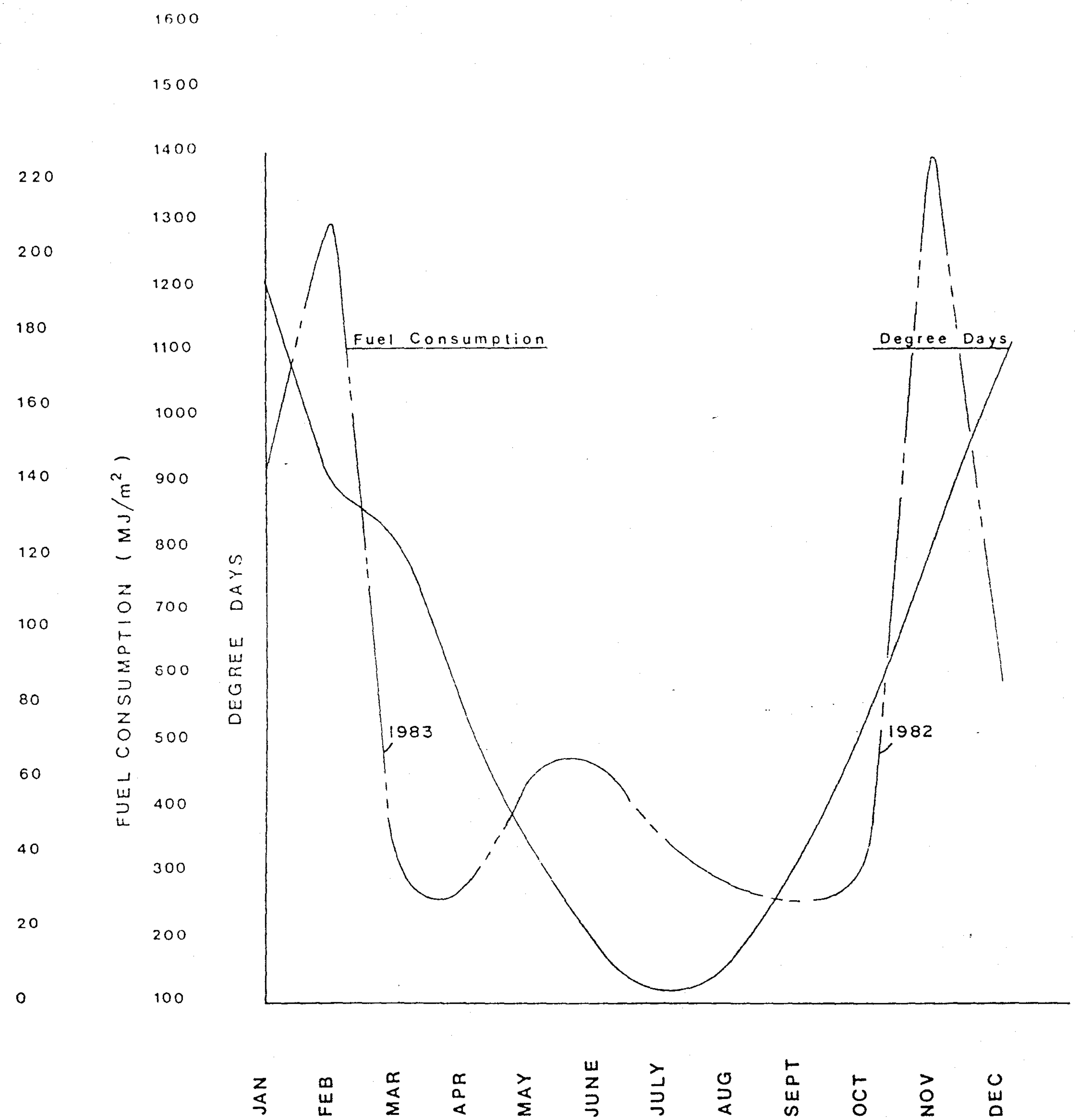
4.5 Sheffield Hotel

The Sheffield Hotel is located on Wood Street in Whitehorse, Yukon. (See Fig. 3.1). It is one of the largest hotel complexes in the City with a total conditioned floor space of 9,720 square metres. The building consists of guest rooms, banquet rooms, restaurant, lounge, retail outlets, and office space. The building is heated principally from two locations. Both mechanical rooms contain two Byran Boilers, Model No. CL 150 WW TFD and CL 240 WF. The older boilers have a firing rate of 37.9 litres per hour using an 80 degree nozzle angle while the new units have a firing rate of 57 litres per hour. Of these units, only two fire continually while a third cuts in intermittently during peak loads. The total fuel consumption during these periods is calculated at approximately 95 litres per hour. Fuel consumption records for the year mid-1982 to mid-1983 were provided and have been tabulated in Table 4.5.

TABLE 4.5 **SHEFFIELD HOTEL - FUEL CONSUMPTION DATA - 1982-1983**

Month	Fuel Consumption (L)	Btu	Btu/ Sq.Ft.	kWh/ Sq.Ft.	MJ/m^2
July ('82)	11,766	422,434,698	4,055.3	1.19	46.0
Aug	9,057	325,173,471	3,121.6	0.91	35.4
Sept	7,507	269,523,821	2,587.4	0.76	29.4
Oct	8,037	288,552,411	2,770.1	0.81	31.4
Nov	63,525	2,280,738,075	21,894.8	6.42	248.5
Dec	24,014	862,174,642	8,276.8	2.43	93.9
Jan ('83)	40,017	1,439,961,621	13,823.5	4.05	156.9
Feb	58,372	2,095,729,961	20,118.8	5.90	228.3
Mar	10,873	390,373,319	3,747.5	1.10	42.5
Apr	8,488	304,744,664	2,925.5	0.86	33.2
May	17,279	620,367,937	5,955.5	1.75	67.6
June	18,754	673,324,862	6,463.8	1.89	73.4
Totals	277,689	9,973,099,482	95,740.6	28.07	1,086.5

A plot of fuel consumption and degree days versus month and year is shown in Figure 4.4.



YEAR 1982-83

FIGURE 4.4

4.6 Whitehorse Performance Centre

The Whitehorse Performance Centre is located at 4141 - 4th Avenue. (See Figure 3.1.) It is a new building and in operation only 2 months at the time of this writing. The building construction consists of slab on grade foundation, 50 x 200 stud walls with moderate sloping roof. It has a total floor area of 935 square metres, broken down into approximately 374 square metres of service garage with 5 metre ceiling height, and 299 square metres of retail space with 280 square metres of office space over. The building is heated with two Malibu oil-fired boilers dispersing hot water to perimeter baseboards and ceiling mounted unit heaters through five zones. Energy consumption records were available for only one month ($580.00 or 1380 litres Jan 15 - Feb 15).

Fuel consumption volumes, therefore, had to be extrapolated for this building and were prepared from the following data: Boiler gross output - 87 W x 2; Hot Water output - 74 W x 2; Fuel Nozzle Rate - 9 L/hr x 2 using 60 degree nozzle.

The building has RSI 5.0 insulated walls with RSI 7.0 insulated ceilings. The monthly fuel consumptions have been calculated as shown in Table 4.6 following.

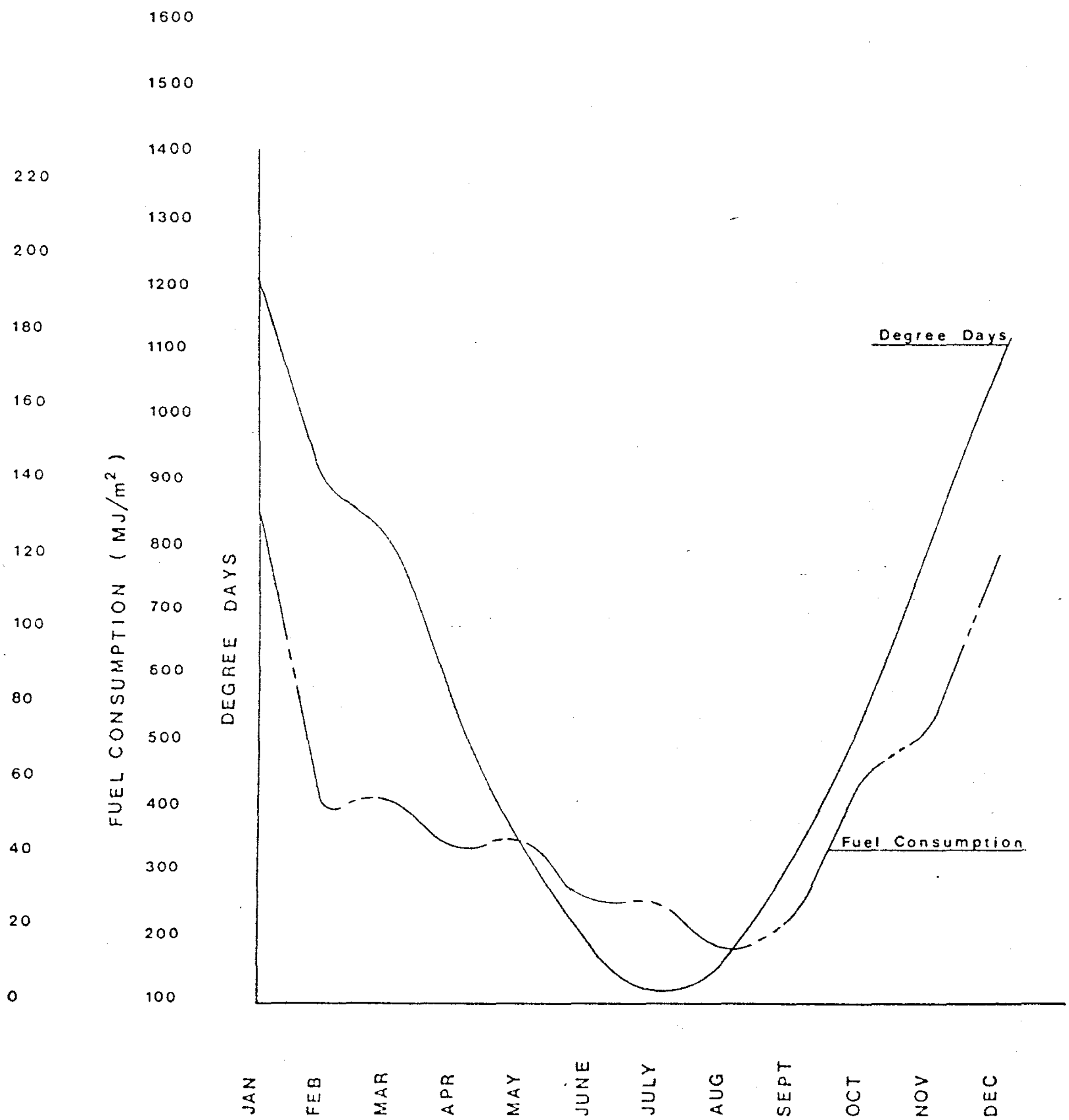
TABLE 4.6 **WHITEHORSE PERFORMANCE CENTRE - FUEL CONSUMPTION DATA AND PROJECTIONS**

Month	Fuel Consumption (L)	Btu	Btu/ Sq.Ft.	kWh/ Sq.Ft.	MJ/m^2
Jan	3,500	125,660,500	12,566	3.68	142.6
Feb	1,380	49,546,140	4,955	1.45	56.2
Mar	1,440	51,700,320	5,170	1.52	58.0
Apr	1,080	38,775,240	3,877	1.14	44.0
May	1,260	45,237,780	4,234	1.33	48.0
June	720	25,850,160	2,585	0.76	29.3
July	720	25,850,160	2,585	0.76	29.3
Aug	360	12,925,080	1,292	0.38	19.2
Sept	540	19,387,620	1,938	0.57	22.0
Oct	1,620	58,162,860	5,816	1.70	66.0
Nov	1,980	71,087,940	7,109	2.08	80.7
Dec	3,400	122,070,200	12,207	3.58	138.5
Totals	18,000	646,254,000	64,334	18.95	733.8

A plot of fuel consumption and degree days versus month year is shown in Figure 4.5.

WHITEHORSE PERFORMANCE CENTER

FUEL CONSUMPTION AND DEGREE DAYS VS MONTH - YEAR



YEAR 1984

FIGURE 4.5

4.7 Stratford Motel

Located at 401 Jarvis Street, Whitehorse, Yukon, the Stratford Motel was identified at the onset of this study as a potential customer. From discussions with the owners, it was ascertained that they are not interested in participating in this project or in the purchase of potential hot water from the central plant. Because of this, no further assessment of their particular requirements was made.

4.8 Polaris Building

Located at the corner of Fourth Avenue and Wood Street in Whitehorse, Yukon, the Polaris Building consists of approximately 384 m^2 of conditioned floor area on each of two floors. It is an old, poorly-insulated building, containing retail outlets on the main floor and offices on the second floor. The building is heated with a 622 MBtuh Warden King hot-water boiler. The only energy consumption records available indicate that the building used 25,356 L of oil in 1982. An energy consumption summary is given in Table 4.7 below.

TABLE 4.7 **POLARIS BUILDING - FUEL CONSUMPTION DATA - 1982**

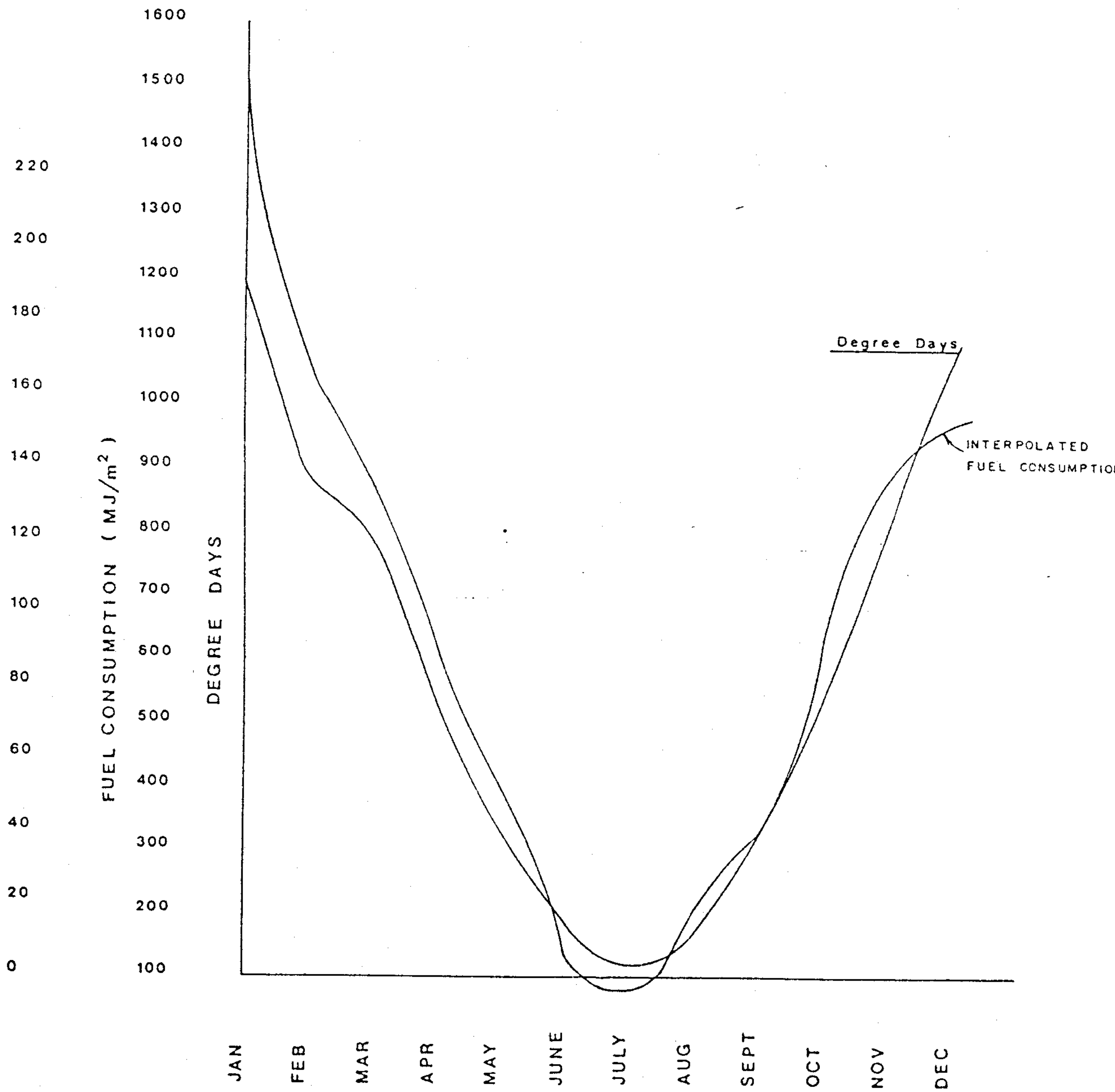
Month *	Fuel Consumption (L)	MBtu	Btu/ Sq.Ft.	kWh/ Sq.Ft.	MJ/m^2
Jan	5,123	183,931	22,258	6.52	252.6
Feb	3,394	121,854	14,746	4.32	167.3
Mar	2,853	102,431	12,395	3.63	140.7
Apr	2,032	72,955	8,828	2.59	100.2
May	1,308	46,961	5,683	1.66	64.4
June	526	18,884	2,285	0.67	25.9
July	321	11,525	1,395	0.41	15.8
Aug	678	24,342	2,946	0.86	33.4
Sept	944	33,892	4,101	1.20	46.5
Oct	2,079	74,642	9,032	2.65	102.5
Nov	2,952	105,986	12,825	3.76	145.5
Dec	3,155	113,274	13,707	4.01	155.5
Totals	25,356	910,677	110,201	32.28	1,250.3

* Monthly totals were interpolated from year totals using heating degree days.

A plot of fuel consumption and degree days versus month (1982) is shown in Figure 4.6.

POLARIS BUILDING

FUEL CONSUMPTION AND DEGREE DAYS VS MONTH - YEAR



YEAR 1982

FIGURE 4.6

4.9 The Law Centre

This building is located at Block 18, Lots 1 - 12 inclusive in Downtown Whitehorse. (See Figure 3.1). The building essentially consists of steel frame construction on full concrete basement and strip footings. The overall building area is 9663.6 square metres, primarily consisting of offices, parkade, atrium, etc. Limited records of fuel consumption were available as well as the information provided by the mechanical engineers, D. W. Thompson and Associates.

The information from D. W. Thompson consisted of the following:

- 1.2 million Btu/hr heat load demand
- 1.2 million Btu/hr vent load demand
- 1.2 million Btu/hr parking exhaust load demand
- 13,135,000,000 Btu annual energy requirements

Electric boilers were proposed to take advantage of preferred rates during hours of off-peak electrical loads, but never installed. Three 31,500 L water tanks are used to store surplus heat and to provide a buffer for the heating plant during periods of peak demand. We were advised that estimated annual fuel consumption should be 112,500 L of fuel oil, which does not seem to agree with the annual energy requirements. That figure would represent almost 176,000 L of fuel oil.

Using this limited data, BTU requirements per month have been extrapolated and shown as follows in Table 4.8. From these figures, it can be seen that fuel consumption would be 50% more than the figure of 112,500 L per annum quoted to us by D. W. Thompson personnel.

TABLE 4.8 **THE LAW CENTRE - FUEL CONSUMPTION DATA**

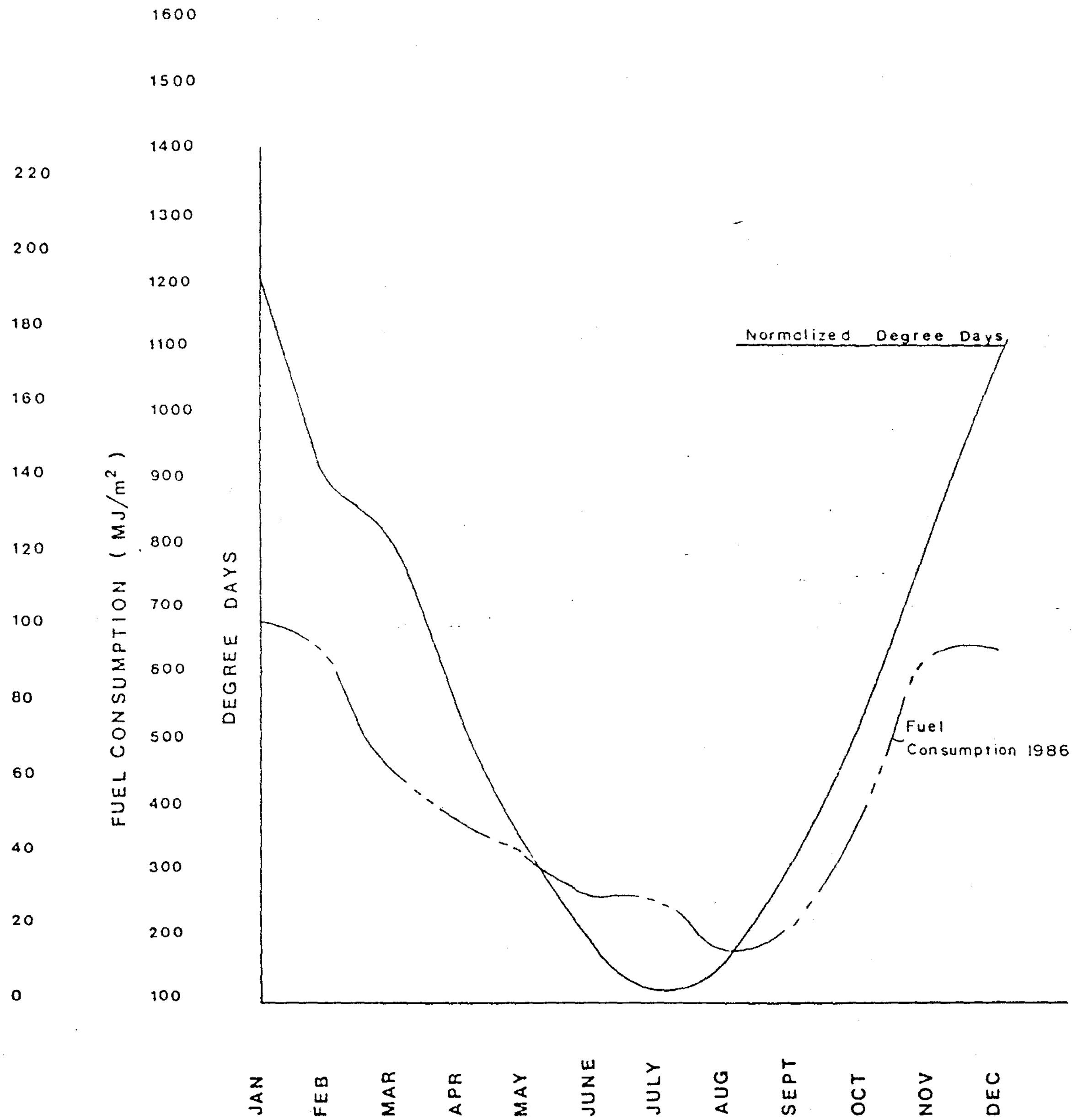
Month	Fuel Consumption (L)	MBtu	Btu/ Sq.Ft.	kWh/ Sq.Ft.	MJ/m^2
Jan	26,348	922,186	8,919	2.61	101.25
Feb	24,592	860,707	8,324	2.44	94.50
Mar	15,809	553,312	5,351	1.57	60.75
Apr	12,296	430,354	4,162	1.22	47.25
May	10,539	368,875	3,568	1.04	40.50
June	7,026	245,916	2,378	0.70	27.00
July	7,026	245,916	2,378	0.70	27.00
Aug	3,513	122,958	1,189	0.35	13.50
Sept	5,270	184,437	1,784	0.52	20.25
Oct	14,052	491,833	4,756	1.39	54.00
Nov	24,592	860,707	8,324	2.44	94.50
Dec	24,592	860,707	8,324	2.44	94.50
Totals	175,655	6,147,908	59,457	17.42	675.00

Data Provided: Square footage 103,400, Department of Public Works, YTG.
Total Annual Heating Load 13,135,000,000 Btu, D. W. Thompson

A plot of fuel consumption versus degree days is shown in Figure 4.7.

LAW CENTER

FUEL CONSUMPTION AND DEGREE DAYS VS MONTH-YEAR



YEAR 1986

FIGURE 4.7

5.0 WOOD CHIP BOILER SIZING

As mentioned in Section 4.0, selection of the proper plant size is important to the viability of the wood chip Central Heating Plant. Some of the installation costs will vary little as plant size increases, resulting in a lower cost per unit of plant output as plant size increases. A larger plant will allow greater energy to be sold. Unfortunately, the larger the plant, the less fully it will be utilized. Increased plant size can reduce the cost per unit of energy but under-utilization will increase the cost per unit of energy.

If there were an unlimited range of boiler capacities available, a differential equation or a computer program would have to be developed to optimize the boiler selection. For this study, however, only certain boiler capacities are available. They can be analyzed independently and the capacity that provides the best return for the investment can be chosen. The boiler manufacturer proposed for this project has boiler models of 3 million, 4 million, and 5 million Btu/hr capacities that could suit this project.

Another factor that can influence the choice of boiler is the temperature of water required by the customer's heating plant. To avoid the cost of providing 24-hour surveillance for the boiler operation, the boiler must be in the low pressure range. This limits the boiler to 103 kPa pressure and 121°C steam temperature for a steam plant or 121°C for a hot water plant. When a hot water boiler is operated at or near the maximum temperature, the pressure must be maintained high enough to prevent the water from flashing to steam. The heat output from a wood-fuelled fire is not as closely controlled as a liquid or gaseous fuel and the risk of the water flashing to steam is greater. To overcome this problem, it is not uncommon to use a steam boiler to generate steam and produce hot water with a close coupled converter. This option represents a higher capital cost for the heating plant, but it could save costs in the distribution system. With higher temperature water in the system, a greater temperature drop can be allowed through the heat exchanger. This will permit the same quantity of heat to be transferred with a lower water flow rate. If the flow rate can be decreased sufficiently, a small pipe size can be used. Both options were investigated, although there was reluctance on the part of the boiler manufacturers to consider the steam option.

The total demand heating load from all identified sources has been computed in Tables 5.0 and 5.1. The monthly demands have been calculated using the heating degree days for a normal (average over last 30 years) year. Because all the customers' demands have been normalized, they may be summed in Table 5.1, to provide an estimate of the total heating demand that may be expected each month. Table 5.0 enables a comparison of the relative efficiencies of each building and provides a check that all the information on fuel consumption is fairly accurate.

TABLE 5.0	HEATING DEMAND LOAD Per Unit Area (MJ/m^2)												
Facility	Month												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Sheffield	162.9	242.2	43.5	37.5	75.0	88.2	59.7	30.3	33.0	27.3	227.4	107.3	1134.3
Pulse N.	178.7	95.6	87.9	72.6	64.3	26.7	42.3	0	31.7	123.7	148.3	160.4	1032.2
Y.B.S.	236.7	138.8	144.8	91.6	72.7	0	29.7	42.4	49.1	94.2	108.8	102.7	1111.5
Law Ctr.*	101.2	94.5	60.8	47.2	40.5	27.0	27.0	13.5	20.2	54.0	94.5	94.5	674.9
Perform *	142.6	56.2	58.0	44.0	48.0	29.3	29.3	19.2	22.0	66.0	80.7	138.5	733.8
Stratford	Information not available												
Polaris **	233.7	154.8	130.2	92.7	59.6	24.0	14.6	30.9	43.0	94.8	134.6	143.9	1156.8

* Extrapolated due to limited data available.
** Interpolated using normalized heating degree days.

As Table 5.0 above shows, the new buildings, the Law Centre and Whitehorse Performance Centre, have lower energy consumption rates per unit area than the older buildings in this study. This is to be expected and supports the credibility of the information used to estimate the heating demands.

TABLE 5.1	HEATING DEMAND LOAD (GJ)												
Facility	Month												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Sheffield	1583	2354	423	365	729	857	580	295	321	265	2210	1043	11025
Pulse N.	250	134	123	102	90	37	59	0	44	173	208	225	1445
Y.B.S.	157	92	96	61	48	0	20	28	33	63	72	68	738
Law Ctr.*	978	913	588	456	391	261	261	130	195	522	913	913	6521
Perform *	133	53	54	41	45	27	27	18	21	62	75	129	685
Stratford	Information not available												
Polaris **	179	119	100	71	46	18	11	24	33	73	103	111	888
Totals	3280	3665	1384	1096	1349	1200	958	495	647	1158	3581	2489	21302

* Extrapolated due to limited data available.
** Interpolated using normalized heating degree days.

After analysis of the heat output and demand estimates in Table 4.1 and the information in the above table, the proposed wood chip boiler will have a capacity of 4,000,000 Btu/hr (1160 kW). This boiler size will handle the requirement for about 60% to 70% of the total heating load as calculated. The wood chip boiler would be the first boiler on line to produce heat to the buildings. When the wood chip boiler is operating at 100% of its capacity, and a larger heating load is required, the customer boilers would automatically come on line to carry this additional load.

New boiler controllers must be installed in each customer building to ensure that the wood chip boiler, through a motorized valve, is the first boiler to produce heat. If additional heat is required, this controller would also start the customer boilers in firing order.

The wood chip boiler has the capability to supply heating water at 121°C. The various clients require heating water at 121°C at a -40°C outside temperature. Given the temperature losses in the distribution system, the wood chip boiler would be set to provide 121°C heating water as required. Since the temperature of heating water for the individual clients varies, methods of adjustment of the temperature at each client's location will have to be determined to suit client conditions.

A boiler supplying water at 121°C at a hydrostatic pressure of 30 psig will not result in the production of steam. The wood chip boiler would be set to operate at a pressure of approximately 15 psig. A temperature sensor at each customer's building would activate a motorized valve and a pump which would deliver heated water to a heat exchanger. Given the potential heating demands of the various clients, selected heat exchanger sizing and pumping rates have been computed for each. Consideration should be given to the development of low pressure steam, therefore taking advantage of a higher heating value. This would also allow the use of smaller diameter piping systems and a greater temperature drop, as well as the elimination of the use of glycol as a heating medium.

6.0 DEGREE DAYS

The foregoing data analysis has been based on several factors, the most important of which is the degree day.

A degree day is defined as a unit based upon temperature difference and time used in estimating fuel consumption and specifying a nominal heating load of a building in winter. For any one day when the mean temperature is less than 18°C, there will be as many degree days as there are centigrade degree differences in the mean temperature for the day and 18°C. Looking at normal Degree Days on a monthly basis for Whitehorse, we would get the following:

TABLE 6.0 **AVERAGE MONTHLY TEMPERATURES**

Month	No. of Days	No. of Degree Days	Average Δ T	Mean T
Jan	31	1199	39	-20.7
Feb	28	882	31	-13.2
Mar	31	811	26	- 8.2
Apr	30	532	18	0.3
May	31	352	12	6.7
June	30	183	6	12.0
July	31	124	4	14.1
Aug	31	173	6	12.5
Sept	30	315	10	7.5
Oct	31	538	17	0.6
Nov	30	804	27	- 8.8
Dec	31	1073	35	-16.6

Where Δ T equals the difference between 18°C inside temperature and outside mean temperature.

Annual fuel costs bear a direct relationship to the number of degree days in a locality. Looking at the average monthly temperature variations (Table 6.0), we can see that approximately 50% of the hottest month (July) could conceivably require heat at night. From Tables 6.1 and 6.2, one could see that heat is required to be generated twelve months of the year. The demands would not be as high in July, August and September and, therefore, in determining the months in which saleable energy could be produced, these months were not considered in the revenue producing period.

TABLE 6.1 **WHITEHORSE TEMPERATURES CELSIUS**

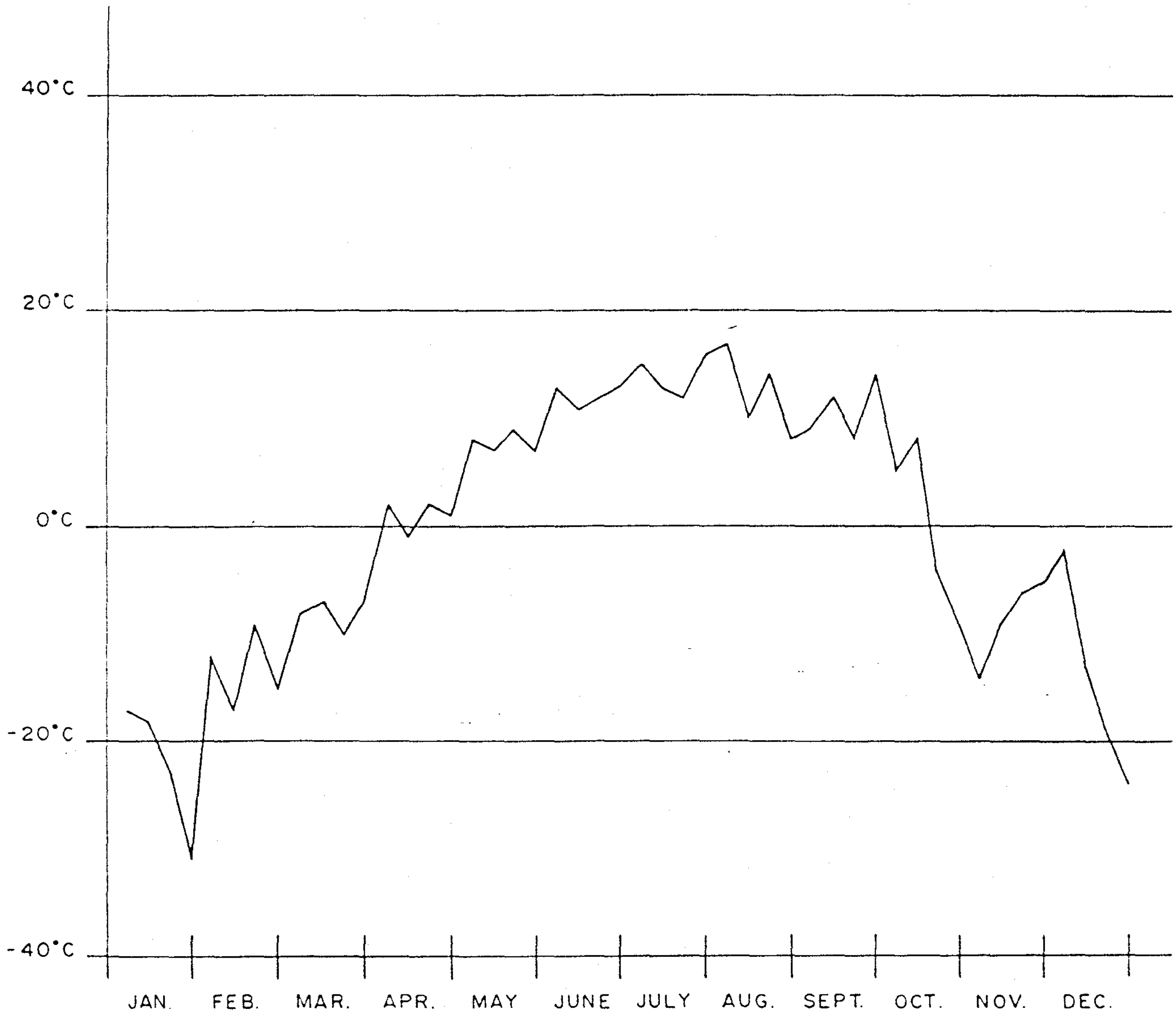
Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	−18.5	−10.9	−11.7	− 2.6	6.9	6.9	11.8	16.4	13.0	9.0	−21.1	−12.2
2	− 8.9	− 5.6	− 6.4	− 0.7	3.3	7.4	13.2	16.5	12.5	6.9	−18.2	−13.2
3	−10.2	−15.9	− 9.5	2.2	3.7	6.0	13.8	17.3	8.9	0.5	−18.7	− 7.2
4	−11.1	−14.2	− 5.0	0	3.7	6.3	16.2	20.2	9.4	1.9	−15.6	− 3.2
5	−19.1	−12.9	− 9.8	0	3.3	10.6	15.4	18.6	11.2	1.0	− 4.4	+ 1.6
6	−23.5	−10.4	− 6.3	− 4.3	4.3	9.2	18.8	21.3	9.8	7.1	− 7.2	− 2.1
7	−30.5	−13.8	− 8.3	− 3.8	6.2	12.6	15.7	11.8	10.5	8.6	− 5.8	− 3.5
8	−32.7	−20.4	− 7.4	− 2.6	6.3	10.9	15.3	13.4	12.1	7.9	− 6.3	+ 1.2
9	−28.0	−19.3	− 7.7	− 2.4	8.4	12.1	13.4	11.6	11.6	5.2	− 5.8	− 6.4
10	−18.1	−21.1	− 3.1	0.5	7.6	11.6	14.5	11.4	13.6	4.9	− 7.6	−17.1
11	−12.6	−16.9	− 4.2	0	8.2	14.1	13.1	12.7	13.5	6.6	− 6.3	−14.3
12	−15.0	−16.7	− 6.0	0.3	7.0	11.4	12.4	10.4	13.0	0.8	− 6.5	−15.1
13	− 8.9	−13.6	− 9.7	0	5.9	10.7	11.4	7.0	12.1	1.8	−18.5	−17.5
14	−11.0	− 9.6	−15.3	1.1	7.1	11.0	12.5	8.9	8.9	0.2	−16.5	−18.8
15	−12.5	−10.2	−12.3	1.3	8.4	9.0	12.8	13.8	7.9	−2.3	−17.8	−29.4
16	−12.9	− 9.2	−14.6	.5	10.5	8.2	14.7	13.7	9.0	−2.0	− 5.8	−26.5
17	−19.2	− 7.9	−10.9	0	9.2	14.8	13.6	15.9	12.1	−3.3	− 7.2	−19.6
18	−26.0	−10.2	−10.6	1.2	8.8	15.0	9.9	12.7	11.4	−3.8	− 7.0	−12.0
19	−24.7	− 9.2	− 5.3	5.0	6.3	13.6	10.1	12.9	10.4	−6.6	− 6.9	− 5.2
20	−16.8	− 7.5	− 9.6	2.5	8.8	12.3	13.6	13.8	11.7	−1.5	− 3.5	−18.8
21	−34.5	−13.4	− 7.1	3.5	8.8	12.3	14.9	12.0	12.3	−1.8	− 2.3	−22.1
22	−28.6	−13.6	−10.0	0.5	7.6	12.0	14.4	9.7	14.4	3.1	+ 1.4	−22.3
23	−36.1	−12.4	− 6.8	3.8	8.8	15.9	17.0	9.4	14.2	3.1	− 1.3	−16.8
24	−40.1	−15.4	− 6.7	− 2.7	9.1	13.5	17.4	14.4	13.8	−0.7	− 3.6	−14.8
25	−43.9	−17.7	− 7.6	1.0	7.7	13.9	16.3	16.3	12.4	−3.7	− 5.3	−23.5
26	−31.9	−20.7	− 5.2	0.3	6.6	14.5	14.3	7.8	12.7	−11.3	− 8.1	−28.6
27	−20.3	−14.0	− 6.2	− 0.6	5.6	12.1	15.1	1.1	14.7	−16.0	− 8.5	−24.6
28	−14.6	−13.4	− 7.0	4.0	3.5	9.6	15.4	0.8	15.5	−12.6	−11.8	−35.9
29	−14.1	−11.5	− 5.7	5.4	7.1	10.7	18.3	3.9	9.5	−17.9	−10.4	−34.9
30	− 9.0		− 3.4	4.6	6.0	9.3	17.5	4.6	7.4	−22.5	−10.7	−25.3
31	− 7.5		− 5.3		7.6		16.9	6.9		−20.8		−13.8
Mean	−20.7	−13.2	− 8.2	0.3	6.7	12.0	14.1	12.5	7.5	0.6	− 8.8	−16.6

Average Daily Temperatures 1985 Normal

TABLE 6.2 **AVERAGES: TEMPERATURES DEGREES CELCIUS**

Month	1st Week	2nd Week	3rd Week	4th Week	5th Week
Jan	-17.4	-18.6	-22.3	-30.7	-10.2
Feb	-12.0	-16.8	- 9.6	-15.3	-11.5
Mar	- 8.4	- 7.2	-10.0	- 7.0	- 4.8
Apr	+ 1.9	- 0.4	+ 2.0	+ 0.9	+ 5.0
May	+ 8.4	+ 7.2	+ 8.6	+ 6.9	+ 6.9
June	+13.3	+11.7	+12.1	+13.0	+10.0
July	+15.0	+13.2	+12.8	+15.7	+17.5
Aug	+17.4	+10.7	+13.5	+ 8.5	+ 5.1
Sept	+10.75	+12.1	+10.6	+13.9	+ 8.4
Oct	+ 5.0	+ 3.9	- 2.1	- 5.4	-20.4
Nov	-13.0	- 8.9	- 5.8	- 5.3	-10.5
Dec	- 1.74	-12.6	-19.0	-23.7	-24.6

Temperature Weekly Averages 1985 for each 7-day period.



WEEKLY TEMPERATURE VARIATIONS

FIGURE 6.1

7.0 FUEL CONSUMPTION AND COSTS

Oil consumption and cost for space heating and domestic hot water varies from customer to customer. Reduced rates are available to consumers having fuel tanks in excess of 2250 L. The average cost is 40 cents/L for customers other than the Y.T.G. which gets its oil at 35.2 cents/L (1985).

Oil consumption usually varies with the outside temperature and, with the exception of certain customers such as the Sheffield Hotel, summer consumptions are quite low. In the majority of instances, domestic hot water is provided during the months of June, July and August from electric hot water boilers. It is anticipated that the wood chip boiler would be shut down during this time as the domestic hot water load from those using oil for heating is too small for this unit. The minimum loading on the wood chip boiler is about 19% of the 4 million Btu output or 750,000 Btu/hr.

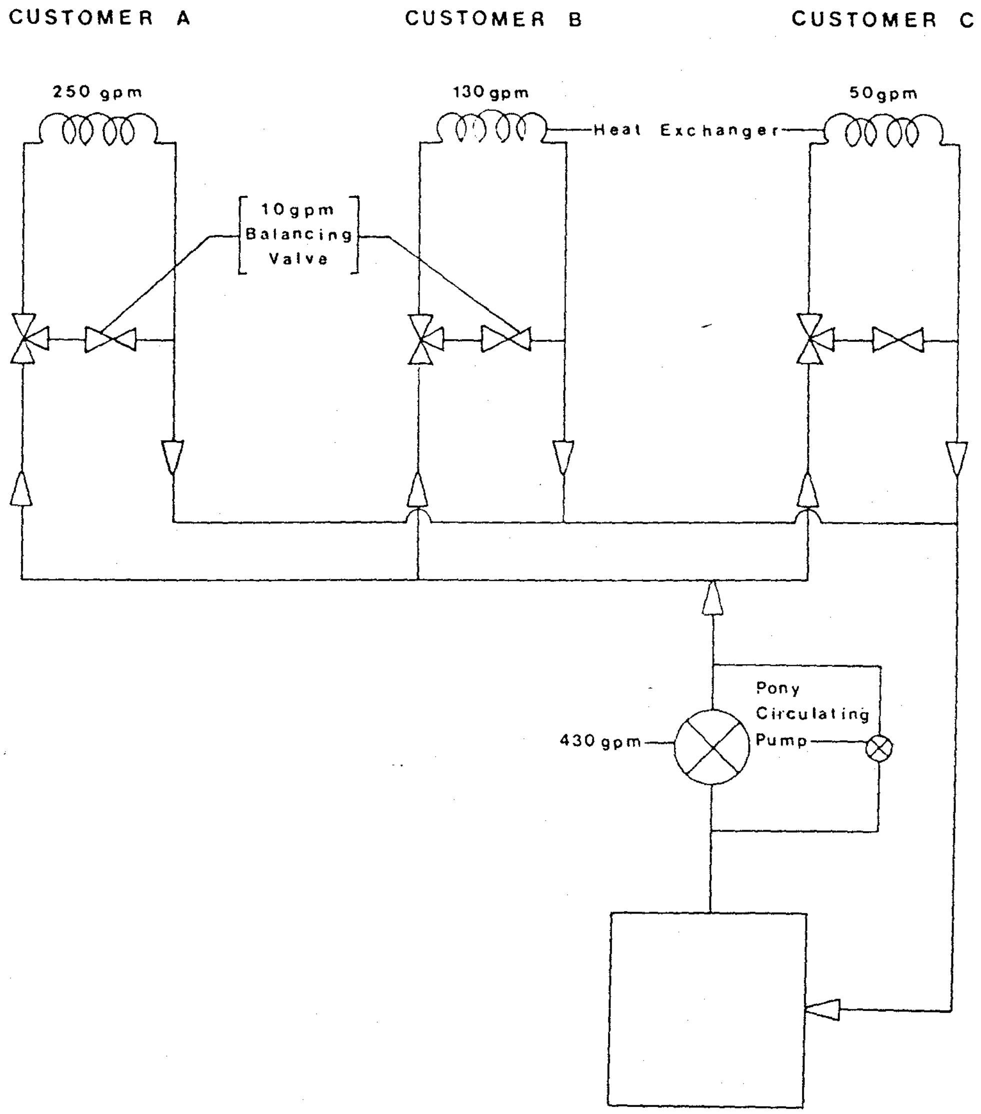
A breakdown of the amount of oil consumed for domestic hot water was not available at the time of this writing and, for the three months in question, is estimated at about 5% of total yearly consumption.

The 4,000,000 Btu/hr. wood chip boiler would handle the heating load for about 65% of the time during the heating season. On the average year, the operation of the wood chip boiler would replace approximately 379,000 L of oil (84,000 gals) not counting transmission losses. The cost of 379,000 L (84,000 gals) at 40 cents/L (depending on customer) is $151,600.

8.0 PIPING AND DISTRIBUTION SYSTEMS

Possible routings of the distribution system are shown on Figure 3.1. The primary route description leaves the central heating plant at the south and parallels the fire lane running east and west. This route would provide the most direct linkage between four of the potential customers, namely, the Law Centre, the Pulse North Building, the Yukon Business Services Building and the Polaris Building. Branch connections parallel 3rd Avenue south to the fire lane on the west of the Sheffield Hotel, thence east to the west end of the Sheffield Building. From this location, the piping would go under the building and be suspended from the floor joists in the crawl space to the mechanical rooms. A piping schematic showing a typical system is shown in Figure 8.1.

A plate-type liquid-to-liquid heat exchanger would be installed in each customer's boiler room. The capacity of the heat exchanger is determined either by the central plant's maximum capacity or the customer's maximum demand, whichever is smaller. The heat exchanger will allow the heat from the central heating plant to be transferred to the building's heating system while isolating the two circulating systems. The heat exchanger will act similarly to another boiler connected in series with the customer's existing boilers. The customer's boiler limit controls would be adjusted so that the heat exchanger would be the "lead" boiler and the customer's boilers would automatically cut in when the central plant was unable to provide sufficient heat.



SCHEMATIC DIAGRAM A

FIGURE 8.1

Our analysis was based on providing a modulating three-way valve on the central plant's supply and return piping at each customer's building. This will allow circulation in all loops regardless of whether heat is required or not. By restricting the by-pass on the three-way valve, static pressure will increase in the system when one or more customers are using less than their full heat demand. This will force more flow to those customers still demanding heat and ensure them maximum capacity. This motorized valve could also be used to control the system if it was desired to have a "preferred" customer on the system.

A third component that will be required at the customer's premises is a metre to measure the heat delivered to the customer. We based this study on a "Btu" metre manufactured by ITT Barton, Model 381C flow totalizer. It determines heat delivered by measuring the difference in the temperature of the supply and return water and the rate of flow in the central plant piping at the heat exchanger. The units can be equipped with a remote readout.

We recommend two circulating pumps: one large pump at 2/3 the system capacity and a smaller pump at 1/3 the system capacity. This will allow three different pumping rates depending on system loads. A pressure switch would operate either pump singly or both pumps together in response to system static pressure. Pump sizes are dictated by the size of the heating plant and the heat exchangers. Designing a system with a maximum temperature change of 11°C through the heat exchanger units will require a circulation rate of 25 L/s through the central plant and the supply and return lines to buildings with heat exchangers equivalent to the capacity of the plant. At maximum flow rates, 150 mm pipe should be used. This would result in approximately 21 M static head at maximum pumping rate. This would require the small pump to have a 3.7 kW motor and the larger pump to have a 5.6 kW motor.

Heat exchanger, flow rates and pipe sizes for the potential customers based on an 11°C temperature drop in the heat exchanger and a 1200 kW central heating plant is shown in Table 8.1.

TABLE 8.1 **HEAT TRANSFER EQUIPMENT CHARACTERISTICS**

Location	Heat Exchanger	Flow Rate	Pipe Size
Sheffield	1200 kW	25 L/s	150 mm
Law Centre	700 kW	15 L/s	150 mm
Pulse North	366 kW	7.9 L/s	75 mm
Yukon Business Ser.	182 kW	3.9 L/s	50 mm
Performance Centre	170 kW	3.7 L/s	50 mm
Polaris Building	380 kW	8.1 L/s	75 mm

If a higher temperature drop is used through the heat exchangers, flow rates can be reduced, resulting in capital and operating cost savings by using smaller pipes and pumps. The lower temperature of the operating range is limited by the customers' requirements and the upper temperature of the operating range is limited by the Boiler and Pressure Vessels Ordinance for heating plants. Operating a hot water boiler near the upper limits of the temperature range can cause operational problems if sufficient pressure is not maintained on the system to prevent the water from flashing to steam in the boiler. In some systems, this is overcome by generating steam in a low pressure boiler and heating the water of the system with a close coupled converter.

Table 8.2 shows the difference in flow rates, pipe size and pump power requirements between a system with an 11°C temperature drop and a system with a 16.7°C temperature drop.

TABLE 8.2	COMPARISON BETWEEN $\Delta T = 11^{o}C$ AND $\Delta T = 16.7^{o}C$					
	$11^{o}C\ \Delta T$			$16.7^{o}C\ \Delta T$		
Location	Flow Rate	Pipe Size	Power	Flow Rate	Pipe Size	Power
Sheffield	25 L/s	150 mm		16.8 L/s	100 mm	
Law Centre	15 L/s	150 mm		10.1 L/s	100 mm	
Pulse North	7.9 L/s	75 mm		5.3 L/s	75 mm	
Yukon Bus. Ser.	3.9 L/s	50 mm		2.6 L/s	50 mm	
Performance Ctr.	3.7 L/s	50 mm		2.5 L/s	50 mm	
Polaris Bldg.	8.1 L/s	75 mm		5.4 L/s	75 mm	
Small Pump			3.7 kW			3.7 kW
Large Pump			5.6 kW			5.6 kW

The difference in the temperature drop ranges is not sufficient to make a significant change because of the limited ranges available in pipe sizes and pump motor sizes. Only the 150 mm pipe could reduce to 100 mm. Pump motor size did not change because a slight increase in pressure due to the smaller pipes overcame the advantages due to decreased volumes pumped. Approximately $15,000 could be saved in the piping cost. This would be offset by the extra cost of a steam boiler and converter so the concept was not pursued. Klondike Central Heating Ltd. was also not favourably inclined to consider the steam plant and converter.

We propose that the heat transfer medium of the central plant be hot water, treated as necessary to reduce corrosion on system components. Although risk of freezing is a consideration during a plant failure, the pipe insulation and the thaw bulb around the buried pipe will allow up to 48 hours to either get heated water circulating or the system drained before freezing could occur. The high capital cost, poorer heat transfer characteristics and maintenance problems with pump seals and control valves make the use of an antifreeze solution an unattractive safeguard to the low risk of freezing in a properly designed system.

The heating piping costs were based on Bondstrand reinforced thermosetting resin (RTL) pipe and fittings. All piping should be insulated. Sufficient valves, thermometers and pressure gauges would be installed on the system to provide isolation, control and monitoring.

The installation of the piping should be carried out by skilled mechanical contractors. The work should be done during the summer and therefore minimize down time of the various customer buildings.

Pumping requirements are dictated by the size of the heat exchangers. Since the largest heat exchanger is to meet 4,000,000 Btu/hr output, line sizes and heat exchangers are sized to meet this requirement as outlined below.

Assuming a pumping rate 1 gpm = 10,000 Btu based on a 20 degree temperature drop, a 4,000,000 Btu/hr heat exchanger requires a 30 L/s pumping rate.

Given a pumping rate of 30 L/s and friction and line loss of 21 m of head, a selected pump to meet this requirement is 30 L/s, 10 hp @ 30 m TDH. Friction losses and 30 L/s rate dictate size at 150 mm piping.

Heat Exchanger Sizes for:

SHEFFIELD	4,000,000 Btu/hr	@	30 L/s
LAW CENTRE	2,400,000 Btu/hr	@	15 L/s
PULSE NORTH	1,250,000 Btu/hr	@	9.4 L/s
PERFORMANCE CTR.	580,000 Btu/hr	@	4.4 L/s
YUKON BUSINESS	620,000 Btu/hr	@	4.6 L/s
POLARIS BUILDING	1,300,000 Btu/hr	@	8.0 L/s

By generating low pressure steam at the plant and using a heat exchanger, smaller heated water piping sizes and lower pumping rates could also be used to advantage. As pointed out in Section 5.0, reduced line sizes can lower the capital cost of the system significantly.

9.0 ESTIMATED COSTS

9.1 Costing Rationale

A.	BOILER BUILDING	$ 90,000.00
B.	CITY SERVICE CONNECTION	6,700.00
C.	BOILER CONTROLS ETC.	120,000.00
D.	DISTRIBUTION SYSTEM	
	Piping)	
	Heat Exchangers)	
	Pumps) See Appendix A.	
	Valves)	
	Btu meters, etc.)	155,651.00
E.	ELECTRICAL SERVICE CONNECTION	15,000.00
F.	LEGAL COSTS RE SITE DEVELOPMENT	5,000.00
G.	ENVIRONMENTAL GUIDELINES AND MONITORING	5,000.00
H.	LAND COSTS	10,000.00
		407,351.00
I.	ENGINEERING	28,000.00
		435,351.00
J.	CONTINGENCY	24,800.00
		460,151.00
	OTHER COSTS:	
	Metered Water	400.00
	Building Permit	2,500.00
	TOTAL CAPITAL COSTS	**$463,051.00**

NOTE: These figures do not include costs associated with servicing the Stratford Motel and Whitehorse Performance Centre.

9.2 Operation and Maintenance Costs

START-UP COSTS		$ 750.00
LEGAL COSTS		1,000.00
INSURANCE COSTS		1,500.00
FUEL COSTS	1000 T @ $25.00	25,000.00
ELECTRICAL COSTS		6,800.00
LABOUR COST PER ANNUM	Qualified Operator Provisional	43,600.00
BANK FINANCE CHARGES		??
ACCOUNTING COSTS	4hr/mo x 12 @ $35/hr	1,680.00
BUSINESS LICENSE		250.00
MAINTENANCE ALLOWANCE		3,000.00
OFFICE AND ADMINISTRATIVE SUPPLIES		1,200.00
TOTAL OPERATION AND MAINTENANCE COSTS		**$84,780.00/yr.**

10.0 REVENUE

Using a 4,000,000 Btuh plant, Figure 4.1 indicates that the plant could sell about 70% of the energy demanded. With this assumption and the total energy demand estimates of Table 5.0, the plant could sell about 15,000 GJ of energy each year. Selling this energy at $10.50/GJ would generate $157,000 in revenue annually. However, if the Whitehorse Performance Centre is eliminated from the project as recommended, annual revenue will drop slightly to an estimated $152,000. At an oil price of $0.45/L, the cost of energy is $15.75/GJ, assuming a boiler efficiency of 75%.

11.0 FINANCIAL ANALYSIS

1.	CAPITAL COSTS	$463,051.00
2.	CONTINGENCY	25,000.00
3.	OPERATING CAPITAL	17,393.00
	TOTAL CAPITAL REQUIRED	$505,444.00

FINANCING

1.	GOVERNMENT GRANT 30% Grant	$115,000.00 (max)
2.	BANK LOANS 14% B of M	100,000.00
3.	OTHER LOANS Y.T.G. Low Interest 8%	50,000.00
4.	OWNERS EQUITY	240,444.00
		$505,444.00

OPERATION AND MAINTENANCE (See Section 9.2 for breakdown) — $ 84,780.00/yr

12.0 CUSTOMER SELECTION

To determine if it is economical to service all of the potential customers, a financial assessment of each customer is required. Table 12.1 below shows annual projected revenue comparisons for each of the customers with the capital expenditure to service this load (not including plant).

TABLE 12.1 **PROJECTED REVENUE AND CAPITAL COST COMPARISON**

CUSTOMER	ANNUAL PROJECTED REVENUE ($) *	CAPITAL COST TO SERVICE
Law Centre	$ 48,081.00	$ 74,931.00
Sheffield Hotel	81,265.00	48,807.00
Pulse North Building	10,651.00	6,664.00
Yukon Business Services Bldg.	5,440.00	6,059.00
Polaris Building	6,545.00	11,465.00
Whitehorse Performance Centre	5,056.00	21,969.00
Stratford Motel	----	----
Totals	$157,038.00	$169,895.00

* Assuming 70% of the heat demanded could be supplied by the plant.

The Whitehorse Performance Centre is a new facility and very energy efficient, as can be seen from the preceding table. Therefore, the unit should not be considered in the initial installation because of the long payback on investment.

This effectively leaves five units for consideration. The Yukon Business Services Building and the Pulse North facility sit on either side of the proposed central heating plant and are relatively inexpensive to be serviced. Together, however, they do not have sufficient heating demand to warrant a plant of this magnitude. The success of the operation depends entirely on either the Law Centre or the Sheffield Hotel or both coming on stream.

Based on the foregoing, several scenarios in Time Stream Financial Analysis have been prepared for consideration:

1) No Change in Fuel Price.
   - expenditures inflate by 5% per annum

2) No Inflation at All.
   - assuming that cost increases due to inflation cancel out revenue increases.

3) Inflate both revenue and costs by 5%.

4) Inflate both revenue and costs by 9%.

APPENDIX ´A´

Capital Costs

APPENDIX A - CAPITAL COSTS

MATERIALS TAKE-OFF

LAW CENTRE	408 L.M. 150 mm Pipe (insulated)	$ 68,748.00
	2.4 MBtuh Heat Exchanger	4,500.00
	Btu Meter	1,851.00
	3-Way Valve (150x50x150)	426.00
	Motorized Controls	210.00
	50 mm Balancing Valve	48.00
	Labour	648.00
		76,431.00
SHEFFIELD HOTEL	244 L.M. 150 mm Pipe (insulated)	41,114.00
	4 MBtuh Heat Exchanger	4,500.00
	Btu Meter	1,861.00
	3-Way Valve (150x50x150)	426.00
	Motorized Controls	210.00
	50 mm Balancing Valve	48.00
	Labour	648.00
		48,807.00
PULSE NORTH BUILDING	18 L.M. 75 mm Pipe (insulated)	1,971.00
	1.25 MBtuh Heat Exchanger	1,500.00
	Btu Meter	1,861.00
	3-Way Valve (150x50x150)	426.00
	Motorized Controls	210.00
	50 mm Balancing Valve	48.00
	Labour	648.00
		6,664.00
YUKON BUSINESS SERVICES	18 L.M. 50 mm Pipe (insulated)	1,516.00
	0.6 MBtuh Heat Exchanger	1,350.00
	Btu Meter	1,861.00
	Motorized Controls	210.00
	3-Way Valve (150x50x150)	426.00
	50 mm Balancing Valve	48.00
	Labour	648.00
		6,059.00

POLARIS BUILDING	60 L.M. 75 mm Pipe (insulated)	6,572.00
	1.3 MBtuh Heat Exchanger	1,700.00
	Btu Meter	1,861.00
	Motorized Controls	210.00
	3-Way Valve (150x50x150)	426.00
	50 mm Balancing Valve	48.00
	Labour	648.00
		11,465.00
	Sub Total	149,426.00

OTHER COSTS		
(i)	Asphalt Restoration 100 sq. m @ $20.00	2,000.00
(ii)	Break into and ties to existing buildings 5 units @ $500.00/ unit	2,500.00
(iii)	10 gpm 70´ TDH 2 hp. Pump	875.00
(iv)	System Filling and Testing	850.00
		6,225.00

TOTAL CAPITAL COSTS **$155,651.00**