Salt Lake City Water Distribution System County Service Area Fire Protection Study

Prepared for

SALT LAKE CITY DEPARTMENT OF PUBLIC UTILITIES

WATER RECLAMATION and STORM DRAINAGE
WATER SUPPLY and WATERWORKS

SALT LAKE COUNTY

Prepared by

CH2M HILL

November 1994

CH2M HILL
Engineers
Planners
Economists
Scientists

November 9, 1994

RMW37123.A0

Mr. LeRoy W. Hooton, Jr.
Department of Public Utilities
1530 South West Temple
Salt Lake City, Utah

Dear LeRoy:

Subject: County Service Area Fire Protection Study

We are pleased to submit to you our finished County Service Area Fire Protection Study. This study was conducted to determine the facilities needed to provide fire protection to the portion of the Salt Lake City service area outside of the City limits. We are pleased to report that the majority of the service area has adequate pipeline capacity to meet fire fighting needs. This report contains the results of computer modeling to locate areas that are deficient in fire flow capacity. We have also prepared estimates of cost to bring deficient areas up to current standards.

I would like to express my appreciation to your staff for their assistance in performing field work needed to calibrate the model and in helping us to understand the operation of this very complex system. Without their help this study would not have been completed.

If you have any questions or require additional information please call.

Sincerely,

CH2M HILL

Clifford R. Forsgren

Clifford R. Forsgren
Project Manager

c: Tim Doxey, Scott Cardwell

rmw37123.007.doc

p:\rmw37123\cvrltr.doc

Salt Lake City Office
4001 S. 700 E., Suite 850
Salt Lake City, UT 84107-2177
801 269-0110
Fax No. 801 269-1115

Salt Lake City Water Distribution System County Service Area Fire Protection Study

Prepared for

SALT LAKE CITY DEPARTMENT OF PUBLIC UTILTIES

WATER RECLAMATION and STORM DRAINAGE
WATER SUPPLY and WATERWORKS

SALT LAKE COUNTY

Prepared by

CH2M HILL

November 1994

CONTENTS

Tables

Figures

Purpose, Scope, Authorization, and Summary of Recommendations

Chapter 1

Purpose, Scope, Authorization, and Summary of Recommendations

Introduction

Water service for the unincorporated portion of Salt Lake County roughly bounded by 3300 South, 700 East, 8000 South, and the Wasatch Mountains is provided by the Salt Lake City Public Utilities Department (SLCPUD). Some of the distribution system in this area has developed without adherence to current standards for water distribution mains. Other portions of the system were developed over 60 years ago when the needs and expectations of a culinary water system were much different than they are today. As the unincorporated portions of the County have developed, the concern for adequate fire protection has increased. In the past, pressure has not always been adequate to fight fires in some areas.

The concern over the ability of the storage and distribution system to provide an adequate supply of water for fire protection led to this joint study effort between Salt Lake County and the SLCPUD.

Purpose of Study

The primary objectives of this study are:

- To identify areas in Salt Lake City's county water distribution system where fire flows of 1,000 gallons per minute (gpm) at a minimum pressure of 20 pounds per square inch (psi) cannot be maintained.
- To develop system improvements that will allow fire flows to be delivered meeting the above criteria.

Scope and Authorization

This study was authorized by a contract between Salt Lake City Corporation and CH2M HILL dated January 19, 1993. The study was to be conducted as described below.

Task 1: Collect and Review Data

Collect and review system data, fire flow data, and operating data required to calibrate a hydraulic model to field conditions.

Task 2: Evaluate and Select Appropriate Computer Program

Identify a computer program that will simulate operation of the complex water distribution system in the study area. This program must also have the capability to be used in conjunction with the City's Arc-Info GIS system in the future and become a tool that the City can use in the future.

Task 3: Develop and Calibrate a Model of the Existing System

Develop and calibrate a computer model of the existing water distribution system in the study area that can be used in conjunction with the computer program selected in Task 2 to simulate system operation.

Task 4: Identify Problem Areas in the System

Identify portions of the water distribution system within the study area where fire flows of 1,000 gpm at 20 psi are not available. Identify sources of system deficiencies.

Task 5: Develop Improvements That Will Resolve System Problems

Identify specific system improvements that will resolve each of the fire flow problems identified in Task 4.

Task 6: Develop Cost Opinions For Recommended Improvements

Develop an engineering opinion of the cost for each set of improvements identified in Task 5.

Task 7: Report Preparation

Prepare a report that will summarize the results of this study.

This report has been prepared as part of the joint fire flow study. The results of the evaluations and recommendations for improvements are presented.

Summary of Recommendations

Most of the area studied is able to deliver the required flow and pressure. However, there are some areas that are deficient. Most of the problems are associated with small-diameter pipe (less that 6 inches) or long dead end lines. If either of these conditions exist, it is almost impossible to meet the minimum fire requirements. This report presents the results of the evaluations of each pressure zone. Where conditions do not permit the system to meet the required fire flow and pressure, improvements were developed and cost estimates prepared. Table 1-1 presents a summary of the improvement costs by zone. The details of the improvements and the cost are given in the chapter describing the zone.

Table 1-1 Estimated Improvement Costs by Zone				
Zone	**Construction**	**Eng, Admin and Legal**	**Contingency**	**Total**
Victory/Tanner	3,120,483	468,072	538,283	4,126,839
Sugarhouse	3,823,086	573,463	659,482	5,065,031
Eastwood	1,807,185	271,078	311,739	2,390,002
Teton	170,841	25,626	29,470	225,937
Mt. Olympus	50,000	7,500	8,625	66,125
Cove	306,118	45,918	52,805	404,841
Cottonwood Hills (Gravity 1)	517,123	77,568	89,204	683,895
Indian Rock	104,583	15,687	18,041	138,311
6200 South High	1,278,031	191,705	220,460	1,690,197
Crestview Estates (Gravity 0)	2,284,377	342,657	394,055	3,021,089
Russell Park	13,198	1,980	2,277	17,454
Total	$13,475,025	$2,021,254	$2,324,441	$17,820,721

RMW37123\REPORT\002.WP5

System Description

Chapter 2
System Description

General

Salt Lake City serves approximately 28,800 water customers in unincorporated Salt Lake County. The area served covers approximately 20 square miles and includes about 397 miles of pipeline. The pipe sizes range from 1 inch to 36 inches in diameter. There is also considerable elevation difference between the east edge of the service area and the west. The elevation ranges between a high of approximately 5800 feet on the east to a low of approximately 4300 feet on the west. This elevation difference will cause excessive pressures in the distribution system unless pressure is reduced as the elevation drops to the west. To control pressure in the unincorporated service area, the SLPUD has divided the system into eighteen pressure zones. Each of the zones has been evaluated and is treated individually in this overall report. The system is shown in Figure 2.1.

Distribution System

As mentioned previously, the distribution system contains approximately 397 miles of pipeline. The pipe diameter is roughly distributed as follows:

- Pipe less than 6 inches in diameter – 106 miles or approximately 27 percent of the total.
- Pipe equal to 6 inches in diameter – 222 miles or approximately 56 percent of the total
- Pipe greater than 6 inches in diameter – 69 miles or approximately 17 percent of the total

It is important to note the amount of pipe less than 6 inches in diameter. Small diameter pipe is not capable of delivering the fire flows required. Twenty seven percent of the pipe in the unincorporated county service area is less than 6 inches in diameter. 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 1,000 gpm, the velocities in 4-inch-diameter pipe and smaller are very high; this results in high pressure loss. This loss in pressure is illustrated in Figure 2.2, 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 between a 4-inch-diameter pipe and a 6-inch diameter pipe. The pressure loss over one block in a 4-inch-diameter pipe is approximately eight times as great as a 6-inch pipe. A 4-inch-diameter pipe carrying 1,000 gpm will lose approximately 143 psi in a block. Since most areas do not have 143 psi to begin with, it is impossible to deliver 1,000 gpm through a block of 4-inch-diameter pipe and maintain a pressure at the hydrant of 20 psi.

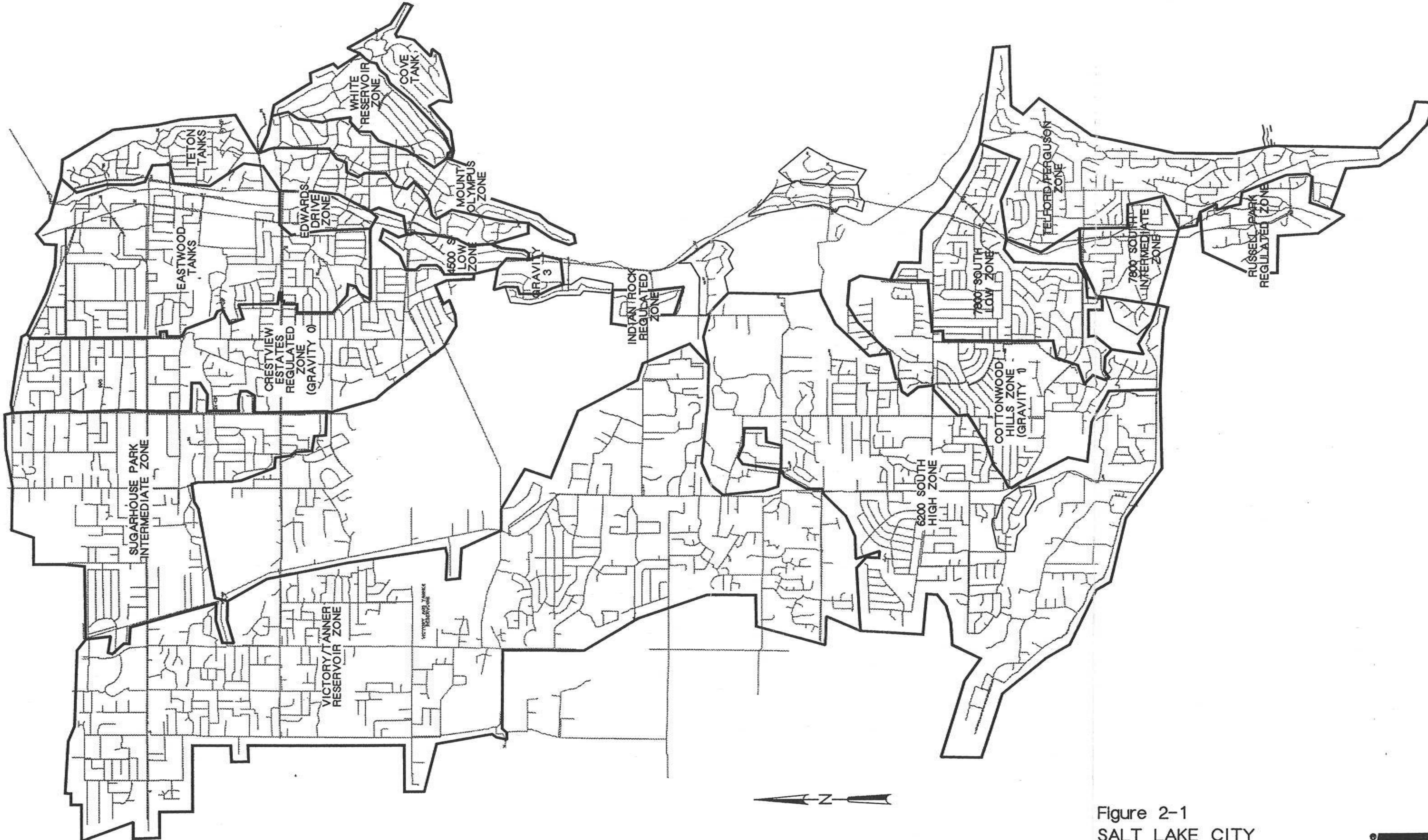


Figure 2-1

SALT LAKE CITY RESERVOIR ZONING PLAN

SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

CH2M HILL

RMW37123/FIGURES/FIRES/FIG2-1.DLV

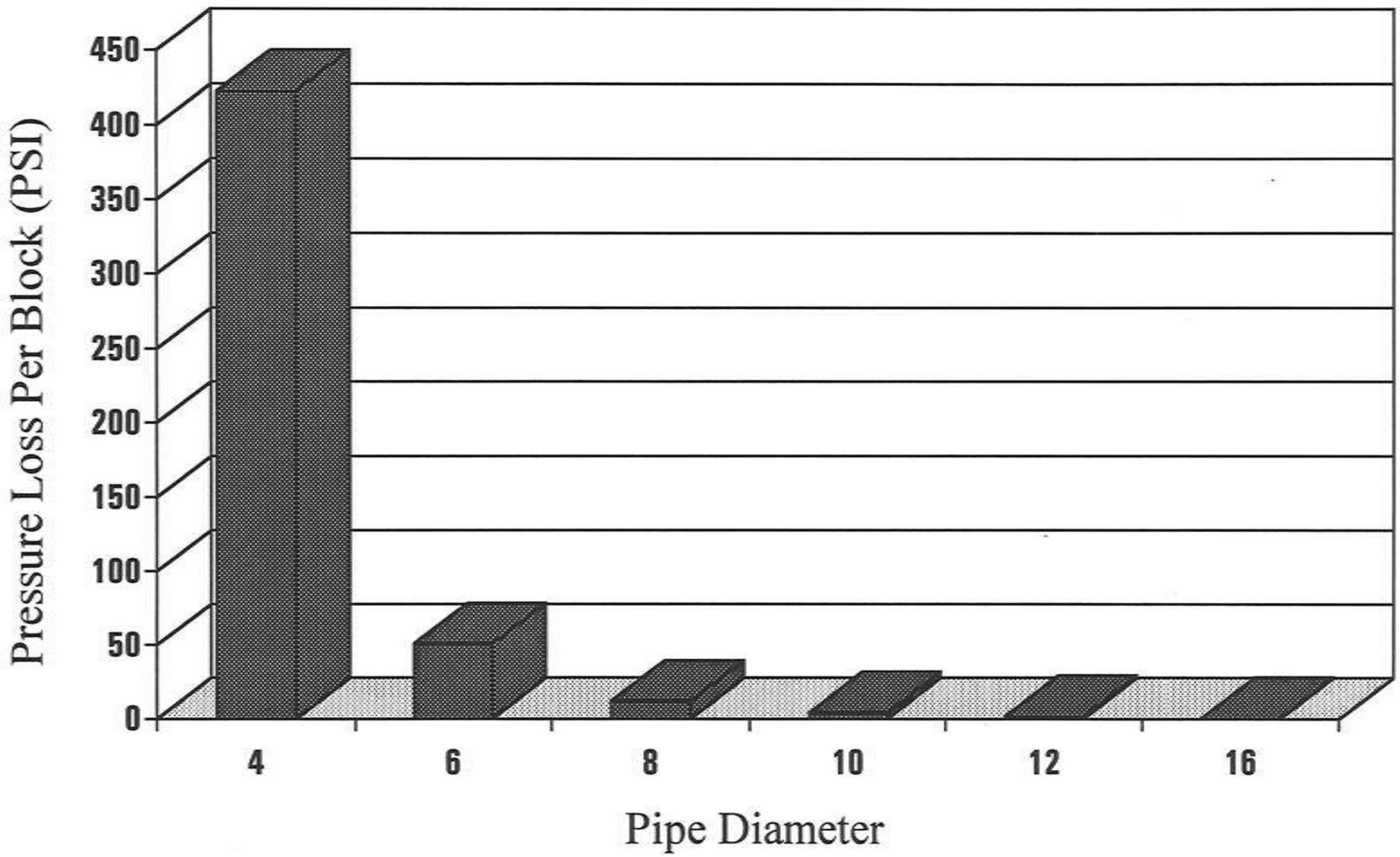


Figure 2-2

PRESSURE LOSS PER BLOCK OF PIPE AT 1000 GPM

SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

660 FT

CH2M HILL

The small diameter pipe can be found throughout the unincorporated service area, but most of it is concentrated in a few areas. The results presented in this report will show that the majority of the problems associated with the distribution system are in those areas with the smallest diameter pipe.

Another important consideration when evaluating a water distribution system is dead end lines. Flow for a fire at the end of a dead end line must all come through a single pipe. If the line is long enough, eventually the pressure losses will be great enough to reduce the pressure to less than the minimum required. If a system is looped so that fire flow can be delivered from more than one direction, the pressure losses will be much less. A 50 percent reduction in the flow in a single pipe will result in a 75 percent reduction in pressure loss. By looping a system and delivering fire flow in more than one pipe, pressure can be maintained much easier.

In addition to pipe size and looped distribution lines, fire hydrants are also important elements of a distribution system. Hydrants should be spaced close enough together to provide fire fighters with a source of water close to the fire. Recommended spacing of fire hydrants is 500 feet. The principle of high pressure loss in small diameter lines applies to fire hoses as well as pipelines. The task of locating and counting fire hydrants was not included in the scope of this study. However, it should be noted that there are many areas with spacing between hydrants that is much greater than 500 feet. If it becomes necessary to stretch long runs of fire hose between the hydrant and a pumper truck the residual pressure at the hydrant may be in excess of 20 psi but still not sufficient to carry 500 to 1,000 gpm through several hundred feet of small diameter fire hose.

Demand

The distribution system must be able to continue to supply the customer demand for water at the same time it is delivering the needed water to fight a fire. Typically distribution systems should be able to meet the average demand occurring over the highest 24-hour demand period in the year. The maximum day demand for the study area is estimated to be 45 million gallons per day (mgd). An examination of Salt Lake City supply records and meter records for the study area was used to establish this number.

RMW37123\REPORT\003.WP5

Model Description

Chapter 3
Model Description

General

Water distribution systems can be complex and it is impossible to manually predict with any degree of accuracy the performance of a large system under a given set of conditions. With computers, large and complex systems such as the Salt Lake City County service area can be modeled and performance under various conditions estimated. The system analyzed in this study has been evaluated using a recently developed computer program written to construct a mathematical model of water distribution systems. The mathematical model describes the system behavior under a given set of circumstances. The computer can predict with some accuracy how a system will perform under given conditions. The secret is developing conditions that represent what really exists in the field.

Initially the computer was used to do the mathematical calculations needed to determine the system operating characteristics for the conditions being analyzed. Today computer modelling packages contain additional features that make it more efficient to analyze, evaluate and present the data and results from a modeling effort. The elements of a computer modeling package used on this study included:

- Graphics Interface
- Database Interface
- Hydraulic Simulation Program

This chapter describes each of the above program elements and provides a general description of the model.

Database and Graphics Interfaces

Water distribution system models were first developed in the early 1970s when computer systems were much less powerful than they are today. At that time, data was input into the computer via punched cards and output via reams of paper that required many hours to interpret and understand. Often, additional time was required in preparing graphs and charts of the results so that people could easily understand the results. The time required to prepare input and review output was so great that even small systems were skeletonized (some pipes not modeled) in order to simplify the analysis. Today's computer systems allow large water distrubuiton systems to be handled much easier than in the past.

As computers have evolved over the past 25 years, so have the interfaces between the data within the computer and the people interpreting the data. The power available in today's computers allows the development of graphical interfaces that can display or plot distribution system features or analysis results to scale. This allows easier evaluations of results by the user. The graphics interface used in the development of the computer model used in this study is coupled with a program called MicroStation. MicroStation is a commercially available

Computer Aided Drafting (CAD) program.

In order to run a hydraulic simulation model, the computer must have information other than just the physical layout of the components shown by the graphic interface. Data such as pipe diameters, reservoir elevations, pump curves, etc. must also be known. This information is stored in a database. It is preferable to have a database linked to the graphic interface so that information can be retrieved and reviewed in an efficient manner. A computer program called *LYNX* is the database interface that serves this purpose for the model that was developed for this project.

LYNX stores information (attributes) describing each of the components of the water distribution system. The software can be used to review or change any of these attributes without leaving the Microstation based graphics interface. For Salt Lake County, *LYNX* is configured for standard water system attributes; however, *LYNX* can be programmed to track any infrastructure system attribute.

LYNX also serves as the interface for the hydraulic simulation model. The input files are generated, the model is run, and the results imported back to the graphic interface by this program. Loading the results from the model into the *LYNX* database is an important aspect that saves the modeler time in interpreting the model results. For a water distribution model, results such as pressures and hydraulic grade lines can be quickly viewed to determine if the model is responding as anticipated by the modeller. For an overall picture of the model results, any attribute can be contoured and either displayed or saved.

Attributes in *LYNX* are called either the "idsys" or the "tag." The purpose of the "idsys" is to number each component with a separate unique numerical identifier assigned by the computer so that the computer can track the components. For some modellers this identifier is also useful to identify the element when discussing model components. Other modelers prefer a non-numeric or alpha-numeric identification system. The "tag" attribute is assigned by the user when the component is first placed in the model and can have a more easily remembered name. For example, in the Salt Lake distribution model, the Hansen Database (GIS) node numbers were maintained. These nodes were identified by the water atlas sheet number on which they occurred. As the model evolved, however, some of these nodes were removed from the model as extraneous while others were added in new locations. The new nodes do not follow the Hansen database nomenclature. At some point in the future it may be worthwhile to develop a new node & pipe tag identification system and to reassign tag numbers. This can be accomplished in a spreadsheet program and the data imported through *LYNX* into the database.

Hydraulic Simulation Model
General

The hydraulic software used to model the Salt Lake County water system was a program called *EPANET*. *EPANET* was developed by the USEPA at the Risk Reduction Engineering Laboratory in Cincinnati, Ohio. Version 1.1 of this program was released in January 1994. The program was adapted by CH2M HILL for use with the *LYNX* software package. Although not within the scope of this contract, dynamic, extended period, and water quality simulations of the County water system will be something Salt Lake City Public Utilities should be interested in performing in the future. These can all be accomplished using *EPANET*.

EPANET was chosen to model the Salt Lake County distribution system following difficulties in getting other modeling programs to perform well. Attempts were made with both *NETWK* and *KYPIPE2* to model the Salt Lake County system. One possible explanation for the success of *EPANET* where other modelling software were unsuccessful could be the mathematical techniques used to solve the large matrices generated by the modelling program. *EPANET* has been developed recently and uses more advanced techniques than its predecessors (both *NETWK* and *KYPIPE* were developed in the 1970s). No attempt was made to explain this success.

Network Components

EPANET models a water distribution network as a collection of many individual components. Each component is discussed briefly in this section. A more detailed and more technical discussion of the components can be found in the *EPANET* users manual.

Pipes

Pipes transport water from one location to another throughout the distribution system. Water moves from higher potential energy to lower potential energy (higher hydraulic grade line to lower hydraulic grade line) at a rate proportional to the difference in potential energy. The energy loss or friction loss within each pipe can be calculated from one of the three friction loss equations: Hazen-Williams, Darcy-Wiesbach, or Chezy-Manning. The Darcy-Wiesbach equation was used in the Salt Lake County distribution system model.

Nodes

Nodes are locations within the distribution network where a change occurs in the pipe data. The most common change is pipe branching typical of a Tee fitting in a distribution system. Another obvious node location would be a change in pipe diameter. A less obvious change requiring the insertion of a node would be a change in pipe material or pipe age. *LYNX* determines a pipe's friction factor based upon pipe diameter, age, and material; therefore, a node is required if any of these attributes change.

Demands were placed on each node within the distribution system based on the fraction of service area that the node represented. The total maximum day demands of the system were then distributed amongst these nodes based on the fractional areas.

Pumps

Both well (source) pumps and booster pumps are modelled in *EPANET*. In the case of the source pump, the suction side of the pump connects to a reservoir with a hydraulic grade line (HGL) equal to the ground water surface. In the case of a booster pump, the suction of the pump connects to a piping network.

In either case the pumps can be modelled in one of four different manners:

1. Constant Pump Horsepower (least accurate)
2. Standard Pump Curve with No Extended Flow Range
3. Pump Curve with No Extended Flow Range
4. Pump Curve with Extended Flow Range (most accurate)

Several of the above techniques have been used for the pumps in the study area. These techniques will be described in later sections of this report for each pump. In every case, the most accurate method available based upon the data provided by the SLCPUD was used. As better data is developed or field verification of existing data is conducted, correcting the data used as input will improve the overall performance of the model.

Valves

The following five valve types can be modeled using *EPANET*:

1. Pressure Reducing Valves (PRVs)
2. Pressure Sustaining Valves (PSVs)
3. Pressure Breaker Valves (PBVs)
4. Flow Control Valves (FCVs)
5. Throttle Control Valves (TCVs)
6. Check Valves (CVs)
7. System Valves (SVs)

Only PRVs and SVs have been modelled at this time in the Salt Lake County distribution system.

PRVs limit the pressure on their downstream side to not exceed a pre-set value when the upstream pressure is above the setting. If the upstream pressure is below the setting, the flow through the valve is unrestricted. Should the pressure on the downstream end exceed that on the upstream end, the valve closes to prevent reverse flow.

SVs simply do not allow flow in a pipe in either direction under any pressure condition. System valves are modeled by simply closing the pipe in which a closed system valve was located during the model run.

Reservoirs

During a static simulation (a solution for one instance of time), reservoirs are nodes in which the hydraulic grade line (water surface elevation) is known and does not need to be determined by the computer. The only reservoir data required by the computer to determine a static solution is the water surface elevation of the reservoir. During an extended period simulation (which involves many static solutions over a period of time in which model parameters such as demand can change), the computer will change the water surface elevation of the reservoir. The computer requires the minimum and maximum possible water surface elevations in order to do this. At the present time, only static simulation of the Salt Lake County system has been attempted.

Minor Losses, Time Patterns, Reaction Rates, Etc.

Other parameters required for the extended period simulation and water quality simulation components are beyond the scope of this report. A discussion of these parameters can be found in the *EPANET* manual.

Model Development

The geometric data describing the distribution system were obtained from the Salt Lake City GIS database. System features such as pipe age, material, street name, etc., came from a separate database. The two databases were then combined in a form that could be accessed by *LYNX* and the process of building a single model database started. Much of the information contained in the initial databases was not compatible for the development of a distribution system model and was removed. In addition it was necessary to manually input pump characteristics, reservoir elevations, pressure reducing valve (prv) settings, system valve status (open or closed), ground elevation, etc.

While the information stored in the two City databases was being compiled and modified, field crews were taking measurements in the field. Before a model is used to predict the performance of a distribution system it should be tested against known conditions. Salt Lake City crews went into the field and took measurements of pressure before and during fire hydrant flow tests. The flow from the hydrants was also measured. This information was then used to calibrate the model. The model was tested by simulating the demand on the system (including the hydrant flows) and comparing the calculated pressures against the measured pressures. The results of the individual calibrations are presented in the chapters describing the performance of individual pressure zones.

Victory/Tanner Reservoir Zone

Chapter 4
Victory/Tanner Reservoir Zone

System Geometry

The Victory/Tanner Reservoir Zone of the Salt Lake County water distribution system is one of the largest zones in the system. It is located on the west side of the source area in the valley floor and therefore does not see the rapid change in ground surface elevation that many of the zones located on the bench. The Tanner Zone is shown in Figure 4-1.

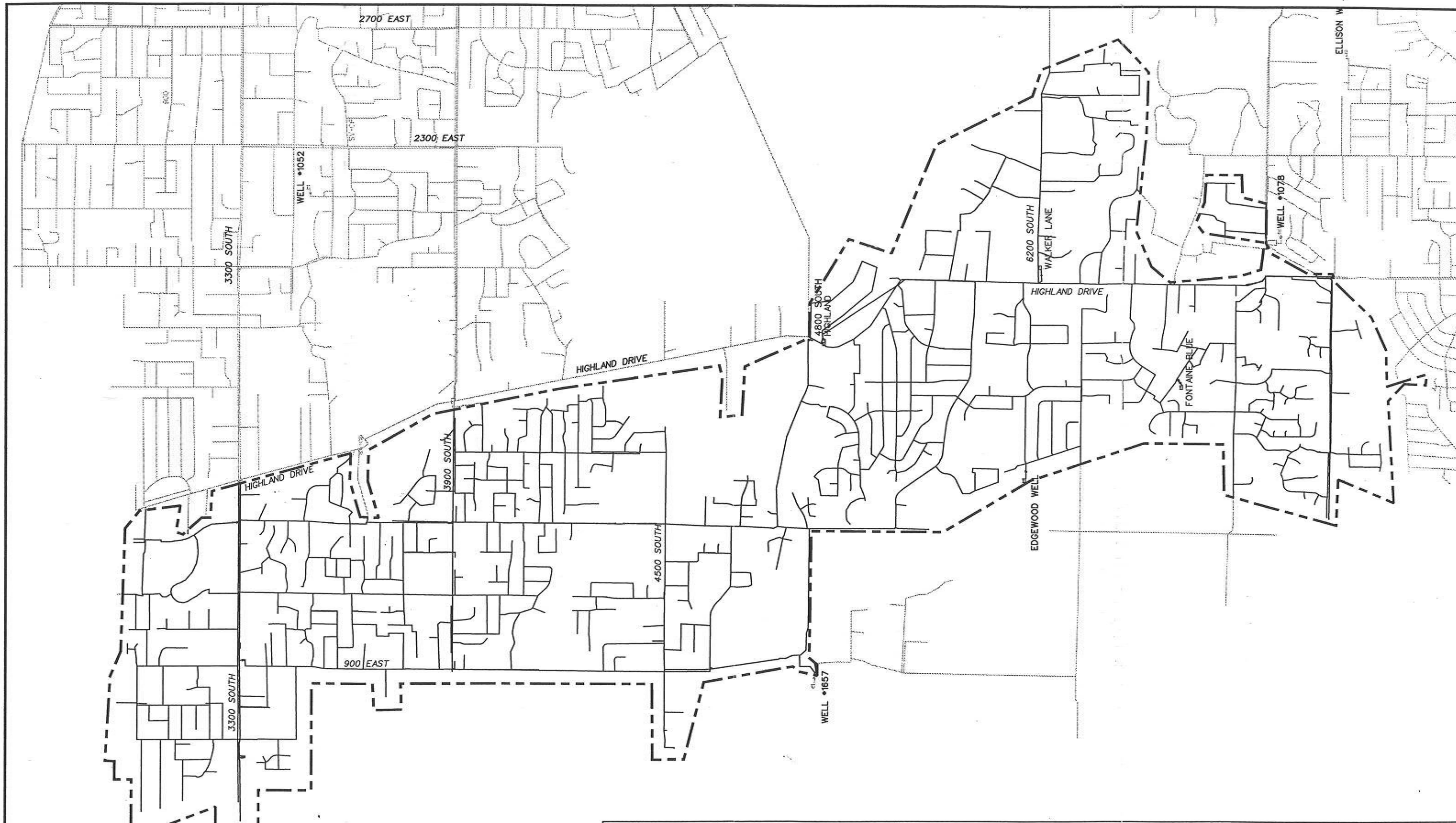
Piping

Table 4-1 indicates the size distribution and total length of the piping within the Tanner Zone.

Table 4-1
Tanner Zone Piping Distribution

Diameter	Length in Zone
4" or less	77,350
6"	265,505
8"	52,540
10"	5,865
12" or greater	59,296
Total Length	460,515

The Victory/Tanner Reservoir Zone is separated from the joining zones through a series of system valves (SVs) and pressure reducing valves (PRVs).



LEGEND:

ZONE BOUNDARY

PIPELINE

SLA - SALT LAKE AQUADUCT

BCC - BIG COTTONWOOD CONDUIT

LCC - LITTLE COTTONWOOD CONDUIT

Figure 4-1
VICTORY/TANNER RESERVOIR ZONE

SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

CH2M HILL

RMW37123\FIGURES\FIRES\ZONE4-1.DLV

Table 4-4 Tanner Zone Source Pumps		
Pump	**Location**	**Status**
Edgewood Well #1650	Lakewood	ON
Walker Lane	Walker Lane	OFF
Well #1657	900 East	ON
Fontaine Blue	Van Winkle	ON
4800 Highland Well #1065A	Highland Dr.	ON

Booster Pumps

There is one booster pump station in the Tanner Zone. Table 4-5 indicates the location of this booster pump.

Table 4-5 Tanner Zone Booster Pumps		
Pump	**Location**	**Status**
Fontaine Blue Booster	Van Winkle	ON

Calibration

Prior to the modelling effort, a series of fire hydrant flow tests were conducted within the Salt Lake County Distribution System to assist in the calibration of the model. Within the Tanner Zone, four such tests were conducted.

After completion of the static calibration, the model was calibrated against the fire flow tests. This is called the dynamic calibration. The intent of the dynamic calibration is to test the system under some stress (high flows) and check the model's performance against that condition. The measured flows from the fire hydrants were modeled and the calculated pressures compared against those measured in the field. Adjustments in the model were made to bring the calculated results in line with the field measured results.

Dynamic calibration often requires an iterative process. Initial field measurements and system maps are used to set up the model, but the situation in the field is frequently not exactly as described in the maps and other system documentation. Inaccurate mapping (with inexact elevations), valves not in the position recorded (either open or closed), or pipes a different size than shown on maps, are all conditions that exist in most water distribution systems. To get an accurate dynamic model it is often necessary to go back into the field and check valve position, elevation, etc. This additional field work to verify model conditions was not done as a part of this study. It is recommended that as time and manpower permit, field verification be undertaken. For example, elevations of reservoirs, pump stations and PRVs are known. However, the elevations for the remainder of the system were obtained from USGS mapping and are likely not completely accurate for a given location. An elevation difference (between actual and the model) of 5 feet would result in a pressure difference of 2.2 psi. The elevation contours on the USGS mapping are 40 feet. Errors in elevations of up to 20 feet could be expected using this type of mapping. A 20 foot elevation difference would result in a pressure difference of almost 9 psi. Static and dynamic calibration results must be viewed with this potential for errors based on erroneous information in mind.

Three of the four dynamic tests within the Tanner Zone resulted in modeled results within 5 psi of the measured. The fourth test was significantly different. This is an area where additional field work may be needed to resolve the differences between the modeled results and the measured data.

During the calibration of the model, runs were made simulating an average demand condition and adjustments made until the measured pressure equalled the modelled pressure as nearly as possible. Typical adjustments included the opening and closing of system valves, the adjustment of PRV pressure settings, and the verification of node elevations. The results of the static calibration are also given in Table 4-6.

Table 4-6
Tanner Zone Calibration Test Results

	Static Pressure		Dynamic Pressure	
Test No.	Measured	Calculated	Measured	Calculated
35	94	94	65	39.82
7	70	70	24	29.41
36	86	82	50	46.73
37	55	61	6	1.28

Fire Run Simulations

The calibrated model was used to simulate fires at various locations within the system. Because of the potential inaccuracies in the model, a minimum pressure of 25 psi was used as the basis for deciding that improvements are needed. Fifty-nine fires were simulated in this zone. The locations of the simulated fires are shown in Figure 4-2. Table 4-7 presents the results of the simulated fire runs for the present system.

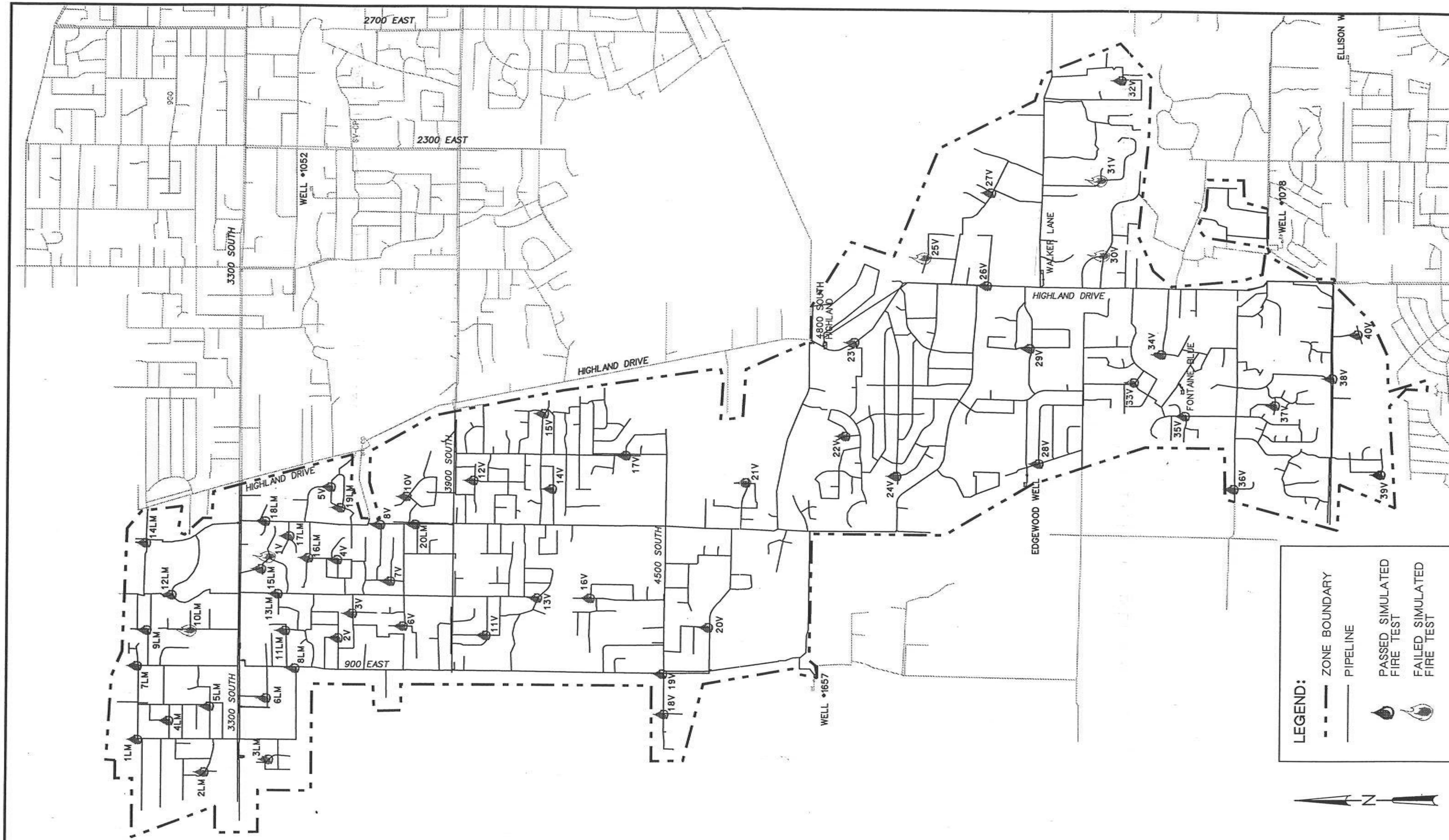


Figure 4-2
VICTORY/TANNER RESERVOIR ZONE

SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

CH2M HILL

RMW37123\FIGURES\FIRES\ZONE4-2.DLV

Table 4-2 indicates the SVs within the Tanner Zone which were closed during the static simulation.

Table 4-2
Tanner Zone System Valves

idsys	Location
10287	5600 South, Edgewood
10687	Vine Street, Vineway

The Tanner Zone portion of the model includes seven PRVs. Table 4-3 shows the location, pressure setting and Hydraulic Grade Line (HGL) of the PRVs.

Table 4-3
Tanner Zone PRVs

Station No.	idsys	Location	Pressure Setting	HGL
R-50	56769	1300 E.	73	4550.70
R-49	56768	900 E.	90	4510.65
R-48A	56767	800 E.	73	4446.00
R-57A	56776	3300 S.	90	4475.65
R-56	56775	Highland Drive	58	4527.31
R-47	56777	Elgin Street	60	4550.35
R-51A	56770	3300 S.	60	4555.52
EX-6	56776	4510 S.	60	4706.93

Reservoirs

Tanner Reservoir controls the hydraulic grade line within the Tanner Zone. The static hydraulic grade line of Tanner Reservoir is 4631 feet.

Source Pumps

There are five source pumps in the Tanner Zone. Table 4-4 indicates the location of these pumps. The status of these pumps during the maximum day simulation is also given.

Table 4-7 Tanner Fire Flow Results					
Simulation No.	**Fire Flow (gpm)**	**Calculated Pressure**	**Simulation No.**	**Fire Flow (gpm)**	**Calculated Pressure**
1V	1006.46	20.81	29V	1012.96	77.95
2V	1006.19	97.94	30V	1011.14	< 0
3V	1006.46	93.22	31V	1011.69	< 0
4V	1004.55	79.51	32V	1010.33	31.86
5V	1009.41	72.98	33V	1005.41	97.11
6V	1005.83	74.40	34V	1007.06	75.04
7V	1006.31	88.31	35V	1007.27	93.45
8V	1005.86	36.90	36V	1024.35	73.64
10V	1006.83	66.74	37V	1003.46	81.51
11V	1008.52	97.82	38V	1011.22	77.08
12V	1004.16	85.08	39V	1004.92	40.62
13V	1006.11	98.28	40V	1006.44	42.74
14V	1007.93	70.97	1LM	1002.00	77.59
15V	1004.97	75.08	2LM	1007.99	72.51
16V	1007.86	55.43	3LM	1004.68	28.07
17V	1002.00	88.34	4LM	1007.46	61.00
18V	1002.00	95.89	5LM	1002.00	65.93
19V	1002.00	98.52	6LM	1002.00	39.42
20V	1017.26	76.24	7LM	1009.50	51.93
21V	1006.84	93.35	8LM	1013.90	94.42
22V	1005.09	83.46	9LM	1005.79	43.87
23V	1031.04	85.50	10LM	1007.04	< 0
24V	1004.62	88.98	11LM	1005.73	39.88
25V	1008.29	< 0	12LM	1017.67	84.46
26V	1002.00	73.69	13LM	1007.56	58.76
27V	1006.50	55.94	14LM	1002.00	48.32
28V	1009.69	107.33	15LM	1006.91	65.85

Table 4-7 continued Tanner Fire Flow Results		
Simulation No.	Fire Flow (gpm)	Calculated Pressure
16LM	1008.87	23.50
17LM	1006.40	< 0
18LM	1003.88	< 0
19LM	1009.89	30.21
20LM	1007.36	78.58

Problem Areas

There were a number of locations where the minimum fire flow criteria could not be met. These locations are shown in Figure 4-2. These areas generally contain small diameter pipe, long dead end lines or a combination of each. The model showed that water could often be delivered to a neighborhood at adequate pressure but the distance traveled in the small diameter pipe or in long dead end lines was great enough to produce excessive pressure loss.

Recommended Solutions

For each of the areas in which the required fire flow and pressure was not achieved, an improvement was developed to overcome the problems associated with that location. Figure 4-3 shows the improvements developed for the Tanner Zone. The same set of simulated fires which were run earlier were run again with the improvements shown on Figure 4-3. The calculated pressures with the improvements were all in excess of the minimum criteria. A cost estimate was prepared for each of these improvements. Table 4-8 shows these cost estimates.

It should be pointed out that the solutions presented in Figure 4-3 may not be the optimum. It may be possible to reduce the amount of pipe used (and thus reduce the costs) by creating more loops. System maps do not contain enough information to determine if looping is possible. Field investigation is recommended.

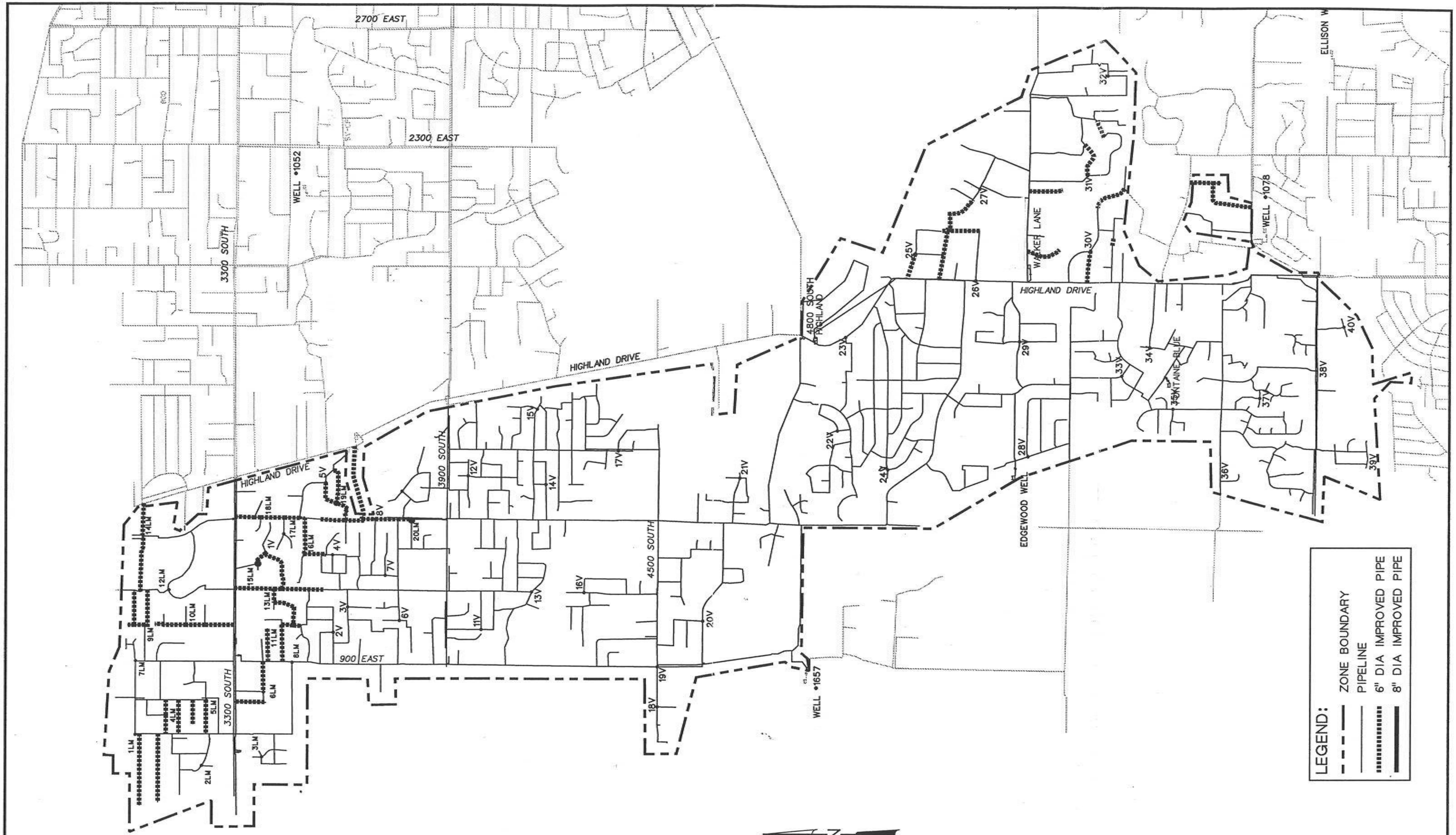


Figure 4-3
VICTORY/TANNER
RESERVOIR ZONE
SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

CH2M HILL

RMW37123\FIGURES\FIRES\ZONE4-3.DLV

Table 4-8

Salt Lake City Department of Public Utilities
Fire Flow Study
Cost Estimate - Tanner Zone

idsys	Existing Length	New Length	Existing Diameter	New Diameter	Number Required Valves	Hydrants	Service	Repair	Cost Pipe	Valves	Hydrants	Service	Repair	TOTAL
	LF	LF	inch	inch	ea	ea	ea	cy	$	$	$	$	$	$
55497	1,567	1,567	4	6	5	4	35	5,222	78,334	3,000	10,000	22,750	19,322	133,406
55499	1,497	1,497	4	6	5	3	34	4,989	74,834	3,000	7,500	22,100	18,459	125,894
55500	412	412	4	6	2	1	10	1,373	20,600	1,200	2,500	6,500	5,081	35,881
55450	335	335	4	6	2	1	8	1,117	16,754	1,200	2,500	5,200	4,133	29,786
55501	747	747	4	6	3	2	17	2,490	37,354	1,800	5,000	11,050	9,214	64,418
55468	529	529	4	6	2	2	12	1,763	26,446	1,200	5,000	7,800	6,523	46,969
55502	747	747	4	6	3	2	17	2,490	37,352	1,800	5,000	11,050	9,214	64,416
55567	140	140	4	6	1	1	4	467	7,000	600	2,500	2,600	1,727	14,427
55565	765	765	4	6	3	2	18	2,551	38,260	1,800	5,000	11,700	9,437	66,197
55566	235	235	4	6	1	1	6	783	11,750	600	2,500	3,900	2,898	21,649
55564	827	827	4	6	3	2	19	2,758	41,375	1,800	5,000	12,350	10,206	70,730
55575	1,227	1,227	4	6	4	3	28	4,089	61,330	2,400	7,500	18,200	15,128	104,558
55625	20	20	4	6	1	1	1	67	1,000	600	2,500	650	247	4,997
55631	18	18	4	6	1	1	1	60	903	600	2,500	650	223	4,876
55620	700	700	4	6	3	2	16	2,333	35,000	1,800	5,000	10,400	8,633	60,833
55555	203	203	4	6	1	1	5	676	10,136	600	2,500	3,250	2,500	18,986
55588	487	487	4	6	2	1	11	1,622	24,326	1,200	2,500	7,150	6,000	41,177
55590	416	416	4	6	2	1	10	1,387	20,802	1,200	2,500	6,500	5,131	36,133
55586	626	626	4	6	2	2	14	2,087	31,311	1,200	5,000	9,100	7,723	54,335
4242	638	638	4	6	2	2	15	2,126	31,892	1,200	5,000	9,750	7,867	55,709
4237	675	675	4	6	3	2	15	2,249	33,733	1,800	5,000	9,750	8,321	58,604
4266	719	719	4	6	3	2	16	2,398	35,969	1,800	5,000	10,400	8,872	62,041
4444	817	817	4	6	3	2	19	2,723	40,842	1,800	5,000	12,350	10,074	70,067
4563	257	257	4	6	1	1	6	856	12,840	600	2,500	3,900	3,167	23,008
4598	165	165	4	6	1	1	4	550	8,249	600	2,500	2,600	2,035	15,984
54794	396	396	4	6	2	1	9	1,320	19,798	1,200	2,500	5,850	4,883	34,231
4568	462	462	4	6	2	1	11	1,538	23,077	1,200	2,500	7,150	5,692	39,619
4333	305	305	4	6	1	1	7	1,017	15,253	600	2,500	4,550	3,762	26,666
4341	870	870	4	6	3	2	20	2,898	43,477	1,800	5,000	13,000	10,724	74,002
4439	168	168	4	6	1	1	4	560	8,400	600	2,500	2,600	2,072	16,173
4447	999	999	4	6	4	2	23	3,330	49,952	2,400	5,000	14,950	12,322	84,624
4260	314	314	4	6	1	1	7	1,045	15,678	600	2,500	4,550	3,867	27,195
4645	599	599	4	6	2	2	14	1,996	29,933	1,200	5,000	9,100	7,383	52,616
54792	311	311	4	6	1	1	7	1,038	15,572	600	2,500	4,550	3,841	27,064
4190	442	442	4	6	2	1	10	1,473	22,090	1,200	2,500	6,500	5,449	37,739
4215	125	125	4	6	1	1	3	417	6,251	600	2,500	1,950	1,542	12,843
4449	508	508	4	6	2	2	12	1,692	25,378	1,200	5,000	7,800	6,260	45,637
4593	356	356	4	6	2	1	8	1,187	17,805	1,200	2,500	5,200	4,392	31,097
4617	104	104	4	6	1	1	3	347	5,208	600	2,500	1,950	1,285	11,543
57335	798	798	4	6	3	2	18	2,661	39,910	1,800	5,000	11,700	9,844	68,254
4727	386	386	4	6	2	1	9	1,285	19,279	1,200	2,500	5,850	4,756	33,585
4772	113	113	4	6	1	1	3	377	5,652	600	2,500	1,950	1,394	12,097
54781	558	558	4	6	2	2	13	1,859	27,890	1,200	5,000	8,450	6,880	49,420
4947	554	554	4	6	2	2	13	1,848	27,718	1,200	5,000	8,450	6,837	49,205
4869	618	618	4	6	2	2	14	2,058	30,876	1,200	5,000	9,100	7,616	53,792
4884	799	799	4	6	3	2	18	2,662	39,928	1,800	5,000	11,700	9,849	68,276
5057	404	404	4	6	2	1	9	1,347	20,198	1,200	2,500	5,850	4,982	34,731
5167	283	283	4	6	1	1	7	945	14,169	600	2,500	4,550	3,495	25,314
5297	494	494	4	6	2	1	11	1,646	24,690	1,200	2,500	7,150	6,090	41,630
5330	99	99	4	6	1	1	3	330	4,943	600	2,500	1,950	1,219	11,212
5401	197	197	4	6	1	1	5	657	9,857	600	2,500	3,250	2,431	18,638
9872	344	581	4	6	2	2	13	1,937	29,050	1,200	5,000	8,450	7,166	50,866
57984	NEW	404	0	6	2	1	9	1,347	20,200	1,200	2,500	5,850	4,983	34,733
53881	553	553	4	6	2	2	13	1,843	27,650	1,200	5,000	8,450	6,820	49,121
53871	1,604	1,090	4	6	4	3	25	3,633	54,500	2,400	7,500	16,250	13,443	94,093
53875	271	412	4	6	2	1	10	1,373	20,600	1,200	2,500	6,500	5,081	35,881
57985	NEW	513	0	6	2	2	12	1,710	25,650	1,200	5,000	7,800	6,327	45,977
57986	NEW	394	0	6	2	1	9	1,313	19,700	1,200	2,500	5,850	4,859	34,109
10265	781	781	4	6	3	2	18	2,602	39,035	1,800	5,000	11,700	9,629	67,163
10266	751	751	4	6	3	2	17	2,505	37,574	1,800	5,000	11,050	9,268	64,692
10358	702	702	4	6	3	2	16	2,338	35,076	1,800	5,000	10,400	8,652	60,928
10457	787	787	4	6	3	2	18	2,625	39,370	1,800	5,000	11,700	9,711	67,582
57981	NEW	159	0	6	1	1	4	530	7,950	600	2,500	2,600	1,961	15,611
57982	NEW	440	0	6	2	1	10	1,467	22,000	1,200	2,500	6,500	5,427	37,627
57987	NEW	442	0	6	2	1	10	1,473	22,100	1,200	2,500	6,500	5,451	37,751
10664	507	507	4	6	2	2	12	1,689	25,342	1,200	5,000	7,800	6,251	45,593
10764	1,257	1,257	4	6	4	3	28	4,191	62,867	2,400	7,500	18,200	15,507	106,475
					145	106	826	119,336	1,790,040	87,000	265,000	536,900	441,543	3,120,483

Eng, Legal & Admin	15%	468,072
Subtotal	-	**3,588,556**
Contigency	15%	538,283
TOTAL	-	**4,126,839**

Sugarhouse Park Intermediate Zone

Chapter 5
Sugarhouse Park Intermediate Zone

System Geometry

The Sugarhouse Park Intermediate Zone is located in the north central section of the study area. This zone is fed from supply pipelines running from east to west. The water comes directly from the Big Cottonwood Conduit and the Salt Lake Aqueduct. The Sugarhouse Park Intermediate Zone is shown in Figure 5-1.

Piping

Table 5-1 indicates the size distribution and total length of the piping within the Sugarhouse Park Intermediate Zone.

Table 5-1
Sugarhouse Park Intermediate Zone
Reservoir Piping Distribution

Diameter	Length in Zone
4" or less	71,541
6"	82,761
8"	10,412
10"	0
12" or greater	33,400
Total Length	198,063

Valves

The Sugarhouse Intermediate Zone is separated from adjacent zones through a series of SVs and PRVs. Table 5-2 indicates the SVs within the Sugarhouse Park Intermediate Zone which were closed during the static simulation. Table 5-3 gives the location and setting of the PRVs.

LEGEND:

N

— — — ZONE BOUNDARY

——— PIPELINE

SLA - SALT LAKE AQUADUCT

BCC - BIG COTTONWOOD CONDUIT

LCC - LITTLE COTTONWOOD CONDUIT

Figure 5-1

SUGARHOUSE PARK INTERMEDIATE ZONE

SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

CH2M HILL

RMW37123\FIGURES\FIRES\ZONESXXX.LV

Table 5-2 Sugarhouse Park Intermediate Zone Reservoir System Valves	
idsys	**Location**
4268	2300 E., 3380 S.
4686	3510 S., 2300 E.
5077	Murphys, 1300 E.
5243	3700 S., 2300 E.
5838	2300 E., 3900 S.
54704	2300 E., Keller
55242	3900 S., 2300 E.
56053	3300 S., 2300 E.

Table 5-3 Sugarhouse Park Intermediate PRVs				
Station No.	**idsys**	**Location**	**Pressure Setting**	**HGL**
R-53	56772	3300 S.	106	4772.00
R-54	56773	3300 S.	75	4767.00
R-55	56774	2300 E.	70	4754.00
R-51A	56770	3300 S.	60	4555.52
R-52	56771	3300 S.	120	4693.66
	57954	2700 S.	85	4774.23
CR-2	56658	3900 S.	65	4738.00

Reservoirs

There are no reservoirs serving the Sugarhouse Intermediate Zone directly. Water is supplied directly from the Big Cottonwood Conduit and the Salt Lake Aqueduct.

Source Pumps

There is one source pump in the Sugarhouse Park Intermediate, well # 1052, which is not in service.

Booster Pumps

There are no booster pumps serving the Sugarhouse Park Intermediate Zone.

Calibration

Prior to the modelling effort, a series of fire hydrant flow tests were conducted within the Salt Lake County Distribution System to assist in the calibration of the model. Within the Sugarhouse Park Intermediate, three such tests were conducted.

Table 5-4
Sugarhouse Park Intermediate Calibration Test Results

	Static Pressure		Dynamic Pressure	
Test No.	Measured	Calculated	Measured	Calculated
27	76	74	62	109.70
30	106	99	70	< 0
31	90	94	48	51.75

During the static calibration of the model, runs were made at an average demand condition and adjustments made until the measured pressure equalled the modelled pressure as near as possible. Typical adjustments included the opening and closing of system valves, the adjustment of PRV pressure settings, and the verification of node elevations.

After completion of the static calibration, the model was calibrated against the fire flow tests. This is called the dynamic calibration. The intent of the dynamic calibration is to test the system under some stress (high flows) and check the model's performance against that condition. The measured flows from the fire hydrants were modeled and the calculated pressures compared against those measured in the field. Adjustments in the model were made to bring the calculated results in line with the field measured results.

Dynamic calibration often requires an iterative process. Initial field measurements and system maps are used to set up the model, but the situation in the field is frequently not exactly as described in the maps and other system documentation. Inaccurate mapping (with inexact elevations), valves not in the position recorded (either open or closed), or pipes a different size than shown on maps, are all conditions that exist in most water distribution systems. To get an accurate dynamic model it is often necessary to go back into the field and check valve position, elevation, etc. This additional field work to verify model conditions was not done as a part of this study. It is recommended that as time and manpower permit, field verification be undertaken. For example, elevations of reservoirs, pump stations and PRVs are known. However, the elevations for the remainder of the system were obtained from USGS mapping and are likely not completely accurate for a given location. An elevation difference (between actual and the model) of 5 feet would result in a pressure difference of 2.2 psi. The elevation contours on the USGS mapping are 40 feet. Errors in elevations of up to 20 feet could be expected using this type of mapping. A 20 foot elevation difference would result in a pressure difference of almost 9 psi. Static and dynamic calibration results must be viewed with this potential for errors based on erroneous information in mind. The results of the calibration runs are presented in Table 5-4.

The static calibration runs for this zone are very close to the measured static. However, the dynamic runs vary widely in two of the three tests. They not only vary widely, they vary in different directions (one is high and another is low). This type of variation cannot be explained with elevation, friction factor or other general system feature. There is a significant difference between the way the system is described in the model and the way it is operating in the field. It may be valves in different position than believed, pipe sizes not as recorded, or pipes connected differently than believed. It is recommended that additional field work be performed in this zone.

Fire Run Simulations

The calculated model was used to simulate fires at various locations within the system. Because of the potential inaccuracies in the model, a minimum pressure of 25 psi was used as the basis for deciding that improvements are needed. Thirty-three fires were simulated in this zone. The locations of the simulated fire runs are shown in Figure 5-2. Table 5-5 presents the results of the simulated fire runs for each system.

Table 5-5
Sugarhouse Park Intermediate Fire Flow Results

Simulation No.	Fire Flow (gpm)	Calculated Pressure	Simulation No.	Fire Flow (gpm)	Calculated Pressure
1S	1005.02	73.05	18S	1010.77	< 0
2S	1009.91	< 0	19S	1004.34	75.70
3S	1009.96	74.00	20S	1012.08	41.81
4S	1009.97	49.60	21S	1002.00	89.39
5S	1025.09	< 0	22S	1009.37	74.53
6S	1019.42	4.25	23S	1016.03	65.98
7S	1008.37	48.92	24S	1006.54	79.68
8S	1015.40	< 0	25S	1012.29	76.88
9S	1003.77	74.53	26S	1005.36	< 0
10S	1007.38	< 0	27S	1009.03	< 0
11S	1002.00	< 0	28S	1020.71	49.02

Table 5-5 Sugarhouse Park Intermediate Fire Flow Results					
Simulation No.	Fire Flow (gpm)	Calculated Pressure	Simulation No.	Fire Flow (gpm)	Calculated Pressure
12S	1002.00	77.67	22LM	1002.00	79.60
13S	1007.99	< 0	25LM	1005.81	38.50
14S	1008.47	54.07	27LM	1006.41	51.70
15S	1007.73	48.05	28LM	1002.00	47.75
16S	1005.99	67.09	29LM	1010.88	30.92
17S	1002.00	< 0			

Problem Areas

The Sugarhouse Intermediate Zone contains a large number of long small-diameter pipelines. It also contains a significant number of long dead end lines. There is adequate pressure under average conditions but when the system is required to deliver high volumes of water the pressure is dissipated in the small diameter pipe.

Recommended Solutions

For each of the areas in which fire flow and pressure was not achieved, an improvement was developed to overcome the problems associated with that location. Figure 5-3 shows the improvements for the Sugarhouse Park Intermediate Zone. The same set of simulated fires run on the existing system were run again with the improvements shown in Figure 5-3. The calculated pressures were all in excess of the minimum criteria. A cost estimate was prepared for each of these improvements. Table 5-6 shows the cost estimates.

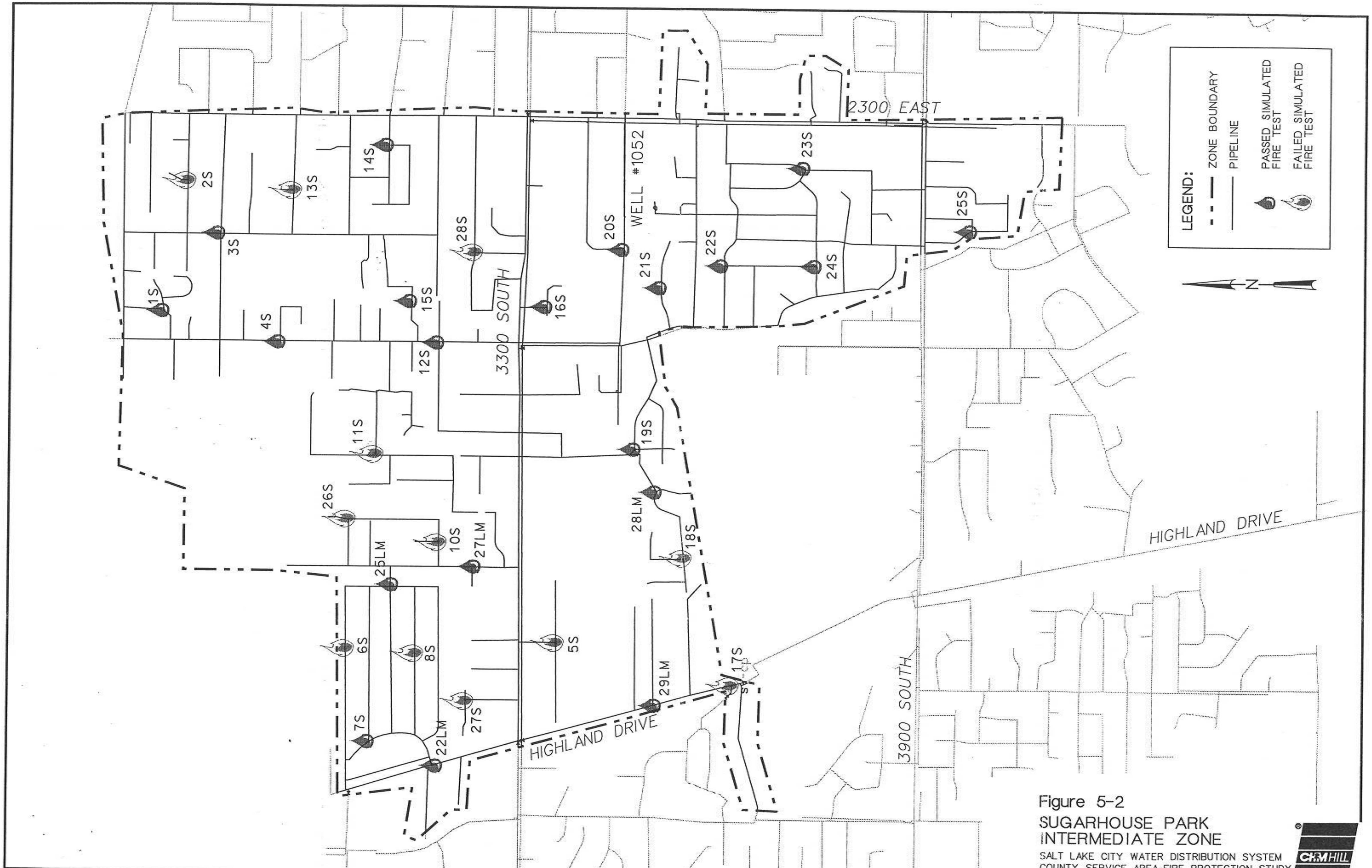


Figure 5-2
SUGARHOUSE PARK
INTERMEDIATE ZONE
SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

CH2M HILL

RMW37123\FIGURES\FIRES\ZONE5-2.DLV

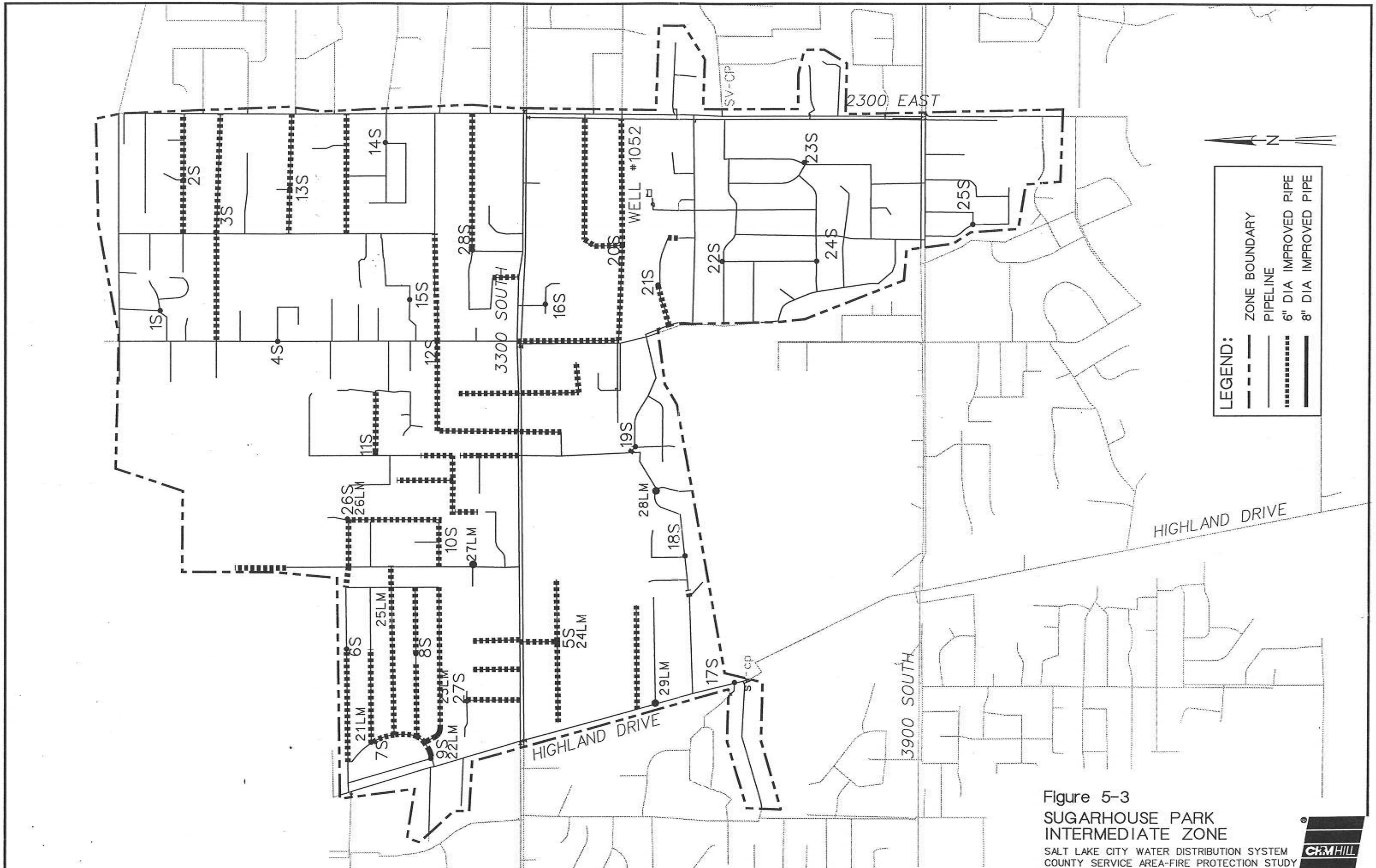


Figure 5-3
SUGARHOUSE PARK
INTERMEDIATE ZONE
SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

Table 5-6

Salt Lake City Department of Public Utilities
Fire Flow Study
Cost Estimate - Sugarhouse Zone

Idsys	Existing Length	New Length	Existing Diameter	New Diameter	Number Required: Valves	Hydrants	Service	Repair	Cost: Pipe	Valves	Hydrants	Service	Repair	TOTAL
	LF	LF	inch	inch	ea	ea	ea	cy	$	$	$	$	$	$
3819	306	306	4	6	1	1	7	1,019	15,292	600	2,500	4,550	3,772	26,715
3960	703	703	4	6	3	2	16	2,344	35,158	1,800	5,000	10,400	8,672	61,031
4185	720	720	4	6	3	2	17	2,402	36,024	1,800	5,000	11,050	8,886	62,760
4187	434	434	4	6	2	1	10	1,448	21,722	1,200	2,500	6,500	5,358	37,280
4189	939	939	4	6	3	2	21	3,130	46,945	1,800	5,000	13,650	11,580	78,975
4257	1,053	1,053	4	6	4	3	24	3,511	52,662	2,400	7,500	15,600	12,990	91,152
4453	1,186	1,186	4	6	4	3	27	3,954	59,310	2,400	7,500	17,550	14,630	101,389
4504	1,163	1,163	4	6	4	3	26	3,878	58,171	2,400	7,500	16,900	14,349	99,320
4512	1,115	1,115	4	6	4	3	25	3,715	55,732	2,400	7,500	16,250	13,747	95,629
4585	1,211	1,211	4	6	4	3	27	4,038	60,573	2,400	7,500	17,550	14,941	102,964
5077	1,642	1,642	4	6	5	4	37	5,476	82,122	3,000	10,000	24,050	20,257	139,428
54679	1,528	1,528	4	6	5	4	34	5,095	76,421	3,000	10,000	22,100	18,851	130,372
54687	356	356	4	6	2	1	8	1,185	17,780	1,200	2,500	5,200	4,386	31,066
54743	697	498	4	6	2	1	12	1,660	24,900	1,200	2,500	7,800	6,142	42,542
55060	114	291	4	6	1	1	7	970	14,550	600	2,500	4,550	3,589	25,789
55062	273	957	4	6	3	2	22	3,190	47,850	1,800	5,000	14,300	11,803	80,753
55064	287	287	4	6	1	1	7	955	14,330	600	2,500	4,550	3,535	25,515
55642	1,094	1,094	4	6	4	3	25	3,647	54,711	2,400	7,500	16,250	13,495	94,356
55643	1,723	1,723	4	6	6	4	39	5,742	86,131	3,600	10,000	25,350	21,246	146,326
55644	842	842	4	6	3	2	19	2,806	42,083	1,800	5,000	12,350	10,380	71,613
55650	776	776	4	6	3	2	18	2,586	38,791	1,800	5,000	11,700	9,569	66,860
55651	1,310	1,310	4	6	4	3	30	4,368	65,516	2,400	7,500	19,500	16,161	111,077
55656	2,183	1,912	4	6	6	4	43	6,373	95,599	3,600	10,000	27,950	23,581	160,729
55677	290	290	4	6	1	1	7	967	14,508	600	2,500	4,550	3,579	25,737
55897	2,006	2,006	4	6	7	5	45	6,688	100,313	4,200	12,500	29,250	24,744	171,006
55905	461	461	4	6	2	1	11	1,537	23,050	1,200	2,500	7,150	5,686	39,586
55907	225	225	4	6	1	1	6	750	11,251	600	2,500	3,900	2,775	21,026
55908	290	290	4	6	1	1	7	967	14,508	600	2,500	4,550	3,579	25,736
55909	665	665	4	6	3	2	15	2,216	33,242	1,800	5,000	9,750	8,200	57,992
55916	658	658	4	6	2	2	15	2,193	32,900	1,200	5,000	9,750	8,115	56,965
55917	369	369	4	6	2	1	9	1,230	18,450	1,200	2,500	5,850	4,551	32,551
55922	798	798	4	6	3	2	18	2,660	39,903	1,800	5,000	11,700	9,843	68,246
55926	550	550	4	6	2	2	13	1,834	27,516	1,200	5,000	8,450	6,787	48,954
55928	518	518	4	6	2	2	12	1,727	25,908	1,200	5,000	7,800	6,391	46,299
55947	740	740	4	6	3	2	17	2,468	37,019	1,800	5,000	11,050	9,131	64,000
55990	475	475	4	6	2	1	11	1,584	23,755	1,200	2,500	7,150	5,859	40,464
56025	715	715	4	6	3	2	16	2,383	35,745	1,800	5,000	10,400	8,817	61,762
56059	1,613	1,613	4	6	5	4	36	5,377	80,654	3,000	10,000	23,400	19,895	136,948
56090	672	672	4	6	3	2	15	2,240	33,601	1,800	5,000	9,750	8,288	58,439
56091	360	360	4	6	2	1	9	1,201	18,010	1,200	2,500	5,850	4,442	32,002
56092	370	370	4	6	2	1	9	1,234	18,510	1,200	2,500	5,850	4,566	32,626
56529	1,258	1,258	4	6	4	3	28	4,193	62,889	2,400	7,500	18,200	15,513	106,501
56867	883	883	4	6	3	2	20	2,942	44,132	1,800	5,000	13,000	10,886	74,818
56869	520	520	4	6	2	2	12	1,734	26,014	1,200	5,000	7,800	6,417	46,430
56874	1,403	1,403	4	6	5	3	32	4,678	70,174	3,000	7,500	20,800	17,310	118,783
58090	NEW	80	0	6	1	1	2	267	4,000	600	2,500	1,300	987	9,387
58133	1,361	232	4	6	1	1	6	773	11,593	600	2,500	3,900	2,860	21,453
58092	NEW	75	0	6	1	1	2	250	3,750	600	2,500	1,300	925	9,075
55035	630	630	4	6	2	2	15	2,100	31,500	1,200	5,000	9,750	7,770	55,221
3847	551	551	4	6	2	2	13	1,838	27,564	1,200	5,000	8,450	6,799	49,013
3843	550	550	4	6	2	2	13	1,834	27,508	1,200	5,000	8,450	6,785	48,944
58093	NEW	99	0	6	1	1	3	330	4,950	600	2,500	1,950	1,221	11,221
58094	NEW	238	0	6	1	1	6	793	11,900	600	2,500	3,900	2,935	21,835
55679	238	238	4	6	1	1	6	794	11,907	600	2,500	3,900	2,937	21,844
58096	NEW	240	0	6	1	1	6	800	12,000	600	2,500	3,900	2,960	21,960
58097	NEW	99	0	6	1	1	3	330	4,950	600	2,500	1,950	1,221	11,221
56879	466	466	4	6	2	1	11	1,552	23,277	1,200	2,500	7,150	5,742	39,869
56875	627	627	4	6	2	2	14	2,091	31,367	1,200	5,000	9,100	7,737	54,404
52599	1,361	1,361	4	6	5	3	31	4,536	68,043	3,000	7,500	20,150	16,784	115,477
56877	310	310	4	6	1	1	7	1,034	15,507	600	2,500	4,550	3,825	26,983
4680	500	500	4	6	2	1	12	1,665	24,976	1,200	2,500	7,800	6,161	42,637
58098	NEW	112	0	6	1	1	3	373	5,600	600	2,500	1,950	1,381	12,031
					164	121	1017	147,654	2,214,815	98,400	302,500	661,050	546,321	3,823,086

Eng, Legal & Admin	15%	573,463
Subtotal	-	**4,396,548**
Contigency	15%	659,482
TOTAL	-	**5,056,031**

It should be pointed out that the solutions presented in Figure 5-3 may not be the optimum. It may be possible to reduce the amount of pipe replaced (and thus the cost) by creating more loops. System maps do not contain enough information to determine if looping is possible. Field investigation is recommended.

Eastwood Tanks Zone

Chapter 6
Eastwood Tanks Zone

System Geometry

The Eastwood Tanks Zone is located at the north end of the study area. This zone is characterized by a significant amount of small diameter pipe. There are some dead end lines but this zone is generally well looped. The Eastwood Tanks Zone is shown in Figure 6-1.

Piping

Table 6-1 indicates the size distribution and total length of the piping within the Eastwood Tanks Zone.

Table 6-1
Eastwood Tanks Zone
Reservoir Piping Distribution

Diameter	Length in Zone
4" or less	32,766
6"	105,614
8"	18,082
10"	5,120
12" or greater	27,447
Total Length	188,968

System Valves

The Eastwood Tanks Zone is separated from the adjoining zones by a series of SVs. Table 6-2 indicates the SVs within the Eastwood Tanks Zone Which were closed during the static simulation.

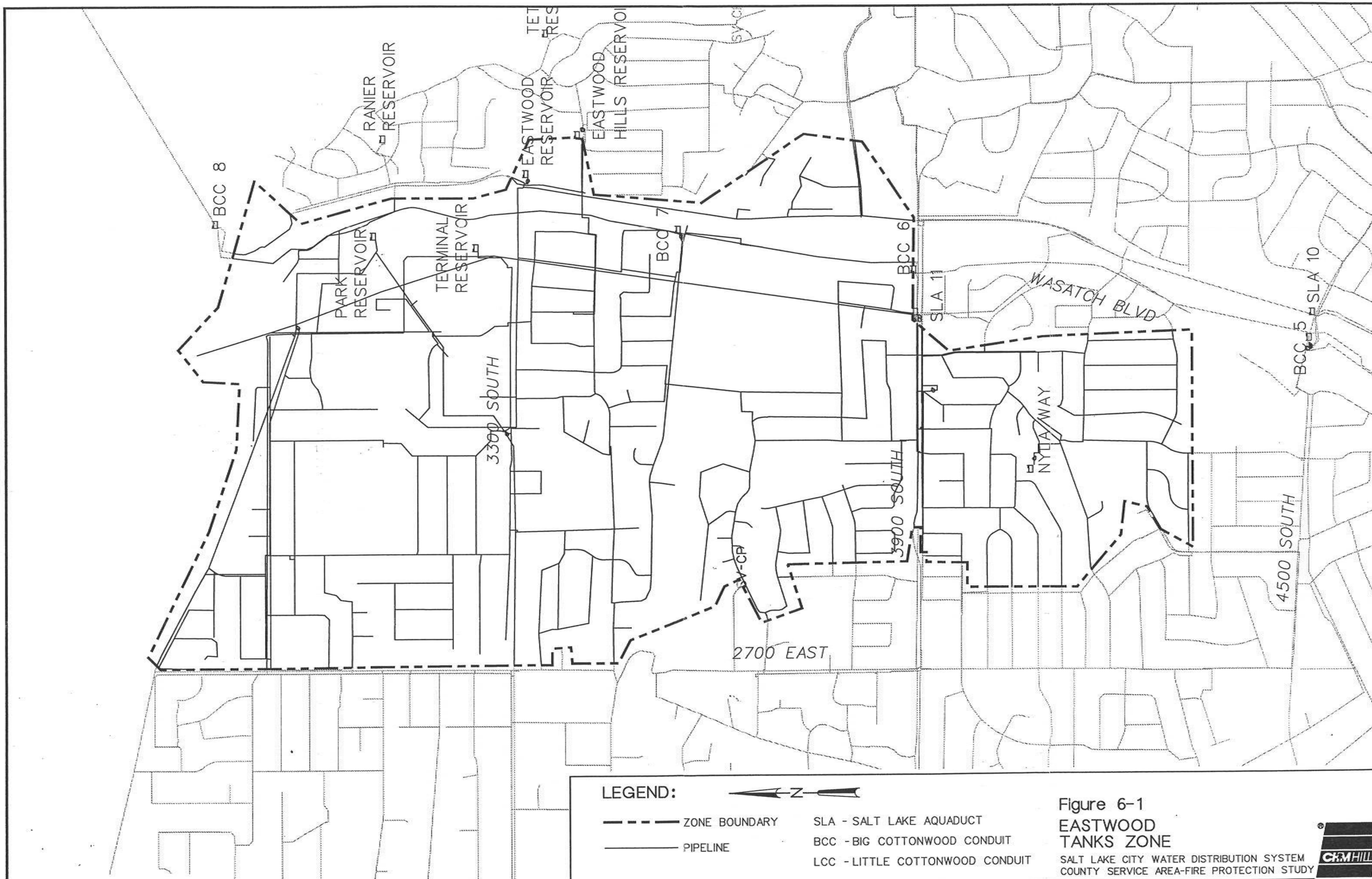


Figure 6-1
EASTWOOD TANKS ZONE
SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

RMW37123\FIGURES\FIRES\ZONEXXXLV

Table 6-2
Eastwood Tanks Zone
Reservoir System Valves

idsys	Location
3977	33rd Booster
4035	33rd Booster
4253	2940 E., Kearns Line
5198	Mt. View
5210	Monza, Wasatch Blvd
5379	Upland, Laurel Crest
5515	Upper Boundary Spring, Wasatch Blvd
5971	3900 S., 3250 E.
6537	3990 S., 3250 E.
7035	Majestic, Marquis
7404	Coronet, Marquis
54336	3900 S., 3250 E.
54343	3120 E., 3900 S.
54360	3075 E. 300 S.
54363	3900 S., 3075 E.
54364	3100 E., 3900 S.
54612	3350 S., Wasatch Blvd
54641	Kearns Line, Metropolitan Way
55707	Eastwood Hills
56340	3300 E., Kearns Line
56459	Wasatch Blvd, 3020 S.
57057	2870 E., Louise
57639	3900 S., 3165 E
57949	Valley Street, FootHill Drive

Reservoirs

Eastwood Reservoir controls the hydraulic grade line within the Eastwood Tank Zone. The static maximum hydraulic grade line of Eastwood Tank is 5054 feet.

Source Pumps

There is one source pump in the Eastwood Tanks. Table 6-3 indicates the location of this source pump, the elevation of the water surface in the well casing, and the status of the pump during the simulation.

Table 6-3
Eastwood Tanks Source Pump

Pump	Location	Status
Nyla Way	3100 E	ON

Booster Pumps

There are five booster pumps in the Eastwood Tanks Zone. Table 6-4 indicates the location of these booster pumps and the status of the pump during the static simulation.

Table 6-4
Eastwood Tanks Zone
Reservoir Booster Pumps

Pump	Location	Status
Eastwood Pump	3300 S.	ON
3900 S. Pump	Kenton	OFF
Virginia-Millcreek	Millcreek	ON
3300 S. Booster	Kearns Line	ON
Kenton Booster	Kenton	ON

Calibration

Prior to the modelling effort, a series of fire hydrant flow tests were conducted within the Salt Lake County Distribution System to assist in the calibration of the model. Within the Eastwood Tanks, two such tests were conducted.

Table 6-5 Eastwood Tanks Calibration Test Results				
	Static Pressure		Dynamic Pressure	
Test No.	Measured	Calculated	Measured	Calculated
26	97	94	72	64.56
29	120	118	38	< 0

During the calibration of the model, runs were made simulating an average demand condition and adjustments made until the calculate pressure was close to the measured pressure as near as possible. Typical adjustments included the opening and closing of system valves, the adjustment of PRV pressure settings, and the verification of node elevations.

After completion of the static calibration, the model was calibrated against the fire flow tests. This is called the dynamic calibration. The intent of the dynamic calibration is to test the system under some stress (high flows) and check the model's performance against that condition. The measured flows from the fire hydrants were modeled and the calculated pressures compared against those measured in the field. Adjustments in the model were made to bring the calculated results in line with the field measured results.

Dynamic calibration often requires an iterative process. Initial field measurements and system maps are used to set up the model, but the situation in the field is frequently not exactly as described in the maps and other system documentation. Inaccurate mapping (with inexact elevations), valves not in the position recorded (either open or closed), or pipes a different size than shown on maps, are all conditions that exist in most water distribution systems. To get an accurate dynamic model it is often necessary to go back into the field and check valve position, elevation, etc. This additional field work to verify model conditions was not done as a part of this study. It is recommended that as time and manpower permit, field verification be undertaken. For example, elevations of reservoirs, pump stations and PRVs are known. However, the elevations for the remainder of the system were obtained from USGS mapping and are likely not completely accurate for a given location. An elevation difference (between actual and the model) of 5 feet would result in a pressure difference of 2.2 psi. The elevation contours on the USGS mapping are 40 feet. Errors in elevations of up to 20 feet could be expected using this type of mapping. A 20-foot elevation difference would result in a pressure difference of almost 9 psi. Static and dynamic calibration results must be viewed with this potential for errors based on erroneous information in mind.The results of the calibration runs are presented in Table 6-5.

The static calibration runs for this zone are very close to the measured static. However, the dynamic runs vary widely in two of the three tests. They not only vary widely they vary in different directions (one is high and another is low). This type of variation cannot be explained with elevation, friction factor or other general system feature. There is a significant difference between the way the system is described in the model and the way it is operating in the field. It may be valves in different position than believed, pipe sizes not as recorded, or pipes connected differently than believed. It is recommended that additional field work be performed in this zone

Fire Run Simulations

The calibrated model was used to simulate fires at various locations within the system. Because of the potential inaccuracies in the model, a minimum pressure of 25 psi was used as the basis for deciding that improvements are needed. Twenty-three fires were simulated in this zone. The locations of the simulated fires are shown in Figure 6-2. Table 6-6 presents the results of the simulated fire runs.

Table 6-6
Eastwood Tanks Fire Flow Results

Simulation No.	Fire Flow (gpm)	Calculated Pressure	Simulation No.	Fire Flow (gpm)	Calculated Pressure
1E	1008.68	L.T.0	13E	1007.20	L.T.0
2E	1008.62	L.T.0	14E	1005.90	24.11
3E	1004.22	L.T.0	15E	1006.82	L.T.0
4E	1008.00	123.92	16E	1007.64	241.05
5E	1015.58	113.87	17E	1008.90	L.T.0
6E	1007.06	100.92	18E	1010.14	107.65
7E	1010.44	119.15	19E	1008.48	103.49
8E	1005.98	L.T.0	20E	1002.00	96.08
9E	1009.68	L.T.0	21E	1008.98	94.94
10E	1008.06	88.86	22E	1005.18	88.38
11E	1003.66	112.29	23E	1007.42	51.21
12E	1005.76	106.15			

Problem Areas

The Eastwood Tank Zone contains a large number of long small-diameter pipelines. It also has some long dead end lines. There is adequate pressure under average conditions but when the system is required to deliver high volumes of water the pressure is dissipated in the small diameter pipe.

Areas in which fire flow and pressure were not achieved are also shown in Figure 6-2.

Recommended Solutions

For each of the areas in which fire flow and pressure were not achieved, an improvement scenario was developed to deliver the required quantity of water to the location at an adequate pressure. Figure 6-3 shows the required improvements for the Eastwood Tanks Zone. The same set of simulated fires run in the existing system were run again with the improvements shown in Figure 6-3. A cost estimate was prepared for each of these improvements. Table 6-7 shows these cost estimates.

It should be noted that the solutions presented in Figure 6-3 may not be the optimum. It may be possible to reduce the amount of pipe replaced (and thus the cost) by creating more loops. System maps do not contain enough information to determine if looping is possible. Field investigation is recommended.

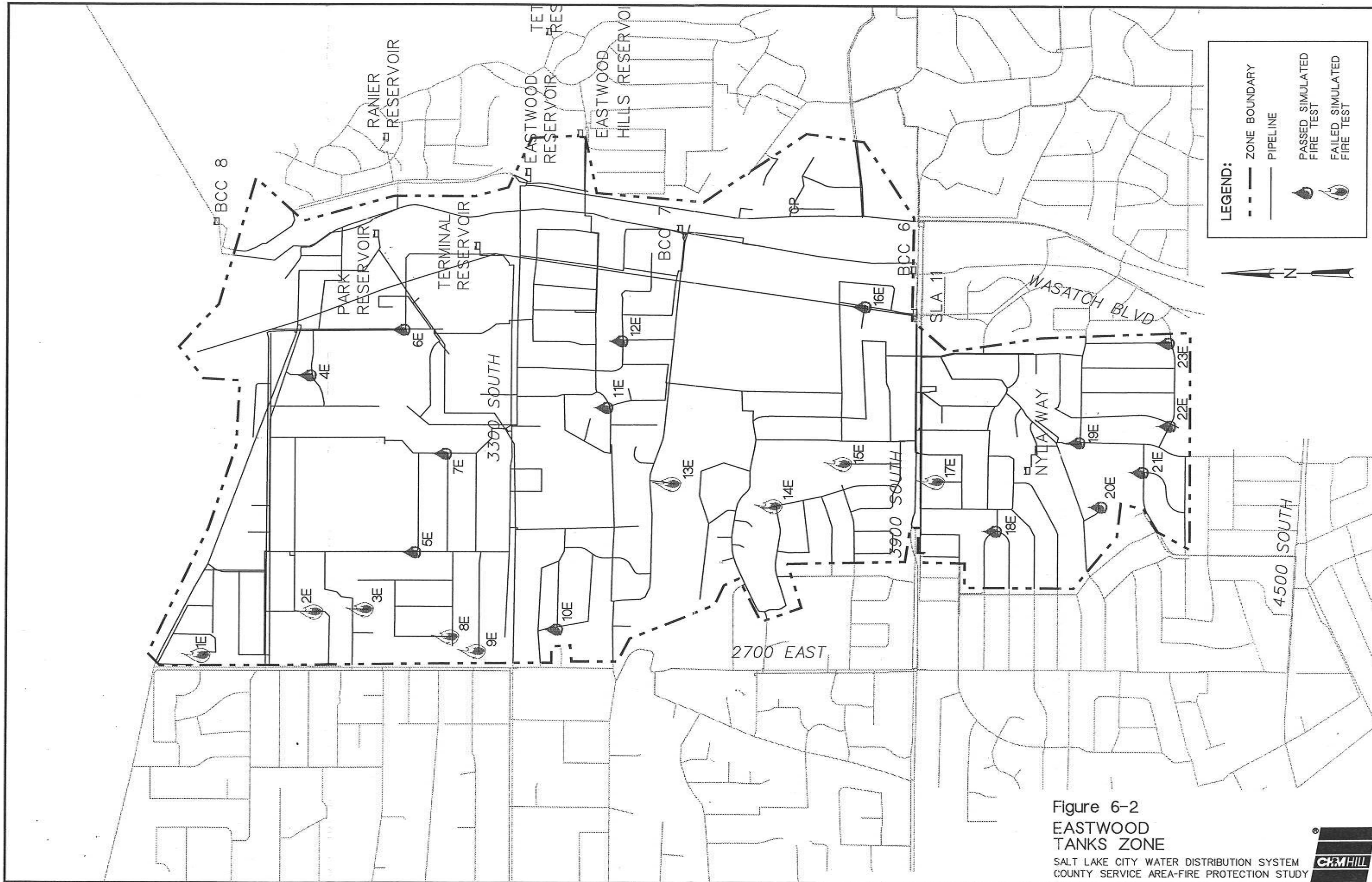


Figure 6-2
EASTWOOD
TANKS ZONE

SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY

CH2M HILL

RMW37123\FIGURES\FIRES\ZONE7-2.DLV

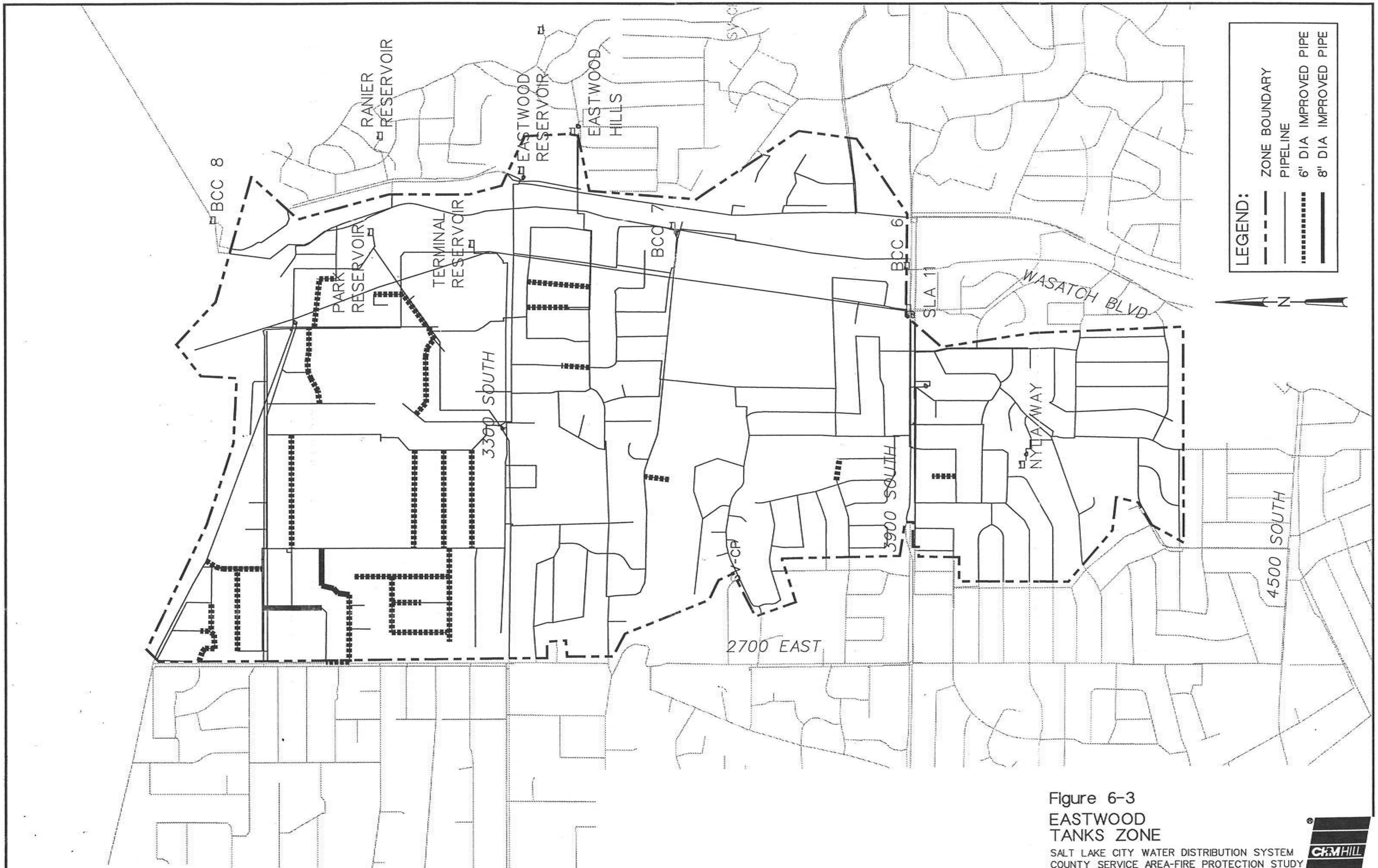


Figure 6-3
EASTWOOD
TANKS ZONE
SALT LAKE CITY WATER DISTRIBUTION SYSTEM
COUNTY SERVICE AREA-FIRE PROTECTION STUDY
CH2M HILL

RMW37123\FIGURES\FIRES\ZONE7-3.DLV

Table 6-7

Salt Lake City Department of Public Utilities
Fire Flow Study
Cost Estimate - Eastwood Zone

Idsys	Existing Length	New Length	Existing Diameter	New Diameter	Number Required				Cost					
					Valves	Hydrants	Service	Repair	Pipe	Valves	Hydrants	Service	Repair	TOTAL
	LF	LF	inch	inch	ea	ea	ea	cy	$	$	$	$	$	$
57012	491	491	2	6	2	1	11	1,636	24,536	1,200	2,500	7,150	6,052	41,439
57005	311	311	1	6	1	1	7	1,036	15,547	600	2,500	4,550	3,835	27,032
58089	563	563	4	6	2	2	13	1,878	28,170	1,200	5,000	8,450	6,949	49,769
57056	77	291	4	6	1	1	7	970	14,550	600	2,500	4,550	3,589	25,789
57047	308	308	4	6	1	1	7	1,025	15,375	600	2,500	4,550	3,793	26,818
57015	1,367	1,367	4	6	5	3	31	4,558	68,366	3,000	7,500	20,150	16,864	115,880
56205	911	911	4	8	3	2	21	3,037	59,221	2,340	5,000	13,650	14,608	94,819
56259	273	273	4	6	1	1	7	911	13,672	600	2,500	4,550	3,373	24,695
56260	435	388	4	6	2	1	9	1,293	19,400	1,200	2,500	5,850	4,785	33,735
56272	431	431	4	6	2	1	10	1,437	21,551	1,200	2,500	6,500	5,316	37,066
56244	302	302	4	6	1	1	7	1,007	15,099	600	2,500	4,550	3,724	26,474
56209	1,024	1,024	4	6	4	3	23	3,414	51,216	2,400	7,500	14,950	12,633	88,699
56240	347	347	4	6	2	1	8	1,155	17,330	1,200	2,500	5,200	4,275	30,505
56233	304	304	4	6	1	1	7	1,013	15,202	600	2,500	4,550	3,750	26,602
56273	674	674	4	6	3	2	15	2,247	33,701	1,800	5,000	9,750	8,313	58,564
58090	563	563	4	6	2	2	13	1,878	28,170	1,200	5,000	8,450	6,949	49,769
56286	1,146	1,146	4	6	4	3	26	3,821	57,314	2,400	7,500	16,900	14,138	98,252
56285	1,144	1,144	4	6	4	3	26	3,812	57,184	2,400	7,500	16,900	14,105	98,089
56284	1,144	1,144	4	6	4	3	26	3,812	57,178	2,400	7,500	16,900	14,104	98,082
56241	1,149	1,149	4	6	4	3	26	3,831	57,463	2,400	7,500	16,900	14,174	98,437
56393	399	399	4	6	2	1	9	1,330	19,951	1,200	2,500	5,850	4,921	34,422
2915	532	532	4	6	2	2	12	1,774	26,606	1,200	5,000	7,800	6,563	47,168
58092	NEW	38	0	6	1	1	1	127	1,900	600	2,500	650	469	6,119
56991	342	272	4	8	1	1	7	907	17,680	780	2,500	4,550	4,361	29,871
56989	252	252	4	8	1	1	6	839	16,359	780	2,500	3,900	4,035	27,574
58093	NEW	120	0	6	1	1	3	400	6,000	600	2,500	1,950	1,480	12,530
58094	47	47	4	6	1	1	2	157	2,350	600	2,500	1,300	580	7,330
58098	70	70	4	6	1	1	2	233	3,500	600	2,500	1,300	863	8,763
4734	286	286	4	6	1	1	7	954	14,316	600	2,500	4,550	3,531	25,497
6444	276	276	4	6	1	1	7	918	13,775	600	2,500	4,550	3,398	24,823
56466	764	764	4	6	3	2	17	2,545	38,179	1,800	5,000	11,050	9,418	65,447
56999	412	412	2	6	2	1	10	1,372	20,584	1,200	2,500	6,500	5,077	35,861
58101	NEW	167	0	6	1	1	4	557	8,350	600	2,500	2,600	2,060	16,110
56323	956	956	4	6	3	2	22	3,187	47,804	1,800	5,000	14,300	11,792	80,696
56330	173	173	4	6	1	1	4	576	8,643	600	2,500	2,600	2,132	16,475
56423	367	367	4	6	2	1	9	1,223	18,350	1,200	2,500	5,850	4,526	32,426
58091	479	479	4	6	2	1	11	1,596	23,936	1,200	2,500	7,150	5,904	40,690
4402	468	468	4	6	2	1	11	1,560	23,406	1,200	2,500	7,150	5,774	40,030
4276	491	491	4	6	2	1	11	1,636	24,533	1,200	2,500	7,150	6,052	41,435
4406	731	731	4	6	3	2	17	2,436	36,541	1,800	5,000	11,050	9,014	63,405
					82	60	472	68,099						1,807,185
									Eng, Legal & Admin				15%	271,078
									Subtotal				-	**2,078,263**
									Contigency				15%	311,739
									TOTAL				-	**2,390,002**

Teton Zone