Logan City Water Distribution System Master Plan

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Purpose, Scope, and Authorization

Introduction

Municipal water for the residents of the City of Logan (the City) is provided by water storage, transmission, and distribution systems owned and operated by the City. As the City grows, it has become increasingly evident that a master plan is needed to provide the citizens with high quality water service, consistent throughout the City. This report evaluates the existing system and considers changes that will improve the quality of water service overall.

Purpose of Study

This study was commissioned by the City to provide a comprehensive assessment of the total water storage, transmission, and distribution systems. The goal is to provide the best service to City residents. This study has been prepared to provide that comprehensive assessment through the following primary objectives:

- Identify areas in the City of Logan water distribution system where adequate peak hour and fire flows cannot be maintained from 1995 through 2020. This will be done utilizing information developed in other reports and an existing water distribution system computer model.
- Identify water distribution system improvements (mains, storage, and other system elements) that will enable the water system to meet present and projected customer demands and fire flows.

Scope and Authorization

This study was authorized by a contract between CH2M HILL and the City. The scope of the study is described below. The preparation of the City of Logan Water Master Plan will be completed using the following tasks:

Task 1 Collect and Review Data and Review EPANET Computer Model

Become familiar with system data used to develop the City's EPANET computer model, fire flow data, operating data, and existing pertinent reports and develop a plan to incorporate this information into the Water System Master Plan.

Task 2 Extend Growth and Demand Planning

Estimate water demands in the northwest and southwest quadrants of the City for the planning period using the information contained in the Logan City Water Rights Master Plan and City water production and customer billing records.

Task 3 Establish System Evaluation Criteria

Establish the criteria that will be used to evaluate the present water supply, storage, transmission and distribution system and evaluate alternatives that will resolve existing or projected deficiencies in the existing system. These criteria will include, but not be limited to:

- Storage Requirements (Operational, Emergency, and Fire)
- Fire Flow and Pressure Requirements
- Minimum Pipe Size
- Water Age
- Minimum and Maximum System Pressures
- Future Demand Conditions
- Future System Boundaries

Task 4 Identify Problem Areas and Develop Improvements

Identify portions of the Logan City water supply, storage, transmission and distribution system that do not meet the criteria established in Task 3 for either present or anticipated conditions and develop improvement plans to enable the system to meet the criteria.

Task 5 Develop Cost Opinions and Recommendations for Improvements and Include in a Master Plan Report

Identify recommended alternatives and develop an engineering opinion of cost to implement recommended system improvements. Results of system evaluations, recommended improvements and opinions of cost will be presented in a Master Plan Report.

Task 6 Development of GIS Plan to Interface with EPANET

Develop a plan and system for organizing the ARC INFO GIS database files so that they can be interfaced with the EPANET computer program. A list of criteria for an acceptable ARCINFO/EPANET interface will also be developed.

CHAPTER 2

Review of Previous Work and Establishment of System Requirements

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Review of Previous Work and Establishment of System Requirements

Introduction

Before an evaluation of the existing water supply, storage, and distribution system is undertaken, it is important to establish the existing, or baseline, conditions; estimate the future conditions that must be satisfied; and establish the level of service that must be met to satisfy water systems customers.

This chapter summarizes previous planning work on the water system, establishes the water supply and demand conditions that must be met now and in the future, and establishes the level of service criteria that will be used to examine the existing system's performance and plan future improvements.

Previous Studies

Three previous studies prepared for Logan have been used in the preparation of this water master plan. The information, conclusions, and recommendations contained in each of these previous studies for the water master plan have been included. The previous studies are described below:

Ten-Year Water and Sewer Capital Improvements Plan, Montgomery-Watson, August 1994. This report was prepared to identify and estimate the cost of needed improvements to the City's water and sewer system. The report supported the City's efforts to evaluate and update the utility rate structure. It is an interim plan only and was not prepared using the same level of analysis used in the master plan. However, it does provide insight into the improvements that City staff felt were needed based upon present operating experience.

Water and Sewer Cost of Service Study, J.S. Sawvel and Associates, November 1993. This report was prepared as part of the City's plan to update its utility rates. The information included in this report is not directly applicable to the preparation of the water master plan, but it has been helpful in providing background information.

Logan City Water Rights Master Plan, Eckhoff, Watson and Preator Engineering (EWP), August 1995. This water rights master plan included extensive analysis of present and projected water demands. This information was used as the basis for the water distribution system master plan. It did not analyze the entire service area included in this study. Those areas not included as part of the Water Rights Master Plan were addressed in this plan.

This report was prepared assuming the conclusions presented in the above reports can be incorporated into this master plan.

The following sections present the standards that were used in establishing the level of service criteria in this report. In some cases these standards are regulatory requirements, and in others they are recommendations from various regulatory and industrial groups.

Definitions

The following terms have been used in this report and are defined below:

- Average Daily Demand (ADD). The average demand in million gallons per day (mgd).
- Maximum Daily Demand (MDD). The total demand in mgd (indoor, irrigation, commercial, residential, and fire flow) on the day with the highest water use.
- Peak Hour Demand (PHD). The greatest total flow, in gallons per minute (gpm), occurring at the hour of highest use in the distribution system.

State of Utah Public Drinking Water Regulations

The evaluation of a water distribution system master plan demands that both the existing and future water requirements for the community have been developed properly, and that these requirements adhere to existing regulations. The *State of Utah Public Drinking Water Regulations* state the following limits with respect to water quantity requirements:

- The source capacity must be capable of meeting both the maximum daily flow and average yearly flow requirements. "The source must be capable of providing 800 gallons per day (gpd) equivalent residential connection for indoor use. In addition, they must be able to provide a total of 146,000 gallons per equivalent residential connection per year." This criteria is generally used in cases where there is no historic water use data. Where historic water use is available, that data is used in the planning process.
- The MDD design requirement consists of the sum of the required indoor demand, irrigation demand, and fire flow demands.
- Storage capacity shall be great enough to provide 400 gallons per equivalent residential connection.
- The distribution system shall be designed to provide minimum pressure of 20 psi (pounds/square inch) under peak instantaneous demand.

In general, these criteria have been used as the basis for evaluation in this report. However, historic conditions and recommendations of the American Waterworks Association (AWWA) have also been considered. In some cases, the more conservative criteria has been applied if conditions appeared to support something different than State regulations. For example, 20 psi under peak demand is lower than most systems find acceptable (unless the demand is the result of fire flows). For the purpose of this report, a minimum pressure of 60 psi was used as the standard.

Population

Due to the unpredictable nature of the growth that is now occurring in the City, the task of accurately forecasting future population numbers is a difficult one. The City is growing at an unprecedented rate. This growth has been occurring for several years and no reason for a future decline is apparent for some time. To prepare for this growth, Logan City has developed estimates of its population through the year 2020. These projections are being used throughout the City as a basis for the City's planning efforts. Table 2.1 summarizes the Logan City yearly population growth projections.

Table 2.1
Population Projections For Logan

Year	Projected Population
1990	32,762
2000	37,377
2010	42,995
2020	47,398

Logan City Water Rights Master Plan

It must be recognized that the numbers in Table 2.1 are estimates only. It is impossible to predict the final population, or even the rate of long term growth. This plan should be seen as a guide that must be reviewed and updated periodically (3 to 5 years is recommended). If growth occurs faster than anticipated, it may be necessary to accelerate some capital improvements. If growth occurs slower than forecasted, it may be possible to postpone some capital improvements. The computer model developed as part of this study will prove to be a valuable tool to assist the City in maintaining a high level of water service as conditions change in the future.

Historic Water Use

Water for the City is obtained from wells and springs. Records of recent production were summarized and presented in the Water Rights Master Plan. These records as well as other production data were used as the basis to establish peaking factors in the Water Rights Master Plan. Table 2.2 summarizes the total water sold and peaking factors for this time period. Peaking factors (pf) are used to indicate the amount of water that is used during the maximum day of the year (pf = total water used during maximum use day/average daily water use) and peak hour (pf = maximum water used in 1 hour/average hourly water use). The records of past water usage indicate that water demand in the community is currently growing at a rate of 0.5 to 0.8 per cent per year. Water demands on the maximum use day has, based upon recent historic data, been approximately 2.25 times the average day demand. There are no data from which to determine the peak hour to average day ratio. Based upon systems with similar use patterns the present peak hour demand is estimated to be approximately 3.75 times the average day demands.

Table 2.2
Logan City Historic Water Use

Year	Annual Water Use (acre-feet)	Ave. Daily Demand (mgd)
1990	**15,518**	**13.85**
1991	**14,942**	**13.34**
1992	**15,400**	**13.75**
1993	**14,776**	**13.19**
1994	**15,878**	**14.17**

The water use figures presented in Table 2.2 represent City water supplies. The average water use has been 393 gallons per capita per day (gpcd), total water use. The State average water use has been reported as 284 gpcd. While Logan's average water use is greater than the State average, it is lower than average for the Bear River Basin (Logan City Water Rights Master Plan, August 1995.)

Fire Protection

The State of Utah Public Drinking Water Standards require the City to provide fire protection. The fire flow and normal peak instantaneous demand must be met, while maintaining a residual pressure of 20 psi at all points within the system. In addition, a minimum 6-inch-diameter water main is required at all fire hydrants. Recent standards proposed by the Division of Drinking Water would require minimum 8-inch-diameter water lines. In most cases this will be adequate. Minimum line sizes are discussed in Chapter 4. Fire flow requirements are related to the type and size of the structure being protected, but are not to be less than 1,500 gpm, according to the 1994 Uniform Fire Code (UFC). Fire demand requirements may range from this minimum 1,500 gpm up to 8,000 gpm for large commercial buildings, as illustrated in Table 2.3. A standard of 1,500 gpm has not yet been adopted by all agencies in Logan City, however, this is expected to happen in the foreseeable future. For this study, a minimum fire flow of 1,500 gpm was used.

The evaluation of the Logan community water system included the simulation of a number of fires placed strategically throughout the system at points near dead end lines or at higher elevations, both of which were considered "worst case" locations. Fire flows of 1,500 gpm to 3,500 gpm were simulated at these points under the condition of a future maximum daily demand flow. The results of this evaluation are presented in Chapter 4.

Table 2.3
1994 Uniform Fire Code Requirements

Building Area (Square Feet)					Fire Flow (Gallons Per Minute)	Flow Duration (Hours)
Type I-F.R. II-F.R.[1]	Type II One-HR. III One-HR.[1]	Type IV-H.T. V-One-HR.[1]	Type II-N III-N[1]	Type V-N[1]	x 3.785 for L/min.	
<22,700	<12,700	<8,200	<5,900	<3,600	1,500	2
48,300	24,200	17,400	12,600	7,700	2,250	2
70,900	39,700	25,500	18,400	11,300	2,750	2
83,700	47,100	30,100	21,800	13,400	3,000	3
128,700	72,400	46,400	33,500	20,600	3,750	3
145,900	82,100	52,500	37,900	23,300	4,000	4
295,900	166,500	106,500	77,000	47,400	5,750	4
Greater	Greater	115,800	83,700	51,500	6,000	4

[1] Types of construction are based upon the Building Code.

Future Water Requirements

The future water requirements for Logan's present City boundary were prepared as part of the Water Rights Master Plan. The future maximum day water demand for the year 2020 assumes a 35 percent reduction in irrigation demand. This will result in lower maximum day and peak hour multiplication factors because irrigation demand is primarily responsible for the seasonal variation in water demand. For the purposes of this study it has been assumed that the maximum day to average day demand ratio will over time reduce to 2.0 and the peak hour to average day ratio will reduce to 3.25. Additional water will be required to serve the demand in the expanded study area. The demand in the expanded service area considered in this study was developed assuming similar commercial/industrial density and water use throughout the City. Table 2.4 presents a summary of the projected water demand.

Table 2.4
Anticipated Future Water Demand For Logan

Year	Estimated Water Customers	Anticipated Demand Maximum Day (Mgd)
2000	**14,150**	**33.40**
2010	**16,762**	**36.18**
2020	**19,073**	**38.96**

Source: Logan City Water Rights Master Plan

Summary

The objective of this Water System Master Plan is to develop a plan of transmission and distribution system improvements that will enable Logan City to meet its anticipated needs through the year 2020. For planning purposes, the year 2020 criteria follow:

- Minimum system pressure at peak hour demand will be 60 psi.
- Minimum residual pressure under fire demand conditions will be 20 psi.
- Fire demands will range between 1,500 gpm and 3,500 gpm under maximum day demand conditions.

CHAPTER 3

Storage

CHAPTER 3

Storage

Introduction

Storage is one of the most critical elements in any water supply system. This section examines the storage available in Logan City and evaluates its ability to meet the needs of the water distribution system. The present and future storage volume needs have been developed as part of the Water Rights Master Plan prepared by EWP. This report will not evaluate the quantity of storage , but will look at the most cost effective means of meeting the storage needs.

Existing Storage

Logan City presently has nine water storage reservoirs with a combined storage volume of 6.75 million gallons. The location of the storage reservoirs is shown in Figure 3.1, at the end of this chapter. The existing storage reservoirs are located to provide service to three general areas.

University Bench Area.

The highest portion of the Logan City Water Distribution System is the area around Utah State University (USU). At the present time the storage for this area is provided by a 1.0 million gallon reservoir owned by USU. There is not much developable area left on this bench and the existing storage volume is probably adequate. The expansion plans of USU may be cause for concern. As the university grows, its storage needs will increase also, leaving less volume available for Logan City customers. The reservoir is university owned and the City and USU are moving toward independent water systems. In the future it will likely be best to have storage provided from a reservoir that is owned by Logan City.

Southeast Bench Area.

The southeast bench is directly south and west of the university bench area. This area is served by a single 1.0 million gallon reservoir. There are plans to add a second 1.0 million gallon reservoir in this area. There is still developable land in this area and the demand is expected to increase in the future.

City Service Area.

The remaining city area is served by the seven reservoirs located on the east bench. Water is delivered from these reservoirs through a 24-inch-diameter transmission pipeline. One of the 0.5 million gallon reservoirs is only 9 feet deep and has the same overflow elevation as the other reservoirs. The remaining reservoirs are 16 feet deep. The differences in bottom elevations present some operational problems. If the entire volume of the deeper reservoirs is used, it means the shallow tank is emptied. This causes the silt that settles at the bottom of the reservoir to be flushed into the system. It also provides a means for other foreign matter to enter the water supply. If the reservoirs are operated in a manner that does not allow the shallow reservoir to empty the additional volume in the deeper one is of no use. This amounts to a 44 percent reduction in useable storage. The two 0.5 mg reservoirs are the oldest of the reservoirs and are in poor condition. Present plans call for their replacement in the near future.

The Water Rights Master Plan, prepared by EWP recommends 16.5 million gallons of storage to meet present storage needs. In order to bring the system into compliance with this recommendation an additional 9.75 million gallons of storage is needed.

Future Storage

Water Rights Master Plan recommends 20.0 million gallons of storage to meet Logan's 2020 needs. This storage need can be met in one of two ways. The reports suggests additional reservoir volume or utilizing wells to meet the peak day and hour demand. These options are discussed in this section.

Future Storage Alternatives

The additional storage that is needed can be provided in several different ways. Each of these is discussed below.

Continue to Build Storage on the University Bench.

Under this storage alternative additional storage will be constructed on the university bench in the same area as the existing reservoirs. This will require transmission lines to be constructed throughout the City in order to carry water from the storage location to the areas with the demand.

Advantages

- Logan's largest water source is DeWitt Springs. The water flows by gravity from the springs to the storage where it can be distributed.
- There will be no pumping associated with storage a this location. The entire service area (except for the two bench areas discussed above) could be served from one location.
- The City owns the land.

Disadvantages

- The storage will be located on the east edge of the City and the growth is occurring to the west.
- The system will be vulnerable to a loss of storage if the transmission line was out of service.

Construct Elevated Storage Throughout the Distribution System.

This alternative consists of constructing elevated storage at critical points throughout the distribution system. Optimum reservoir size will be approximately 1.0 million gallons. This alternative should be used in conjunction with one of the others in order to reduce the number of reservoirs constructed.

Advantages

- Storage will be placed throughout the system and reduce the need for larger transmission pipelines.
- The system will be less vulnerable because of the dispersed storage.
- The pressure across the system will be maintained at a more constant level because the elevated storage will be dispersed.

Disadvantages

- Elevated storage is expensive. Ground level storage gets less expensive per gallon as the volume increases. Elevated storage costs stay the same or increase as the volume increases due to the cost of the supporting structure.
- There is a higher maintenance cost associated with this alternative because the reservoirs will be steel and will require regular coating maintenance in order to maximize their useful life.
- The storage will require purchasing additional land.
- The reservoirs will not be very aesthetic.

Ground Level Storage Above 600 East.

For ground level storage, an alternate location to the university bench would be somewhere east of 600 East. The elevation will be consistent with the pressure regulator settings for the main distribution system which will allow storage here to be used in conjunction with the storage higher up. However, since storage at this elevation will be above the pressure regulators, a separate transmission line will be required.

Advantages

- Ground level storage is much less expensive than elevated storage.
- The system will not be as vulnerable because separate transmission lines will be required.

Disadvantages

- There is not an obvious location to place the storage. Land is scarce and expensive.
- There will still be some vulnerability associated with this alternative since much of the supply to this storage will come through the upper transmission line.

- If some of the supply were to come from wells, they would require separate transmission lines to carry the water across the pressure zone boundary to the new reservoir.

Ground Level Storage Below 600 East.

A fourth storage alternative is to construct ground level storage below 600 East. Booster pumping stations will be required in order to maintain system pressure. The reservoirs will be filled during periods of low demand from the system. During periods of high demand water will be pumped into the system. Since the demand will likely vary over a wider range than a single pump can supply, it will be necessary to have multiple booster pumps (most likely 2) at each ground level storage location.

Advantages

- Storage will be distributed throughout the system and reduce vulnerability to disruption.
- By distributing storage around the system, the need for transmission lines will be reduced.
- Ground level storage is less costly than elevated storage.
- Multiple booster pumps will allow operation over a wide range of demands.

Disadvantages

- There will be no need for this storage in the winter. With the other storage alternatives the reservoirs can be kept on line when demand is low and there will be some turnover in the water, keeping the reservoirs clean. A ground level reservoir with booster station will likely be taken off-line in the winter. In order to bring it back on-line when the demand increases, the reservoir will have to be cleaned and disinfected.
- Increased operation and maintenance costs associated with the booster pumps.

Groundwater Storage.

A fifth storage alternative is to use groundwater as stored water. Wells would be constructed and the water withdrawn when it is needed. The Water Rights Master Plan suggests this as one alternative for meeting the storage needs. In order for wells to fill both the storage and supply functions, standby power will be needed to assure the water will be available in the event of an emergency.

Advantages

- The wells will be distributed throughout the system, reducing the need for transmission lines.
- Wells are less costly to construct, and require less land than reservoirs.

Disadvantages

- Water rights will have to be obtained and they must allow withdrawal at the rate needed to meet peak hour or fire demand.
- Standby power will be required in order to meet fire flow requirements.

Cost

Recently, Logan City has constructed storage in 1 million gallon increments. This is a small increment. Future storage should be constructed in increments of 3 to 5 million gallons. There are two reasons for this recommendation. First, as the size of the reservoir increases the cost increases, at a lower rate, making the storage cheaper on a cost per gallon basis. Second, Logan's storage requirements are going to be substantial and fewer reservoirs will be required if larger ones are constructed. A 5 million gallon reservoir does not take any more time to maintain than a 1 million gallon reservoir. The fewer reservoirs there are to maintain, the easier it will be to keep them in good condition. For the purposes of developing costs for this report, a 3 million gallon reservoir has been used. The estimated costs associated with each of the alternatives presented are shown in Table 3.1

Recommendations

The recommended storage plan for Logan City is a combination of additional storage on the university bench and wells in the distribution system. Logan plans to develop additional groundwater supplies. By adding standby power, the wells will be considered a reserve supply for fire and emergency purposes. This will substantially reduce the amount of storage required. The amount of reservoir storage that will be displaced by a well is determined by adding the total system supply (in gpm) and subtracting the maximum day demand (in gpm). The difference (if it has the protection of standby power) is the amount of water that can be considered as coming from storage. The volume available for fire protection will be determined by multiplying the difference (up to 3,500 gpm) by 4 hours. In addition to the wells, the following storage is recommended over the next 5 years

- Replace the two 0.5 million gallon reservoirs with a 3 million gallon reservoir at the same location. The new reservoir should have the same overflow and bottom elevation as the other reservoirs at the site.
- Construct a 1.0 million gallon reservoir to replace the USU reservoir that is providing storage for the university bench customers. A 1.0 million gallon reservoir is smaller than the recommended size, but this will serve a small area and more storage is not needed.
- Construct a 1.0 million gallon reservoir on the southeast bench. Another 1.0 million gallons is needed to meet the projected needs of this area.

The estimated costs of each of the recommended storage alternatives is presented in Table 3.2.

CHAPTER 4

Distribution System

CHAPTER 4

Distribution System

Introduction

Demand simulations have been run for both existing and future flows on the present water distribution system and on the system with proposed improvements for comparison. Throughout the modeling study, the following have been used as guidelines in the evaluation of the distribution system network performance. These standards come from the State of Utah Public Drinking Water Standard and recommendations of the AWWA.

- A minimum residual pressure of 25 psi must be maintained throughout the system given the sum total demand of indoor use, irrigation requirements, and fire flows. This figure includes a factor of safety that accounts for inaccuracies in the model.
- All fire hydrant service lines must meet or exceed a 6-inch-diameter minimum pipe size (these are state standards and AWWA recommendations). Proposed state standards will increase this to an 8-inch-diameter pipe for all new and upgraded pipe.
- A minimum pressure of 40 psi must be maintained under peak hour demand without fire. This is the minimum standard required by the State of Utah Division of Drinking Water. For this study, a minimum residual pressure of 60 psi under peak hour demand was used as the minimum service standard.

Existing System Evaluation

CH2M HILL has simulated the existing Logan water distribution system under a number of demand conditions to establish a baseline for comparison with future improved runs. Present operational characteristics were maintained throughout the simulations. Figure 4.1 (all figures located at the end of this chapter) illustrates the present water distribution system as it was modeled. The Logan system is composed of three pressure zones with the primary dividing boundary running north and south along 300 East. Six pressure reducing valves regulate the flow entering the western pressure zone. The third pressure zone is a separate, closed system east of 800 East and north of 700 North.

The results of the modeling runs have been illustrated in Figures 4.3 through 4.8. Pressure contours have been plotted to illustrate the anticipated pressures throughout the system. Where the contours show pressures less than 60 psi, the system does not meet the criteria established for this study. As can be seen in Figures 4.3 through 4.8, the current system possesses regions of inadequate performance when subjected to future maximum flow conditions. Lower pressures found in the two pressure zones on the west and southeast sides of Logan may be a result of poor transmission capacity to the west side of Logan. Figure 4.1 confirms that the current system is not well crossed with main lines, (lines with diameters greater than six inches), and offers little looping or redundancy in certain areas. Under such conditions, fire flows or temporary changes for system maintenance may cause severe pressure drops throughout the network. Increasing the capacity of the transmission lines from east to west in Logan could reduce these fluctuations in pressure. The northeast pressure zone, however, is able to maintain the minimum pressure necessary due to the difference in head between the storage tanks and demand points.

Another area of concern includes the presence of 2-, 3- and 4-inch-diameter pipes in the system. The areas where these pipes are concentrated can be seen in Figure 4.1. As can be seen in Figures 4.6 through 4.8, the current 3- and 4-inch-diameter pipes in downtown Logan and west downtown cannot provide the necessary pressures needed for fire flow and increasing demands for water in the future.

As water moves through a pipeline it loses pressure due to friction losses between the water and the pipe wall. The amount of pressure lost is a function of pipe wall roughness and the velocity of the water. In order to carry a 1,500 gpm fire flow, the velocities in 4-inch-diameter pipe and smaller are very high, resulting in high pressure loss. This loss in pressure is illustrated in Figure 4.2, which shows the relative pressure loss in pipe ranging from 4 inches in diameter up through 16 inches in diameter. The pressure loss is shown over a block of pipe. The most dramatic difference is seen between the 4- and 6-inch-diameter pipe. A 4-inch-diameter pipe carrying 1,500 gpm will lose approximately eight times the pressure that a 6-inch pipe will over the same distance. A 4-inch-diameter pipe under such flow conditions will lose 143 psi in a block. Since most areas in the system do not have 143 psi to begin with, it is impossible to deliver 1,500 gpm through a block of 4-inch-diameter pipe and maintain a pressure at the hydrant of 25 psi.

Long dead end lines existing in the system also present long term problems. There are several dead end 6-, 8-, and 10-inch-diameter pipes that are over 1,000 feet long. The pipe locations are illustrated in Figure 4.1 and their characteristics can be seen in Table 4.1. Over a distance of 1,000 feet, a 6-inch-diameter pipe carrying 1,500 gpm will lose close to 60 psi. Since many of these lines do not have much more than 60 psi to begin with, adequate pressure for fire flows is very difficult to maintain.

As part of this study, fires were simulated at a number of locations throughout the City. In general when the fire was simulated on a looped line, adequate pressures could be maintained. When a fire was simulated at the end of a dead end line, pressures were not acceptable. The locations of the simulated fires are shown on Figure 4.1 and the results are summarized in Table 4.2. As can be seen in Table 4.2, with fire flow to the dead end line on 1000 West, south of 1000 South, the minimum pressure cannot be maintained. With added redundancy through looping and increased transmission line capacity the pressure can be maintained. It is our understanding that Logan has a program under way in which loops are being added to eliminate some of these dead end lines. As these improvements are completed, the pressure in these areas will improve considerably.

Table 4.1
Existing Dead End Pipeline Characteristics

Length (ft)	Diameter (in)	Location
7,200	8,10	On 1000 West, south of 1000 South
1,385	6	On 400 North, between 1000 West and 800 West
1,360	8	On 800 West, north of 1400 North
2,640	10	On Main Street, between 1400 and 1800 North
2,270	8	Quail Way, southeast side of Logan
8,600	8, 10	On 600 West, from 1400 North to 2500 North and up Airport Road
1,350	6	On 800 North, east of 1000 West
1,040	6	On 1600 North, northeast side of Logan

Table 4.2
Existing System Performance with Simulated Fires

Node Number (See Figure 4.1)	Fire Demand (gpm)	Existing System Pressure (psi) (Shaded cells below 25 psi)
24	1500	84.43
30	2500	61.54
32	2500	44.18
58	1500	< 0
72	1500	24.15
79	3000	18.8
89	1500	75.36
111	3000	57.58
127	3000	< 0
134	3000	11.78
145	2500	< 0
148	2500	5.9
149	2500	54.23
150	3000	< 0
151	2500	< 0
158	3000	52.44
159	2500	11.88
170	3000	55.92
171	2500	< 0
181	1500	< 0
186	1500	5.89
197	2500	16.73
206	1500	36.26
213	1500	23.36
215	1500	< 0
232	1500	66.23
243	1500	< 0
247	1500	40.26
258	1500	< 0
261	1500	< 0
310	3000	56.75
315	2500	< 0
397	1500	< 0
440	1500	< 0
475	1500	11.14
801	2500	22.19
802	3000	16.73
842	1500	58.8
883	1500	< 0

where necessary. The result is a much more stable distribution network which will be capable of providing the Logan community with water at an acceptable pressure under the most demanding future flow conditions. Pressure contours of the proposed system under future conditions are shown in Figures 4.10 through 4.12 and the results of the fire flow simulations are presented in Table 4.3.

Although the improved system performs very well for fire flow conditions, locations at the intersection of 400 North and 800 West and the intersection of Center Avenue and 400 South do not maintain the minimum pressure required for fire flow. Both nodes are located on dead end pipes (6-inch-diameter) each 310 and 360 feet long, respectively.

A number of buildings on the west side of the Logan system were originally built with fire suppression systems designed using the residual pressure existing at the time of construction. With increasing demands to the system as a whole, these water pressures cannot be maintained in demanding fire flow conditions. As a result, when such flow conditions exist the pressure reducing valves (PRV) located on the east side of the system must be bypassed. This can be accomplished with the addition of bypass loops at each PRV. Valves on these bypass loops may be opened or closed depending upon demand.

Comparison between the existing and improved contour plots (Figures 4.3 to 4.8 and 4.10 to 4.12) for the Logan network reveals the obvious advantages provided by these proposed improvements. Notice that the improved system is capable of delivering water above minimum pressure to nearly all of the Logan network. The existing system however, fails to meet minimum pressure requirements at many of the nodes in the network under such flow conditions. The few pressure deficiencies visible in the improved system near College Reservoir were caused by a low head due to the proximity of the nodes to the water source.

Table 4.3
Proposed System Performance with Simulated Fires

Node Number	Fire Demand (gpm)	Future System Pressure (psi)
24	1500	78.92
30	2500	54.11
32	2500	41.41
48	2500	55.15
58	1500	32.60
72	1500	52.02
79	3000	28.57
89	1500	36.05
111	3000	58.52
127	3000	44.10
134	3000	26.95
145	2500	41.89
148	2500	20.65
149	2500	51.65
150	3000	62.18
151	2500	60.91

Proposed Improvements

A number of improvements are recommended to upgrade the existing system to the future demand capacity. CH2M HILL recommends that the City implement the following system upgrades:

- Upgrade or add pipelines to sizes shown in Figure 4.9.
- Wherever possible, require all lines longer than 1,000 feet in length to be looped.
- Require all future dead end pipelines over 1,000 feet in length to be a minimum of 12 inches in diameter.
- Require all future dead end pipelines under 1,000 feet in length to be a minimum of 8 inches in diameter.

CH2M HILL has evaluated the future development and street master plan and recommended additional transmission pipeline in areas where future development will result in increased demand. By connecting the present system to the proposed system extending to the limits of the proposed annexation area to the north, south and west of the city, a more reliable network is created, providing a safety factor to the Logan system. Transmission lines 18 inches in diameter extending into the proposed annexation area should provide sufficient capacity in the future. Built-in looping and redundancy in the distribution system allows the flow of water to reach a given point from a number of directions, thereby allowing for system maintenance and more efficient operation under the extreme case of a fire within the community.

Although a significant number of the improvements will be in the future growth area, many improvements will also be made to the existing system to provide the pressures needed for future flow demands. To eliminate pressure deficiencies in areas with small diameter pipe, all 4-inch pipelines in these areas will be replaced with 8-inch lines. Several transmission lines will also be upgraded to provide additional flow capacity to the west side of Logan. Additional looping and redundancy has been proposed to increase fire flow pressures and either eliminate the dead end lines (in excess of 1,000 feet) altogether or decrease their length considerably. To provide the pressure necessary on 1000 West, south of 1000 South, the pipe will be looped in with the line along U.S. Highway 89/91 and with the system in the proposed annexation area. Similar proposals, as shown in Figure 4.9, have been made to the other major dead end lines discussed previously.

The improved model was next subjected to varying degrees of flow to test the overall efficiency of the distribution system. Included in these tests were the same fire simulations which were developed to simulate the impact of fire flows at points throughout the existing network. Table 4.3 summarizes the pressures seen at each of the fire flow nodes after the improvements were made. Figure 4.9 shows the locations of the nodes where fires were simulated.

As can be seen in Table 4.2, when the existing system is subjected to the future flow conditions, many points within the system fail to provide adequate pressure for fighting fires. The proposed improvements to the Logan network will correct these points of low pressure with looping and redundancy in the system, and by enlarging pipe diameter

Table 4.3
Proposed System Performance with Simulated Fires

Node Number	Fire Demand (gpm)	Future System Pressure (psi)
158	3000	54.32
159	2500	45.01
170	3000	60.28
171	2500	57.78
181	1500	31.08
186	1500	25.92
197	2500	37.04
206	1500	44.97
213	1500	91.28
215	1500	25.64
232	1500	64.67
234	2500	45.01
236	2500	45.41
243	1500	48.26
247	1500	51.61
258	1500	16.85
261	1500	44.19
310	3000	57.34
315	2500	<0
397	1500	55.61
440	1500	41.72
475	1500	48.74
801	2500	48.78
802	3000	53.43
842	1500	54.55
883	1500	42.05
1002	3500	81.36
1005	3500	66.16
1007	3500	77.31
1012	3500	71.26
1014	3500	95.83
1016	3500	80.75
1023	3500	60.10
1025	3500	83.51
1027	3500	82.82

Cost of Proposed Improvements

Many of the improvements shown in Figure 4.9 are required to meet increased demand. Others, primarily those lines less than 6 inches in diameter, are needed to meet present service standards. Table 4.4 summarizes the estimated cost of the proposed improvements.

Those dead end 6-inch-diameter lines that have been recommended for replacement may be retained if there are opportunities to loop them with other 8-inch-diameter, or larger, lines. The priority for installation of the recommended improvements is also shown in Table 4.4.

Table 4.4 Water Capital Improvements
Logan City, Utah Water Department, as of 2/11/97

Project Title	Logan Fax (1/21/97)	1998	1999	2000	2001	2002	2003	2004	2005	2006
Water System Improvement Projects										
100 North, 100 W. to 50 W.	14,882	14,882	0	0	0	0	0	0	0	0
100 South, 200 E. to 300 E.	28,021	0	0	0	0	0	28,021	0	0	0
100 West, 300 N. to 500 N.	51,820	51,820	0	0	0	0	0	0	0	0
100 West, 400 S. to 600 S.	14,882	14,882	0	0	0	0	0	0	0	0
100 West, Center to 100 S.	30,000	30,000	0	0	0	0	0	0	0	0
100 West, Center to 50 N.	16,632	16,632	0	0	0	0	0	0	0	0
1000 South, 1000 W. to 800 W.	55,000	0	55,000	0	0	0	0	0	0	0
1600 East, Sunset to Saddle Hill	13,050	0	0	13,050	0	0	0	0	0	0
1800 N./300 W. to 1700 N./200 W.	252,000	0	0	252,000	0	0	0	0	0	0
1800 N./200 W. to 1700 N./Main	135,529	0	0	135,529	0	0	0	0	0	0
200 East, 100 to 200 S.	29,265	29,265	0	0	0	0	0	0	0	0
200 East, 100 to 300 S.		0	0	0	0	0	0	0	0	0
200 East, 200 to 300 S.	29,265	0	29,265	0	0	0	0	0	0	0
200 East, Center to 50 N.		0	0	0	0	0	0	0	0	0
300 East, 400 to 500 N.	30,358	30,358	0	0	0	0	0	0	0	0
400 East, 500 to 600 N.	29,913	29,913	0	0	0	0	0	0	0	0
400 East, 700 to 900 N.	52,725	0	52,725	0	0	0	0	0	0	0
400 North, 500 to 600 W.	19,083	19,083	0	0	0	0	0	0	0	0
500 East, 400 to 600 N.	59,642	0	0	59,642	0	0	0	0	0	0
500 East, 800 to 1000 N.	53,042	0	53,042	0	0	0	0	0	0	0
500 East, 800 to 600 N.	57,250	57,250	0	0	0	0	0	0	0	0
500 South, Center to SW	66,139	0	66,139	0	0	0	0	0	0	0
500 South, Park Ave. to 500 W.	59,642	0	0	59,642	0	0	0	0	0	0
500 West, 200 to 300 S.	27,108	27,108	0	0	0	0	0	0	0	0
500 West, 300 N. to Center St.	77,563	0	77,563	0	0	0	0	0	0	0
500 West, 300 to 500 N.	51,820	51,820	0	0	0	0	0	0	0	0
500 West, 600 to 800 N.	51,820	0	0	0	0	0	0	51,820	0	0
600 South, 1440 W. to 1000 W.	16,522	0	0	16,522	0	0	0	0	0	0
700 North, 1500 E. to Canyon Rd.	73,970	0	0	73,970	0	0	0	0	0	0
700 North, 1500 to 1900 East, 24"	254,050	254,050	0	0	0	0	0	0	0	0
800 N./800 W. to 100 N./850 W.	96,635	0	0	0	0	0	96,635	0	0	0
800 West, 1600 N. to 1800 N.	60,364	0	0	0	0	0	60,364	0	0	0
Canyon Rd, Hwy 89 to Island Dr.	101,933	0	0	101,933	0	0	0	0	0	0
Center Street, 400 to 600 W.	54,233	54,233	0	0	0	0	0	0	0	0
Center Street, 50 to 100 W.	14,882	14,882	0	0	0	0	0	0	0	0
Center Street, 500 W. to Riverside	72,713	72,713	0	0	0	0	0	0	0	0
Hwy 89/91 - 1000 W. to LeGrande	117,643	117,643	0	0	0	0	0	0	0	0
LeGrand St. SR 165 to 1200	46,217	46,217	0	0	0	0	0	0	0	0
Park Avenue, 400 to 600 S.	61,233	61,233	0	0	0	0	0	0	0	0
Reservoir, University Beach 1M Gal.	600,000	0	0	0	0	0	0	600,000	0	0
Reservoir, SE Bench 1M Gal.	600,000	0	0	0	0	0	600,000	0	0	0
System Upgrades	4,500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
Subtotal Water System Improvements	**7,976,846**	**1,493,984**	**833,734**	**1,212,288**	**500,000**	**500,000**	**1,285,020**	**1,151,820**	**500,000**	**500,000**

Table 4.4 Water Capital Improvements

Logan City, Utah Water Department, as of 2/11/97

Project Title	Logan Fax (1/21/97)	1998	1999	2000	2001	2002	2003	2004	2005	2006
Water System New Construction										
1000 West, 1800 N. to 2500 N.	184,250	0	0	0	0	184,250	0	0	0	0
1000 W./1600 N. to 800 W./1800 N.	100,000	0	100,000	0	0	0	0	0	0	0
2500 North, 1000 W. to Main	266,139	0	0	0	0	0	266,139	0	0	0
400 N./1000 W. to 1440 W./2100 S.	385,678	0	0	0	0	0	0	385,678	0	0
600 North, 600 W. to 100 W.	556,685	0	0	0	0	0	556,685	0	0	0
600 N./200 E. to 700 N./500 E.	231,675	0	231,675	0	0	0	0	0	0	0
600 West, 1800 N. to 2500 N.	292,883	0	0	0	0	292,883	0	0	0	0
600 West, 600 N. to 1800 N.	569,111	0	0	0	0	569,111	0	0	0	0
700 North, Main to 50 W.		0	0	0	0	0	0	0	0	0
700 North, 100 W. to 200 W.	179,510	0	0	179,510	0	0	0	0	0	0
Hwy 89/91, 1700 S. to 1000 W./2100 S.	229,722	0	0	0	0	0	0	229,722	0	0
Park Avenue, 1100 to 1600 S.	147,106	147,106	0	0	0	0	0	0	0	0
Reservoir, 3M Gal.	1,200,000	0	0	0	1,200,000	0	0	0	0	0
Well, 1600 S./600 W.	1,040,000	0	0	0	0	1,040,000	0	0	0	0
Well, 50 N. at 350 East	1,040,000	0	0	0	0	0	0	1,040,000	0	0
Subtotal Water System New Construction	**6,422,759**	**147,106**	**331,675**	**179,510**	**1,200,000**	**2,086,244**	**822,824**	**1,655,400**	**0**	**0**
Total Water Projects	**14,399,605**	**1,641,090**	**1,165,409**	**1,391,798**	**1,700,000**	**2,586,244**	**2,107,844**	**2,807,220**	500,000	500,000
Total Water Projects Future $ (3% Inflation)										
Inflation Assumption	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**	**3.0%**	3.0%	3.0%

4,198,267

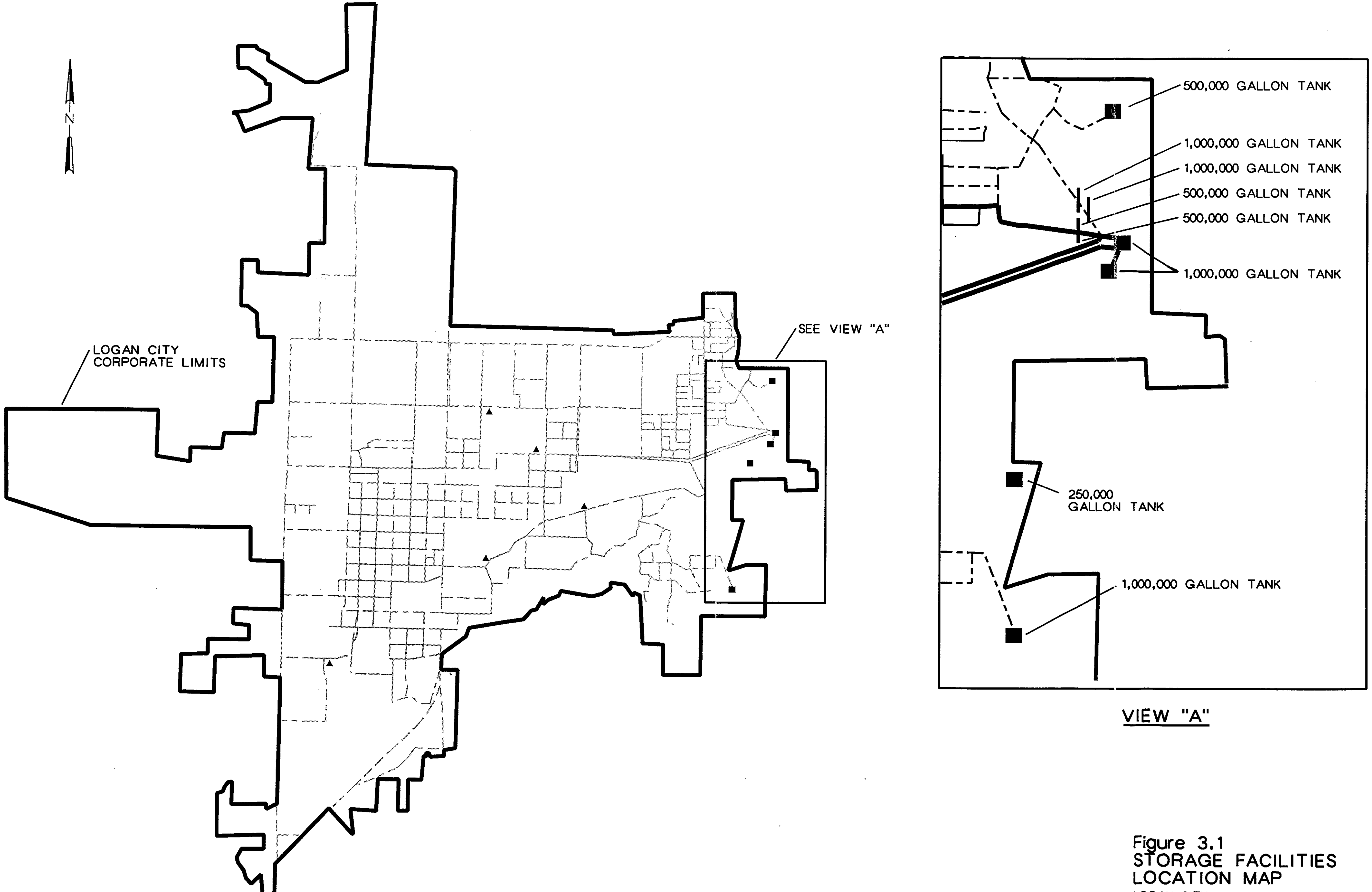

Figure 3.1
STORAGE FACILITIES
LOCATION MAP

LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/STORAGE.FG1

CH2MHILL

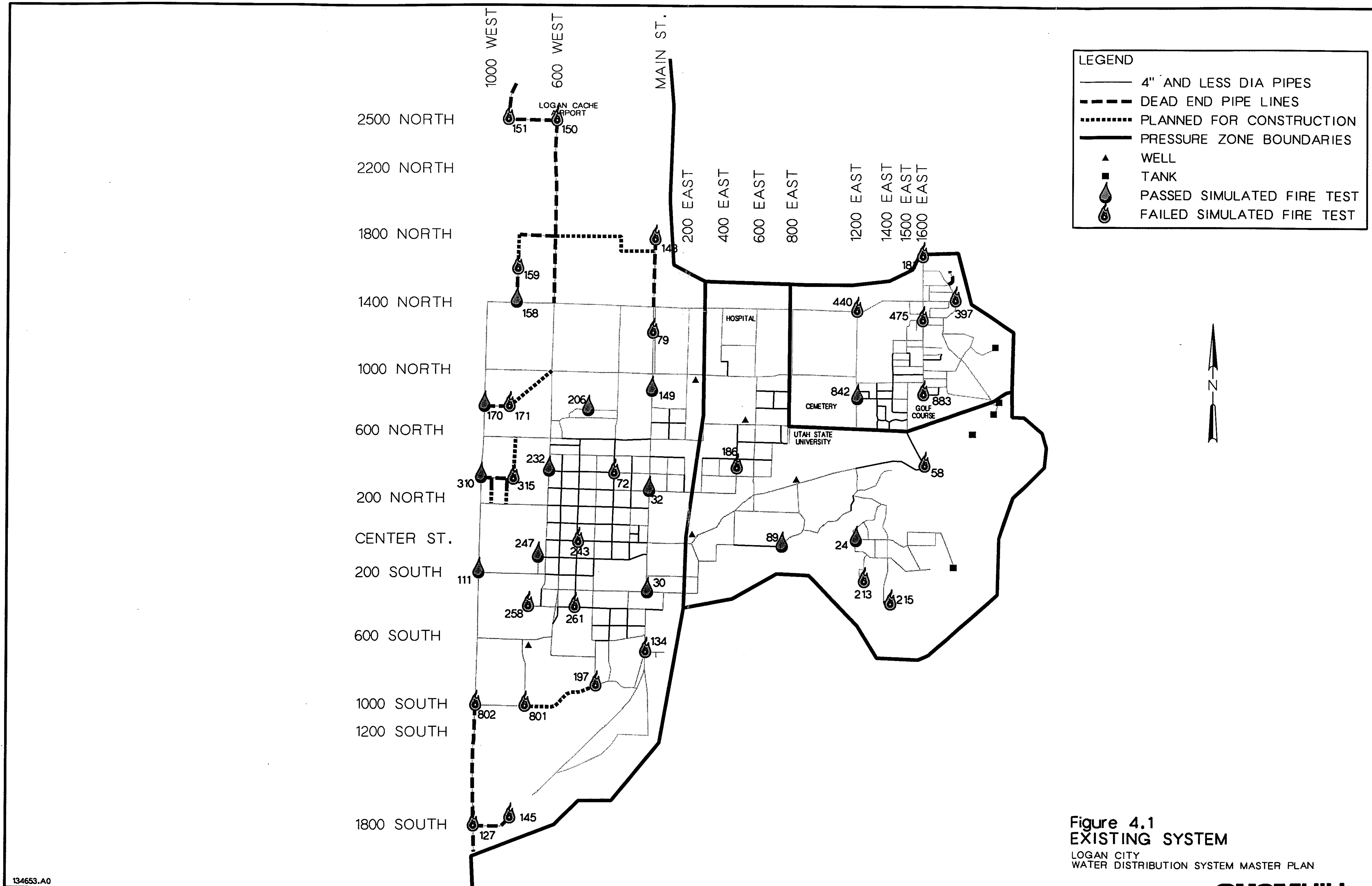

Figure 4.1
EXISTING SYSTEM
LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

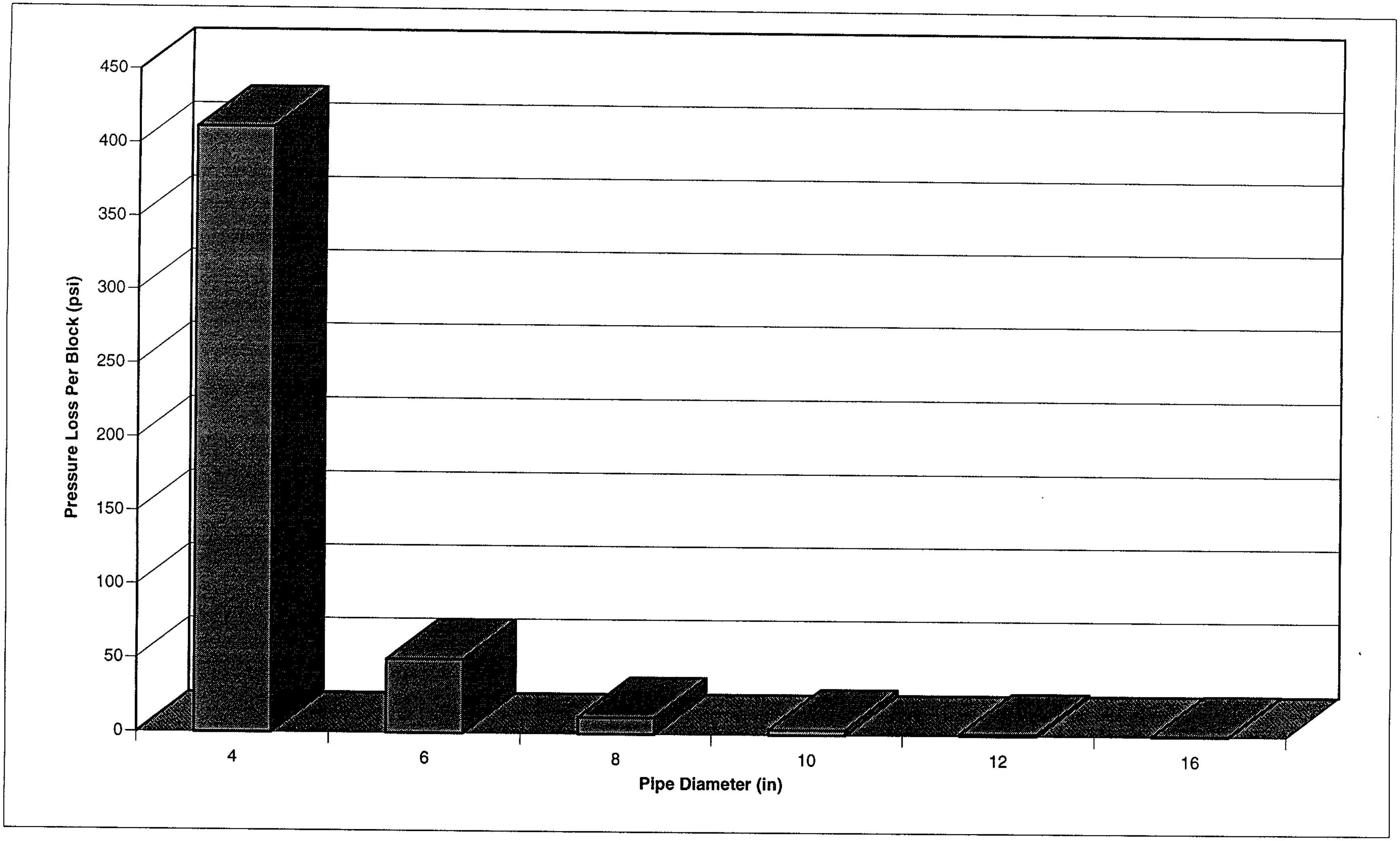

Figure 4.2
PRESSURE LOSS PER BLOCK OF PIPE AT 1500 GPM
Logan Water Distribution System

134653\drawing\firech

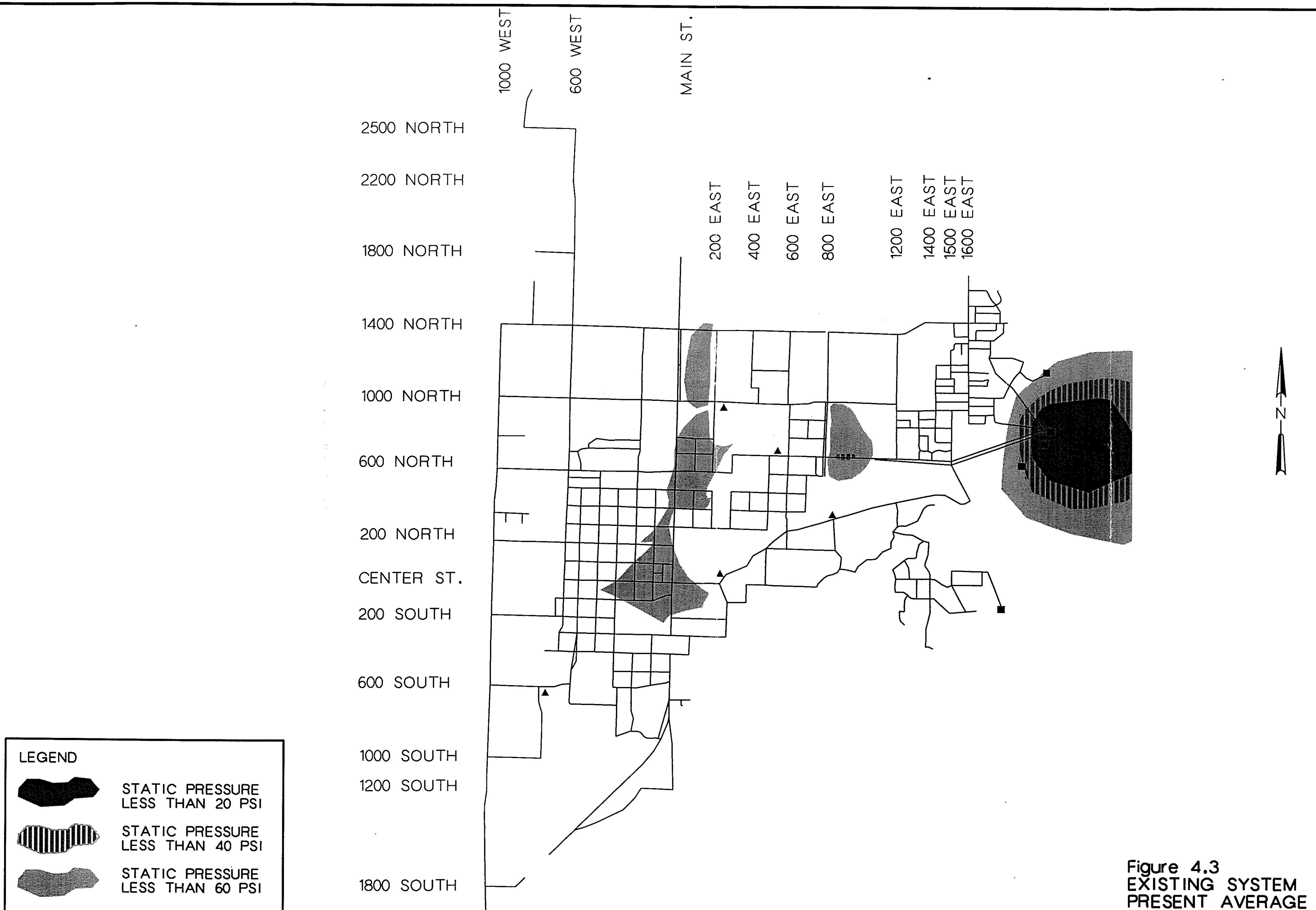

Figure 4.3
EXISTING SYSTEM
PRESENT AVERAGE DAY DEMAND
LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/E-PADD.FG1

CH2MHILL

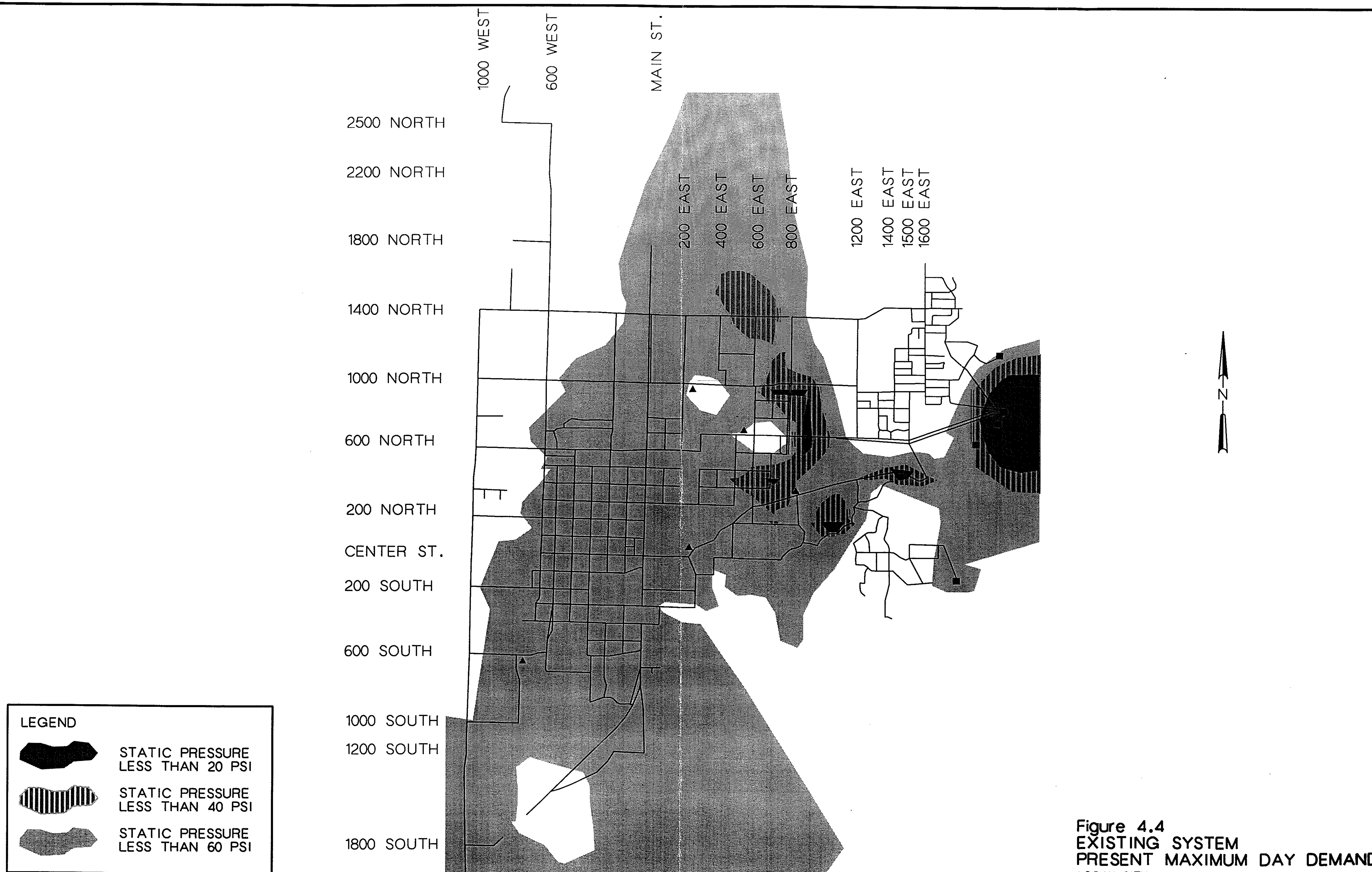

Figure 4.4
EXISTING SYSTEM
PRESENT MAXIMUM DAY DEMAND

LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/E-PMDD.FG1

CH2MHILL

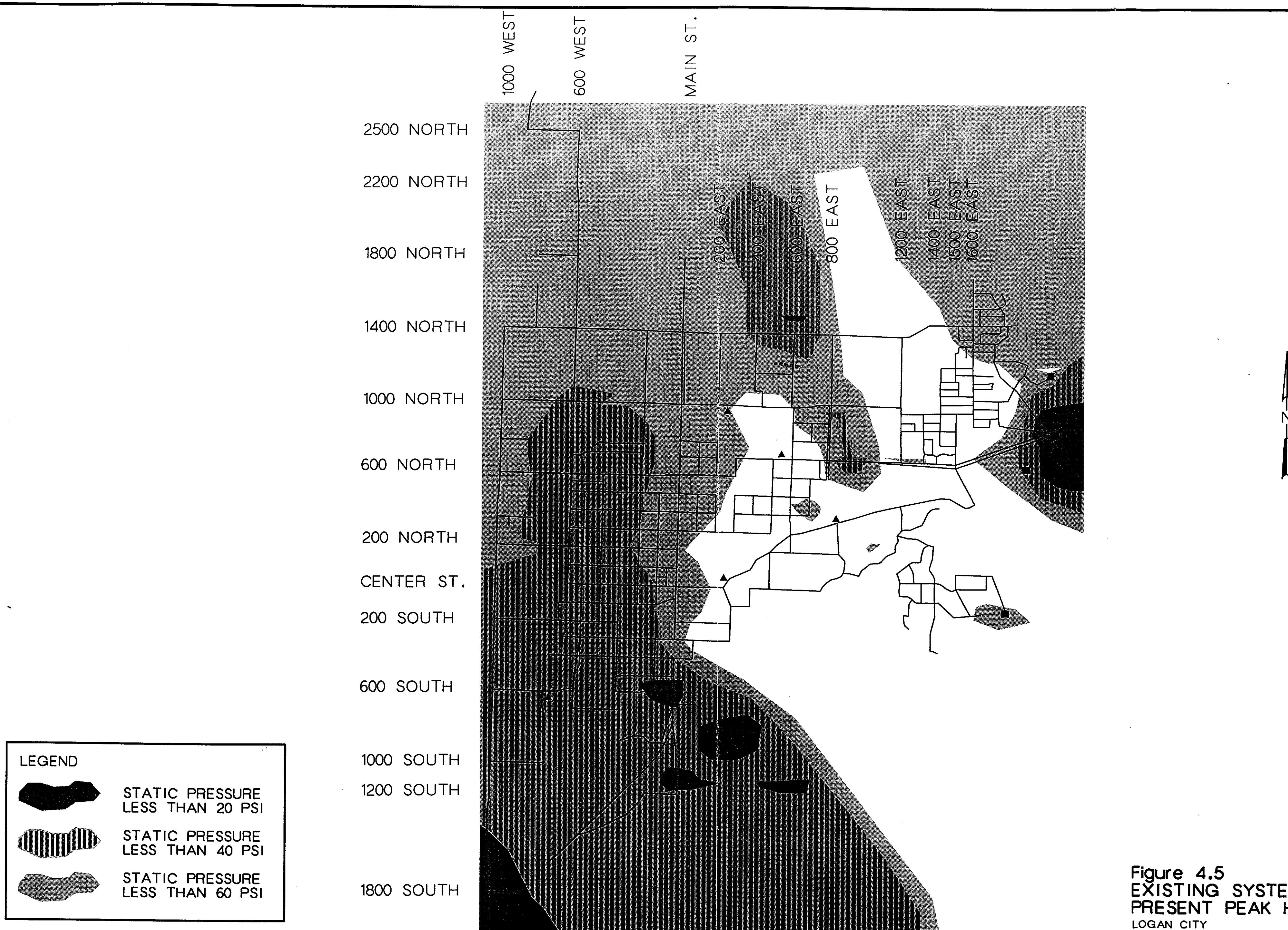

Figure 4.5
EXISTING SYSTEM
PRESENT PEAK HOUR DEMAND
LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/E-PPHD.FG1

CH2MHILL

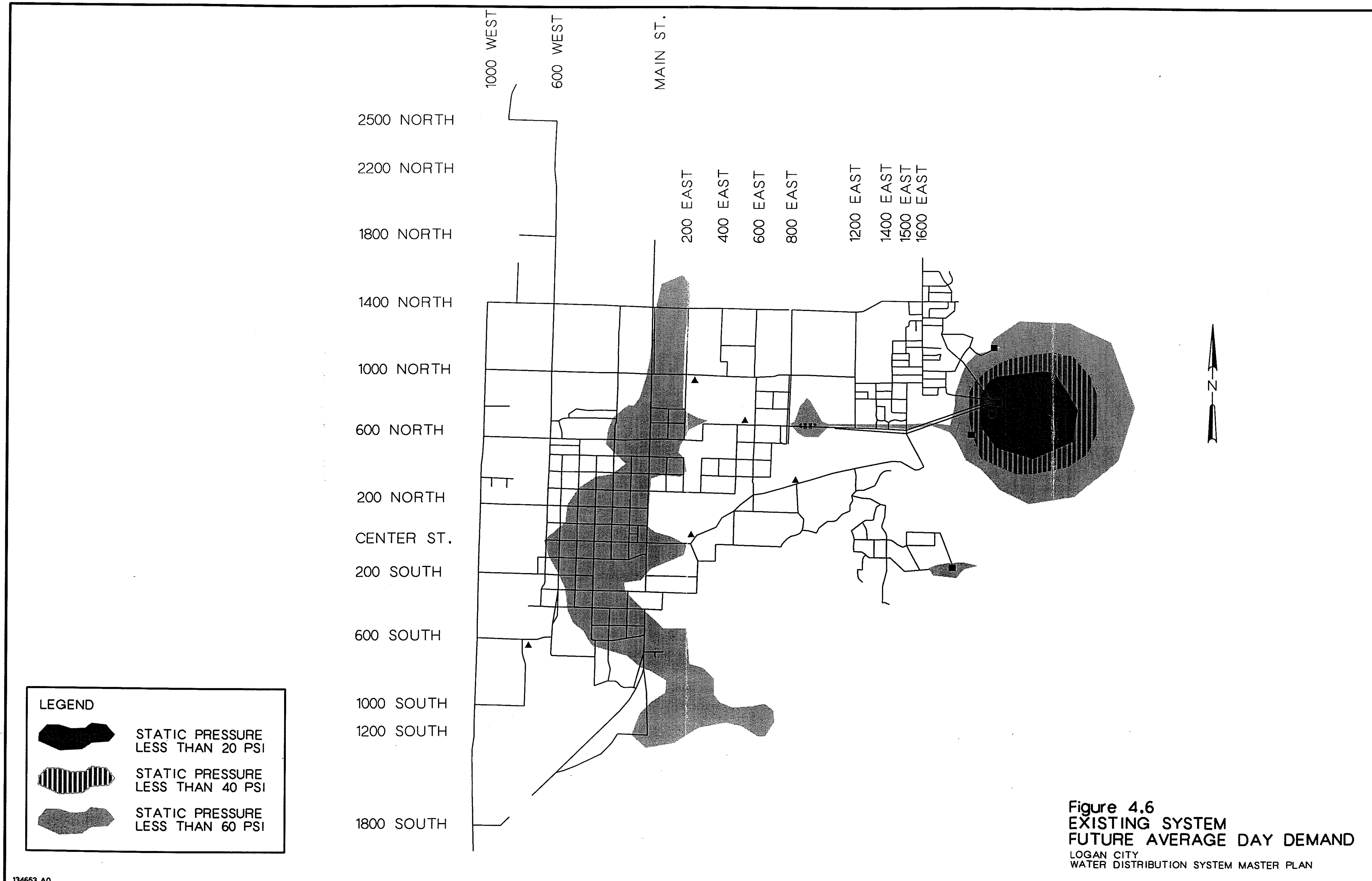

Figure 4.6
EXISTING SYSTEM
FUTURE AVERAGE DAY DEMAND

LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/E-FADD.FG1

CH2MHILL

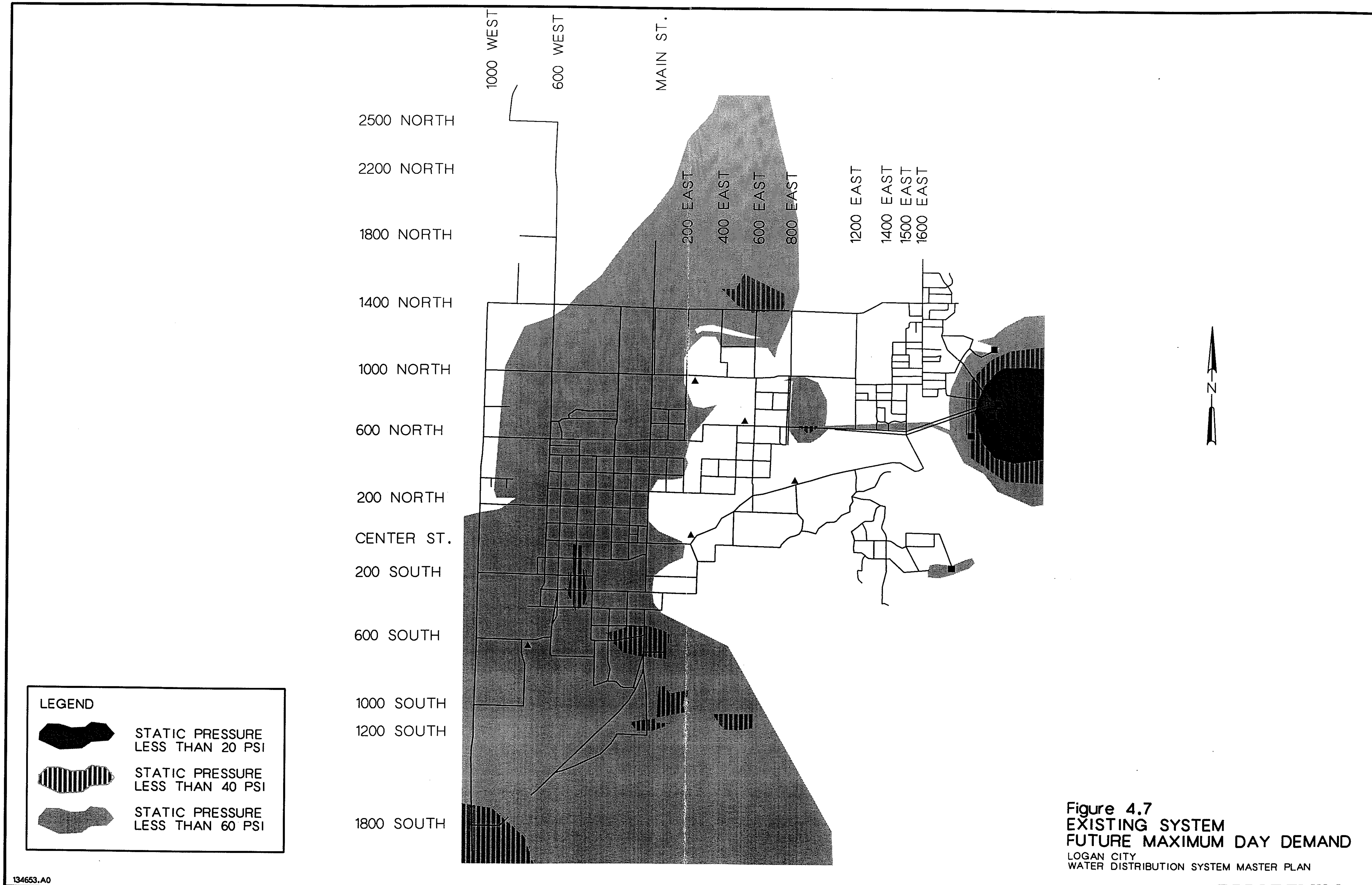

Figure 4.7
EXISTING SYSTEM
FUTURE MAXIMUM DAY DEMAND
LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/E-FMDD.FG1

CH2MHILL

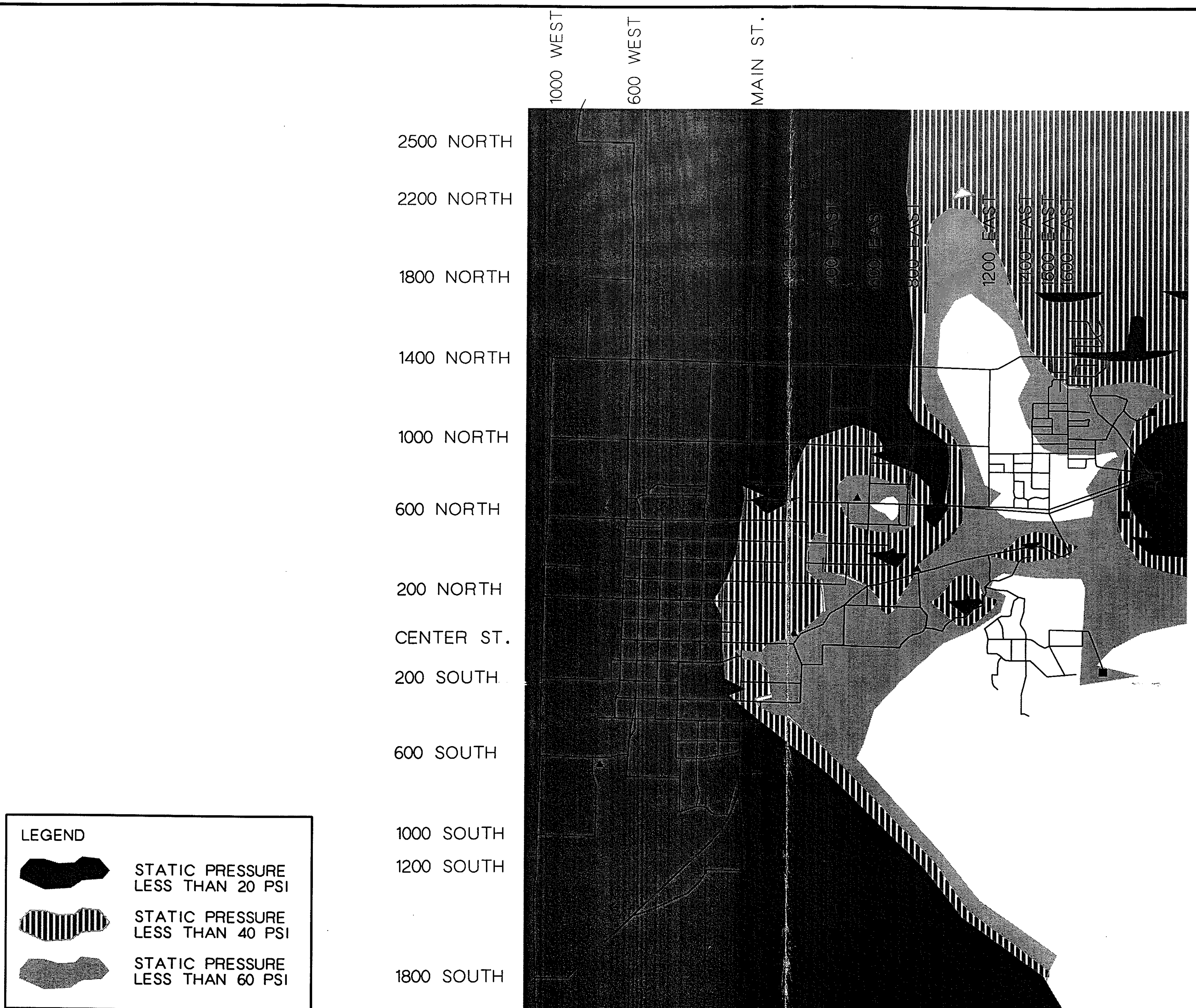

Figure 4.8
EXISTING SYSTEM
FUTURE PEAK HOUR DEMAND
LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

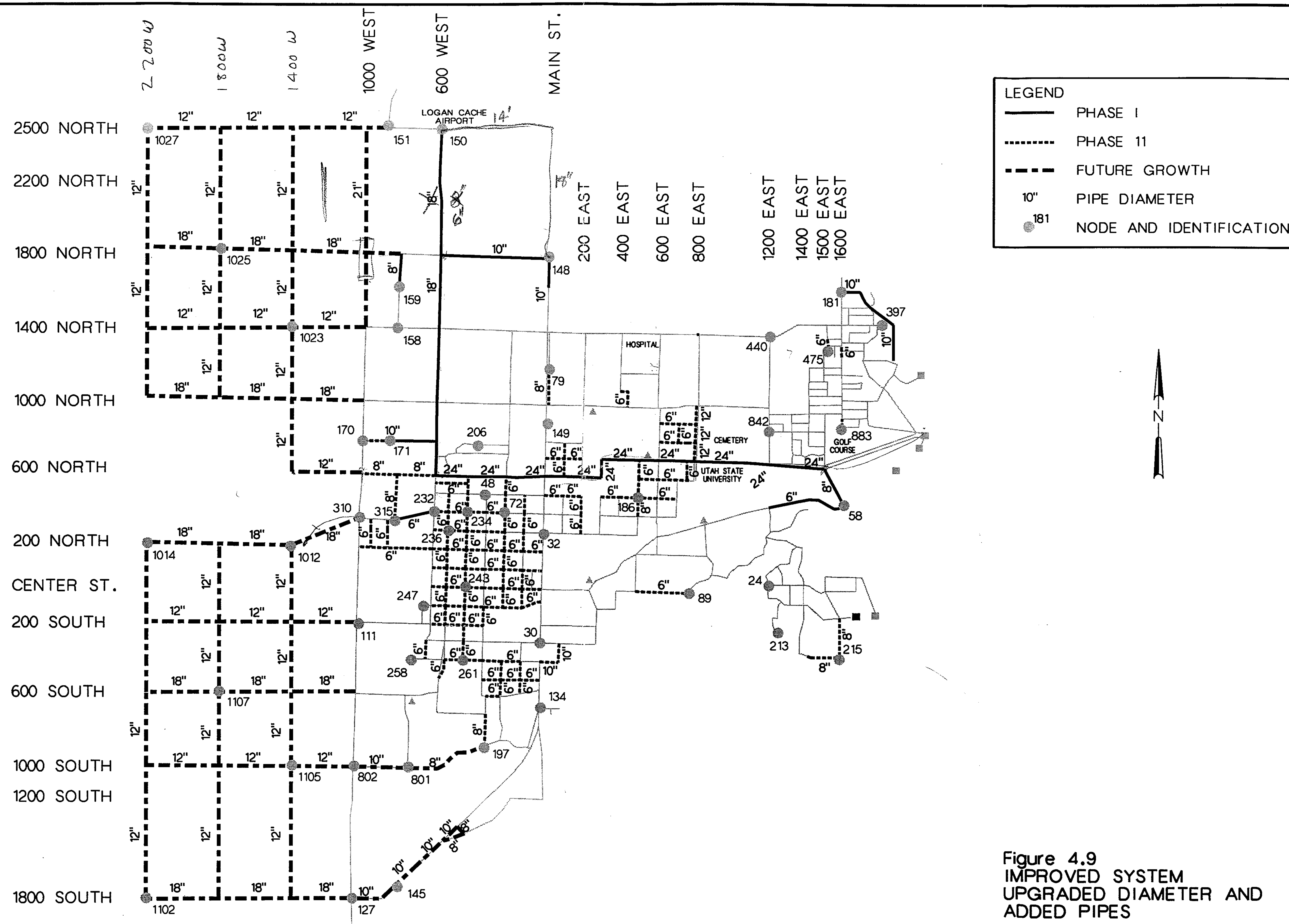

Figure 4.9
IMPROVED SYSTEM
UPGRADED DIAMETER AND
ADDED PIPES
LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/i-upgrad.FG1

CH2MHILL

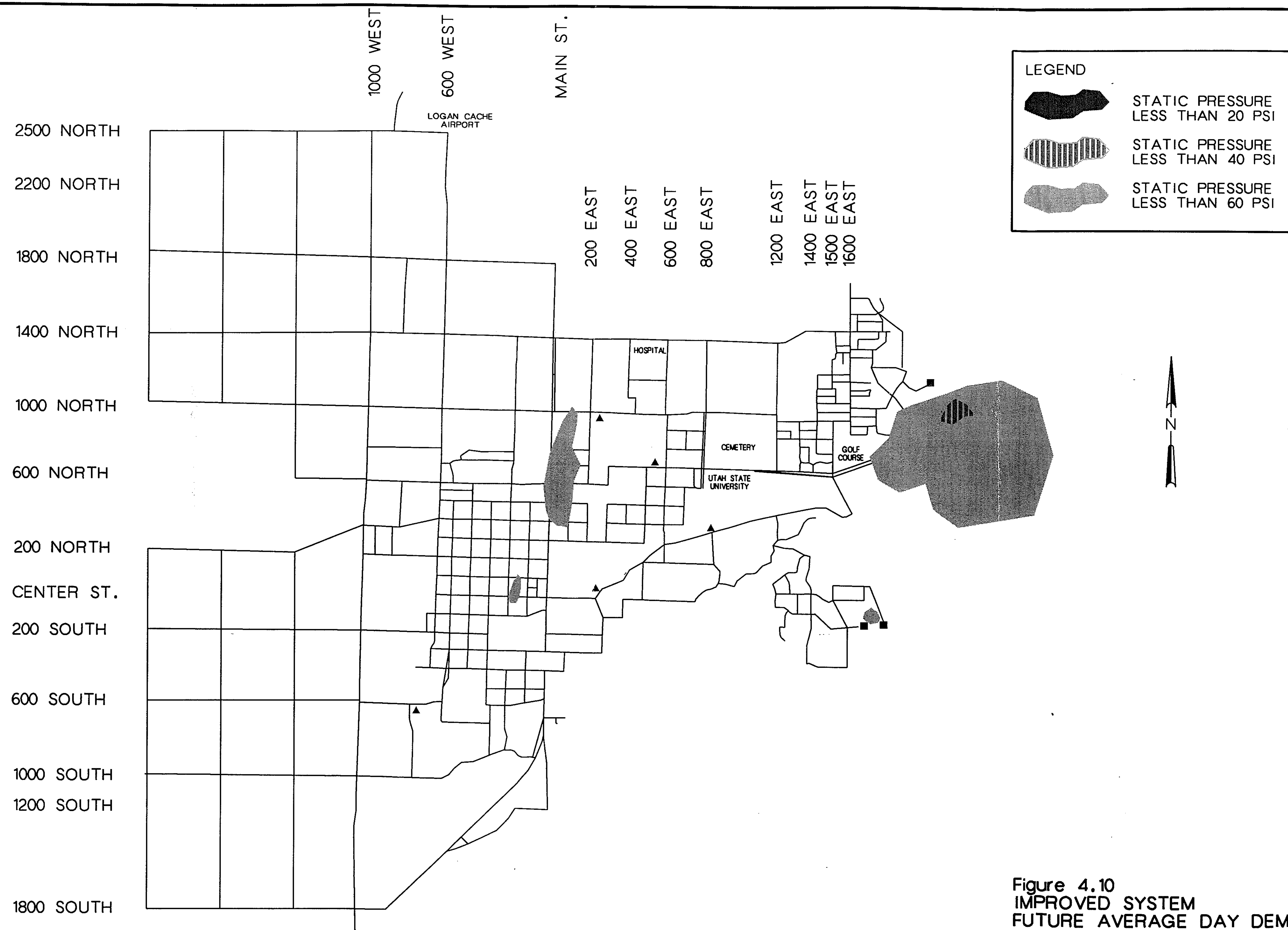

Figure 4.10
IMPROVED SYSTEM
FUTURE AVERAGE DAY DEMAND

LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/F-FADD.FG1

CH2MHILL

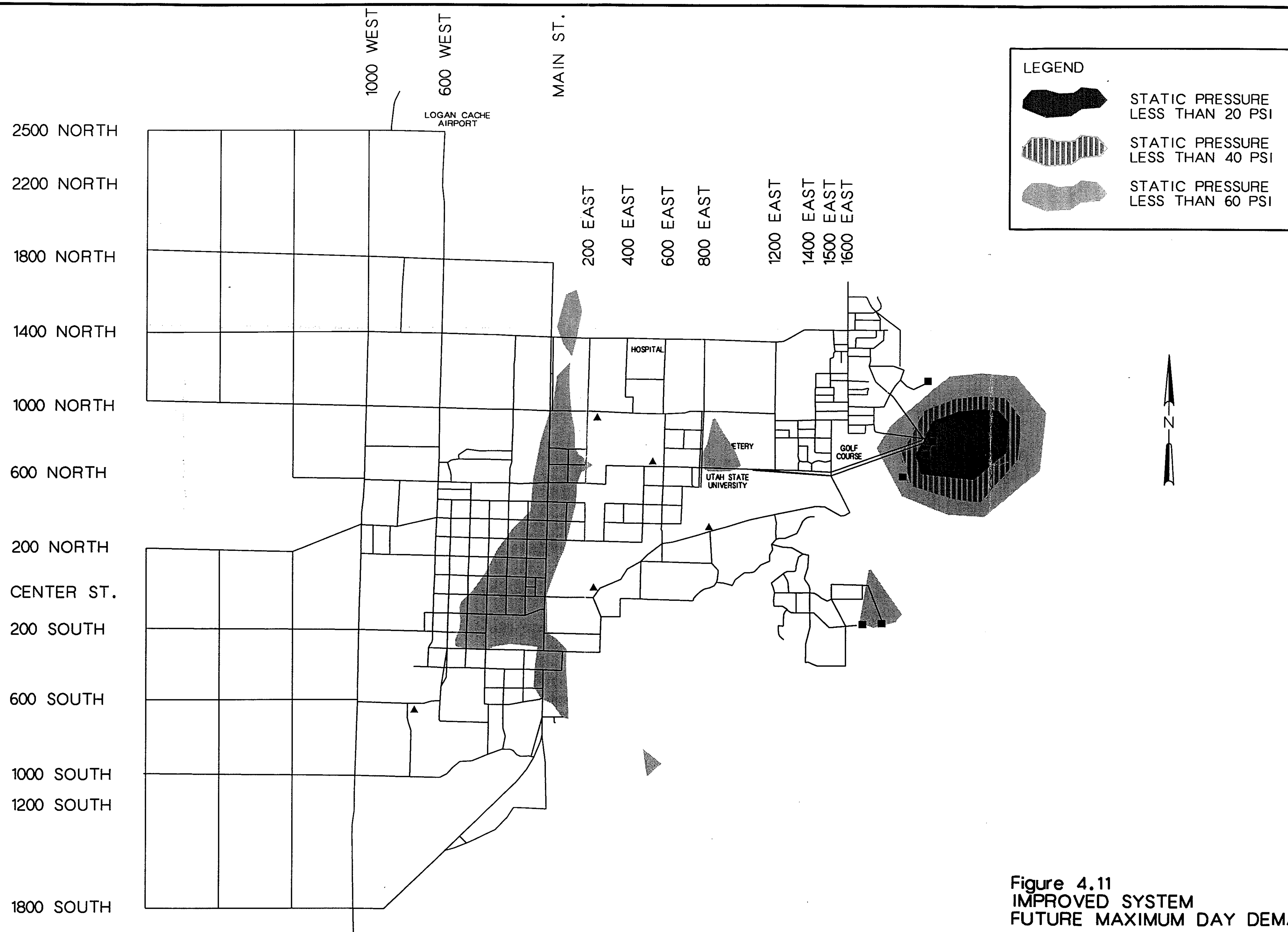

Figure 4.11
IMPROVED SYSTEM
FUTURE MAXIMUM DAY DEMAND

LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/F-FMDD.FG1

CH2MHILL

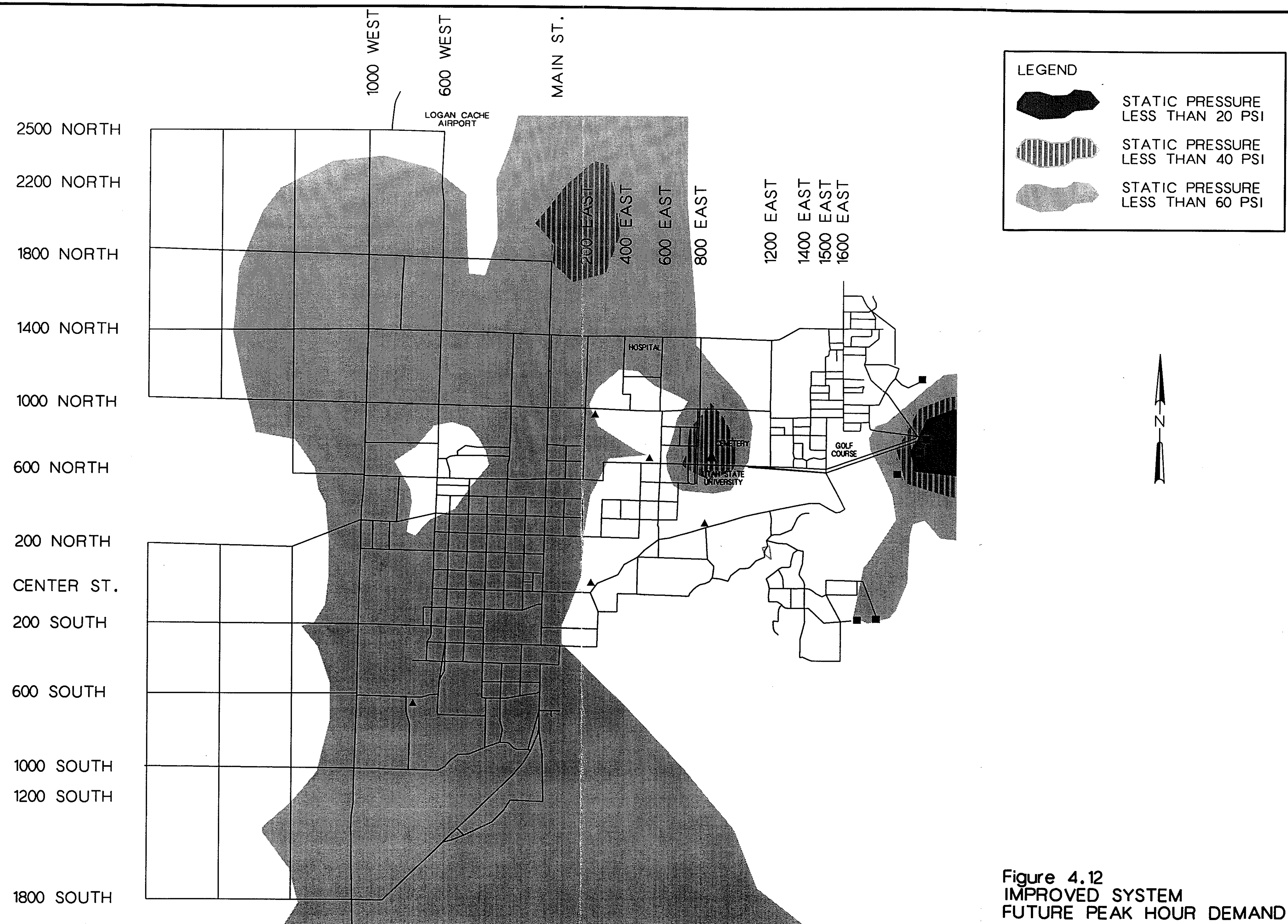

Figure 4.12
IMPROVED SYSTEM
FUTURE PEAK HOUR DEMAND

LOGAN CITY
WATER DISTRIBUTION SYSTEM MASTER PLAN

134653.A0
1314653/DRAWINGS/F-FPHD.FG1

CH2MHILL