1986

PROCEEDINGS OF THE

INTERNATIONAL DISTRICT HEATING AND COOLING ASSOCIATION

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IDHCA

PLANNING FOR CONVERSION TO HOT WATER
WORLD'S LARGEST RESIDENTIAL STEAM DISTRICT HEATING SYSTEM
VIRGINIA, MINNESOTA

By: David C. Rian, P.E., Chief Mechanical Engineer
Abe W. Mathews Engineering Company

ABSTRACT

For sixty years the Virginia Department of Public Utilities has provided district heating for public, commercial and residential buildings in the City of Virginia. A centrally located coal fired steam cogeneration plant provides steam to the distribution system from extraction type turbine generators with a maximum capacity of 270,000 pounds per hour of steam for the heating system and firm electrical generating capability of approximately 32 MW.

The steam district heating system serves over 3000 residential and commercial customers. The condensate is directed to the sewer system and none is returned to the plant. The deteriorated distribution piping, insulation, steam leaks and lack of condensate return has resulted in increasing costs for operating the system. Records indicate that distribution system losses are in excess of 40 percent.

The Department of Public Utilities was awarded a $50,000 Phase II Grant by the Minnesota Department of Energy and Economic Development to investigate the feasibility of converting the existing steam district heating system to a modern hot water system.

This paper will summarize the Phase II study work completed, and results, including collection of data for existing customers, development of customer building conversion schemes, costs and alternatives, preliminary system design and cost, economic analysis, financial feasibility and implementation plans for conversion and expansion of the system.

With an estimated cost of $40 million, the project represents a major undertaking for a city the size of Virginia (population approximately 12,000), but is necessary for the survival of the Utility, stabilization of the community's socio-economic base and for increased economic development within the City.

BACKGROUND

The City of Virginia, Minnesota, located in the northeastern part of the state, is approximately 65 miles northwest of Duluth and the tip of Lake Superior.

The City through its Department of Public Utilities owns and operates the "Worlds Largest Residential Steam District Heating System". The system which was initially built about 1915 to 1920 has been expanded over the years and currently serves approximately 3100 residential, commercial and public buildings in the City. The Department of Public Utilities is directed by a Public Utilities Commission consisting of five members appointed by the Mayor and City Council.

Virginia is substantially dependent economically on the local iron ore mining industry which with current reduced activities and staff reductions has adversely affected the local economy. A revitalized district heating system can assist to stabilize the local economy and population base as well as providing incentives for attracting new industries to the City.

Steam is provided from the centrally located coal fired steam electric station, with three high pressure boilers and two low pressure boilers. The high pressure boilers are rated at 82,000 pounds per hour, 132,000 pounds per hour and 178,000 pounds per hour at 600 psig and 825°F. The two low pressure boilers are rated at 52,000 pounds per hour at 400 psig and 700°F and can be used for emergency backup only.

The plant provides steam at 50 psig and 10 psig to the distribution system from two extraction type turbine generators with extraction at 50 psig; one turbine generator with extraction at 175 psig and exhaust at 10 psig, and provisions for introducing direct steam into the system. The plant is capable of supplying a maximum of 270,000 pounds per hour of steam to the existing heating system. The firm electrical generating capability of the plant is approximately 32 MW.

The steam district heating system presently serves approximately 3071 residential and commercial customers including the downtown business area, city public buildings and central and northside residential areas. Steam is distributed at 50 psig and 10 psig with pressure reducing stations utilized on the 50 psig system to provide 10 psig delivered pressure at various locations. The condensate is directed to sewer at customer connection and none is returned to the plant. The deteriorated distribution piping insulation, steam leaks and lack of condensate return has resulted in increasing costs for operating the system. Records indicate that distribution system losses were 49% for the year ending December 31, 1984.

Recent major rehabilitation work has been completed as follows:

1. In 1980 a new 50 psig steam line was installed from the power plant to the hospital to serve the northside area. Two 12 inch diameter pipes were installed to accommodate anticipated

future conversion to hot water. One of these lines is currently used to supply steam to the northside area.

2. In 1981 a new 50 psig steam line was installed around the north side of Bailey's Lake to serve the Finntown area.

Maintenance work was completed during the 1985 construction season to enable operation of the deteriorating steam distribution system. Steam line work included replacement of expansion joints, valves, fittings and pipe in various locations throughout the service area.

The peak load for the district heating system is estimated to be approximately 260,000 pounds per hour. Actual peak load for 1983 was 199,000 pounds per hour.

The Department of Public Utilities operates its power plant and purchases electric power to serve its electrical and heating customers on the most economical basis. Also, the Utility has an agreement with the area's major electrical supplier, Minnesota Power, to utilize excess power produced during the heating season. Currently the average electrical rate is 6.59 cents per kilowatt hour and steam rate at $0.763 per hundred pounds of steam.

The existing steam district heating system is in a substantially deteriorated condition with no condensate return. System losses are in excess of 40%. Previous engineering studies have indicated that the most feasible method of insuring continued operation of this district heating system on a long term basis would be to convert the system to a hot water district heating system.

OBJECTIVES OF THE PHASE 2 STUDY

The Department of Public Utilities requested Secondary Planning Grant funds to study the feasibility of proceeding with final design and construction of the conversion to hot water and to obtain information on building conversion, preliminary design and operating and installation cost estimates.

Virginia received one of seven Phase 2 District Heating Study Grants of $50,000 awarded by the State of Minnesota, Department of Energy and Economic Development in 1984. In addition to the local $5,000 match, the Utility provided substantial in kind services to the project.

The purpose of this project was to determine the feasibility and cost of converting the existing steam district heating system serving the City of Virginia to a hot water district heating system.

CUSTOMER SURVEY

A market study was completed to collect information on present fuel consumption and present heating system type for each building currently served by the steam system.

A Heat Load Survey Form was mailed to each steam customer. Questions were asked about building type, use, size and age; heating system type; domestic water heater type; whether or not the building had air conditioning; recent energy conservation measures; annual energy use; and attitudes about district heating. 1,128 customers responded to the survey or 37% of the total customers. Of those responding 1,104 or 98% indicated an interest in remaining connected to the district heating system.

On-site surveys were conducted for each type of residential and commercial building and for each large customer. Information was collected about building use, building description, primary heating system description, process steam requirements if any, secondary heating system description, domestic water heating system and additional data relating to conversion to hot water. A total of 36 buildings were surveyed representing all types of customers and heating systems.

Steam heat service records of the Department of Public Utilities were reviewed for each customer. Data collected included size of building, number and size of radiators, hot water tank size and type, steam consumption and degree days for the period July, 1983 to June, 1984. Annual energy use, estimated peak hourly use and installed space heating capacity were calculated from the collected data. The survey provided an extensive base of data on existing customers for other parts of the study.

ENGINEERING INVESTIGATIONS

Alternate methods were investigated for the distribution system, building conversions and heat source. Annual energy use data and estimated peak hourly use data were tabulated for each zone. With this data, a thermal map was prepared showing energy use for the entire City.

The thermal map allowed comparisons of alternative distribution systems to be made. Various distribution networks, piping systems and routings were investigated.

Alternate designs, materials and methods were investigated for the distribution system, steam to hot water conversion station and customer building heating system conversions. Results of these investigations provided a preliminary design described as follows for completing cost estimates and economic analysis.

The proposed low temperature hot water district heating system consists of a new steam-to-hot water conversion station, a new distribution system to replace the existing steam system and building heating system conversions.

The conversion station which will be located at the Utilities power plant will convert the 400°F, 50 psig steam presently available for district heating to 230°F water. The design capacity for the conversion station will be 200 million BTUH.

The steam pressure is reduced to 10 psig with a pressure reducing station and the steam temperature is reduced to 240°F with a desuperheater. The 240°F, 10 psig steam is then passed through heat exchangers to produce 230°F water for the disrict heating system.

The pumps required to circulate the hot water through the underground mains to the customers are located at the conversion station. A variable volume pumping system will be used to vary the quantity of hot water distributed depending on the heat demand. Additional auxiliary equipment within the conversion station includes: expansion tanks, water treatment, condensate pumps and a BTU meter to measure heat delivered to the distribution system.

The low temperature hot water piping network from the conversion station is identified as the primary piping system. Each building is supplied with primary water and will have a secondary piping system for space heating requirements. The primary piping system is designed to operate at less than 250°F and 150 psig. Normal conditions will be about 230°F supply water temperature with a 180°F return water temperature. Maximum pressure will normally be 100 psi. However, these conditions are at periods of peak load and actual temperature and pressures may be lower during part load conditions.

There are several alternate methods for installing underground distribution piping for hot water supply and return including installation in a tunnel or conduit and direct burial. The direct burial method selected consists of a pre-insulated, field joined carrier pipe with a prefabricated high density polyethylene jacket. The carrier pipe can be either steel or copper depending on pipe size. Steel has been used for the larger main distribution pipes and copper for the smaller service pipes. Insulation will be a urethane foam bonded to the pipe. The polyethylene jacket provides a water barrier to protect the insulation but more importantly to protect the piping from external corrosion. A leak detection system has been included to save time in locating a leak and minimizing potential damage and interruption of service.

Burial method includes two feet minimum cover with added protection at heavy traffic areas. Other components of the distribution system includes isolation valves, drains and vents, and expansion devices and anchors as required.

Building space and domestic hot water heating system conversions fall into three basic categories; those with existing steam, hot water, and forced air systems for space heating.

A typical existing steam system conversion requires the installation of a water to water heat exchanger and pump to supply low pressure (less than 30 psi) hot water, on the secondary side of the exchanger, through the present steam heating system after removal of the steam traps. A double wall, water to water heat exchanger is required to supply domestic hot water. As much of the present system as possible would be retained. In a typical residential application the heat exchangers, pump, and valves would be supplied in a packaged unit. Larger applications require separate components.

A typical existing hot water heating conversion requires the installation of a water-to-water heat exchanger for space heating and a water-to-water double wall heat exchanger for domestic hot water. The existing system including the circulating pumps and expansion tanks will be reused. In some installations, the primary hot water supply may be connected directly to the existing hot water system after removal of the existing steam-to-water heat exchanger.

A typical existing forced air space heating system conversion would be accomplished by connecting the hot water supply to a new hot water coil in the forced air unit. The existing steam coils may be reused at some installations. Water to water, double wall heat exchangers would be required for heating domestic water.

All building conversions will also include shut off valves, an energy usage measurement meter, and pressure testing of existing components.

ECONOMIC ANALYSIS

Thermal energy sales were projected to be 421,265 million BTU per year based on the results of market surveys and review of Department of Public Utilities data. Thermal sales were summarized by billing zone and customer size.

Detailed cost estimates were prepared for the conversion to hot water including engineering and construction costs for the heat source modifications, distribution system and building conversions. Cost estimates for building conversions were summarized as "City Costs" and "Customer Costs". The City cost included heat exchangers, meter, primary side piping valves and controls while the customer cost included connection of heating system and potable water to heat exchangers and required building heating system modifications.

The cost for converting the existing steam system to a modern hot water system was estimated as follows:

Capital Costs	
1. Conversion station	$ 2,514,000
2. Distribution system	21,798,200
3. Building conversions	13,357,900
4. Engineering and contingencies	2,700,000
5. Total capital cost	40,370,100

Department of Public Utilities historical cost data and operating requirements and procedures were reviewed and utilized to determine expected cost savings in operations for conversion of the district heating system to hot water.

Expected cost savings for hot water were estimated as follows:

Cost Savings	
1. Fuel - reduced steam production	$1,950,000/yr.
2. Fuel - reduced make-up water	296,000
3. Coal unloading labor	25,000
4. Chemicals - reduced make-up water	60,000
5. Distribution maintenance	350,000
6. Miscellaneous production costs	62,000
7. Administration and general costs	112,000
Total cost savings	$2,855,000/yr.

Since reduced steam production is required for the heating system and with the plant operating in response to heating system requirements less electrical power will be generated. Additional costs therefore will occur for purchasing power. There will also be an additional cost for pumping heating system water.

Expected additional costs for hot water are as follows:

Additional Cost	
1. Additional purchased power	$ 655,000/yr.
2. Water pumping power costs	22,000
Total additional costs	$ 677,000/yr.
Net cost savings.	$2,178,000/yr.

Cost benefit information was developed for each major customer and typical data was developed for remaining customers.

The cost benefit analysis developed for major customers resulted in simple paybacks ranging from 6 to 19 years based on the total building conversion cost.

The typical cost benefit analysis developed for remaining customers resulted in simple paybacks ranging from 3.9 to 55 years for residential customers (less than 75 MBH) depending how large a share of the conversion costs are paid by the individual customer. The simple payback for the remaining customers in this group varies from 2.4 to 44 years depending on cost sharing of conversion costs.

Cost comparisons were developed with alternative heating systems including electric, L.P. gas, No. 2 fuel oil, natural gas and wood fuel for residential customers (less than 75 MBH).

Cost benefit analysis completed for these customers indicate that even with the customer paying for a portion of the conversion a new hot water system is the most economical alternative available.

Our assessment of the feasibility of converting the existing steam district heating system to a modern hot water district heating system completed as a part of this task indicates that the project can be economically feasible.

The feasibility of this project however, will be determined by the ability to finance the conversion and the investment will provide a minimum financial rate of return.

Whatever the source of borrowed funds, it must be noted that present debt is pledged by the combined revenues of the utility including water, electricity, gas and steam. Debt terms require that such revenues be maintained to provide an annual cash flow not less than 125% of interest and principal payments for both old and new debt.

Cash flow available for debt payment in 1984 was $1,727,000 which is the sum of gross income, depreciation and interest payments. Analysis indicated that a significant savings in annual operating costs ($2,178,000 based on 1984 costs) can be attained if the system is converted to hot water. Simple financial projections based on a phased implementation over 11 years, debt requirements for the utility, and each year borrowing the capital funds required at 8% for 20 years indicated that rate increases must be applied to maintain a positive cash flow throughout the life of the project, in 1989, 1991 and 1993.

MARKETING STRATEGY

Marketing the conversion of an existing steam system to a hot water system is considerably different than marketing a system expansion or establishment of a new system.

The marketing strategy developed for this project says that space heating and water heating can be provided to customers more economically and more efficiently with a modern hot water district heating system than with any other alternative.

Heating system alternatives were investigated for customer buildings with less than a 75 MBH heating load. This group of buildings is generally residential and represents 90% of the existing district heating system customers. Existing heating systems in these buildings are either direct steam radiation, steam with a heat exchanger to convert to hot water or forced air with steam coil in the air stream.

Alternative individual heating systems to replace the existing steam district heating system in lieu of the proposed hot water district heating system would include electric, L.P. gas, No. 2 fuel oil, natural gas and chunk wood fuels.

Conversion to electric heat was based on installation of new electric baseboard units. Systems for other fuels utilized the following:

- Hot Water, Includes new hot water boiler, domestic water heater, chimney, and piping as required for tie-in to customers existing systems.

- Forced Air, Includes new forced air furnace, water heater, chimney, and piping as required for tie-in to customers existing system.

- Steam, Includes new hot water boiler, circulating pump and expansion tank, water heater, chimney, removal of steam trap internals, and piping as required for tie-in to customers existing system.

The following tables list the results of our investigations and indicate that the new hot water district heating system can provide heating at lower energy costs than any other source except chunk wood and existing heating systems can be converted to hot water at insignificant cost.

TABLE NO. 1

HEAT SYSTEM ALTERNATIVES
FUEL COST COMPARISON

Fuel	Heating Value BTU/Unit	Unit Price	$/MMBTU Delivered	% Eff.	$/MMBTU Useable
Elect.	3,413/KWH	$ .066	$19.4	100	$19.4
L.P. Gas	91,500/Gal.	.83	9.07	80	11.3
#2 F.O.	140,000/Gal.	1.07	7.64	80	9.55
N.G.	1,000/MCF	7.00	7.00	80	8.75
Steam	1,000/M#	7.89	7.89	100	7.89
Hot Water	1,000,000/MMBTU	7.89	7.89	100	7.89
Wood	21,200,000/Cord	50.	2.39	50	4.72

TABLE NO. 2

BUILDING CONVERSION ALTERNATIVES
LESS THAN 75 MBH SIZE
CONVERSION COST COMPARISON

Fuel	Average Annual Fuel Cost	Capital Cost (Customer) Hot Water	Forced Air	Steam
Elect.	1700	3100	3100	3100
L.P. Gas	980	3000	2100	3400
#2 F.O.	830	5600	3800	6000
N.G.	760	3000	2100	3400
Steam	690	0	0	0
Hot Water	620	100	100	300
Wood	410	4400	3700	4800

IMPLEMENTATION PLANS

Implementation of converting the existing steam district heating system serving the City of Virginia to a modern hot water district heating system can be best accomplished with a phased construction plan over a number of years.

The factors which must be considered when establishing a phased implementation plan include the following:

- With over 3,000 buildings to convert and to minimize disruption of other services, it appears that it would not be practical to complete the project in less than 9-11 years.

- The area being converted each year should be large enough to take advantage of economies of scale.

- Sequence of implementation areas should be flexible to accommodate unexpected developments during implementation.

- Initial areas converted should be those with the greatest load density and provide maximum savings in operating cost with minimum capital cost.

- Areas should be flexible so that they could be decreased (or increased) once installation bids have been received.

- Implementation should be accomplished so that work can be stopped or delayed between phases.

- The implementation plan must be finalized in conjunction with plans for financing the work.

The implementation plan initially proposed would accomplish the conversion to hot water in phases as described below and as shown on the accompanying implementation map.

Phase	Year	Area
1	1986	School complex and portion of Billing Zone 3
2	1987	Approximately one half of Billing Zone 3
3	1988	Remaining portion of Billing Zone 3
4	1989	Approximately one half of Billing Zone 2
5	1990	Remaining portion of Billing Zone 2
6	1991	Approximately one half of Billing Zone 5
7	1992	Approximately one half of Billing Zone 4
8	1993	Remaining portion of Billing Zone 5
9	1994-1996	Remaining portion of Billing Zone 4

Billing Zone 3 with a large number of commercial buildings, has a higher load density than other areas. Also Zone 3 is closer to the power plant than any other area. Zones 2 and 4 have about the same thermal load densities with some commercial and many residential buildings. Zone 5 has the lowest thermal load density with mainly residential buildings. Zones 4 and 5, however, must be worked together since they share common distribution piping. Zone 2, therefore, should be converted after Zone 3 and followed by Zones 4 and 5.

Implementation of the hot water distribution system would require the use of temporary heat exchanger stations for some areas. When construction begins at the far end of each area, a temporary heat exchanger station would supply hot water for those customers farthest away from the power plant. The heat exchangers would be supplied with steam from the existing distribution system. The existing distribution pipes would still provide steam to the customers closest to the power plant. Eventually all customers would be converted using this approach, working toward the power plant.

During the construction phase, areas being converted could be concurrently served by the existing steam system and the new hot water system until all buildings in the area are converted and the steam can be shut off. The new hot water pipes could be installed over or alongside the existing steam pipes without disturbing them. After construction is complete, the hot water will provide all heating requirements for each customer and the existing steam system can be abandoned.

Potential future expansion of the system could be implemented once all existing service areas are converted or prior to completing the conversion of some existing areas whichever best suits the needs of the City.

Phase 1, may be considered a demonstration of the test area. Using the selection guidelines previously discussed, which includes the High School Complex, consisting of the Roosevelt School, Technical Building and Laboratory Annex, and a portion of adjacent commercial and residential area has one of the largest thermal loads in the City and is very close to the power plant. A demonstration project utilizing the school would involve direct community contact which could be useful in the marketing strategies for the rest of the City.

Since over 90% of the district heating customers in the City of Virginia are small residential users, it would be appropriate to include at least one block of residences, and a few commercial buildings, in the initial project. Conversion of small users could provide valuable data which would be useful in the further implementation and marketing of the project collected might include:

Knowledge gained from a small scale project could save considerable time and money on the subsequent project phases.

Following the completion of the Phase 2 study, the Department of Public Utilities requested and received technical assistance (TA) from HUD through the U.S. Conference of Mayors. As a result of the technical assistance assessment, an alternate area was selected for the initial project.

The initial project now being pursued includes utilizing existing distribution piping to serve the Mesabi Community College, Virginia Regional Medical Center, Golf Course Clubhouse and Olcott Park Buildings.

A dual pipeline was installed in 1980 from the power plant to the Virginia Regional Medical Center Complex. The lines currently distribute steam to the north side of Virginia including the four customers proposed for conversion to hot water as part of this project. In preparation for a future conversion of the steam system to hot water, a Class A piping system was installed which can handle either steam or hot water.

The piping system is designed for temperatures up to 450°F and pressures up to 400 psig which are well above the current steam properties of 50 psig and 300°F and the temperature and pressure limits of 250°F and 150 psig for the proposed low temperature hot water system. Since the operating conditions for the proposed hot water system are considerably lower than the design temperatures and pressures, it is expected that the expected service life of the piping will be extended.

The existing dual pipeline has a capacity to provide hot water to the entire north side. Conversion of the proposed customers will use approximately 25% of the pipeline capacity. Therefore, considerable flexibility and capacity remain for future expansion.

The proposed project will include minimum repairs to an existing steam line so that other customers presently served by the dual line can be accommodated, hot water conversion station at the power plant and building heating system conversions.

The proposed hot water conversion includes heat exchangers, pumps, piping and accessories, power plant modifications and electrical work to convert the 50 psig steam at 400°F presently available to 230°F hot water. The installed capacity will be 12 million BTUH, but the components will be sized for future expansion to 50 million BTUH which is the approximate capacity of the pipeline.

Heating systems for each building proposed for conversion will require the installation of heat exchangers, pumps, an energy meter, valves and piping, and connection to the existing system. Both the space heating and the domestic hot water system will be converted from steam to hot water.

The annual steam consumption for these 4 customers represent approximately 7.1% of the annual energy use for the entire district heating system. Estimated peak load is approximately 11,751 MBTUH with an annual energy use of 30,033 MMBTU.

The estimated cost for (the initial) project is:

-	Repair existing steam line	$ 50,000
-	Heat exchanger station at plant	800,000
-	Building conversions	310,000
-	Engineering and contingency	155,400
-	Total project cost	$1,315,400

The Department of Public Utilities has applied for funding from US DOE, through their District Heating and Cooling Research Opportunity Program. The Utility is also currently applying for loan funding from the State of Minnesota through the District Heating Loan Program.

Completion of this initial phase is planned for the 1987-88 heating season.

The result of the Secondary Planning Study is that the Department of Public Utilities is moving closer to implementing a conversion of the existing steam district heating system to a hot water system.

Support for conversion to a hot water system has been strengthened by completion of the current studies. The first step will be to finalize methods of financing the project and individual building conversions. With financing options arranged, public information phase should proceed with public meetings, news articles and presentations to various groups to distribute the information available and establish, improve and maintain positive support for the hot water conversion. The next step then will be to proceed with final design and construction of the conversion to hot water.

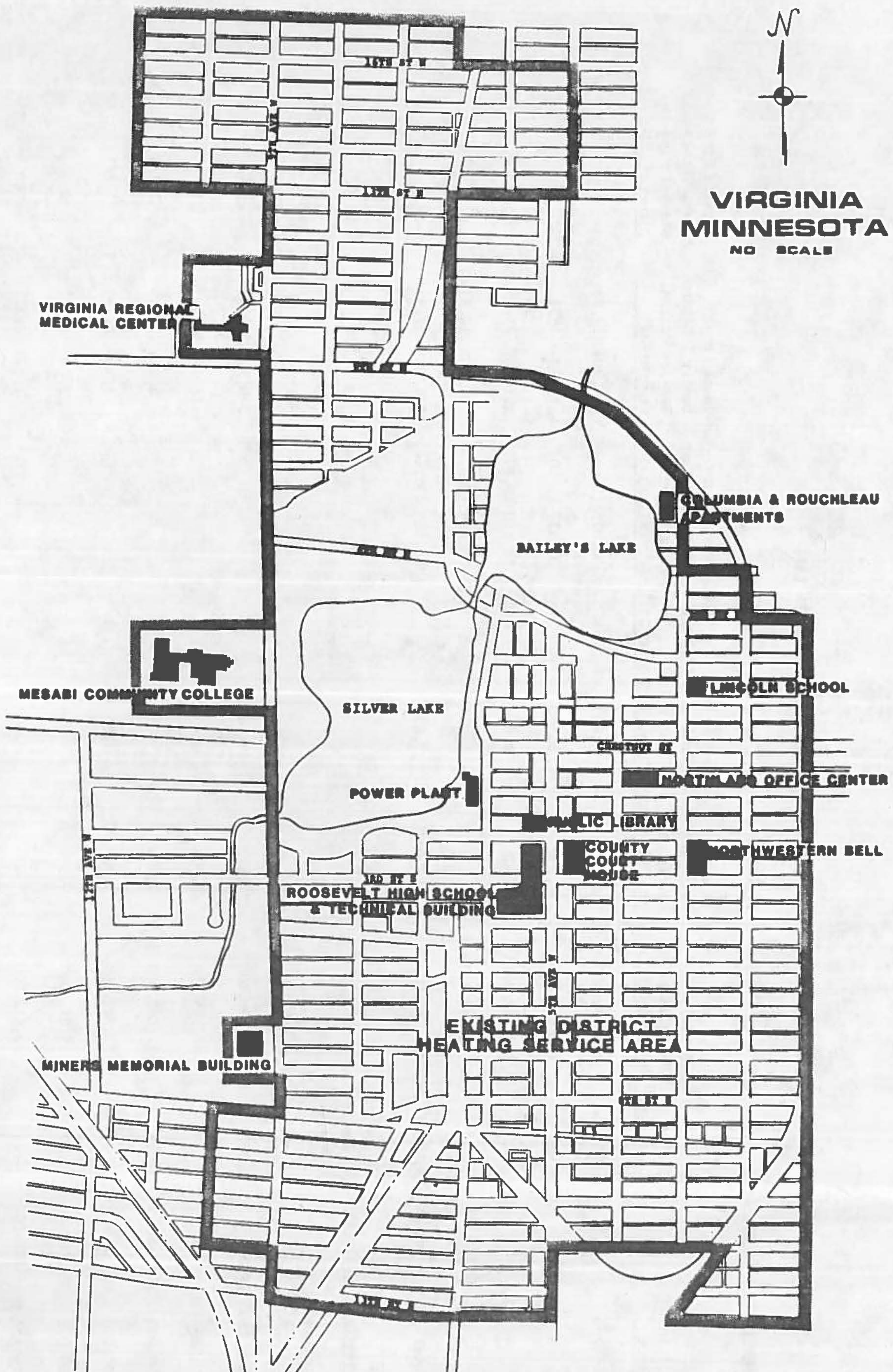
TABLE 3
HOT WATER DISTRICT HEATING SYSTEM DATA

Summary By Billing Zones

Billing Zones	No. of Customers	Annual Heat Use, BTU x 1000	Estimated Peak Hourly Heat Use, BTU x 1000	Estimated Minimum Hourly Heat Use, BTUH x 1000	Total Length Supply & Return Main Piping, Ft. (Miles)	Total Length Supply & Return Service Piping, Ft. (Miles)	Service Pipe Size, Inches Nominal Pipe Diameter
2	791	113,072,000	46,300	4,630	50,875 (9.64)	94,920 (17.9)	-
3	666	122,160,000	51,800	5,180	31,137 (5.90)	79,920 (15.1)	-
4	927	117,261,000	49,500	4,950	52,660 (9.97)	111,240 (21.1)	-
5	737	68,772,000	29,100	2,910	50,848 (9.63)	88,440 (16.8)	-
Total	3,121	421,265,000	176,700	17,670	185,520 (35.14)	374,520 (70.9)	-

Summary By Customer Size

Customer Size, BTUH	No. of Customers	Annual Heat Use, BTU x 1000	Estimated Peak Hourly Heat Use, BTU x 1000	Estimated Minimum Hourly Heat Use, BTUH x 1000	Total Length Supply & Return Main Piping, Ft. (Miles)	Total Length Supply & Return Service Piping, Ft. (Miles)	Service Pipe Size, Inches Nominal Pipe Diameter
Less than 75,000	2,838	246,990,000	103,600	10,360	-	340,560 (64.5)	3/4
75,000 - 150,000	184	44,105,000	18,500	1,850	-	22,080 (4.18)	1
150,000 - 250,000	37	17,642,000	7,400	740	-	4,440 (0.84)	1-1/4
250,000 - 400,000	33	23,841,000	10,000	1,000	-	3,960 (0.75)	1-1/2
400,000 - 800,000	17	25,271,000	10,600	1,060	-	2,040 (0.39)	2
Greater than 800,000	12	63,416,000	26,600	2,660	-	1,440 (0.27)	Greater than 2"
Total	3,121	421,265,000	176,700	17,670	-	374,520 (70.9)	-



HEAT LOAD MAP

FIGURE NO. 1


THE CITY OF
VIRGINIA
IMPLEMENTATION MAP
NORTH
INITIAL PROJECT
4
5
5
VIRGINIA
LAKE
SILVER
LAKE
3
POWER PLANT
1
2
9
7
8
6

FIGURE NO. 2