LOGAN CITY

DRINKING WATER SYSTEM MASTER PLAN

(HAL Project No.: 139.07.100)

FINAL REPORT

JULY 2016

HANSEN ALLEN & LUCE inc
ENGINEERS

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GLOSSARY OF TECHNICAL TERMS

Average Daily Flow: The average yearly demand volume expressed in a flow rate.

Average Yearly Demand: The volume of water used during an entire year.

Build-out: When the development density reaches maximum allowed by planned development.

Demand: Required water flow rate or volume.

Distribution System: The network of pipes, valves and appurtenances contained within a water system.

Drinking Water: Water of sufficient quality for human consumption. Also referred to as Culinary or Potable water.

Dynamic Pressure: The pressure exerted by water within the pipelines and other water system appurtenances when water is flowing through the system.

Equivalent Residential Connection: A measure used in comparing water demand from non-residential connections to residential connections.

Fire Flow Requirements: The rate of water delivery required to extinguish a particular fire. Usually it is given in rate of flow (gallons per minute) for a specific period of time (hours).

Head: A measure of the pressure in a distribution system that is exerted by the water. Head represents the height of the free water surface (or pressure reduction valve setting) above any point in the hydraulic system.

Head Loss: The amount of pressure lost in a distribution system under dynamic conditions due to the wall roughness and other physical characteristics of pipes in the system.

Peak Day: The day(s) of the year in which a maximum amount of water is used in a 24-hour period.

Peak Day Demand: The average daily flow required to meet the needs imposed on a water system during the peak day(s) of the year.

Peak Instantaneous Demand: The flow required to meet the needs imposed on a water system during maximum flow on a peak day.

Pressure Reducing Valve (PRV): A valve used to reduce excessive pressure in a water distribution system.

Pressure Zone: The area within a distribution system in which water pressure is maintained within specified limits.

Service Area: Typically, the area within the boundaries of the entity or entities that participate in the ownership, planning, design, construction, operation and maintenance of a water system.

Static Pressure: The pressure exerted by water within the pipelines and other water system appurtenances when water is not flowing through the system, i.e., during periods of little or no water use.

Storage Reservoir: A facility used to store, contain and protect drinking water until it is needed by the customers of a water system. Also referred to as a Storage Tank.

Transmission Pipeline: A pipeline that transfers water from a source to a reservoir or from a reservoir to a distribution system.

Water Conservation: Planned management of water to prevent waste.

ABBREVIATIONS

ac	acre
ac-ft	acre-feet
DDW	The State of Utah Division of Drinking Water
ERC	Equivalent Residential Connection
GIS	Geographic Information System
gpd	Gallons per Day
gpd/conn	Gallons per Day per Connection
gpm	Gallons per Minute
HAL	Hansen, Allen & Luce, Inc.
MG	Million Gallons
PRV	Pressure Reducing Valve
psi	Pounds per Square Inch
SCADA	Supervisory Control And Data Acquisition

CHAPTER 1 - INTRODUCTION

PURPOSE

The purpose of this master plan is to provide specific direction to the City of Logan for decisions that will be made over the next 5 to 40 years in order to help the City provide adequate water to customers at the most reasonable cost. Recommendations are based on City drinking water demand data and standards established by the Utah Division of Drinking Water (DDW).

SCOPE

The scope of this master plan includes a study of the City’s drinking water system and customer water use including: build-out growth projections, source requirements, water rights, storage requirements, distribution system requirements and water quality. From this study of the water system, an implementation plan with recommended improvements has been prepared. The implementation plan includes conceptual-level cost estimates for the recommended improvements.

The conclusions and recommendations of this study are limited by the accuracy of the development projections and other assumptions used in preparing the study. It is expected that the City will review and update this master plan about every 5 years as new information about development, system performance, or water use becomes available. This master plan replaces the one completed by Black & Veatch in 2007.

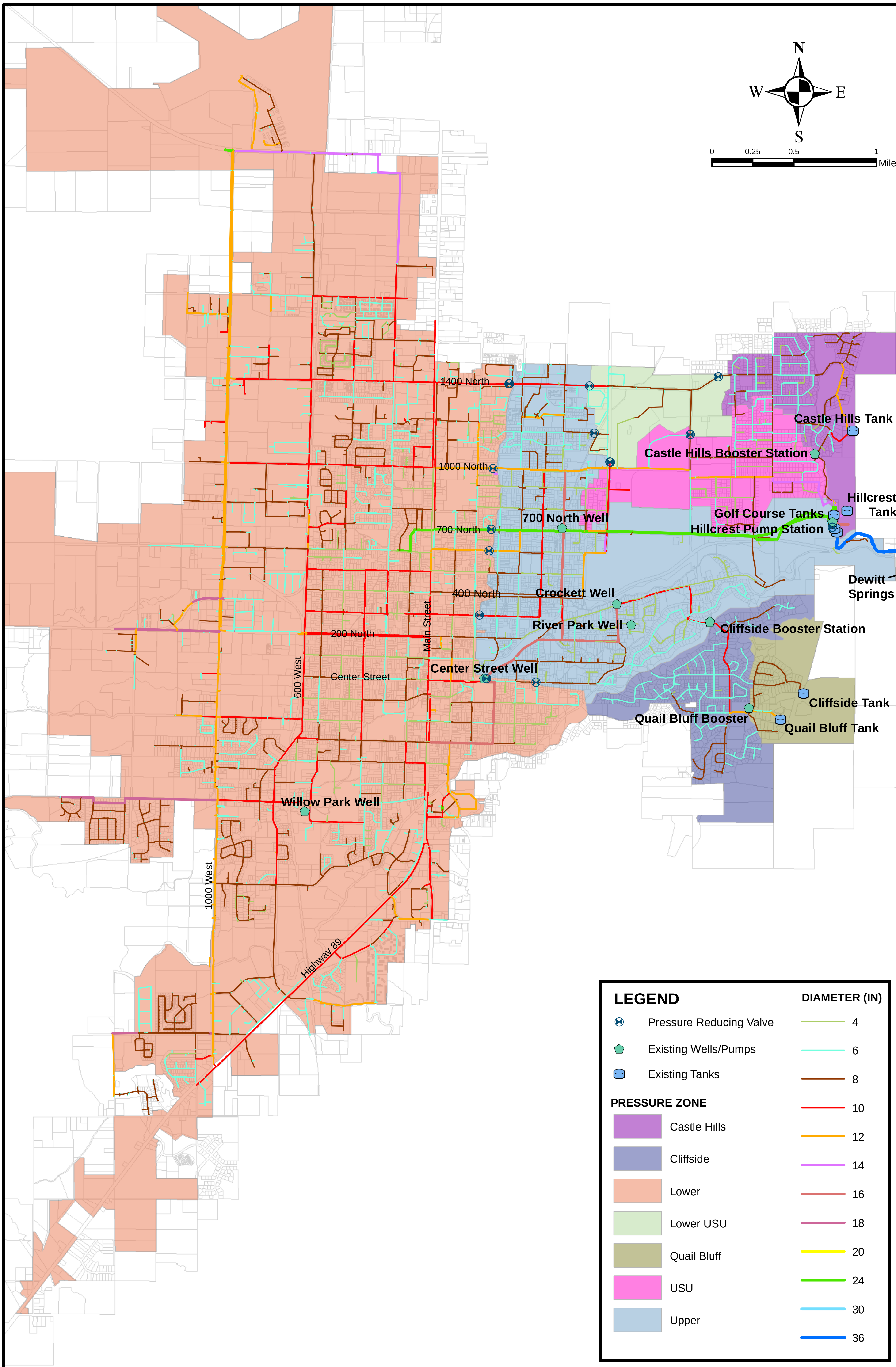
BACKGROUND

Logan City is located in Cache County, Utah and is the county seat and largest city within the county. The City is on the eastern edge of Cache Valley and is bounded on the east by the Bear River Mountains. As of the 2010 census, Logan had a population of 48,174. Except for a few tracts of undeveloped land against the foothills of the Bear River Mountains, the eastern portion of the City is mostly developed. Moreover, East of Main Street, expansion of Logan City is mostly blocked to the north and south by the neighboring cities of North Logan, River Heights, and Providence. However, since Logan has expanded farther to the west than these communities, expansion to the north and south is less restricted in the western portion of the City. As Logan expands westward, the City is also expanding to the northwest and southwest.

Figure 1-1 illustrates the extent of the Logan drinking water system. As shown, the distribution network is divided into six pressure zones with the highest zones along the eastern edge of the City and generally moving lower while progressing to the west.

WATER SYSTEM MASTER PLANNING APPROACH

The Logan water distribution network is made up of a variety of components including pumps, storage facilities, valves, and pipes. The City water system must be capable of responding to daily and seasonal variations in demand while concurrently providing adequate capacity for firefighting and other emergency needs. In order to meet these goals, each of the distribution system components must be designed and operated properly. Furthermore, careful planning is required in order to ensure that the distribution system is capable of meeting the City's needs over the next several decades.



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LOGAN DRINKING WATER MASTER PLAN

EXISTING SYSTEM

FIGURE 1-1

Both present and future needs were evaluated in this master plan. Present water needs were calculated according to Utah Division of Drinking Water (DDW) requirements and compared with actual water use records obtained from billing records and production data. Future water use projections were calculated by analyzing the existing demands for the various types of land uses present in Logan. After determining the unit demand associated with an existing type of land use, the unit demand was applied to undeveloped areas based on the City's future land map.

In order to facilitate the analysis of the Logan water system, a computer model of the system was prepared and analyzed in two parts. First, the performance of existing facilities with present water demands was analyzed. Next, projected future demands were input to the model and the analysis was repeated. Recommendations for system improvement were prepared based on the results of these analyses. In general, this report is organized to follow the outline of the DDW requirements found in section R309-510 of the Utah Administrative Code entitled "Minimum Sizing Requirements".

KEY SYSTEM DESIGN CRITERIA AND PERFORMANCE FINDINGS

Summaries of the key water system design criteria and performance findings for the Logan drinking water system are included in Table 1-1. The design criteria were used in evaluating system performance and in recommending future water system improvements. Criteria development is described in later chapters.

TABLE 1-1
KEY SYSTEM DESIGN CRITERIA

	CRITERIA	2015 EXISTING REQUIREMENTS	ESTIMATED BUILD-OUT REQUIREMENTS
EQUIVALENT RESIDENTIAL CONNECTIONS	Calculated	20,948	48,468
SOURCE			
Peak Day Demand	R309-510-7(2) & (3)	26,676 gpm	61,721 gpm
Average Yearly Demand	R309-510-7(2) & (3)	10,221 gpm	23,650 gpm
STORAGE			
Equalization	R309-510-8(2)	19.2 MG	44.4 MG
Fire Suppression	Total fire flow volume	3.7 MG	3.7 MG
Total		22.9 MG	48.1 MG
DISTRIBUTION MODELING			
Peak Instantaneous	1.21 x Peak Day Demand	32,328 gpm	74,940 gpm
Minimum Fire Flow	@ 20 psi	1,000 gpm	1,000 gpm
Max Operating Pressure	City Preference	130 psi	130 psi
Min. Operating Pressure	City Preference	50 psi	50 psi

Table 1-2 presents the design flows analyzed for the distribution system modeling.

TABLE 1-2
DISTRIBUTION MODELING FLOW SUMMARY

DEMAND	DEMAND PER ERC (gpm)	TOTAL EXISTING DEMAND (gpm)	TOTAL BUILD-OUT DEMAND (gpm)	FLOW RATIO
Average Day	0.49	10,221	23,650	ADD/ADD = 1.00
Peak Day	1.27	26,676	61,721	PDD/ADD = 2.61
Peak Instantaneous	1.73	32,328	74,940	PID/ADD = 3.17

CHAPTER 2 - CONNECTIONS

EXISTING CONNECTIONS

According to connection info for 2015, the Logan distribution network included 10,086 connections. Monthly billing summaries for July 2013 to June 2014 showed the Logan distribution network served an average of 16,266 units during that time. Of that total, 8,587 were residential units while 7,679 units were commercial or multifamily units. An Equivalent Residential Connection (ERC) is a measure used in comparing water demand from non-residential connections to residential connections. The number of ERCs served by the Logan drinking water system was calculated in accordance with guidelines provided by R309-110-4. By definition, each residential connection represents 1 ERC. The average demand per ERC was determined by dividing the total annual residential demand by the total number of residential connections. Using flow data provided by Logan City, the annual volume of water used by residential customers between July 2013 and June 2014 was 5,855 acre-feet. Converting the annual volume to an average flow and dividing by the number of residential connections gives an average demand of 0.42 gpm/ERC. In order to express non-residential demands in terms of ERCs, each non-residential demand was divided by the average demand per residential connection. The total number of ERCs computed for the Logan system was 20,948. The raw data associated with the ERC calculations are included in Appendix A. A per zone breakdown of the ERC distribution is shown in Table 2-1.

TABLE 2-1
EXISTING ERCS

ZONE	ERCs
Logan Canyon	72
Quail Bluff	277
Cliffside	1,462
Castle Hills	721
USU	2,371
Lower USU	327
Upper	3,998
Lower	11,720
TOTAL	**20,948**

Actual usage was considered in formulating a design flow for modeling the Logan drinking water system. Indoor and outdoor demands were determined by reviewing the City's billing data from August and December 2013. The average demand for December 2013 was 3,978 gpm. Converting the average flow to a daily volume and dividing by the total number of ERCs gives a December demand of 273 gpd/ERC. Similarly, the average demand for August 2013 was 19,016 gpm. Converting the August demand to a daily volume and dividing by the total ERCs gives an August demand of 1,307 gpd/ERC. Since there is no outdoor usage in December, the December demand was used to determine the City's indoor demand. Moreover, it was assumed that the indoor demand would be relatively unchanged between December and

August. Based on this assumption the City's outdoor demand was calculated by subtracting the December demand from the August demand. Using this approach, total outdoor demand was calculated to be 15,038 gpm, or 1,034 gpd/ERC.

The calculated value of outdoor demand was compared against the minimum source guidelines for outdoor demands as defined by R309-510-7(3) of the Utah Administrative Code. Logan is located in zone 4 of the map "Irrigated Crop Consumptive Use Zones and Normal Annual Effective Precipitation". As a result, the peak day demand for irrigation is specified as 3.96 gpm/irrigated acre. To facilitate the comparison with State Standards, the outdoor demand of 1,034 gpd/ERC was converted to 0.718 gpm/ERC. Dividing 0.718 gpm/ERC by 3.96 gpm/irrigated acre gives a value of 0.181 irrigated acres per ERC. This was judged to be a reasonable value for Logan City. Therefore, the flow data indicate that outdoor water usage in Logan is similar to the outdoor usage requirement defined by State Standards.

The overriding objective in defining a design flow for modeling was to develop a demand that is representative of the actual conditions of a peak day demand event. The design flow should have a reasonable degree of conservatism; however, excessively conservative demands can lead to over-sizing facilities and pipelines. In order to incorporate conservatism in the design flow, the average indoor demand was assumed to be 400 gpd/ERC, which results in a total average indoor demand of 5,819 gpm. The outdoor demands were not augmented, but were left as 1,034 gpd/ERC so that the total demand for the design flow is 1,434 gpd/ERC. Based on this unit demand, the total of the current indoor and outdoor demands was 20,857 gpm. Two sets of data were available for comparison against the design flow. The first was monthly billing data. As noted previously the August 2013 monthly billing demand was 19,016 gpm. The design flow represents an increase of 1,841 gpm August 2013 flow or about 10%. In addition, production data from August 2013 gave a flow of 20,490 gpm.

This design flow rate indicated in the preceding paragraph is not intended to take the place of the peak day flow of 26,676 gpm as shown in Table 1-1. The peak day source requirement is defined by State Standards and was calculated in accordance with R309-510-7(2) and R309-510-7(3). The required source capacity and fire flow capacity were evaluated based on the peak day flow as outlined by State Standards. The peak day flow is conservative, about 30% higher than the actual observed flows. In evaluating other aspects of general system performance, it can be useful to apply a more realistic flow scenario. For example, representative demands are necessary in order to obtain meaningful results when modeling system efficiency and water quality. The per ERC demand associated with the design flow rate (0.996 gpm/ERC) was also used in calculating the number of build-out ERCs.

CONNECTIONS PROJECTED AT BUILD-OUT

The number of build-out ERCs was determined by starting with the existing ERCs and adding to that number the incremental amount of ERCs associated with future demands. The first step employed in calculating future ERCs was to consider the existing water use for the various types of land uses present within Logan. . Existing water use values were calculated using the City's future land use map and water billing data. The billing data were distributed within GIS and then the demands associated with the various land use types were analyzed. Table 2-2 presents the observed peak day unit demands for land use types in Logan City.

TABLE 2-2
FUTURE LAND USE UNIT DEMANDS

Land Use Type	Peak Day Unit Demand (gpm/ac)
Airport	3.71
Commercial	3.54
Campus Residential	5.43
Commercial Service	3.54
Gateway Overlay	3.54
Industrial Park	3.71
Mobile Home	5.60
Mixed Residential Low	4.03
Mixed Residential Medium	6.72
Mixed Use	4.65
Traditional Neighborhood Residential	5.97
Public	4.03
Resource Conservation	0.0
Recreation	2.80
Town Center	5.24

Based on the demands shown in Table 2-2 along with the City's future land use map, future demands, in gpm, were calculated for the currently undeveloped portions of Logan City. The incremental demand associated with future development was 27,401 gpm. After determining the demands associated with the undeveloped areas, ERCs were calculated by dividing the future demand by 0.996 gpm/ERC. Therefore 27,520 ERCs were added to represent future demands. A per zone breakdown of the build-out ERC distribution is shown in Table 2-3.

TABLE 2-3
BUILD-OUT ERCS

ZONE	ERC
Logan Canyon	72
Quail Bluff	696
Cliffside	2,226
Castle Hills/USU	3,388
Upper/Lower USU	5,158
Lower	36,928
TOTAL	**48,468**

Within the Distribution System Section (Chapter 5) of this report, it is recommended that the Lower USU zone be combined into the Upper Zone and the Castle Hills and USU zones be combined. The ERC totals in Table 2-3 assume that these zone boundary changes will be made. Throughout the remainder of this document, the combined Castle Hills/USU zone will be referred to as the Castle Hills zone and the combined Upper/Lower USU zone will be referred to as the Upper zone. A comparison between Tables 2-2 and 2-3 demonstrate that the majority of the new growth in Logan City is expected to occur in the Lower zone.

As an additional check, the growth in ERCs was compared against the overall population growth for the City. The 2013 population for Logan was estimated to be about 48,174. Using the 2012 Baseline City Population Projections developed by the Utah Governor's Office of Planning & Budget, the population of Logan City is projected to increase to 111,717 in 2060, an increase of about 132%. The ERC projections are intended to cover the same time frame and increase from 20,948 to 48,468, a gain of about 131%. Therefore, the ERC projections are in good agreement with the overall population projections.

CHAPTER 3 - SOURCES

EXISTING SOURCES

Logan currently uses a spring and four wells to provide water to the City's drinking water system. A summary of the City's sources is provided in Table 3-1.

TABLE 3-1
SUMMARY OF LOGAN SOURCES

NAME	ZONE	CAPACITY (gpm)
DeWitt Springs	Logan Canyon	10,000
7th North Well	Upper	4,000
Crocket Well	Upper	5,500
Center Street Well	Lower	4,500
Willow Park Well	Lower	4,000

Based on these values, the Logan sources currently have a total capacity of 28,000 gpm, with roughly a third of the City's water coming from springs and the rest from wells.

PUMP STATIONS

Logan has four pump stations. The City's pump stations are summarized in Table 3-2.

TABLE 3-2
LOGAN PUMP STATIONS

NAME	FROM ZONE	TO ZONE	PUMPS	RATED CAPACITY (gpm)
Hillcrest	Upper	USU	2 x 2,500 gpm	2,500
Castle Hills	USU	Castle Hills	2 x 700 gpm	700
Cliffside	Upper	Cliffside	2 x 1,500 gpm	1,500
Quail Bluff	Cliffside	Quail Bluff	2 x 1,000 gpm	1,000

The pump stations allow the City to supply water to zones that do not have sources of their own. The rated capacity of a pump station is the total flow of the pump station with largest pump out of service.

EXISTING SOURCE REQUIREMENTS

DDW standards require that distribution network water sources must be able to meet the expected water demand for two conditions: peak day demand and average yearly demand. These criteria will be addressed in the following paragraphs.

Existing Peak Day Demand
Peak day demand is the water demand on the day of the year with the highest water use and is used to determine the required source capacity under existing and build-out conditions. According to the State of Utah drinking water standards, **26,676 gpm** of source water is required to meet the existing demands of Logan City. A per zone breakdown of the existing source requirements is shown in Table 3-3. "Existing Source Capacity" is the total of the drinking water sources which supply water to the pressure zone. "PRV Flows" summarizes the flow in and out of each zone through PRVs. "In" and "Out" are the flows through the PRVs and "From" and "To" are the origination and destination zones of the flow. Similarly, "Pumped Flows" summarizes the flow in and out of each zone through pump stations. "Remaining Capacity" is the summation of all of the flows into the zone minus all of the flows out of the zone. Overall, the City has a total excess capacity of 1,324 gpm. However, several of the individual zones including the Cliffside, Castle Hills, and USU zones do not have adequate capacity due to limitations in pump station capacity.

Existing Average Yearly Demand
Water utilities must also be able to supply the average yearly demand. Average yearly demand is the average volume of water used during the course of one year. Using State Standards, the average yearly demand for the Logan distribution system was found to be **16,487** ac-ft.

BUILD-OUT SOURCE REQUIREMENTS

Water demand is expected to increase as development within the city continues. As with existing water use, future water source needs were evaluated on the basis of peak day demand and average yearly demand. Each requirement is addressed separately in the following paragraphs.

Build-Out Peak Day Demand
The projected total peak day demand at build-out is **61,721 gpm**. Table 3-4 provides a per zone summary of the build-out source requirements for Logan City with each column heading as previously defined. As mentioned previously, it is recommended that the USU and Castle Hills zones should be combined as will be discussed in Chapter 5. Therefore, the two zones are combined in Table 3-4 which summarizes the build-out source requirements. In all, based on the sources the City is currently utilizing, the projected deficit in source capacity is 33,721 gpm under build-out conditions.

Build-Out Average Yearly Demand
The projected average yearly demand at build-out is **38,147 ac-ft** and the increase between the existing and build-out conditions is projected to be 18,064 ac-ft. It is expected that the increased demand will be offset by increases in the City's well capacity.

SOURCE REDUNDANCY

In addition to meeting the peak day and annual source requirements, it is also recommended that redundancy be incorporated into the drinking water system. The distribution system should have adequate capacity to meet all of the demand objectives with a major source unavailable. Based on the reviewed flow data, the largest source in the Logan system is DeWitt Springs, with a flow of 10,000 gpm.

TABLE 3-3
EXISTING SOURCE REQUIREMENTS

Zone	ERCs	Zone Demand (gpm)	Existing Source Capacity (gpm)	PRV Flows				Pumped Flows				Remaining Capacity (gpm)
				In (gpm)	From	Out (gpm)	To	In (gpm)	From	Out (gpm)	To	
Logan Canyon	72	92	10,000	0	NA	9,908	Upper	0	NA	0	NA	0
Quail Bluff	277	353	0	0	NA	0	NA	353	Cliffside	0	NA	0
Cliffside	1,462	1,862	0	0	NA	0	NA	1,500	Upper	353	Quail Bluff	-715
Castle Hills	721	918	0	0	NA	0	NA	700	USU	0	NA	-218
USU	2,371	3,019	0	0	NA	416	Lower USU	2,500	Upper	700	USU	-1,635
Lower USU	327	416	0	416	USU	0	NA	0	NA	0	NA	0
Upper	3,998	5,091	9,500	9,908	Logan Canyon	6,425	Lower	0	NA	1,500 2,500	Cliffside USU	3,892
Lower	11,720	14,925	8,500	6,425	Upper	0	NA	0	NA	0	NA	0
	20,948	26,676	28,000	15,749		15,749		5,053		5,053		1,324

TABLE 3-4
BUILD-OUT SOURCE REQUIREMENTS

Zone	ERCs	Zone Demand (gpm)	Existing Source Capacity (gpm)	PRV Flows				Pumped Flows				Remaining Capacity (gpm)
				In (gpm)	From	Out (gpm)	To	In (gpm)	From	Out (gpm)	To	
Logan Canyon	72	92	10,000	0	NA	9,908	Upper	0	NA	0	NA	0
Quail Bluff	696	886	0	0	NA	0	NA	1,000	NA	0	NA	114
Cliffside	2,226	2,835	0	0	NA	0	NA	1,500	Cliffside	1,000	Quail Bluff	-2,335
Castle Hills	3,388	4,314	0	0	NA	0	NA	2,500	Upper	0	NA	-1,814
Upper	5,158	6,568	9,500	9,908	Logan Canyon	9,306	Lower	0	Upper	1,500 2,500	Cliffside Castle Hills	-466
Lower	36,928	47,025	8,500	9,306	Upper	0	NA	0	NA	0	NA	-29,219
	48,468	61,721	28,000	19,214		19,214		5,000		5,000		-33,721

SOURCE RECOMMENDATIONS

Under existing conditions, three zones have source capacity deficiencies. The Cliffside, Castle Hills, and USU pressure zones each receive water via pump stations that have insufficient capacity based on state source capacity standards. Because it is recommended that the USU and Castle Hills zones should be combined, the source deficiencies for those zones will be addressed together. The following paragraphs detail the specific recommendations for meeting the source requirements of each pressure zone.

The future combined USU and Castle Hills pressure zone will receive all water via the Hillcrest pump station. In order to meet existing capacity requirements and to plan for future needs for the two zones, the capacity of the Hillcrest pump station will need to be increased by about 2,000 gpm. In addition to increasing the capacity of the pump station, it is further suggested that the pumps and piping should be modified. Currently, the Hillcrest pump station pumps out of the Golf Course 6, 7, 8, 9 tank. Water is supplied to the tank via a pipeline which conveys water from DeWitt Springs down Logan Canyon. When the DeWitt Spring water reaches the storage reservoir, it is run through a hydropower turbine in order to produce power and to reduce the head of the water to the level of the Golf Course 6, 7, 8, 9 tank. It is recommended that the City modify the piping and the Hillcrest pump station to allow water to be pumped to the Hillcrest tank prior to going through the hydroelectric turbine. While this modification would reduce the City's power output, the reductions in the cost to pump water to Castle Hills zone would more than offset the lost power output. Additional discussion regarding this project is included within the Chapter 6 of this report.

Similarly, the Cliffside Zone's sole source of water is the Cliffside pump station. The Cliffside pump station has a capacity shortfall of 715 gpm under existing conditions and 2,335 gpm under buildout conditions. In order to meet the source requirements of the Cliffside Zone, the pump station capacity would need to be increased by about 2,350 gpm in order to meet source requirements. It is recommended that the capacity of the pump station should be increased along with additional improvements that would improve the energy efficiency of the system. The energy efficiency improvements would involve installation of a new supply pipeline to the transmission line at the mouth of Logan Canyon. The new supply line would allow water to be supplied to the Cliffside Pump station at a higher head and would bypass bottlenecks in capacity which exist within the Upper Pressure Zone pipelines. Additional information regarding the recommended supply pipeline are included within Chapters 5 and 6 of this report.

Under build-out conditions, the overall projected shortfall in peak day source capacity is 33,721 gpm. During the preparation of this master plan, the City identified new water sources which they plan to bring online during coming years. Logan City has already constructed a new well at the City's River Park which has not yet been equipped. For this master plan, it has been assumed that the new River Park well will have a capacity of 5,500 gpm. The City also plans to construct a new well at Jens Johansen Park. Because Jens Johansen Park is near River Park, a flow of 5,500 gpm was also assumed for this well. In addition, the City currently owns a well at about 270 East along 1000 North. Although the well is owned by the City, water from the well is not currently used in the drinking water system. Instead, water from the well is discharged to the Logan Northern Canal as part of a water exchange between Logan and Northern Irrigation Company and Logan Hyde Park Smithfield Canal Company. It has been assumed that under build-out conditions the water from the 1000 North Well will be used in the drinking water system. A review of the historical data for the well indicates that the highest average flow rate over a month's time was about 3,700 gpm in August 2001. Based in this data, a peak flow rate of 4,000 gpm was assumed. However, the current status of the well is not known and some work may be needed at the well site in order to prepare the well for drinking water production.

If these planned sources are able to supply water at the stated capacities, the City would be able to increase their current source capacity by 15,000 gpm. However, based on source capacity requirements the City would still have a deficit of about 18,700 gpm. This shortfall could be met by constructing additional wells. Since the majority of the capacity shortfall is associated with the expanding Lower Zone, it is recommended that additional wells should be located in the west, if possible. In particular, new sources would be especially beneficial in the far northwest and southwest areas of the Lower Zone. These areas are quite distant from the City's existing drinking water sources. As a result, under build-out conditions the head loss associated with conveying water to these areas can result in relatively large pressure swings of 30 psi or more. Locating a water source near these outlying areas greatly aids in reducing pressure swings.

Additionally, the City could also consider applying to the Utah Division of Drinking Water (DDW) for a source requirement exemption. Provisions exist within the Utah Code that allow water providers to apply for and receive exemptions with regard to the State defined requirements. In the past, few, if any, exemptions have been granted. However, the State is currently reviewing their practices for evaluating exemption requests. Because of the review, it may become more possible to obtain an exemption in the future. If the City does apply for a source capacity exemption, it is recommended that the minimum capacity that the City should plan for is about 58,300 gpm. This value was obtained based on existing demand data while providing for redundancy. The existing demand for Logan is 0.996 gpm per ERC. Based on this value, the total required capacity is 48,274 gpm under build-out conditions. It is recommended that source redundancy should be included so that the City would have adequate water if their largest drinking water source were off line. For Logan, the largest source is DeWitt springs with a capacity of 10,000 gpm. Therefore, if the City was able to obtain an exemption, it is still recommended that an additional 14,300 gpm should be added to the system. It is anticipated that at least three new wells would need to be constructed to provide this flow volume. Table 3-5 provides a summary of the recommended source projects along with the priority associated with each project. The project priorities were evaluated based on whether the project meets an existing or future need and the expected time frame for when the project would be needed. The locations of the recommended source projects are shown on Figure 5-3 within the "Distribution System" chapter.

TABLE 3-5
SOURCE RECOMMENDATIONS

Priority	Map ID	Improvement
1	W-1	Cliffside Pump Station – Increase capacity by 2,350 gpm and upgrade the pumps to pump from the recommended higher head supply pipeline
2	W-2	Hillcrest Pump Station Improvements – Increase the capacity by 2,000 gpm and reconfigure the pumps and piping so the pump station can pump directly from the DeWitt Spring transmission pipeline
3	W-3	Equip River Park Well and build well house
4	W-4	Construct a new drinking water well at Jens Johansen Park
5	W-5	Upgrade the 1000 North Well, if needed, to allow pumping into the drinking water distribution network
6	W-6	Construct 3 new additional wells, preferably with some of the new wells located within the Lower Pressure Zone

CHAPTER 4 - STORAGE

EXISTING STORAGE

The City's current drinking water system includes seven storage facilities with a total capacity of 11.34 MG. The locations of storage facilities are shown on Figure I-1. Table 4-1 presents a listing of the names and select attributes of the Logan water storage tanks.

TABLE 4-1
EXISTING STORAGE TANKS

Name	Type	Dimensions (ft)	Volume (MG)	Outlet Level	Emergency Storage Level	Fire Suppression Level	Overflow/ Equalization Level
Quail Bluff	Concrete	60	0.24	5,138.1 (0.5 feet)	NA	5146.6 (9.0 feet)	5,149.02 (11.42)
Cliffside	Concrete	110	1.0	5,050.54 (0.3 feet)	NA	5053.1 (2.86 feet)	5,065.09 (14.85)
Castle Hills	Concrete	75	0.5	5,040.63 (0.3 feet)	NA	5046.1 (5.77 feet)	5,055.68 (25.0 feet)
Hillcrest	Concrete	140	2.0	5,039.22 (0.3 feet)	NA	5042.3 (3.38 feet)	5,056.67 (17.75 feet)
Golf Course 3	Concrete	108	1.0	4,853.3 (0.3 feet)	NA	4861.2 (8.2 feet)	4,868.5 (15.5 feet)
Golf Course 4	Concrete	108	1.0	4,853.3 (0.3 feet)	NA	4861.2 (8.2 feet)	4,868.5 (15.5 feet)
Golf Course 6, 7, 8, 9	Concrete	72 x 550	5.6	4854.00 (0 feet)	NA	4861.2 (7.2 feet)	4875.00 (21.0 feet)

DDW standards suggest that emergency storage can be considered in the sizing of storage facilities (R309-510-8(1)(c)). Emergency storage is intended to provide a safety factor that can be used in the case of unexpectedly high demands, pipeline failures, equipment failures, electrical power outages, water supply contamination, or natural disasters. Based on previous experience developing master plans, no emergency storage has been recommended because the required equalization storage as set by Utah R309-510-8 is generally sufficiently conservative such that additional storage for emergencies is not needed. Accordingly, no tank levels were specifically for emergency storage in Table 4-1.

EXISTING STORAGE REQUIREMENTS

According to DDW standards, storage tanks must be able to provide: 1) equalization storage volume to make up the difference between the peak day flow rate and the peak instantaneous demand which is considered to be 400 gallons per ERC; and 2) fire suppression storage volume to supply water for firefighting. A summary of the existing storage requirements for the drinking water system is shown in Table 4-2.

TABLE 4-2
EXISTING STORAGE REQUIREMENTS

PRESSURE ZONE	ERCs	REQUIRED STORAGE (MG)			EXISTING STORAGE (MG)	REMAINING (MG)
		Equalization (MG)	Fire Suppression (MG)	Total (MG)		
Logan Canyon	72	0.07	0.00	0.07	0.00	-0.07
Quail Bluff	277	0.25	0.18	0.43	0.24	-0.19
Cliffside	1,462	1.34	0.18	1.52	1.00	-0.52
Castle Hills	721	0.66	0.18	0.84	0.50	-0.34
USU	2,371	2.17	0.18	2.35	2.00	-0.35
Lower USU	327	0.30	0.18	0.48	0.00	-0.48
Upper	3,998	3.66	1.00	4.66	7.60	2.94
Lower	11,720	10.74	1.70	12.44	0.00	-12.44
TOTAL	20,948	19.19	3.60	22.79	11.34	-11.45

Overall, the City has an existing deficit of 11.45 MG in drinking water storage capacity. Recommendations for addressing the storage deficit have been included at the end of this chapter.

Equalization Storage

The need for equalization storage is highest during the irrigation season on days of peak water use. Equalization storage is used to meet peak demands during the time when demand exceeds the capacity of the sources. For Logan, the required equalization storage was calculated according to the guidelines outlined by Utah Administrative Code R309-510-8(2). The existing equalization storage requirement for Logan was found to be **19.19 MG.**

Fire Suppression Storage

Fire suppression storage is required for water systems that provide water for firefighting. The Logan Fire Department has jurisdiction over the City and the fire flow requirements in this master plan were supplied by the Fire Marshall, Craig Humphreys. The contact information for the Logan Fire department is as follows:

Phone: 435-716-9515

Address: 76 East 200 North
Logan, UT 84321

The minimum fire flow requirement for a building was **1,000 gpm for 2 hours.** Depending on the size of the building and the type of construction, higher flow requirements were assessed based on the International Fire Code and fire department recommendations. The required fire suppression storage for a given zone is determined by the building in the zone with the highest fire flow requirement.

The Logan Self Storage buildings at 1095 West 600 North, which is located in the Lower zone, were assessed a required flow of **7,000 gpm for 4 hours**. The associated storage volume for that fire suppression flow is 1.7 MG. The Upper Zone was assessed a fire storage requirement of 1.0 MG which corresponds to **4,000 gpm for 4 hours**. For a complete listing of the buildings with large fire demands that were reviewed during this study please refer to Appendix B.

In addition, the water system should be managed so that the storage volume dedicated to fire suppression is available to meet fire flow requirements whenever or wherever it is needed. This can be accomplished by designating minimum storage tank water levels that provide reserve storage equal to the required fire suppression storage. Although it is important to utilize equalization storage, typical daily water fluctuations in the tanks should never be allowed below the minimum established levels except during fire or emergency situations. Fire suppression tank levels are included in Table 4-1.

BUILD-OUT STORAGE REQUIREMENTS

The storage volumes required at build-out are based on the same equalization, fire suppression, and operational storage requirements as were calculated for the existing conditions. The build-out equalization storage will be higher than existing conditions because the number of ERCs is projected to increase. Conversely, required fire suppression volumes are projected to decrease as a result of combining the USU and Castle Hill zones and the Lower USU and Upper zones. Additionally, the required fire suppression volumes for individual zones may be lower at build-out as a result of older buildings being replaced with newer buildings that meet updated building codes. However, because it is not known if or when such upgrades will occur, existing fire suppression volumes have been carried over to the build-out projections. The City's future storage requirements at build-out are presented in Table 4-3.

TABLE 4-3
BUILD-OUT STORAGE REQUIREMENTS

PRESSURE ZONE	ERCs	REQUIRED STORAGE (MG)			EXISTING STORAGE (MG)	REMAINING (MG)
		Equalization (MG)	Fire Suppression (MG)	Total (MG)		
Logan Canyon	72	0.07	0.00	0.07	0.00	-0.07
Quail Bluff	696	0.64	0.18	0.82	0.24	-0.58
Cliffside	2,226	2.04	0.18	2.22	1.00	-1.22
Castle Hills	3,388	3.10	0.18	3.28	2.50	-0.78
Upper	5,158	4.73	1.00	5.73	7.60	1.87
Lower	36,928	33.84	1.70	35.54	0.00	-35.54
TOTAL	48,468	44.42	3.24	47.66	11.34	-36.32

STORAGE RECOMMENDATIONS

In order to address the existing storage deficiency of 11.45 MG, it is recommended that Logan construct an additional 10 MG of storage in the Lower Zone and apply for a storage requirement exemption from the undersecretary of the Utah Division of Drinking Water. Additional information regarding these recommendations is provided within the following paragraphs.

The Lower Zone has the largest existing storage shortfall of 12.44 MG. In addition, the majority of Logan's new growth is projected to occur along the west edge of the City within the Lower Zone. As a result, most of the new storage volume should serve that Zone. Several areas within the City were reviewed and given a preliminary evaluation regarding storage tank suitability. A few of the areas that were considered are as follows:

1. Bluff located between Sumac Drive and Quail Way at about 1450 East
2. Gravel pit just east of 1200 East at about 1300 North
3. Property just east of 1113 Cliffside Drive
4. Parking lot just south of USU's Old Main building

Potential tank locations were given preliminary consideration based on having the proper elevation to supply water to the Lower Zone. Next, the locations were evaluated based on property availability and proximity to water sources. Proximity to existing and planned water sources was considered in order to minimize the need for additional transmission pipelines.

Based on the outlined criteria, the preferred location recommended for constructing a new storage tank is site #1. Site #1 is relatively close to existing sources and property is available at the proper elevation. Site #2 would be a good location based on land availability and location. Moreover, an additional storage tank that would feed the northern portion of the lower zone would also benefit the hydraulics of the distribution system. However, there are no sources near site #2. Therefore, building a tank at that location would require a significant investment in transmission pipelines in order to convey water between existing sources and the tank, and between the tank and the Lower Pressure Zone. Options #3 and #4 are more conveniently located with regard to existing sources; however, due to concerns regarding the availability of land, those locations received lower consideration.

For convenience, the new tank at Site #1 will be referred to as the Bluff Tank. Based on the size and shape of the site, it is estimated the Bluff Tank could be built with a capacity of 10 MG. As stated previously, the new tank would be relatively close to existing and planned water sources. However, a new transmission pipeline will be needed to connect the proposed tank and planned drinking water sources to the Lower Zone. Recommendations for the new transmission pipeline are provided within Chapter 5 of this report.

With the completion of the new Bluff Tank, small storage deficits will remain in Logan's higher elevation pressure zones. However, modeling indicates that the storage in those zones is adequate for system operation. For that reason, it is recommended that Logan apply for a storage requirement exemption rather than build additional storage to serve the higher elevation pressure zones. The Utah Division of Drinking Water (DDW) requires drinking water utilities within the State to meet minimum sizing guidelines as defined by Utah Administrative Code R309-510. If the facilities of a drinking water provider do not meet the outlined criteria, the DDW may disallow the provider from adding new connections or beginning new projects until the deficiency has been addressed. A storage exemption would provide Logan City with formal recognition that their storage facilities are not deficient, even though Logan's storage is less than outlined by the Utah Code.

Under the projected build-out conditions, the storage deficit grows to 36.32 MG. Some of the future storage deficit could also be met by receiving a storage exemption. However, even if a storage exemption is granted to Logan, additional storage will be needed in order for the distribution to operate properly. Specifically, new storage is recommended for the Cliffside and the Lower pressure zones even if a storage exemption is granted to Logan City.

Although there is an existing deficiency of 0.52 MG for the Cliffside Zone, modeling indicates that the additional storage will not be needed until significant new development occurs. Therefore, if Logan is able to receive a storage exemption, the new storage will not be needed until development occurs on the land south of the existing Cliffside Zone. The new tank would be constructed to the southwest of the existing pressure zone. Extensive development is not expected in that area during the immediate future, and it is expected that construction of the tank will not be needed for many years.

Water is conveyed a long distance in order to serve the western edge of the Lower Zone, particularly at the northern and southern extremes. As a result, the pressure fluctuations in those areas are relatively large during peak day flows, especially under build-out conditions. One possible solution for limiting pressure fluctuations in these areas is constructing on-grade storage in the northwest and/or southwest areas of the Lower Zone. The storage could be utilized by allowing water to fill the tank during off peak times and then pumping out of the tank into the Lower zone during peak usage times. An alternative option would be to construct new wells in these locations as mentioned previously in the Chapter 3 (Source Recommendations). The new wells could pump either directly into the Lower Zone or into storage tanks and then pumped into the zone via booster stations. However, there is no state requirement for pressure fluctuations, and the City is able to meet all of the minimum pressure guidelines without the addition of on-grade storage. For that reason, costs have not been included for the on-grade storage facilities or for the associated booster stations that would also be needed. Instead, these options are presented for the City's consideration in determining the level of service they would prefer to supply. A specific discussion of the pressure fluctuations is included within Chapter 5 of this report. Table 4-4 provides a summary of the recommended storage projects and the respective priority of the project. The priorities of the storage projects were evaluated based on the timing of when the project would be needed.

TABLE 4-4
STORAGE RECOMMENDATIONS

Priority	Map ID	Improvement
1	S-2	Construct a 10 MG tank on the Bluff located between Sumac Drive and Quail Way at about 1450 east
2	S-1	Construct a 1 MG Cliffside Zone storage tank southwest of the existing Cliffside Zone

CHAPTER 5 - DISTRIBUTION SYSTEM

EXISTING DISTRIBUTION SYSTEM

The distribution system consists of all pipelines, valves, fittings, and other appurtenances used to convey water from the water sources and storage tanks to the water users. The existing water system contains about 220 miles of distribution pipe ranging in size from 4 to 36 inches in diameter. Figure 5-1 presents a summary of pipe length by diameter.

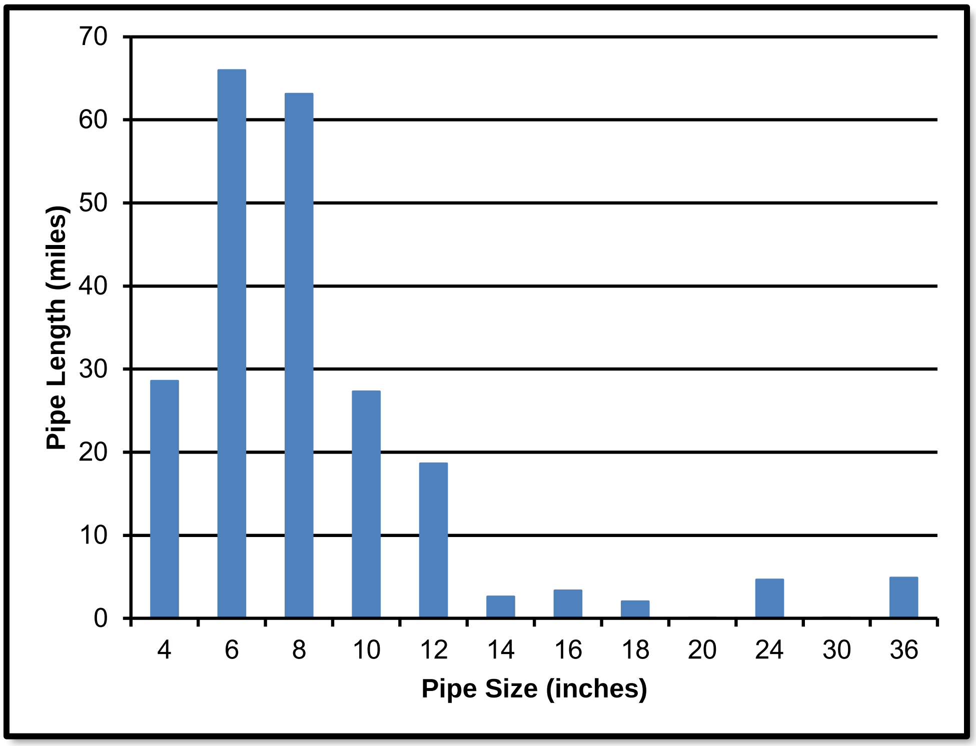


FIGURE 5-1: SUMMARY OF PIPE LENGTH BY DIAMETER

EXISTING DISTRIBUTION SYSTEM REQUIREMENTS

Utah Administrative Code R309-105-9(1) applies to existing systems approved prior to January 1, 2007 and requires that distribution systems be able to maintain 20 psi at all points in the system during normal operating conditions and during conditions of fire flow and peak day demand. R309-105-9(2) adds the following minimum water pressure constraints: (a) 20 psi during conditions of fire flow and fire demand experienced during peak day demand; (b) 30 psi during peak instantaneous demand; and (c) 40 psi during peak day demand. R309 105-9(2) applies to new systems approved after January 1, 2007 and to new areas or subdivisions of existing systems. Much of Logan is subject to R309-105-9(1); however, new developments will need to meet the criteria outlined by R309-105-9(2). In addition, Logan prefers that the distribution system maintain a minimum of 50 psi at all points in the system under peak instantaneous conditions to avoid customer complaints.

Existing Peak Instantaneous Demand

Peak instantaneous demand is the highest demand on the peak day. The pipes in the distribution system must be large enough to convey the peak instantaneous demand while maintaining a pressure at connections above 50 psi. The peak day instantaneous demand was determined based on the design flow of 20,857 gpm and a peaking factor of 1.55. The peaking factor was determined by analyzing SCADA production data for Logan City. With this peaking factor, the peak instantaneous flow rate was **32,328 gpm**.

Existing Peak Day Plus Fire Flow Demand

In accordance with DDW regulations, the distribution system must be capable of delivering fire flow to a specified location within the system while supplying the peak day demand defined by state standards (26,676 gpm) to the entire distribution system and maintaining 20 psi minimum pressure at all delivery points within the distribution system. A minimum fire flow demand of **1,000 gpm** or more is required for all fire hydrants in the system. Larger fire flows are required at larger structures throughout the system based on the International Fire Code and recommendations from the Logan Fire Department. As noted previously, Logan Self Storage was assessed a required flow of **7,000 gpm for 4 hours**, which was the largest requirement in City. The Upper Zone was assessed a required flow of **4,000 gpm for 4 hours,** while the remaining zones were each assessed a flow of **1,500 gpm for 2 hours.**. For a complete listing of the fire flows considered at large buildings refer to Appendix B. All fire flows were simulated under the state defined peak day demand conditions of 26,676 gpm as outlined by R309-510-9(4).

BUILD-OUT DISTRIBUTION SYSTEM REQUIREMENTS

The existing system requirements also apply to the projected build-out system. As previously noted, the DDW requires the distribution system be able to maintain 20 psi at all points in the system under peak instantaneous conditions and peak day plus fire flow.

Build-Out Peak Instantaneous Demand

The build-out peak day design flow for the distribution system was 48,258 gpm. Assuming the same peaking factor of 1.55 applies to the build-out peak day demand gives a peak instantaneous demand of **74,800 gpm**.

Build-Out Peak Day Plus Fire Flow Demand

The build-out peak day plus fire flow scenario was evaluated in a similar manner as compared to the existing peak day plus fire flow scenario. It was assumed that the fire flow requirements would not change between the existing and build-out conditions. Generally, this is a conservative assumption as, over time, older buildings are replaced with newer buildings constructed in accordance with updated building codes. The build-out fire flow scenario was evaluated with a model demand of 61,721 gpm.

COMPUTER MODEL

A computer model of the City's water distribution system was developed to analyze the performance of the existing and future distribution system and to prepare solutions for existing facilities that cannot meet the DDW or City criteria for water system pressures. The software used for the model was InfoWater 10.0. InfoWater 10.0 is a computer program that models the hydraulic behavior of piping networks. At the beginning of the master plan study, Logan City provided HAL with the drinking water model that was being maintained by the City. Based on data provided by the City and communication with City personnel, HAL made additional edits to update and calibrate the model.

Computer models were developed for three phases of water system development. The first phase was the development of a model of the existing system (existing model). This model was used for calibration and to identify deficiencies in the existing system. A second model was developed which was used to identify those corrections necessary to improve existing system deficiencies (corrected existing model). The third phase was the development of a future model to indicate those improvements that will be necessary for the projected “build-out” condition (future model).

MODEL COMPONENTS

The two basic elements of the computer model are pipes and nodes. A pipe is described by its inside diameter, overall length, minor friction loss factors, and a roughness value associated with friction head losses. A pipe can include elbows, bends, valves, pumps, and other operational elements. Nodes are the end points of a pipe and they can be categorized as junction nodes or boundary nodes. A junction node is a point where two or more pipes meet, where a change in pipe diameter occurs, or where flow is put in or taken out of the system. A boundary node is a point where the hydraulic grade is known (a reservoir or PRV).

The computer model of the water distribution system is not an exact replica of the actual water system. Pipeline locations used in the model are approximate and every pipeline may not be included in the model, although efforts were made to make the model as complete and accurate as possible. It is not necessary to include all of the distribution system pipes in the model to accurately simulate its performance.

Pipe Network

As indicated previously, the pipe network layout was based upon the model maintained by Logan City. During model preparation, accuracy of the new model was verified by reviewing data provided by the City. Updates to the model were made by HAL throughout the master plan study.

Demands

Water demands were input to the model based on billing data from the summer of 2010. The peak demand month was determined from the billing data, and then the billing addresses were geocoded in order to link the demands to a physical location. Using GIS, the geocoded demands in gallons per minute were then assigned to the closest model demand node. The peak monthly flows were then scaled in order to convert the monthly flow into a peak day demand flow. The scale factor was based on production data that was provided by the City to HAL and calculations that are included in Appendix A.

Diurnal demand curves were developed for Logan using SCADA production data. The non-dimensional demand curve for the City is shown in Figure 5-2.

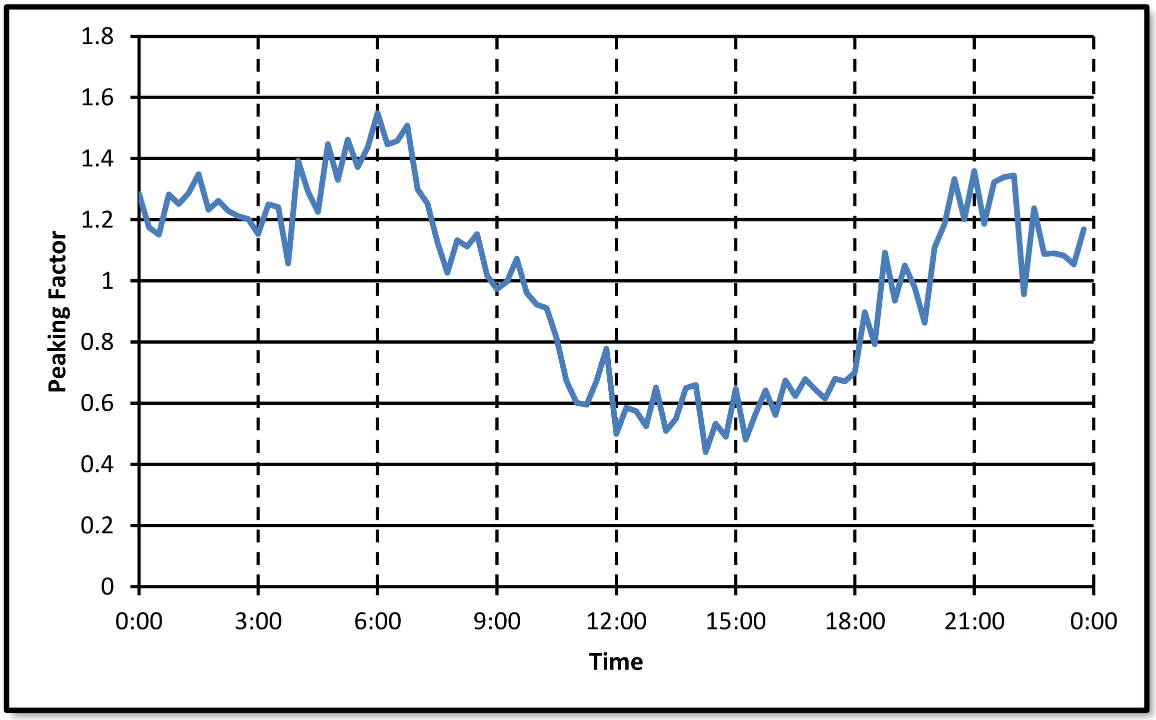


FIGURE 5-2: NON-DIMENSIONAL PEAK DAY DIURNAL CURVE FOR LOGAN CITY

The City's water demand peaks at 6:00 AM before dropping during mid-day. A smaller secondary peak occurs at about 9:00 PM and flow remains relatively high throughout the night. It is believed that the primary driver of the elevated nighttime flows is nighttime irrigation.

Sources and Storage Tanks

The sources of water in the model are Logan's springs and wells. The levels in the tanks are modeled in the extended period model scenario. The extended period model predicts the levels in the tanks as they fill from sources and empty to meet demand in the system.

MODEL CALIBRATION

A water system computer model should be calibrated before it may be relied on to accurately simulate the performance of the distribution system. Calibration is a comparison of the computer results, field tests, and actual system performance. Field tests are accomplished by performing fire flow tests and pressure tests on the system. When the computer model does not match the field tests within an acceptable level of accuracy, the computer model is adjusted to match field conditions. Calibration is especially useful for identifying pipe sizes that are not correct and PRVs or isolation valves that are not operating as expected. Pipe roughness is an additional characteristic which may also be adjusted during calibration.

The model was calibrated primarily through the use of SCADA data. Source flows and tank levels were provided to HAL and the model was calibrated by adjusting source flows and PRV settings so that the overall behavior of network was reproduced within the model. A Darcy-Weisbach roughness coefficient of 0.85 millifeet was used for all model pipes. Calibration results are included in Appendix C. The overall flow patterns in the model matched the observed values very well.

ANALYSIS METHODOLOGY

The InfoWater model was used to analyze the performance of the water system for current and projected future demands under three main operating conditions: low flow (highest pressure) conditions, peak instantaneous conditions, and peak day plus fire flow conditions. Each of these conditions put the water system into a worst-case situation so the performance of the distribution system may be analyzed for compliance with DDW and Logan City's requirements. The results of the model for each of the conditions are discussed below.

High Pressure Conditions

Low flow or static conditions are usually the worst case for high pressures in a water distribution system. In the wintertime, water demand during night time hours is very low, tanks are nearly full, and movement of water through the system is minimal. Under these conditions, the water system approaches a static condition and water pressure in the distribution system is dependent only upon the elevation differences and pressure regulating devices. Another condition similar to static condition that can also cause high pressures in the City's water system occurs in the summer when demand is low and pumps are on to fill storage tanks. During times of low demand, the pumps increase the pressure in the system high enough to reverse the flow coming from the tanks. The highest pressures are reached when pumps are on, tanks are almost full, and demand is low. Both of these high pressure conditions were simulated with the model.

Peak Instantaneous Demand Conditions

Peak Instantaneous demand conditions can sometimes be the worst-case scenario for low pressures throughout a water distribution system. The water system reaches peak instantaneous demand conditions during the hottest days of the summer when both indoor and outdoor water use is the highest. The high demand creates elevated velocities in the distributions pipes which reduces pressure. DDW requires the pipes in the distribution system to be capable of delivering peak instantaneous demand to the entire service area and maintain a minimum pressure of 20 psi at any service connection within the distribution system. Usually, minimum pressures of 20 psi at peak instantaneous demand are too low for customer satisfaction; hence, the City prefers a minimum pressure of 50 psi under this condition.

Peak Day Demand Plus Fire Flow Conditions

Even though peak instantaneous conditions are the worst-case for the lowest pressure and highest demand for the entire system, the peak day plus fire flow is often the worst-case scenario for the lowest pressures for specific locations in the system. This condition occurs when fire hydrants are being used on a day of high water demand. The distribution system must be capable of delivering the required fire flow to the specified location within the system, while supplying the peak day demand to the entire distribution system. In accordance with the requirements outlined by Utah Administrative Code R309-105-9(4), the required fire flows must be delivered while maintaining 20 psi minimum residual pressure at the delivery point and to all service connections within the distribution system.

It is recommended that the model be used to test fire flow capacity. Fire flow tests at hydrants can show higher flow than is actually available. Fire flow tests are typically during the day when demands are low instead of the required peak day demand. Also, most larger fire flows require multiple fire hydrants. It is also recommended, however, that the fire department should regularly conduct fire flow tests for fire hydrant maintenance, to find closed pipelines, and to compare results against the drinking water model. The data from the fire flow tests is useful for identifying model inaccuracies.

Peak Day Extended Period

The peak day extended period model was used to model the water system performance over time. An extended period model is actually a static model run several times for each time period, like a movie is made up of individual pictures put together. The peak day extended period model was used to set system conditions for the static models, calibrate zone to zone water transfers, analyze system controls and the performance of the system over time, analyze system recommendations for performance over time, and analyze the water system for optimization recommendations. The peak day extended period model was run for several days with the peak day demand curve repeating every 24 hours such that the model operated in a stable pattern. The model has reached stabilization when the filling and emptying cycles of the tanks repeat in a consistent pattern without running empty. System recommendations for existing conditions and future conditions at build-out were checked with the extended period model to confirm adequacy.

ANALYSIS RESULTS OF THE EXISTING SYSTEM

The model output primarily consists of the computed pressures at nodes and flow rates through pipes. The model also provides additional data related to pipeline flow velocity and head loss to help evaluate the performance of the various components of the distribution system. Results from the model are available on a CD in Appendix D. Due to the large number of pipes and nodes in the model, it is impractical to prepare a figure which illustrates pipe numbers and node numbers. The reader should refer to the CD to review model output.

For most areas of the City, the observed pressures were below the City's preferred maximum pressure of 130 psi; however, there are portions of some pressure zones that exceed this limit. In the Castle Hills zone, at the far southern part of the zone along Red Fox Trace, peak pressures reach 168 psi. Pressures are also high in the western part of the Cliffside Zone on Canterbury Drive, Canterbury Lane and few other streets in the same general vicinity. The highest observed pressures in those locations reach 184 psi. For both of these high pressure areas, the most direct and least expensive solution would be to carve out small pressure zones by installing PRVs. In order to keep all homes below 130 psi, three PRVs would be needed: one in the 8-inch pipeline in Red Fox Trace, another in the 6-inch pipeline in Mountain Road just east of the 100 South intersection, and the one near the intersection of Mountain Road and Cliffside Drive. The last PRV would be installed in the 6-inch pipeline that serves the homes on 100 North at about 1000 East. As an alternative, the City could also choose to accept the high pressures and not address the high pressures. Due to the limited extent of the high pressures, it is recommended that the City should take no corrective action unless they are experiencing problems in the area due to the high pressures.

Distribution modeling also found high pressures along the west edge of the USU zone. The highest pressures reached 169 psi along 700 East between 700 North and 900 North. The most economical way to address the high pressures would be to move the 700 East pipeline to the Lower Zone between 700 North and 900 North. Additional high pressures were observed in that general area near the Dee Glen Smith Spectrum along 1000 North, 800 East, 700 North, and 900 North. Pipes with high pressures along 700 North and 900 North cold also by moved to the Lower Zone.

Pressures are also high along the west edge of the Upper Zone. The highest observed pressure was 147 psi near Lowe's Home Improvement on 1400 North. Pressures at other locations along the western boundary of the zone reach about 138 psi. The pressures in the Upper Zone are controlled by the Tanks. As a result, lowering the pressures along the west side of the Upper Zone would require great expense. Moreover, the pressures are not excessively high as compared to the 130 psi standard. For these reasons, it is recommended that the City should accept the elevated pressures in the Upper Zone. The highest pressures observed in the Lower Zone are south of Mendon Road and just west of 1430 West. Peak pressures in that area reach 131 psi. However, since the pressures are only slightly above 130 psi, it is not recommended that any changes should be made in order to lower pressures in the area.

With regard to Peak Instantaneous Demand Conditions, two areas were identified where pressures drop below 50 psi. Low pressures were observed along the western boundaries of the Castle Hills and Quail Bluff pressure zones. The minimum pressure observed in the Castle Hills Zone was 30 psi. Based on aerial imagery, there are no houses at the location with the lowest pressures. The lowest pressure observed where homes have been built had a pressure of 39 psi under peak instantaneous conditions. In addition to being less than 50 psi, the low pressure areas in the Castle Hills Zone are very close to the State's minimum pressure requirements of 40 psi under peak day conditions and 30 psi under peak instantaneous conditions. Based on the modeling results, the low-pressure area with the home already built is compliant with state requirements for both conditions. However, the low area pressure where pipes have been installed but no homes have been built yet was not compliant with the 40 psi peak day flow condition. There is no economical way to improve the pressures for the homes that have already been built. Therefore, it is recommended that the city should accept the low pressures and limit future development to elevations where adequate pressure can be maintained. For reference, modeling indicates that 50 psi can be maintained to an elevation of 4,924 feet and 40 psi can be maintained to an elevation of 4,947 feet.

In addition to the low pressures in the Castle Hills Zone, there are also a few areas of the Quail Bluff Zone where pressures are below 50 psi. The problem areas lie in the western part of the pressure zone where homes are adjacent to the mountains. In most areas, the minimum pressures are just short of 50 psi under peak instantaneous conditions. However, along the far west edge of 25 North, there are locations where modeling shows low pressures reach 32 psi. Short of installing a new higher elevation tank in order to serve a handful of homes, there does not appear to be a way to increase pressures to these homes. One positive note is that the homes are situated just west of the Quail Bluff Tank. As a result of their proximity the tank, pressures are very constant. However, the peak pressures only reach about 36 psi. Therefore, pressures of 40 psi under peak day demands are not possible.

Several fire flow pressure deficiencies were identified by modeling the conditions for peak day demand plus fire flow. The majority of the identified shortcomings result from 6-inch diameter pipelines in residential areas. As a result of the undersized pipes in combination with limited pipe looping, these areas are unable to provide the minimum 1,000 gpm fire flow. In addition, several inadequate fire flows are a result of higher fire suppression requirements at schools, industrial buildings, and other large buildings.

EXISTING DISTRIBUTION SYSTEM RECOMMENDATIONS

Recommendations for improvement projects were based on the modeling, as outlined above, and guidance provided by Logan City personnel. Recommendations have been categorized as a fire flow project, a distribution project, or a build-out distribution project. Table 5-1 lists the fire flow projects in order of priority. The project priority was evaluated based on the available fire flow deficiency.

TABLE 5-1
FIRE FLOW PROJECTS

PRIORITY	MAP ID #	LOCATION	PROBLEM	SUGGESTED SOLUTION
1	F-10	Northwest corner of 900 North & 800 East	Inadequate fire suppression flow	Install 430 feet of 8-in pipe in 900 North between the 10-inch pipeline on the east side of 800 East and 727 East
2	F-11	736 East 900 N	Inadequate fire suppression flow	Install 45 feet of 8-in pipe across 800 East at the intersection with 800 North to connect the 10-in pipeline on the east side of the street with the 4-in pipeline on the west side of the street
3	F-20	1080 South Sumac Drive	Inadequate fire suppression flow to school	Install 505 feet of 8-in pipe in Sumac Drive between 1035 South and 1080 South
4	F-22	Hillcrest Elementary School	Existing hydrants do not provide adequate fire suppression flow	Install a new hydrant connected to the 12-in pipeline at about 1410 Ellendale Avenue
5	F-14	625 North Darwin Avenue	Inadequate fire suppression flow	Install 440 feet of 8-in pipe in Darwin Avenue between 700 N and about 625 North
6	F-15	200 South between 400 East and 550 East	Inadequate fire suppression flows along 200 South	Install 1,080 feet of 8-in pipe in 200 South between 400 East and 550 East
7	F-16	300 South 500 East	Inadequate fire suppression flow, lack of connectivity	Install 690 feet of 8-in pipe in 500 East between 200 South and 500 East, install a cross-connection between the 8-inch and 4-inch pipes at the corner of 400 East and 300 South
8	F-18	895 East Canyon Road	Inadequate fire suppression flow, lack of connectivity	Install a cross-connection between the 4-inch and 16-in pipelines in Canyon Road at 900 East Canyon Road
9	F-12	700 East between 700 North and 800 North	Inadequate fire suppression flow	Cut in valve on north side of fire hydrant at 700 North 800 East so that the hydrant is supplied by the 24-in line to the south, install 240 feet of 8-in pipe in 800 North between 800 East and 765 East
10	F-21	545 North 1420 East	Inadequate fire suppression flow	Install 2,230 feet of 10-in pipe in Canyon Road between 1200 East and 1525 East and 480 feet of 8-inch pipe in 1420 East between Canyon Road and 545 North
11	F-3	100 West 900 North	Fire hydrant has less than 1000 gpm fire flow	Install 255 ft of 8-in pipe in 100 West between 950 North and 900 North

TABLE 5-1 CONTINUED

PRIORITY	ID #	LOCATION	PROBLEM	SUGGESTED SOLUTION
12	F-4	1000 North Main Street	Fire hydrant has less than 1000 fire flow	Install 621 ft of 8-in pipe in 900 North between 100 West and Main Street
13	F-7	300 South 100 West	Fire hydrant produces less than 1000 gpm of fire suppression flow	Connect the dead-end 4-in pipeline to the north of 300 South to the pipes in 300 South
14	F-6	400 West 100 South	Fire hydrant by the school supplies 1,154 gpm of fireflow	Install 695 ft of 8-in pipe in 400 West between and Center Street and 100 South
15	F-25	Sumac Drive	Inadequate fire suppression flow, lack of connectivity	Install 500 feet of 12-inch pipe beginning at 1581 East Canyon Road, southwest through the Utah Water Research Laboratory parking lot, and connect to the existing 6-inch pipeline at 1575 East Sumac Drive
16	F-8	Apartments at 1330 North 200 East	Apartments have inadequate fire suppression flow	Install 400 feet of 8-in pipe between 200 East and 250 East and 175 feet of 8-in pipe between 1330 North and 1270 North
17	F-9	1250 North 240 East	Inadequate fire suppression flow	Install 430 feet of 8-in pipe in 1250 North between 200 East and 240 East
18	F-17	805 East 275 North	Inadequate fire suppression flow	Install 700 feet of 8-in pipe in 275 North between 900 East and 805 East
19	F-24	1535 East Oakview Drive	Inadequate fire suppression flow	Install a fire suppression PRV at 1675 Mount Logan Drive, 720 feet of 8-in pipe in Mount Logan Drive between 1675 North and 1582 North, and 280 feet of 10-in pipe in Oakview Drive between 1500 East and 1535 East
20	F-1	Along 1800 North between 600 West and 1000 West	Inadequate fire flows to industrial buildings along 1800 N	Install 725 ft of 8-in pipe between 800 West and 1000 West along the extension of 1800 North
21	F-5	300 North between 100 West and 170 West	Fire hydrants cannot supply 1000 gpm fire flow	Connect the existing 4-in and 10-in pipelines at about 105 West 300 North
22	F-13	Hillside Circle	Inadequate fire suppression flow	Install 275 feet of 8-in pipe in Hillside Circle between 700 N and about 670 North
23	F-19	304 Lauralin Drive	Inadequate fire suppression flow	Install 425 feet of 8-in pipe in Lauralin Drive between Canyon Road and 390 South

Table 5-1 CONTINUED

PRIORITY	ID #	LOCATION	PROBLEM	SUGGESTED SOLUTION
24	F-23	181 North Quail Hollow Road	Inadequate fire suppression flow	Install a fire suppression PRV at 1500 Mountain Road and 1,005 feet of 8-in pipe in Quail Hollow Road between 30 North and 181 North
25	F-2	1175 West 600 North	Fire hydrant has less than 1000 gpm fire flow	Install 2,300 ft of parallel 8-in pipe in 600 N between 1000 West and 1350 West

The fire flow projects represent existing deficiencies and should be addressed as soon as possible. With the completion of the fire flow projects, the existing distribution system was found to operate very well. Nonetheless, several additional projects were identified.

The projects recommended for the existing system that were unrelated to fire flow deficiencies have been classified as either energy efficiency projects or water circulation projects. In general, there is often a significant amount of overlap between the two classifications since projects that will improve efficiency will often improve circulation and vice versa. Additional discussion regarding the efficiency projects is included in Chapter 6. Table 5-2 lists the distribution recommendations that were developed for the existing system along with the associated priority ranking for each project. The priorities of distribution projects were evaluated based on the benefit provided to the system. However, the different types of benefits provided by each project are not directly comparable to each other. Therefore, judgement was exercised in assigning project priorities.

TABLE 5-2
EXISTING DISTRIBUTION SYSTEM RECOMMENDATIONS

PRIORITY	ID #	LOCATION	PROBLEM	SUGGESTED SOLUTION
1	D-1	Hillcrest Tank to Castle Hills Tank	Inadequate transmission supplying water to the USU and Castle Hills Zones, energy efficiency	Combine the two Zones and install 3,000 ft of 12-in pipe between the Hillcrest and Castle Hills Tanks
2	D-4	1800 East Canyon Road to Cliffside Pump Station	Energy efficiency	Install 2,840 feet of 24-inch pipe in Canyon Road between 1800 East and 1600 East, install 2,180 feet of 24-inch pipe southwest to the Cliffside pump station.
3	D-3	1020 North 800 East	Energy efficiency	Install 300 feet of 10-in pipe across 800 east to connect the 6-inch pipe in 800 East to the 12-in Lower Zone pipe in 1000 North
4	D-5	1600 East Canyon Road	Circulation, flow capacity along Canyon Road	New 6-inch PRV between the proposed 24-inch pipeline in Canyon Road (D-4) and the existing 8-inch pipeline

TABLE 5-2 CONTINUED

PRIORITY	ID #	LOCATION	PROBLEM	SUGGESTED SOLUTION
5	D-2	400 East 300 South	Poor circulation	Install a new connection between the existing 8-in and 4-in pipelines at the intersection of 400 East and 300 South
6	D-6	Southwest of Golf Course Tanks 3 and 4	High velocity, energy efficiency	Install 360 feet of 30-inch pipe parallel to the existing 20-inch pipe that is located to the southwest of Golf Course Tanks 3 and 4

Recommended PRV Settings

During the course of analyzing the system, the PRV settings were adjusted with the goal of maximizing the usage of equalization storage while minimizing pressure fluctuations and energy costs. Table 5-3 presents the recommended PRV settings. The PRV setting recommendations assume that the City will implement the pressure zone boundary realignments recommended previously within this master plan (USU and Castle Hills will be combined and Upper and Lower USU will be combined). Also, PRV settings from the Upper to Lower Zones are currently set to work properly with the wells with VFDs in the Lower Zone. When the proposed Bluff Tank is online, the PRVs from the Upper to Lower Zone should be adjusted to maximize equalization storage in the Bluff Tank.

TABLE 5-3
RECOMMENDED PRV SETTINGS

PRV Address	From Zone	To Zone	Elevation (ft)	Setting (psi)
350 East 1400 North[1]	Upper	Lower	4545.7	76
270 East 1000 North	Upper	Lower	4547.4	76
277 East 700 North	Upper	Lower	4548.5	79
250 East 600 North	Upper	Lower	4550.2	79
280 East 300 North	Upper	Lower	4554.9	76
250 East Canyon Rd	Upper	Lower	4538.6	80
500 East Center Street	Upper	Lower	4545.3	82
750 East 1200 North	Upper	Upper	4627.0	Open
700 East 1400 North	Upper	Upper	4600.5	Open
1320 East 1500 North	Castle Hills	Upper	4741.0	54
1200 North 1200 East	Castle Hills	Upper	4784.0	26
1025 North 800 East	Castle Hills	Upper	4677.0	71
1674 Mt Logan Drive	Quail Bluff	Cliffside	4918.4	45
1500 Mountain Road	Quail Bluff	Cliffside	4919.0	45

1. In addition to the PRV at this location, there is also a pressure sustaining valve (PSV) set at 120 psi.

ANALYSIS RESULTS OF THE BUILD-OUT SYSTEM

Recommendations have also been developed for the build-out distribution network. Table 5-4 lists the build-out distribution recommendations. No priority has been assigned to these projects, because the priority of the build-out distribution projects will depend heavily of how development progresses within Logan City.

TABLE 5-4
BUILD-OUT DISTRIBUTION SYSTEM RECOMMENDATIONS

ID #	LOCATION	PROBLEM	SUGGESTED SOLUTION
BD-1	600 North between 160 West and 1000 West	High flow velocities, insufficient capacity	Install 1,715 feet of 16-inch pipe in 600 North between 160 West and 400 West and 3,915 feet of 12-inch pipe in 600 North between 400 West and 1000 West
BD-2	Starting at 450 South Gibbons Parkway southeast to Cliffside Tank #2	Transmission capacity will be needed to connect to future Cliffside Tank #2	Install 1,550 feet of 12-inch pipe between 450 South Gibbons Parkway and the future Cliffside Tank #2
BD-3	Southeast of proposed Bluff Tank	Additional source capacity for proposed Bluff Tank	Install a new control valve to allow pipeline described by project D-4 to flow into the proposed Bluff Tank
BD-4	Between Bluff Tank and 975 East Sumac Drive	Future transmission capacity is needed for proposed Bluff Tank	Install 4,615 feet of 48-inch pipe starting at the proposed Bluff Tank then west to about 1380 East Sumac Drive, in Sumac Drive between 1380 East and 975 East, and in 100 North between 975 East and Riverside Drive
BD-5	Between 100 North 900 East and 200 South 900 West	Future transmission capacity is needed for proposed Bluff Tank	Install 10,620 feet of 54-inch pipe in 100 North between 900 East and 500 East, in 500 East between 100 North and 100 South, in 100 South between 500 East and 300 West, and in 300 West between 100 South and 200 South
BD-6	Between 100 North 900 East and 200 South 900 West	Future transmission capacity is needed for proposed Bluff Tank	Install 4,690 feet of 54-inch pipe in 200 South between 300 West and 1000 West and 2,660 feet of 48-inch pipe in 200 South between 300 West and 1400 West
BD-7	Between 600 South and 200 North along existing/future 1400 West	Additional transmission will be needed along the west edge of Logan	Install 5,440 feet of 36-inch pipe in 1400 West between 600 South and 200 North
BD-8	Between 600 South and 1800 South along future 1400 West and 1600 West	Additional transmission will be needed along the west edge of Logan	Install 7,690 feet of 30-inch pipe between 600 South 1400 West and 1800 South 1600 West

TABLE 5-4 CONTINUED

ID #	LOCATION	PROBLEM	SUGGESTED SOLUTION
BD-9	1800 South between 1600 West and 2000 West	Additional transmission will be needed along the west edge of Logan	Install 2,610 feet of 12-inch pipe in 1800 South between 1600 West and 2000 West
BD-10	Southwest Logan along 1600 West and US 89	Improved transmission capacity in the southwestern area of Logan	Install 7,080 feet of 12-inch pipe in 1600 West between 1800 and and US 89 and in US 89 between 1600 West and 1100 West
BD-11	Future western boundary of Logan City	Additional transmission will be needed along the west edge of Logan	Install 17,430 feet of 30-inch pipe between 1400 West 200 North and 2250 North 2400 West
BD-12	Along the 2400 West and Airport Road	Additional transmission will be needed along the west edge of Logan	Install 8,120 feet of 24-inch pipe in 2400 West between 2250 North and Airport Road and 11,000 feet of 24-inch pipe in Airport Road between 2400 West and 1020 West
BD-13	Between River Park Well and 100 North Riverside Drive	New transmission capacity will be needed to connect River Park Well to other future transmission pipelines	Install 1,830 feet of 24-inch pipe beginning at the River Park Well and then west in River Park Drive to Crocket Avenue, in Crocket Avenue between 300 North and 200 North, and in Riverside Drive between 200 North and 100 North
BD-14	Between Cliffside pump station and the intersection of Quail Way and Mountain Road	Additional transmission capacity will be needed between the Cliffside pump stations and Cliffside pressure zones	Install 680 feet of 12-inch pipe between the Cliffside pump station and Quail way and then 1,500 feet of 12-inch pipe in Quail Way between 260 North and Mountain Road. This pipeline is to be installed parallel to the existing 10-inch pipeline
BD-15	In Winding Way between Mountain Road and Quail Canyon Road	Additional transmission capacity will be needed between to convey water to the Quail Bluff pump station	Install 880 feet of 12-inch pipeline in Winding Way between Mountain Road and Quail Canyon Drive
BD-16	1000 North between 300 East and Main Street	Additional transmission capacity will be needed due to the planned 1000 North Well	Install 2,100 feet of 12-inch pipe in 1000 North between 300 East and Main Street

In general, the primary purpose of the recommended build-out distribution projects is to add transmission capacity so that future demands can be met without large pressure variations at service connections. In particular, significant transmission capacity will be needed between the proposed Bluff Tank and the Lower pressure zone. Projects BD-4 through BD-12 provide the necessary transmission from the Bluff Tank to supply water throughout the Lower Zone. Other projects address more localized capacity issues that arise as demand grows within the system. Figure 5-3 shows the location of each of the recommended projects.

PIPELINE REPLACEMENT

It is recommended that the City fund a pipeline replacement program. Pipelines should be scheduled for replacement based on priority, and in order to take advantage of road resurfacing projects and other situations of convenience. Pipelines smaller than 8-inches in diameter, older pipelines, and pipelines where frequent repairs have been needed should all be considered as high priority for replacement. The State recommends that at least 5% of the annual drinking water budget be set aside for facility replacement.

Within Logan City's previous drinking water master plan (Black and Veatch, 2007) specific recommendations were provided regarding pipeline replacement. At that time, the City reported an existing $8,000,000 backlog in replacement projects. An annual budget of about **$900,000** was proposed through 2027 for pipeline replacement. This proposed budget included a component to address the replacement backlog as well as a component to address planned annual replacement needs. It is recommended that the City fund and maintain an active pipeline replacement program as outlined in the 2007 Master Plan. A summary of the pipeline replacement budget recommendations from the 2007 Master Plan has been included in Appendix E.

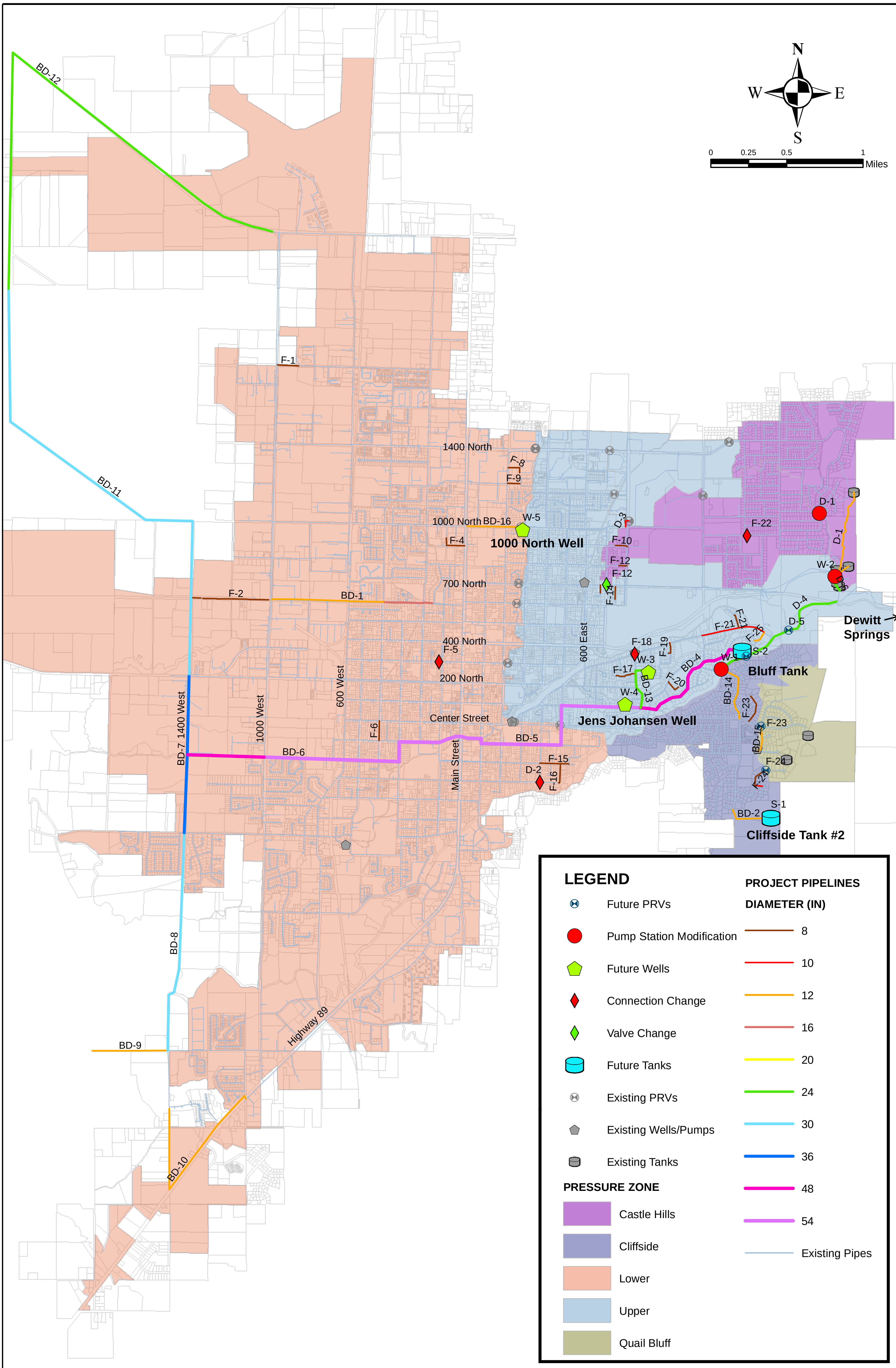
CONTINUED USE OF THE COMPUTER PROGRAM

It is recommended that the City continue updating the model as the water system changes. Below is a list of ways in which the model could help the City with water system management. The computer model can assist City staff in determining:

- Effect on the system if individual facilities are added or taken out of service
- Selection of pipe diameters and location of proposed water mains
- Capacity of the water system to provide fire flows in specific areas
- Water age for water quality monitoring
- Residual chlorine and fluoride levels in the system

The computer model should be maintained for future use. Necessary data required for continued use of the program are:

- The location, length, diameter, pipe material, and ground elevation at each end of each new pipeline constructed
- Changes in water supply location and characteristics
- Location and demand for new large customers
- Changes in chlorine and fluoride dosing rates and procedures



HANSEN ALLEN & LUCE Inc ENGINEERS

LOGAN DRINKING WATER MASTER PLAN

PROPOSED PROJECTS

FIGURE 5-3

CHAPTER 6 - OPTIMIZATION

OPTIMIZATION OVERVIEW

Three parameters drive the operation of a water system: system performance, water quality, and energy efficiency (Figure 6-1). Water systems can be characterized by any degree or combination of these three parameters. One system may perform well but incur high energy costs. Another may be energy efficient but is not sufficiently pressurized during peak demand. Another may perform well hydraulically but fail to meet requirements for chlorine residual. System optimization is the process whereby a distribution network is evaluated in order to identify potential improvements that will allow the network to operate in the region where energy efficiency, system performance, and water quality are balanced.

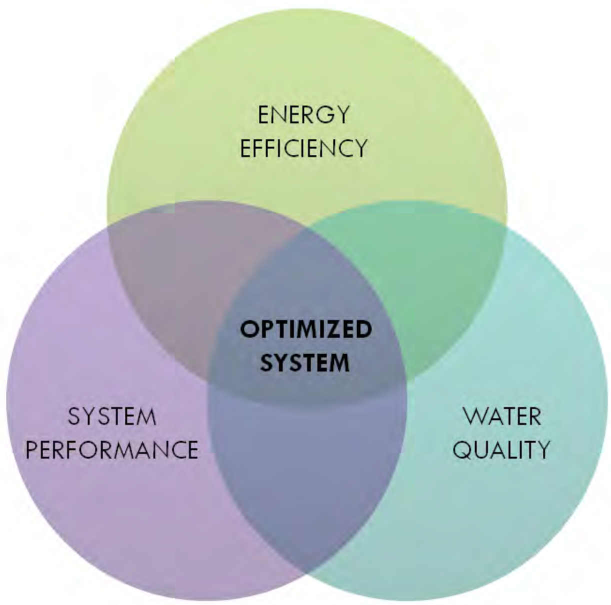


FIGURE 6-1: WATER SYSTEM OPTIMIZATION DIAGRAM

System optimization was considered throughout the development of this master plan. One of the basic principles used was to limit unnecessary energy losses. Energy losses have a direct impact on energy efficiency and system performance. Many of the changes which reduce energy losses also promote water circulation, which improves water quality. In 2013 HAL recommended that the City divide the Upper and Lower pressure zones and reduce the energy required at two wells by pumping into the Lower pressure zone. After implementing our recommendations, the water system cut annual energy costs by 32%, while at the same time reducing water use by 17% and mainline breaks by 40%. Customer complaints dropped and staff could then focus on preventive rather than reactive maintenance. The following paragraphs describe how optimization was applied in the development of the recommendations included in this master plan to further optimize the system.

ENERGY AND SYSTEM PERFORMANCE

PRV settings are an ideal example for the application of optimization principles. PRVs can provide a useful means of reducing pressure fluctuations in lower zones by allow water to flow to the lower zone during peak flow events to prevent low pressures. However, setting a PRV too high can have the opposite effect within the upper zone. High PRV flows elevate the flow velocity in the upper zone, which in turn increases pressure fluctuations. Furthermore, high PRV settings prevent the equalization storage in tanks from being fully utilized which causes a waste of energy. The solution is to set the PRVs at a level where pressures in the lower zones are protected, but flow through the PRV is limited. The settings included within the previous chapter were chosen to keep daily pressure fluctuations under 20 psi while maintaining a minimum pressure of 50 psi under non-emergency flow conditions.

Another example of applying optimization principals is conserving energy by reducing the need to pump water. Several of the proposed projects are designed to either reduce the amount of water that will need to be pumped, or else to reduce the head a pump station needs to supply. Project D-1 is an example of a project that reduces the need to pump water. Presently, water is supplied to the Castle Hills pressure zone via the Castle Hills pump station, which pumps out of the USU pressure zone. However, it was observed that the Hillcrest and Castle Hills tanks are located at about the same elevation and the primary use of the Castle Hills pump station is to overcome transmission losses between to the two tanks. By adding adequate transmission capacity between the tanks, the pump station can be eliminated and the two pressure zones can be combined. In addition to eliminating the need to pump water, combining the two zones increases the looping and interconnections within the system.

Project D-4 will reduce the City’s pumping costs. At present, water is pumped into the Cliffside Zone via the Cliffside pump station. The Cliffside pump station currently pumps out of the Upper Zone at a head of 4,830 feet up to the Cliffside Zone at a head of 5,090 feet. Most of the water in the Upper Zone is supplied by DeWitt Springs. In order to arrive at the Cliffside pump station, water from DeWitt Springs flows into the Golf Course tanks and is conveyed to the pump station by pipelines within the Upper Zone. The DeWitt Springs transmission line has a head of about 5,030 feet at the mouth of Logan Canyon; however, significant energy is lost in discharging the water into the Golf Course tanks and in conveying the water through the system. Project D-4 will provide a transmission pipeline that will directly connect the Cliffside pump station to the DeWitt Springs transmission pipeline and Golf Course Tanks for redundancy. Using the new transmission line, water can be supplied to the Cliffside Pump station at a head of about 5,020 feet. Pumping from the higher head supply pipeline would allow pumping costs to be reduced by about 70%. Additionally, the new pipeline would allow for a new PRV connection at 1600 East Canyon Road. The new PRV would improve circulation and fire flow capacity along the eastern portion of Canyon Road. The pipeline could also be used to fill the proposed Bluff Tank freeing up capacity in the twin 24-inch transmission lines from the Golf Course Tanks. In addition to installing the new pipeline, upgrades would also be required at the Cliffside Pump Station in order to pump from the higher head.

Modifications are also recommended for the Hillcrest pump station. As presently configured water from the DeWitt Springs pipeline discharges in the Golf Couse 6, 7, 8, 9 Tanks and is then pumped up to the Hillcrest Tank. It is recommended the Hillcrest pump station should be modified so that water can be pump directly out of the DeWitt Springs supply line up to the Hillcrest Tank. Under existing conditions, the Hillcrest pump station supplies 190 feet of head in order to pump water to the higher pressure zone. Pumping directly from the DeWitt Springs pipeline would reduce the required head to about 30 feet. It is estimated that energy usage could be reduced by about 85% at the Hillcrest pump station. If the Hillcrest pump station were reconfigured to pump directly from the DeWitt Springs pipeline, it would also be beneficial to remove any bottlenecks in the DeWitt Springs pipeline, which cause energy loss. The pipeline schematic supplied to HAL and upon which the City's drinking water model was based shows all of the DeWitt Springs supply line to the 36-inch pipe, except for a section of 20-inch pipeline in just southwest of the Golf Course 3 and Golf Course 4 Tanks and just east of the golf course. The model shows high velocities occur in that area because of the smaller pipe. The City should verify the size of the pipe and, if needed, increase transmission capacity by adding a parallel pipeline or replace the 20-inch section with 36-inch pipeline.

Project D-3 will also help the City reduce pumping costs. Installing a new pipeline at 1020 North 800 East between the Upper and Lower USU Zones will allow the Lower USU Zone to be combined with the Upper Zone. Currently, the Lower USU Zone receives water from PRV connections with the Castle Hills and USU pressures zones. However, because those zones are supplied by booster pumping stations, water in those zones has a higher delivery cost than water in the Upper Zone. Moreover, the Upper Zone and the Lower USU Zone supply water at a similar head. As a result the zones can be combined with little impact to water customers.

Pumping Costs

Producing, treating, and delivering high-quality water requires energy, which is usually a water utility's largest operational expense and can account for 30%–40% of municipal energy consumption (EPA 2015). Efforts to increase energy efficiency bring financial savings and can facilitate improvements in water quality and hydraulic performance. As part of the optimization analysis, HAL estimated the energy intensity associated with each well and pump station in the Logan distribution system. The results for each of the City's wells, are presented in Figure 6-2.

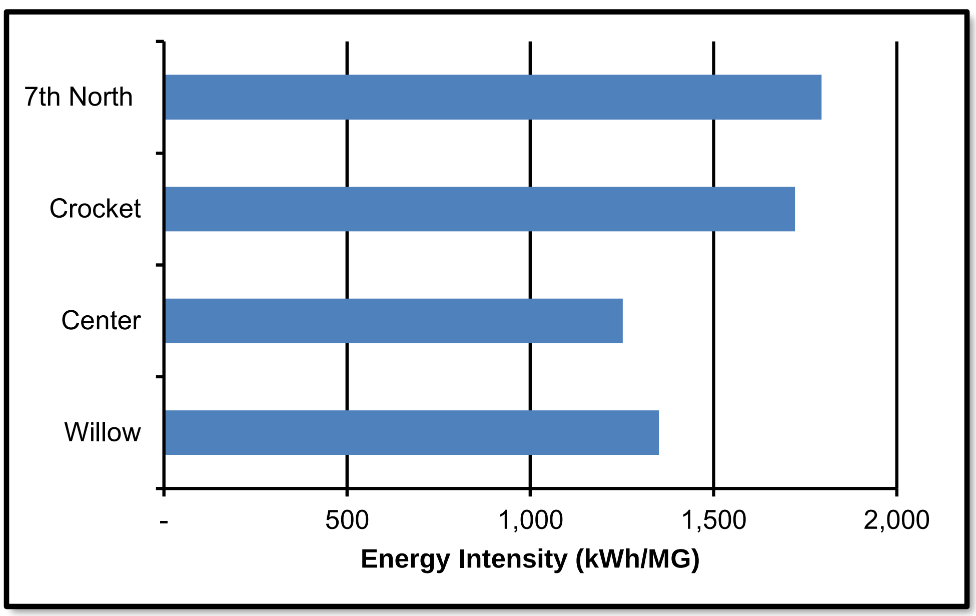


FIGURE 6-2: WELL ENERGY INTENSITY

Of the City's well sources, Center Street Well requires the least amount of energy per million gallons of pumped water. In contrast, the 7th North Well requires the most energy. In general, the City should prioritize usage of water sources with lower energy intensities before using sources with higher energy intensities. Additionally, the City could also explore reducing the energy intensity of a well.

One option to reduce the energy intensity of a well is through physical improvements. Older wells may benefit from mechanical improvements that restore the operation of the well. Additionally, a pumping well may cause high local flow velocities. Elevated velocities result in lost energy and increase the energy intensity of a well. Properly sizing the pipelines in the immediate area of a well can reduce the energy used by the well.

Another option for reducing the energy intensity of a well is to move the well to a lower pressure zone. During much of the year, DeWitt springs can supply all of the water needed in the higher Logan City pressure zones. Moving the Crockett well and possibly the 7th North well to the Lower Pressure zone would result in much lower operating costs for the wells. In order to move the wells to the Lower Zone, the well pumps would need to be replaced along with pipeline improvements. The City would also need a pump station with the capability to pump from the Lower Zone to the Upper Zone in order to provide redundant capacity to the higher elevation pressure zones. The pump station could be built on the new Bluff Tank site or could be combined with the Cliffside Pump Station. It could pump water from the Bluff Tank, up the proposed transmission line to the Golf Course Tanks.

Figure 6-3 presents the energy intensity for each of the City's pump stations. Of the City's pump stations, the Quail Bluff pump station requires the least amount of energy per million gallons of pumped water. In contrast, the Cliffside pump station requires the most energy. It is recommended that the City could also reduce the energy intensity of the pump stations where possible. Previously within this master plan improvements have been recommended which will reduce the energy intensities of the Hillcrest pump station and the Cliffside Pump station. Additionally, projects have been identified which will eliminate the need for the Castle Hills pump station.

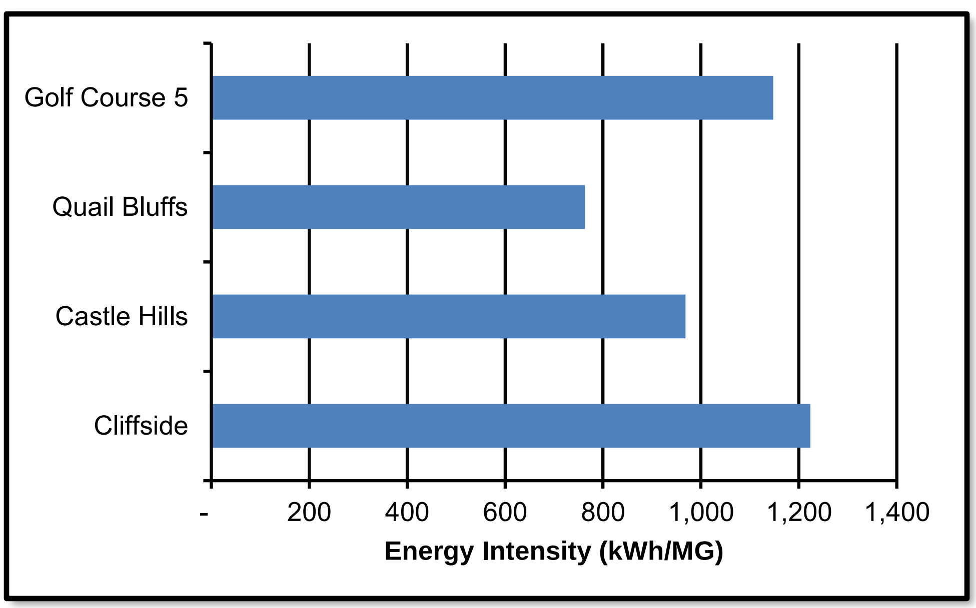


FIGURE 6-3: PUMP STATION ENERGY INTENSITY

DISINFECTION BYPRODUCT EVALUATION

While chlorine is an effective disinfectant in controlling many microorganisms in drinking water, it reacts with natural material found in drinking water to form potentially harmful disinfection byproducts (DBPs). Although the risk of becoming ill from microbial pathogens is tens of thousands of times greater than the risk of becoming ill from DBPs, it is enough of a concern that the Environment Protection Agency (EPA) has developed rules to balance the risks between microbial pathogens and DBPs. A drinking water system needs enough chlorine to destroy pathogens but also not produce excessive DBP.

Logan City provided chlorine field test results for locations with the distribution system that were collected during July 2014. A sample plot of the data collected at 1000 W 500 N is show in Figure 6-4. The data for the other chlorine monitoring locations was generally similar to that shown in Figure 6-4. The concentrations for all of the locations were generally close to 0.2 mg/L with occasional variations. Table 6-1 presents the average field measured concentrations and the average modeled concentrations for three locations within the Logan system.

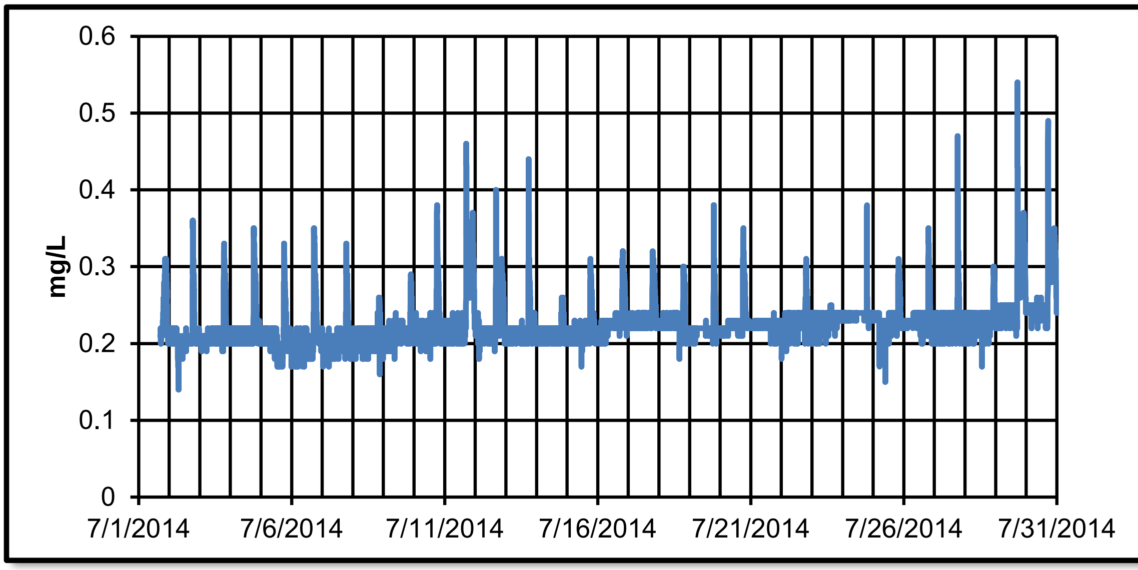


FIGURE 6-4: MEASURED CHLORINE CONCENTRATIONS AT 1000 W 500 N

TABLE 6-1
FIELD VS. MODELED CHLORINE CONCENTRATIONS

Location	Average Field Concentration mg/L	Average Modeled Concentration mg/L
1180 S 1000 W	0.23	0.17
1000 W 500 N	0.23	0.22
1400 W Center St	0.16	0.15

The modeled concentrations match the field concentrations. Figure 6-5 shows the model output from the chlorine modeling. Within the figure, pipes shown in blue represent locations with relatively low chlorine residual while areas shown in red represent comparatively high chlorine concentration. Areas with low chlorine residual include locations that are relatively far from

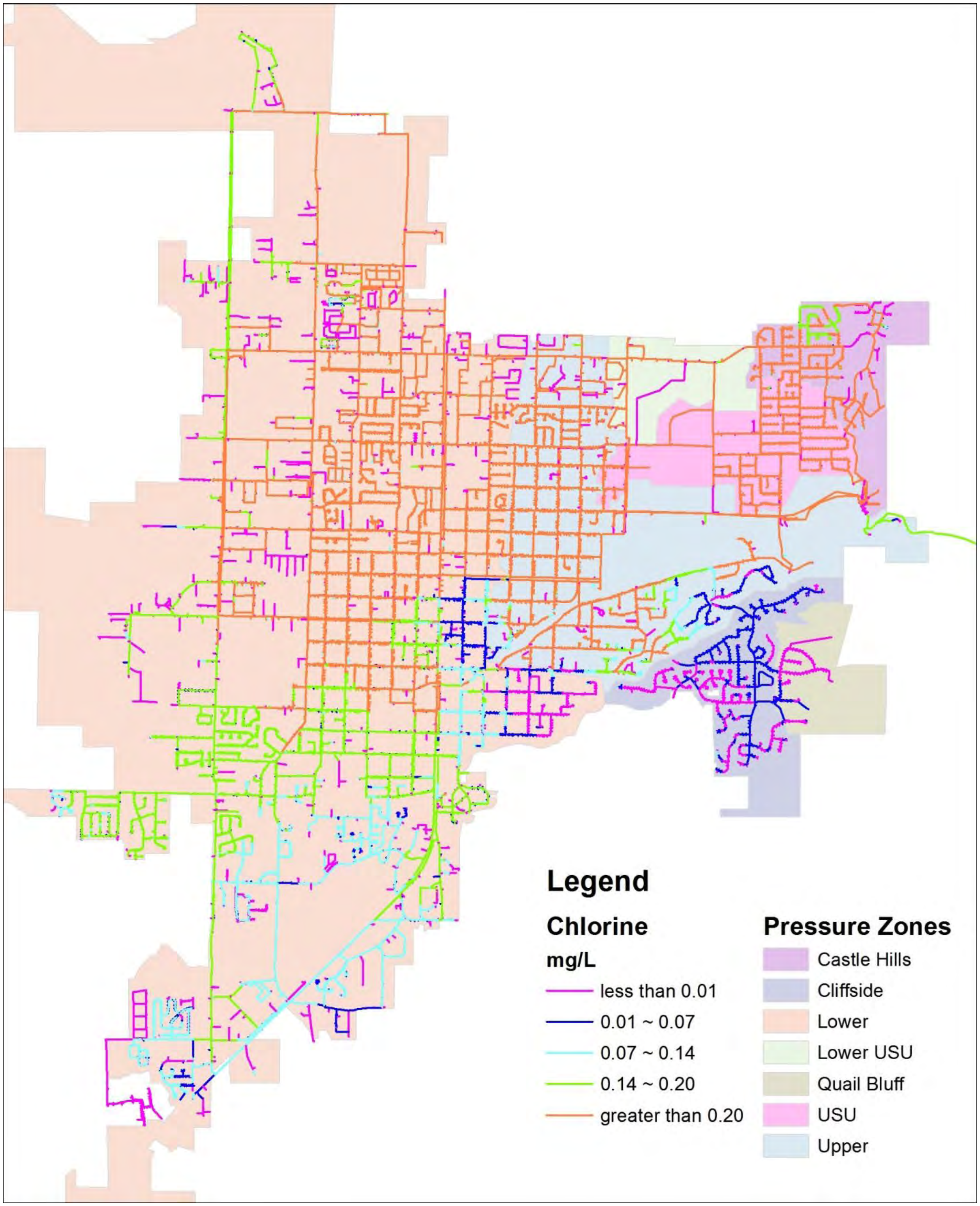


FIGURE 6-5: CHLORINE CONCENTRATIONS IN LOGAN CITY

chlorinated sources or else dead end pipelines with low flow velocities. Also, during the modeled scenario Crockett Well was operating part of the time. When the well is not chlorinated, it pushes unchlorinated water out into the system that is visible in the modeling results.

WATER AGE

The extended period model was used to predict the areas in the water system that have the highest potential for DBP production. The potential for DBP production is higher in warmer and older water, so a water age model typically follows a similar pattern to where DBP production has the highest potential. Water age was calculated for every location in the system by running the model to simulate several days in the summer scenario. The locations having poor circulation and thus the oldest water are usually also the areas that have the highest potential for DBP production. Figure 6-6 illustrates the results of the water age model scenario at 96 hours using the Summer Calibration Model.

Nearly all of the system receives fresh water every three days. Dead end lines with little to no demand have the worst circulation in the model. Areas located along the extremities of the system also tend to have higher water age. It is recommended that the City use the water age model to make sure DBP sampling is occurring at the locations with the highest DBP production potential.

SUMMARY OF OPTIMIZATION RECOMMENDATIONS

Based on the finding and observations presented above, the following recommendations are provided:

1. Set PRVs so that equalization storage is utilized while pressure fluctuations are controlled.
2. Eliminate unnecessary pumping by:
    a. eliminating the Castle Hills pump station by installing a transmission line from the Hillcrest pump station with dedicated controls for the Castle Hills Tank,
    b. upgrading the Hillcrest pump station to pump from the Dewitt Spring pressure,
    c. installing a new pipeline at 1020 North 800 East to combine the Upper and Lower USU pressure zones,
    d. move the Crockett well and possibly the 7th North well to the Lower pressure zone and add a pump station to move the water to the Upper pressure zone when needed, and
    e. modifying the Cliffside pump station to pump from the high pressure transmission line.
3. Prioritize usage of lower cost source water.
4. Monitor water quality test results. In particular, chlorine should be tested in areas the model identifies as having lower chlorine residual levels.
5. Monitor water quality in areas identified as having higher age.

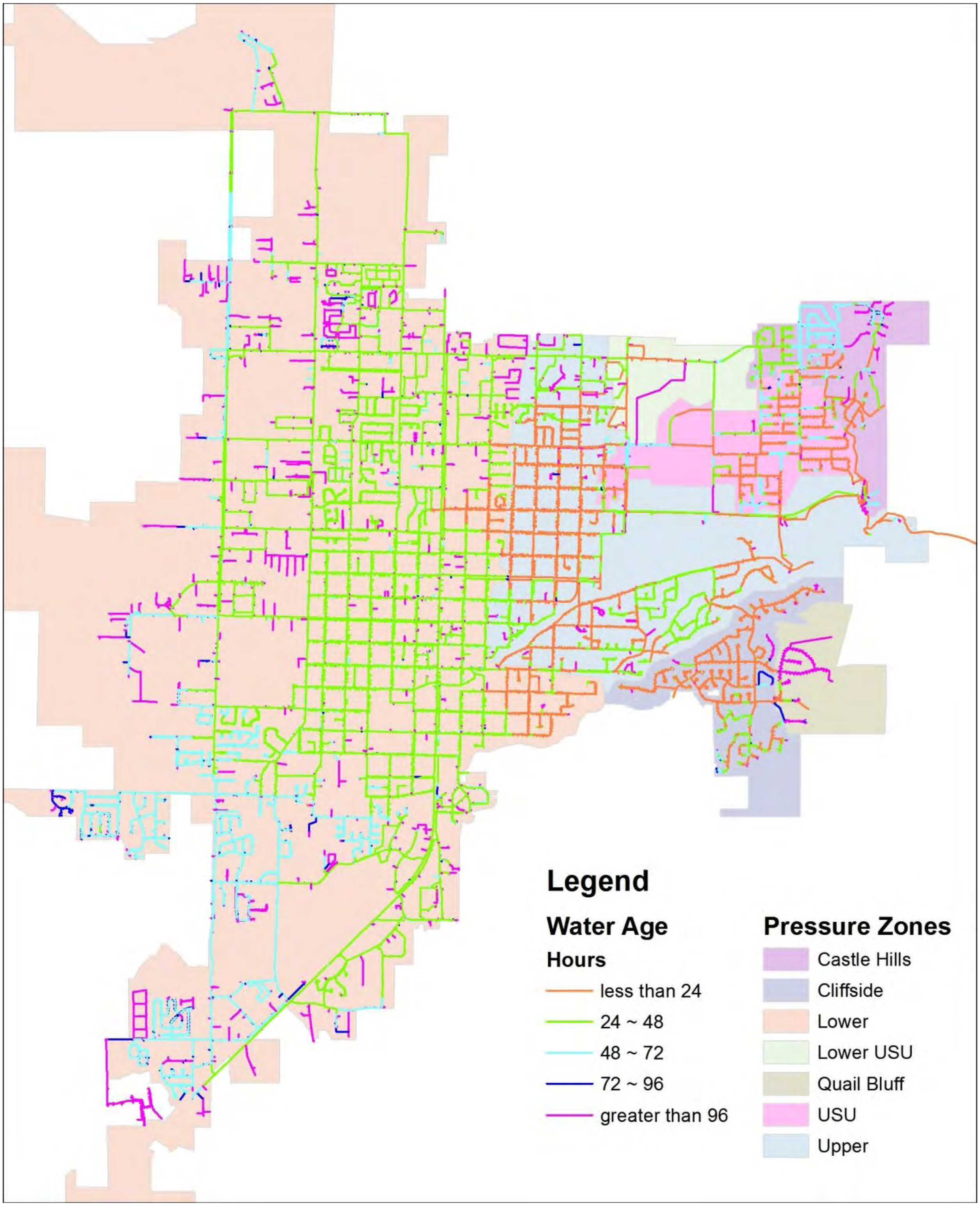


FIGURE 6-6: WATER AGE IN LOGAN CITY

CHAPTER 7 - CAPITAL IMPROVEMENTS PLAN

Throughout the master planning process, the three main components of the City's water system (source, storage, and distribution) were analyzed to determine the system's ability to meet existing demands and the anticipated future demands at build-out. Each of the system deficiencies identified in the master planning process and described previously in this report were presented in an alternatives workshop with City staff. Possible solutions were discussed for each of the identified system deficiencies as well as possible solutions for maintenance and other system needs not identified in the system analysis. After the workshop, HAL studied the feasibility of the solution alternatives and developed conceptual costs.

One important method of paying for system improvements is through impact fees. Impact fees are collected from new development and should only be used to pay for system improvements related to new development. For this reason, it is important to identify which projects are related to resolving existing deficiencies, and which projects are related to providing anticipated future capacity for new development.

PRECISION OF COST ESTIMATES

When considering cost estimates, there are several levels or degrees of precision, depending on the purpose of the estimate and the percentage of detailed design that has been completed. The following levels of precision are typical:

Type of Estimate	Precision
Master Planning	±50%
Preliminary Design	±30%
Final Design or Bid	±10%

For example, at the master planning level (or conceptual or feasibility design level), if a project is estimated to cost $1,000,000, then the precision or reliability of the cost estimate would typically be expected to range between approximately $500,000 and $1,500,000. While this may seem very imprecise, the purpose of master planning is to develop general sizing, location, cost, and scheduling information on a number of individual projects that may be designed and constructed over a period of many years. Master planning also typically includes the selection of common design criteria to help ensure uniformity and compatibility among future individual projects. Details such as the exact capacity of individual projects, the level of redundancy, the location of facilities, the alignment and depth of pipelines, the extent of utility conflicts, the cost of land and easements, the construction methodology, the types of equipment and material to be used, the time of construction, interest and inflation rates, permitting requirements, etc., are typically developed during the more detailed levels of design.

At the preliminary or 10% design level, some of the aforementioned information will have been developed. Major design decisions such as the size of facilities, selection of facility sites, pipeline alignments and depths, and the selection of the types of equipment and material to be used during construction will typically have been made. At this level of design the precision of the cost estimate for a $1,000,000 project would typically be expected to range between approximately $700,000 and $1,300,000.

After the project has been completely designed, and is ready to bid, all design plans and technical specifications will have been completed and nearly all of the significant details about the project should be known. At this level of design, the precision of the cost estimate for the same $1,000,000 project would typically be expected to range between approximately $900,000 and $1,100,000.

SYSTEM IMPROVEMENT PROJECTS

As discussed in previous chapters, several source, storage and distribution system deficiencies were identified during the system analysis. Project costs for water system improvements are presented in Table 7-1 with the location of each project shown in Figure 5-3. Each recommendation includes a conceptual cost estimate for construction.

Unit costs for the construction cost estimates are based on conceptual level engineering. Sources used to estimate construction costs include:

1. "Means Heavy Construction Cost Data, 2016"
2. Price quotes from equipment suppliers
3. Recent construction bids for similar work

All costs are presented in 2016 dollars. Recent price and economic trends indicate that future costs are difficult to predict with certainty. Engineering cost estimates provided in this study should be regarded as conceptual level for use as a planning guide. Only during final design can a definitive and more accurate estimate be provided for each project. A cost estimate calculation for each project is provided in Appendix F and Table 7-1 provides a cost summary for the recommended system improvements.

TABLE 7-1
PROJECT COSTS FOR SYSTEM IMPROVEMENTS

TYPE	MAP ID	RECOMMENDED PROJECT[1]	COST
Source	W-1	Cliffside Pump Station – Increase capacity by 2,350 gpm and upgrade the pumps to pump from the recommended higher head supply pipeline	$675,000
Source	W-2	Hillcrest Pump Station Improvements – Increase the capacity by 2,000 gpm and reconfigure the pumps and piping so the pump station can pump directly from the DeWitt Spring transmission pipeline	$675,000
Source	W-3	Equip River Park Well and build well house	$473,000
Source	W-4	Construct a new drinking water well at Jens Johansen Park	$2,025,000
Source	W-5	Upgrade the 1000 North Well, if needed, to allow pumping into the drinking water distribution network	$473,000
Source	W-6	Construct 3 new additional wells, preferably with some of the new wells located within the Lower Pressure Zone	$6,075,000
Storage	S-1	Construct a 1 MG Cliffside Zone storage tank southwest of the existing Cliffside Zone	$1,350,000
Storage	S-2	Construct a 10 MG tank on the Bluff located between Sumac Drive and Quail Way at about 1450 east	$13,500,000

TABLE 7-1 CONTINUED

TYPE	MAP ID	RECOMMENDED PROJECT[1]	COST
Fire	F-1	Install 725 ft of 8-in pipe between 800 West and 1000 West along the extension of 1800 North	$97,000
Fire	F-2	Install 2,300 ft of parallel 8-in pipe in 600 N between 1000 West and 1350 West	$307,000
Fire	F-3	Install 255 ft of 8-in pipe in 100 West between 950 North and 900 North	$34,000
Fire	F-4	Install 621 ft of 8-in pipe in 900 North between 100 West and Main Street	$83,000
Fire	F-5	Connect the existing 4-in and 10-in pipelines at about 105 West 300 North	$20,000
Fire	F-6	Install 695 ft of 8-in pipe in 400 West between and Center Street and 100 South	$93,000
Fire	F-7	Connect the dead-end 4-in pipeline to the north of 300 South to the pipes in 300 South	$20,000
Fire	F-8	Install 400 feet of 8-in pipe between 200 East and 250 East and 175 feet of 8-in pipe between 1330 North and 1270 North	$77,000
Fire	F-9	Install 430 feet of 8-in pipe in 1250 North between 200 East and 240 East	$57,000
Fire	F-10	Install 430 feet of 8-in pipe in 900 North between the 10-inch pipeline on the east side of 800 East and 727 East	$57,000
Fire	F-11	Install 45 feet of 8-in pipe across 800 East at the intersection with 800 North to connect the 10-in pipeline on the east side of the street with the 4-in pipeline on the west side of the street	$20,000
Fire	F-12	Cut in valve on North side of fire hydrant at 700 North 800 East so that the hydrant is supplied by the 24-in line to the south, Install 240 feet of 8-in pipe in 800 North between 800 East and 765 East	$39,000
Fire	F-13	Install 275 feet of 8-in pipe in Hillside Circle between 700 N and about 670 North	$37,000
Fire	F-14	Install 440 feet of 8-in pipe in Darwin Avenue between 700 N and about 625 North	$59,000
Fire	F-15	Install 1,080 feet of 8-in pipe in 200 South between 400 East and 550 East	$144,000

TABLE 7-1 CONTINUED

TYPE	MAP ID	RECOMMENDED PROJECT[1]	COST
Fire	F-16	Install 690 feet of 8-in pipe in 500 East between 200 South and 500 East, install a cross-connection between the 8-inch and 4-inch pipes at the corner of 400 East and 300 South	$112,000
Fire	F-17	Install 700 feet of 8-in pipe in 275 North between 900 East and 805 East	$94,000
Fire	F-18	Install a connection between the 4-inch and 16-in pipelines in Canyon Road at 900 East Canyon Road	$21,000
Fire	F-19	Install 425 feet of 8-in pipe in Lauralin Drive between Canyon Road and 390 South	$57,000
Fire	F-20	Install 505 feet of 8-in pipe in Sumac Drive between 1035 South and 1080 South	$67,000
Fire	F-21	Install 2,230 feet of 10-in pipe in Canyon Road between 1200 East and 1525 East and 480 feet of 8-inch pipe in 1420 East between Canyon Road and 545 North	$404,000
Fire	F-22	Install a new hydrant connected to the 12-in pipeline at about 1410 Ellendale Avenue	$7,000
Fire	F-23	Install a fire suppression PRV at 1500 Mountain Road and 1,005 feet of 8-in pipe in Quail Hollow Road between 30 North and 181 North	$168,000
Fire	F-24	Install a fire suppression PRV at 1675 Mount Logan Drive, 720 feet of 8-in pipe in Mount Logan Drive between 1675 North and 1582 North, and 280 feet of 10-in pipe in Oakview Drive between 1500 East and 1535 East	$173,000
Fire	F-25	Install 500 feet of 12-inch pipe beginning at 1581 East Canyon Road, southwest through the Utah Water Research Laboratory parking lot, and connect to the existing 6-inch pipeline at 1575 East Sumac Drive	$81,000
Distribution	D-1	Combine the two Zones and install 3,000 ft of 12-in pipe between the Hillcrest and Castle Hills Tanks	$328,000
Distribution	D-2	Install a new connection between the existing 8-in and 4-in pipelines at the intersection of 400 East and 300 South	$20,000
Distribution	D-3	Install 300 feet of 10-in pipe across 800 east to connect the 6-inch pipe in 800 East to the 12-in Lower Zone pipe in 1000 North	$46,000
Distribution	D-4	Install 2,840 feet of 24-inch pipe in Canyon Road between 1800 East and 1600 East, install 2,180 feet of 24-inch pipe southwest to the Cliffside pump station.	$1,437,000

TABLE 7-1 CONTINUED

TYPE	MAP ID	RECOMMENDED PROJECT[1]	COST
Distribution	D-5	New 6-inch PRV between the proposed 24-inch pipeline in Canyon Road (D-4) and the existing 8-inch pipeline	$34,000
Distribution	D-6	Install 360 feet of 30-inch pipe parallel to the existing 20-inch pipe that is located to the southwest of Golf Course Tanks 3 and 4	$137,000
Build-Out Distribution	BD-1	Install 1,715 feet of 16-inch pipe in 600 North between 160 West and 400 West and 3,915 feet of 12-inch pipe in 600 North between 400 West and 1000 West	$310,000
Build-Out Distribution	BD-2	Install 1,550 feet of 12-inch pipe between 450 South Gibbons Parkway and the future Cliffside Tank #2	$251,000
Build-Out Distribution	BD-3	Install a new control valve to allow pipeline described by project D-4 to flow into the proposed Bluff Tank	$135,000
Build-Out Distribution	BD-4	Install 4,615 feet of 48-inch pipe starting at the proposed Bluff Tank then west to about 1380 East Sumac Drive, in Sumac Drive between 1380 East and 975 East, and in 100 North between 975 East and Riverside Drive	$3,589,000
Build-Out Distribution	BD-5	Install 10,620 feet of 54-inch pipe in 100 North between 900 East and 500 East, in 500 East between 100 North and 100 South, in 100 South between 500 East and 300 West, and in 300 West between 100 South and 200 South	$9,290,000
Build-Out Distribution	BD-6	Install 4,690 feet of 54-inch pipe in 200 South between 300 West and 1000 West and 2,660 feet of 48-inch pipe in 200 South between 300 West and 1400 West	$6,171,000
Build-Out Distribution	BD-7	Install 5,440 feet of 36-inch pipe in 1400 West between 600 South and 200 North	$2,769,000
Build-Out Distribution	BD-8	Install 7,690 feet of 30-inch pipe between 600 South 1400 West and 1800 South 1600 West	$2,928,000
Build-Out Distribution	BD-9	Install 2,610 feet of 12-inch pipe in 1800 South between 1600 West and 2000 West	$423,000
Build-Out Distribution	BD-10	Install 7,080 feet of 12-inch pipe in 1600 West between 1800 and and US 89 and in US 89 between 1600 West and 1100 West	$1,147,000
Build-Out Distribution	BD-11	Install 17,430 feet of 30-inch pipe between 1400 West 200 North and 2250 North 2400 West	$6,636,000
Build-Out Distribution	BD-12	Install 8,120 feet of 24-inch pipe in 2400 West between 2250 North and Airport Road and 11,000 feet of 24-inch pipe in Airport Road between 2400 West and 1020 West	$5,472,000

TABLE 7-1 CONTINUED

TYPE	MAP ID	RECOMMENDED PROJECT[1]	COST
Build-Out Distribution	BD-13	Install 1,830 feet of 24-inch pipe beginning at the River Park Well and then west in River Park Drive to Crocket Avenue, in Crocket Avenue between 300 North and 200 North, and in Riverside Drive between 200 North and 100 North	$524,000
Build-Out Distribution	BD-14	Install 680 feet of 12-inch pipe between the Cliffside pump station and Quail way and then 1,500 feet of 12-inch pipe in Quail Way between 260 North and Mountain Road. This pipeline is to be installed parallel to the existing 10-inch pipeline	$353,000
Build-Out Distribution	BD-15	Install 880 feet of 12-inch pipeline in Winding Way between Mountain Road and Quail Canyon Drive	$143,000
Build-Out Distribution	BD-16	Install 2,100 feet of 12-inch pipe in 1000 North between 300 East and Main Street	$340,000
Total			$70,057,000

1. See descriptions in the source, storage and distribution system recommendation summaries presented in previous chapters.

All existing system improvement projects are recommended to be completed in 0 to 5 years. These projects address existing deficiencies within the system, and are not impact fee eligible. Projects in this category are:

- All fire flow projects
- Projects D-1, D-2, D-3, D-5, and D-6
- 31% of project D-4, the 24-inch Cliffside connector
- 31% of project W-1, the proposed Cliffside pump station
- Project W-2, the proposed Hillcrest pump station

The remaining projects will address future population growth within the City, and are impact fee eligible. Projects in this category are:

- All build-out distribution projects
- All remaining well projects (W-3, W-4, W-5, and W-6)
- Project S-1, the proposed additional Cliffside storage tank
- Project S-2, the proposed Bluff storage tank
- 69% of project D-4, the 24-inch Cliffside connector
- 69% of project W-1, the proposed Cliffside pump station

Future and existing costs were broken out for the Cliffside pump station because the pump station will address existing deficiencies as well as future capacity. Calculations included in Table 3-3 show that the pump station is currently short by 715 gpm in meeting existing source requirements. Additionally, similar calculations in Table 3-4 show that the build-out capacity will be deficient 2,335 gpm. The proportion of cost that could be attributed to existing deficiency was calculated as 715 gpm / 2,335 gpm = 0.31. This percentage was applied to projects W-1 and D-4. The sum of all the costs attributable to projects that address existing needs is estimated at $4,223,000 (not including pipeline replacement). These costs are not impact fee eligible. The total estimated cost of projects that address future growth, and are impact fee eligible is $65,834,000.

In addition to the listed existing projects, the City will also need to plan for pipeline replacement, which is a non-impact fee eligible cost. Pipeline replacement is discussed in Chapter 5. A summary of the expected project costs, including pipeline replacement costs, over the next 5 years is shown in Table 7-2 separated by non-impact fee eligible costs and impact fee eligible costs.

TABLE 7-2
FIVE YEAR COST SUMMARY

Project	Non-Impact Fee Eligible Cost	Impact Fee Eligible Cost
Fire Flow Projects:	$2,328,000	$0
Distribution Projects:	$1,010,000	$5,184,000
Source Projects:	$884,000	$1,200,000
Ongoing Pipeline Replacement: ($900,000 annually over 5 years)	$4,500,000	$0
Subtotal	**$8,722,000**	**$6,384,000**
Total	**$15,106,000**	

A summary of the expected costs over the next 6 to 40 years is shown in Table 7-3 separated by non-impact fee eligible costs and impact fee eligible costs.

TABLE 7-3
COST SUMMARY FOR YEARS 6 THROUGH 40

Project	Non-Impact Fee Eligible Cost	Impact Fee Eligible Cost
Distribution projects:	$0	$36,289,000
Source Projects:	$0	$8,312,000
Storage Projects:	$0	$14,850,000
Pipeline Replacement: 6 - 11 years, $900,000 annually; 12 - 21 years, $600,000 annually; 22 - 31 years, $650,000 annually; 32 - 40 years, $675,000 annually;	$23,975,000	$0
Subtotal	**$23,975,000**	**$59,451,000**
Total	**$83,426,000**	

FUNDING OPTIONS

Funding options for the recommended projects, in addition to water use fees, could include the following options: general obligation bonds, revenue bonds, State/Federal grants and loans, and impact fees. In reality, the City may need to consider a combination of these funding options. The following discussion describes each of these options.

With respect to water use fees, it is recommended that the City evaluate water rates periodically. Rates should be sufficient to cover the full cost of producing and delivering water and maintaining the system so that it is not necessary to subsidize with other funding sources. Not keeping up with proper maintenance and pipeline replacement will create an eventual significant financial burden on ratepayers. Old, unstable and leaky pipes cause significant inefficiency, interferes with conservation efforts, and increases the potential for a water quality health risk. Also, falling behind in collecting the proper impact fees can also place a burden on user rates because once the new connections are on the system, the system upgrades cannot be paid for by impact fees. Charging customers for the true current cost of water reinforces the idea that water is a valuable commodity, does not create future financial instability, and protects the health of the public.

General Obligation Bonds

This form of debt enables the City to issue general obligation bonds for capital improvements and replacement. General Obligation (G.O.) Bonds would be used for items not typically financed through the Water Revenue Bonds (for example, the purchase of water source to ensure a sufficient water supply for the City's in the future). G.O. bonds are debt instruments backed by the full faith and credit of the City, which would be secured by an unconditional pledge of the City to levy assessments, charges or ad valorem taxes necessary to retire the bonds. G.O. bonds are the lowest-cost form of debt financing available to local governments and can be combined with other revenue sources such as specific fees, or special assessment charges to form a dual security through the City's revenue generating authority. These bonds are supported by the City as a whole, so the amount of debt issued for the water system is limited to a fixed percentage of the real market value for taxable property within the City.

Revenue Bonds

This form of debt financing is also available to the City for utility related capital improvements. Unlike G.O. bonds, revenue bonds are not backed by the City as a whole, but constitute a lien against the water service charge revenues of a Water Utility. Revenue bonds present a greater risk to the investor than do G.O. bonds, since repayment of debt depends on an adequate revenue stream, legally defensible rate structure and sound fiscal management by the issuing jurisdiction. Due to this increased risk, revenue bonds generally require a higher interest rate than G.O. bonds, although currently interest rates are at historic lows. This type of debt also has very specific coverage requirements in the form of a reserve fund specifying an amount, usually expressed in terms of average or maximum debt service due in any future year. This debt service is required to be held as a cash reserve for annual debt service payment to the benefit of bondholders. Typically, voter approval is not required when issuing revenue bonds.

State/Federal Grants and Loans

Historically, both local and county governments have experienced significant infrastructure funding support from state and federal government agencies in the form of block grants, direct grants in aid, interagency loans, and general revenue sharing. Federal expenditure pressures and virtual elimination of federal revenue sharing dollars are clear indicators that local government may be left to its own devices regarding infrastructure finance in general. However, state/federal grants and loans should be further investigated as a possible funding source for needed water system improvements.

It is also important to assess likely trends regarding federal / state assistance in infrastructure financing. Future trends indicate that grants will be replaced by loans through a public works revolving fund. Local governments can expect to access these revolving funds or public works trust funds by demonstrating both the need for and the ability to repay the borrowed monies, with interest. As with the revenue bonds discussed earlier, the ability of infrastructure programs to wisely manage their own finances will be a key element in evaluating whether many secondary funding sources, such as federal/state loans, will be available to the City.

Impact Fees

Impact fees can be applied to water related facilities under the Utah Impact Fees Act. The Utah Impacts Fees Act is designed to provide a logical and clear framework for establishing new development assessments. It is also designed to establish the basis for the fee calculation which the City must follow in order to comply with the statute. However, the fundamental objective for the fee structure is the imposition on new development of only those costs associated with providing or expanding water infrastructure to meet the capacity needs created by that specific new development. Also, impact fees cannot be applied retroactively.

SUMMARY OF RECOMMENDATIONS

Several recommendations were made throughout the master report. The following is a summary of the recommendations organized by category.

Source

1. It is recommended that the capacity of the Cliffside pump station should be increased by 2,350 gpm and the pumps should be upgraded to pump from the recommended higher head supply pipeline.
2. It is recommended to equip the River Park well, construct a new Jens Johansen Park well, and upgrade the1000 North well for use in the drinking water system in order to meet future demands.
3. Additional wells should be located in the west, if possible. In particular, new sources would be especially beneficial in the far northwest and southwest areas of the Lower Zone.
4. It is recommended that the City apply for a source exemption.
5. It is recommended that redundancy be incorporated into the drinking water system so that the City would have adequate water if their largest drinking water source were off line.

Storage

1. It is recommended that new storage be constructed for the Cliffside and Lower pressure zones. Two new tanks should be built: 1MG Cliffside Zone tank southwest of the existing Cliffside Tank and a 10MG tank on the Bluff between Sumac Drive and Quail Way at about 1450 east.
2. It is recommended that the City apply for a storage exemption.

Distribution

1. It is recommended to complete several fire flow projects that address existing deficiencies as soon as possible. Projects required to meet other existing

deficiencies should also be completed as soon as possible. Future projects should be completed as needed.

2. It is recommended that transmission capacity be added so that future demands can be met without large pressure variations at service connections. In particular, significant transmission capacity should be added between the proposed Bluff Tank and the Lower pressure zone.

Optimization

1. It is recommended that the Lower USU zone be combined into the Upper Zone and the Castle Hills and USU zones be combined.
2. The Hillcrest pump station should be modified so that water can be pump directly out of the DeWitt Springs supply line up to the Hillcrest Tank.
3. It is recommended to set PRVs so that equalization storage is utilized while pressure fluctuations are controlled.
4. It is recommended to minimize pumping costs by:
   a) eliminating the Castle Hills pump station by installing a transmission line from the Hillcrest pump station with dedicated controls for the Castle Hills Tank,
   b) upgrading the Hillcrest pump station to pump from the Dewitt Spring pressure,
   c) installing a new pipeline at 1020 North 800 East to combine the Upper and Lower USU pressure zones,
   d) moving the Crockett well and possibly the 7th North well to the Lower pressure zone and adding a pump station to move the water to the Upper pressure zone when needed, and
   e) modifying the Cliffside pump station to pump from the high pressure transmission line.
5. Lower cost source water usage should be prioritized.
6. Water quality test results should be monitored. In particular, chlorine should be tested in areas the model identifies as having lower chlorine residual levels.
7. Water quality in areas identified as having higher age should be monitored.
8. It is recommended that the City use the water age model to make sure DBP sampling is occurring at the locations with the highest DBP production potential.

General

1. Development should be limited to elevations where adequate pressure can be maintained.
2. It is recommended that the City fund a pipeline replacement program.
3. It is recommended that the City continue updating the model as the water system changes.
4. It is recommended that the City could also reduce the energy intensity of the pump stations where possible.

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APPENDIX A
ERC Calculations

Water Use and ERC Calculations

Population (2013) =	48,174	
Total water use =	14,283	AF
Residential connections =	8,587	
Total Connections =	16,266	
Residential water use =	5,855	AF
Average Residential flow rate =	3,630	gpm
Demand per ERC =	0.423	gpm/ERC
non resdiential water use =	8,428	AF
non resdiential water use =	5,225	gpm
Summation of ERCs from non-residential demands =	12,361	ERCs
Total ERCs =	20948	ERCs

Existing Peak day Model Flow Computation

Indoor Calcs

Peak Day Indoor Demand =	400	gallons
Total Indoor Demand =	5,819	gpm

Outdoor Calcs

Calculate outdoor demand as August Demand minus December demand
IE assume December demand represents true indoor demand

August 2013 volume =	8.49E+08	gallons
	19,016	gpm
December 2013 flow =	1.78E+08	gallons
	3,978	gpm

Outdoor demand =	15,038	gpm
Outdoor demand =	0.718	gpm/ERC
State Standards, outdoor demand =	3.96	gpm/irr acre
Irrigated acres/ERC =	0.181	acres
Total irrigated acreage =	3,797	acres

0.19 irrigated acres/ERC appears reasonable for Logan

Check

Irrigated acres connected to residential ERCs =	1,557	acres
Irrigated acres not connected to residential ERCs =	2,241	acres
Area of parks and open lands =	641	acres

assume 65% is irrigated to account for building parking etc.

65% of area of parks and open lands =	417	acres

CLIENT Logan		SHEET 2 OF 2
PROJECT 2014 DWMP Update		COMPUTED RTC
FEATURE ERC Calculations		
PROJECT NO 139.07.100		DATE 5/12/16

The public facilities zone has an area of 1937 acres, which includes cemeteries, schools, USU, etc. Large portions are not irrigated Assume 25% of the area is irrigated.

Public Facilities acreage = 484 acres

Remaining acreage (total irr. Acreage minus residential minus parks and open space minus public) = 1,340 acres

Remaining acreage is assumed to be associated with landscaping for commercial and industrial areas

Indoor plus outdoor demand

Total demand =	20,857	gpm
Total demand/ERC =	0.996	gpm/ERC

Analysis of Actual Production Volume

Measured peak day flow from production data =	14123	gpm
Demand per ERC using production data =	0.674	gpm/ERC
PD/AD peaking factor =	1.595	
PI/PD peaking factor from production data =	1.55	
Peak instantaneous flow based on production data =	1.04502	gpm/ERC

Future Peak day Model Flow Computation

Target population selected for 2060 was 111,717 (GOPB)

New population = 63,543

The persons per household as of the 2010 Census was 2.8

111717	people	governors office 2060
20733	new residential (currently in GIS)	

APPENDIX B
Large Building Fire Flow Data

Large Building Fire Flow Data

Address	Building Name	Fire Flow Requirement (gpm)
1095 N 600 W	ARMOR STORAGE 4 BUILDINGS	7000
1095 N 600 W	ARMOR STORAGE OF LOGAN 1-158 1S	6500
145 W CACHE VALLEY BLVD	SAM S CLUB 1S	5500
130 CACHE VALLEY BLVD	HOME DEPOT 1S	5000
115 E 400 N	M H KING CO 1S	4500
328 N MAIN ST	WILSON MOTOR CO 1S	4500
1341 N MAIN ST	SHOPKO 1S	4500
815 W 1800 N	CAMPBELL SCIENTIFIC INC 2S	4000
132 S MAIN ST	SMITH BROS LUMBER CO 2S	4000
25 W 300 N	25 WEST 300 NORTH ST 1S	4000
727 N 600 W	LUNDAHL SCHREIBER 1 2S	4000
115 GOLF COURSE RD	UTAH STATE DEPARTMENT 1S	4000
240 E 400 N	MT AIRY GARDENS CONDOMINIUM 3S	3500
255 N MAIN ST	LOGAN CITY LIBRARY 2S	3500
750 W 200 N	EUGENE GOODSELL BLDG 1S	3500
1300 N 200 E	LOGAN POINTE 5 TENANTS 1S	3500
1465 N 200 W	CACHE VALLEY BUILDERS SUPPLY 1S	3500
1465 N 200 W	1465 N 200 WEST ST 1S	3500
280 S 400 W	fulle	3500
1051 N 1000 W	GOSSNER FOODS INC 1S	3500
71 E 1600 N	LARSON NO LOGAN RETAIL BLDG B 1S	3500
695 W 1700 S	WESLO INC ZOLLINGER 1S	3500
1320 N 200 E	LOGAN POINTE LTD 3S	3000
122 E CENTER ST	CENTRAL MILLING LLC 3S	3000
760 W 200 N	OX SPRINGS BUSINESS COMPLEX 2S	3000
1350 N 200 W	PORTAL INC 2 TENANTS 2S	3000
530 N 400 E	ADAMS ELEMENTARY SCHOOL 2S	3000
89 S 500 E	WILSON ELEMENTARY SCHOOL 2S	3000
710 N 600 W	LUNDAHL ASTRO CIRCUITS 2S	3000
165 E 1400 N	VISTA MANAGEMENT WORTHEN BLDG 2S	3000
1073 W 1700 N	INOVAR INC 2S	3000
1079 N MAIN ST	BRIDGERLAND SQUARE 2S	3000
648 W 200 N	NOVAK - 10 TENANTS 1S	3000
1375 W 200 N	VALLEY VIEW BUSINESS PARK 1S	3000
918 W 700 N	DAYCO BLDG 918 1S	3000
1860 S 1000 W	STANDARD PLUMBING 1S	3000
1860 S 1000 W	STANDARD PLUMBING 1S	3000
555 E 1400 N	UNIVERSITY VILLAGE SC LEES MKT 1S	3000
708 W 1800 N	TRI CON INDUSTRIES 1S	3000
815 W 1800 N	CAMPBELL SCIENTIFIC 1S	3000
135 S MAIN ST	EVERTON MATTRESS WHSE 1S	3000
981 S MAIN ST	MY MATTRESS - 4 TENANTS 1S	3000
1050 N MAIN ST	CACHE VALLEY BLDRS-WHSE 1S	3000

Large Building Fire Flow Data

Address	Building Name	Fire Flow Requirement (gpm)
1075 N MAIN ST	CACHE WOOD DESIGN ET AL 1S	3000
1585 N MAIN ST	AARON S - LEASE TO OWN 1S	3000
1717 S 450 W	SEITEC INC 1S	3000
690 W 1700 S	ICON / PROFORM 1S	3000
364 S MAIN ST	CACHE VALLEY INN 2S	2500
75 W 400 N	STATE LIQUOR STORE 1S	2500
710 N 600 W	ELECTROSTAR INC 1S	2500
953 W 700 N	COMMERCIAL CENTER 1 1S	2500
316 N 850 W	BINDRUP PROPERTIES A-C 1S	2500
495 N 1000 W	PLASTIC RESOURCES 1S	2500
265 W 1400 N	SCIENTIFIC PLASTICS 1S	2500
430 W 1400 N	5 OCCY BLDG DESIGNED FOR 15 1S	2500
600 W CENTER ST	CAFE SABOR 1S	2500
990 S MAIN ST	MULTI/OCC 1S	2500
1151 N MAIN ST	MULT OCCY BLDG 1S	2500
1766 BLACKSMITH CT	SOFA SOURCE 1S	2500
675 E 400 N	BAUGH APARTMENTS 3S	2250
51 W 200 S	KAMIN RESTAURANT 2S	2250
250 N MAIN ST	WESTON MOTEL 2S	2250
580 N MAIN ST	CLOCK TOWER 580 2S	2250
843 S 100 W	NEW DAWN TECHNOLOGIES BLDG 1S	2250
370 S 400 W	FULLMER MILL SUPPLY 1S	2250
1850 N 600 W	ECLIPSE WIRELINE - 2 TENANTS 1S	2250
120 S 700 W	GOOD TIMBER FINE LOG FURN 1S	2250
642 N 1000 W	MULTI OCCUPANCY-6 TENANTS 1S	2250
138 N 1175 W	4 TEANT BUILDING 1S	2250
110 W 1200 S	KEITH WATKINS SON PRINTING 1S	2250
235 N 1375 W	PRO TECH CASES 1S	2250
140 S MAIN ST	EZRA LUNDAHL BLDG 1S	2250
839 N MAIN ST	INDUSTRIAL TOOL AND SUPPLY 1S	2250
1114 N MAIN ST	GOLDEN CORRAL RESTNT 1S	2250
1475 N MAIN ST	AXTEL CHEVROLET CO INC 1S	2250
2500 N 900 W	BLDG FL-11 KETONE COMP 1S	2250
129 N 100 E	LE NONNE RESTAURANT 2S	2000
459 S MAIN ST	WESCOR 2S	2000
632 N MAIN ST	THE MAIN PLACE - OFC BLDG 2S	2000
75 W 100 S	DESIGN ANALYSIS ASSOC INC 1S	2000
720 W 200 S	AUTUMN MILL - 2 TENANTS 1S	2000
290 W 300 S	INTERMOUNTAIN THREADING MACH 1S	2000
275 W 400 S	ALCO MFG 1S	2000
1725 N 600 W	DUCWORKS INC 1S	2000
316 N 850 W	BINDRUP PROPERTIES D-E 1S	2000

Large Building Fire Flow Data

Address	Building Name	Fire Flow Requirement (gpm)
412 W 1000 N	TOUCHARD CHOC MEADOW GOLD 1S	2000
1305 N 1000 W	MULTI OCCUPANCY- 2 TENANTS 1S	2000
43 E 1400 N	RUBY TUESDAY RESTNT 1S	2000
355 W 1400 N	TENKO METALS-2 TENANTS 1S	2000
450 W 1400 N	1400 NORTH STORAGE 1S	2000
130 N MAIN ST	MULTI OCCY 1S	2000
244 S MAIN ST	SOFA SOURCE PARKER AWNING 1S	2000
434 S MAIN ST	TRADER S DEN 1S	2000
690 N MAIN ST	ANGIES RESTAURANT 1S	2000
880 S MAIN ST	LOGAN CROSROADS ASSOC S C 1S	2000
1031 N MAIN ST	FISHER CLEARANCE CTR 1S	2000
1045 N MAIN ST	BRIDGERLAND SQUARE 1S	2000
1427 N MAIN ST	CHILI S RESTAURANT 1S	2000
1575 N MAIN ST	HOBBY LOBBY 1S	2000
71 E 1200 S	KATES KITCHEN 1S	2000
390 W 1700 S	PALLETS OF UTAH 1S	2000
839 N 700 E	GROVER APARTMENTS 3S	1750
290 N 400 E	WHITTIER COMMUNITY CENTER 2S	1750
555 N 1000 W	IPACO - MACHINE SHOP 2S	1750
1 N MAIN ST	1-7NORTH MAIN 5-13WEST CENTER 2S	1750
19 N MAIN ST	BLUEBIRD CAFE 2S	1750
33 N MAIN ST	BISHOP PROPERTIES 2S	1750
130 S MAIN ST	CACHE KNITTING MILL BLDG 2S	1750
250 N MAIN ST	WESTON INN-REAR MOTEL 2S	1750
1011 N MAIN ST	CAROUSEL CARPETS 2S	1750
665 W 100 S	ECHOREEL CORP 1S	1750
665 W 100 S	UNITED SUNGLASS APPAREL INC 1S	1750
710 W 200 N	OX SPRINGS DEVELOPMENT BLDG F 1S	1750
720 W 200 N	OX SPRING DEVELOPMENT BLDG G 1S	1750
825 W 200 N	ELECTRICAL WHOLESALE SUPPLY 1S	1750
1510 N 200 W	TEN O GYMNASTICS 1S	1750
35 E 400 N	RAYMOND FAMILY PARTNERSHIP 1S	1750
365 N 600 W	SPENDLOVE RESEARCH FOUNDATION 1S	1750
2005 N 600 W	T AND T LAND COMPANY 1S	1750
120 S 700 W	WESTERN MECHANICAL INC 1S	1750
1860 S 1000 W	STANDARD PLUMBING 1S	1750
255 N 1375 S	CARDALLS INSULATION 1S	1750
155 E 1400 N	RENT-A-CENTER - 9 TENANTS 1S	1750
505 E 1400 N	SHOPPING CENTER 1S	1750
721 W 1800 N	NORTHSTAR II APOGEE 1S	1750
36 W CENTER ST	WHITE OWL INC 1S	1750
202 N MAIN ST	BURGER KING 1S	1750

Large Building Fire Flow Data

Address	Building Name	Fire Flow Requirement (gpm)
432 N MAIN ST	MULTI OCCY 1S	1750
454 N MAIN ST	RAYMOND FAMILY PARTNERSHIP 1S	1750
492 S MAIN ST	BROWN MONUMENT VAULT 1S	1750
909 S MAIN ST	SEARS BUILDING 1S	1750
1010 N MAIN ST	HEALTHY FOODS INC 1S	1750
1095 N MAIN ST	BRIDGERLAND SQUARE 1S	1750
1433 N MAIN ST	MULTI OCCUPANCY-4 TENANTS 1S	1750
695 W 1700 S	ZOLLINGER BLDG D 1S	1750
UNIVERSITY HILL	FINE ARTS BLDG 73 2S	5000
880 N 600 WEST ST	L D SCHREIBER CHEESE CO 1S	5000
190 W 100 S	LOGAN HIGH MAIN BLDG 3S	4500
1105 N 1000 W	EAST SIDE ENTREES/GOSSNER FODS 1S	4500
80 GOLF COURSE RD	OPINIONOLOGY - 2 TENANTS 1S	4500
6700 OLD MAIN HILL	EDITH BOWEM ELEM SCHL 75 1S	4500
UNIVERSITY HILL	PHYSICAL PLT GEN STGE BLDG 38 1S	4500
UNIVERSITY HILL	PHYSICAL EDUCATION BLDG 15 2S	4000
UNIVERSITY HILL	NATURAL RESOURCES BLDG 58 3S	3500
UNIVERSITY HILL	OLD MAIN BLDG 1 3S	3500
UNIVERSITY HILL	WATER RESEARCH LAB BLDG 86 3S	3500
UNIVERSITY HILL	ENG PHY SCIENCE BLDG 68 3S	3500
37 S MAIN ST	CAPITOL THEATRE 2S	3500
UNIVERSITY HILL	SPECTRUM-SPORTS ARENA 14 2S	3500
75 S 400 N	NELSON FIELD HOUSE BLDG 23 2S	3500
699 W 1700 SOUTH ST	ZOLLINGER COLD STGE BLDG C 1S	3500
3000 OLD MAIN HILL	MERRILL LIBRARY BLDG 64 4S	3000
865 S MAIN ST	SUPER 8 3S	3000
UNIVERSITY HILL	STUDENT UNION BLDG 22 3S	3000
UNIVERSITY HILL	UTAH STATE UNIVERSITY BLDG 33 3S	3000
190 W 100 S	LOGAN HIGH SHOP BLDG 2S	3000
290 S 400 W	LOGAN COACH INC 2S	3000
2701 W 1800 SOUTH ST	SEITEC INC 2S	3000
UNIVERSITY HILL	EXCEPTIONAL CHILD CTR BLDG 39 1S	3000
780 W 1600 SOUTH ST	LA ZOLLINGER ICON WHSE 1 2S	3000
UNIVERSITY HILL	LIFE SPAN RESIDENCE 28A 5S	2500
UNIVERSITY HILL	WIDTSOE HALL CHEM BLDG 21 3S	2500
780 W 200 N	OX SPRINGS DEVELOP BLDG A 2S	2500
99 E 700 S	CONSERVICE BLDG 2S	2500
1155 N 1000 W	MILK PROCESSING PLANT 2S	2500
1537 N MAIN ST	HUI MEI SUMS BLDG 2S	2500
UNIVERSITY HILL	TELEVISION STUDIO BLDG 79 2S	2500
61 W 100 N	CACHE CO CORP 1S	2500
1435 N 200 W	3RD GEN MACHINE - 2 OCCUPANTS 1S	2500

Large Building Fire Flow Data

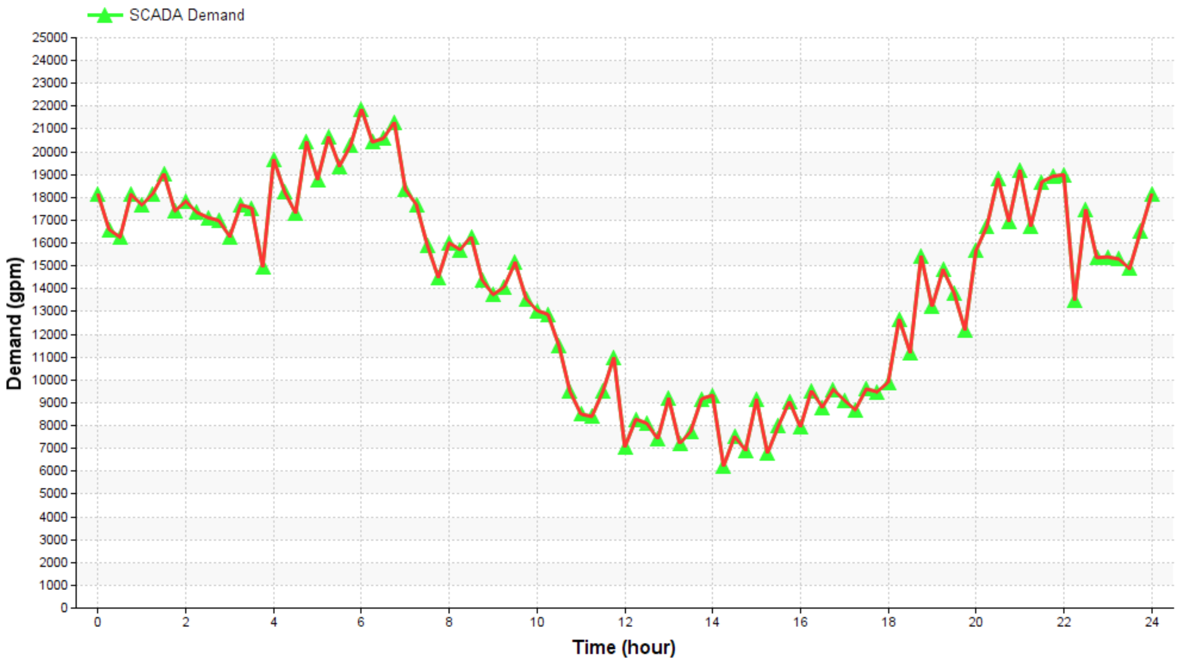
Address	Building Name	Fire Flow Requirement (gpm)
280 W 400 S	QUALITY ARCHITECT L WDWK 1S	2500
294 S MAIN ST	SOFA SOURCE ANDERSON 1S	2500
1094 N MAIN ST	ABBEY TURNAROUND 1S	2500
780 W 1600 SOUTH ST	L A ZOLLINGER ICON 1 2S	2500
1050 W 500 NORTH ST	NIELSENS AUTO BODY 1S	2500
881 W 700 NORTH ST	DAYCO BUILDING 1S	2500
4880 E RTE 89	ZANAVOO LODGE AND RESTAURANT 1S	2500
UNIVERSITY HILL	UTAH STATE UNIVERSITY BLDG 19 3S	2250
UNIVERSITY HILL	PARKING RAMP BLDG 28B 3S	2250
1722 HYCLONE DR	THERMO FISHER SCIENTIFIC 2S	2250
1124 N MAIN ST	MOUNTAIN FARMS INC 2S	2250
180 W 1200 S	BROWSE AROUND ANTIQUE SHOP 1S	2250
1320 N 600 EAST ST	CANYON PROFESSIONAL CENTER 1S	2250
1093 N MAIN ST	BRIDGERLAND SQUARE 1S	2250
UNIVERSITY HILL	TECHNOLOGY BLDG 45 1S	2250
806 W 1600 SOUTH ST	PALLETS OF UT HERITAGE GLASS 1S	2250
UNIVERSITY HILL	UTAH STATE UNIVERSITY BLDG 56 9S	2000
494 N 700 E	UTAH STATE UNIVERSITY BLDG 28 3S	2000
UNIVERSITY HILL	AGRICULTURAL SCIENCE BLDG 53 3S	2000
UNIVERSITY HILL	ENGINEERING BLDG 68A 3S	2000
190 W 100 S	LOGAN HIGH GYM 2S	2000
251 W 1600 NORTH ST	HANBURY MANOR 2S	2000
1260 N 200 EAST ST	BILL RICH BUILDING 2S	2000
25 W CENTER ST	GLAUSER BUILDING 2S	2000
UNIVERSITY HILL	UTAH STATE UNIVERSITY BLDG 52 2S	2000
UNIVERSITY HILL	AGRICULTRUAL ED BLDG 36 2S	2000
254 N MAIN ST	MO 6 TENANT BLDG 1S	2000
461 N MAIN ST	KABUKI JAPANESE STEAKHOUSE 1S	2000
1075 1-2 N MAIN ST	BRIDGERLAND SQUARE 1S	2000
UNIVERSITY HILL	COMPUTER SCIENCE BLDG 57 1S	2000
UNIVERSITY HILL	PHYSICAL PLANT BLDG 37 1S	2000
UNIVERSITY HILL	FAMILY LIFE BLDG 16 3S	1750
76 E 200 N	LOGAN CITY FIRE STATION 2B	1750
55 W CENTER ST	ROTHWELLS RESTNT 1 2S	1750
155 CHURCH ST	IRON GATE GRILL 2S	1750
120 S MAIN ST	CACHE KNITTING MILL BLDG 2S	1750
1170 W 200 N	VINYL TECHNOLOGIES INC 1S	1750
920 E CANYON RD	CSC PROPERTIES LLC 1S	1750
237 S 600 W	WESTON CONSTRUCTION CO 1S	1750
160 S 700 W	REED BINDRUP BLDG-PORPHYRIN 1S	1750
46 E 200 SOUTH ST	THOMPSON FAMILY TRUST 1S	1750
350 W 2500 NORTH ST	S AND S POWER SOUTH BLDG 6 1S	1750

Large Building Fire Flow Data

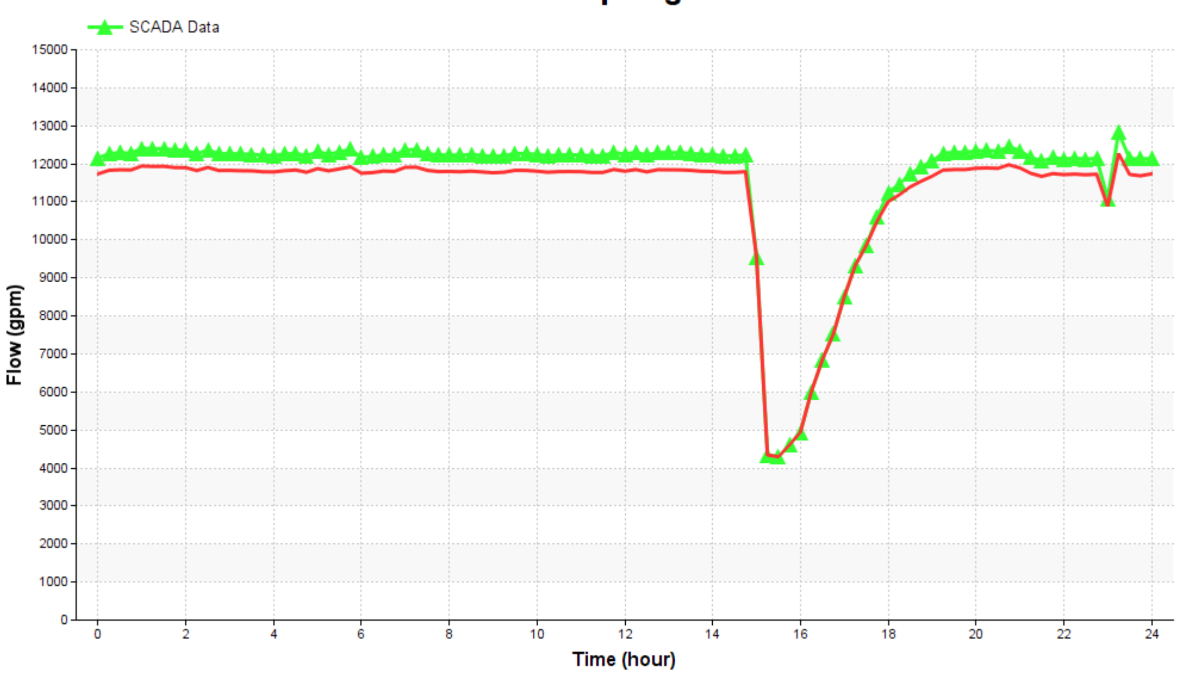
Address	Building Name	Fire Flow Requirement (gpm)
590 S MAIN ST	CREATIVE CABINETS SALES 1S	1750
910 S RTE 89	BAILEY CONSTRUCTION 1S	1750
160 N LOGAN ST	M O 1S	1750

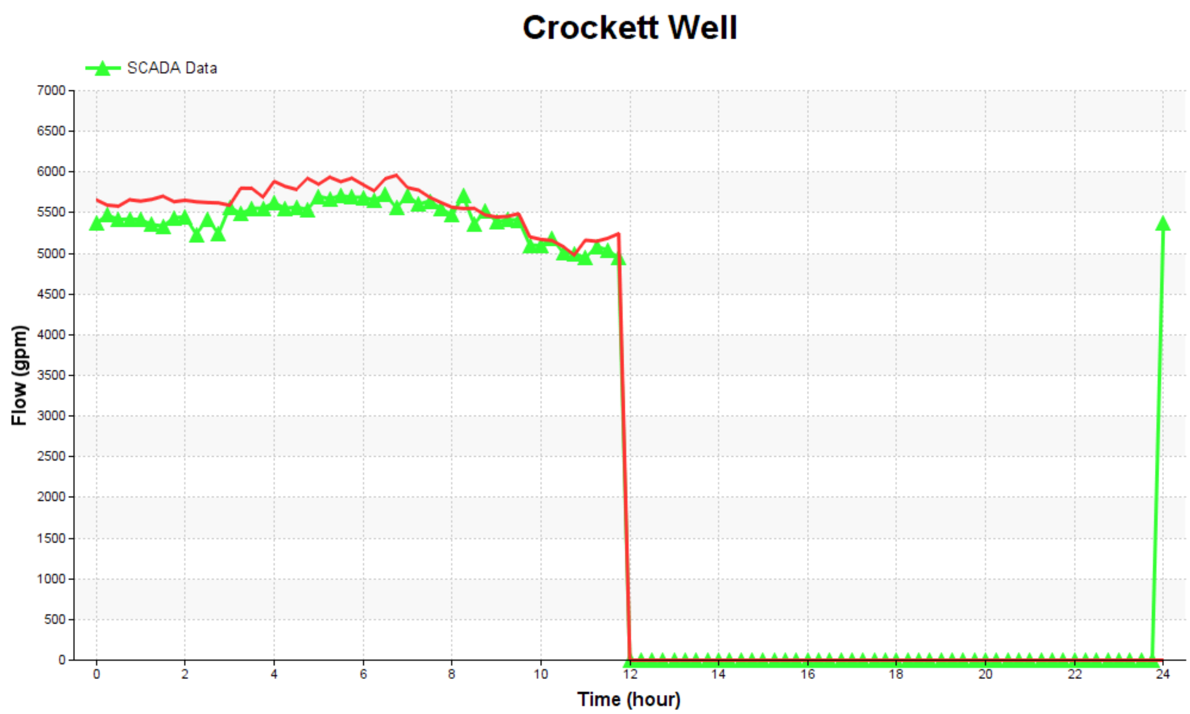
APPENDIX C
Calibration Data

Flow Demanded

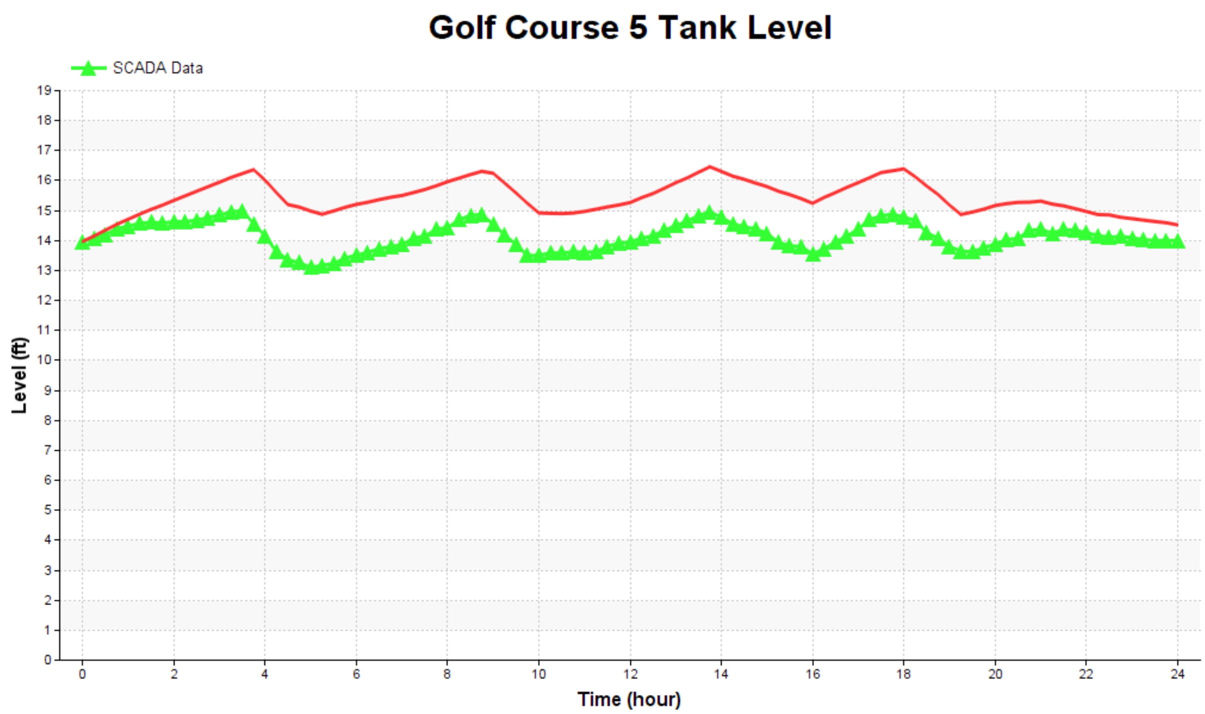


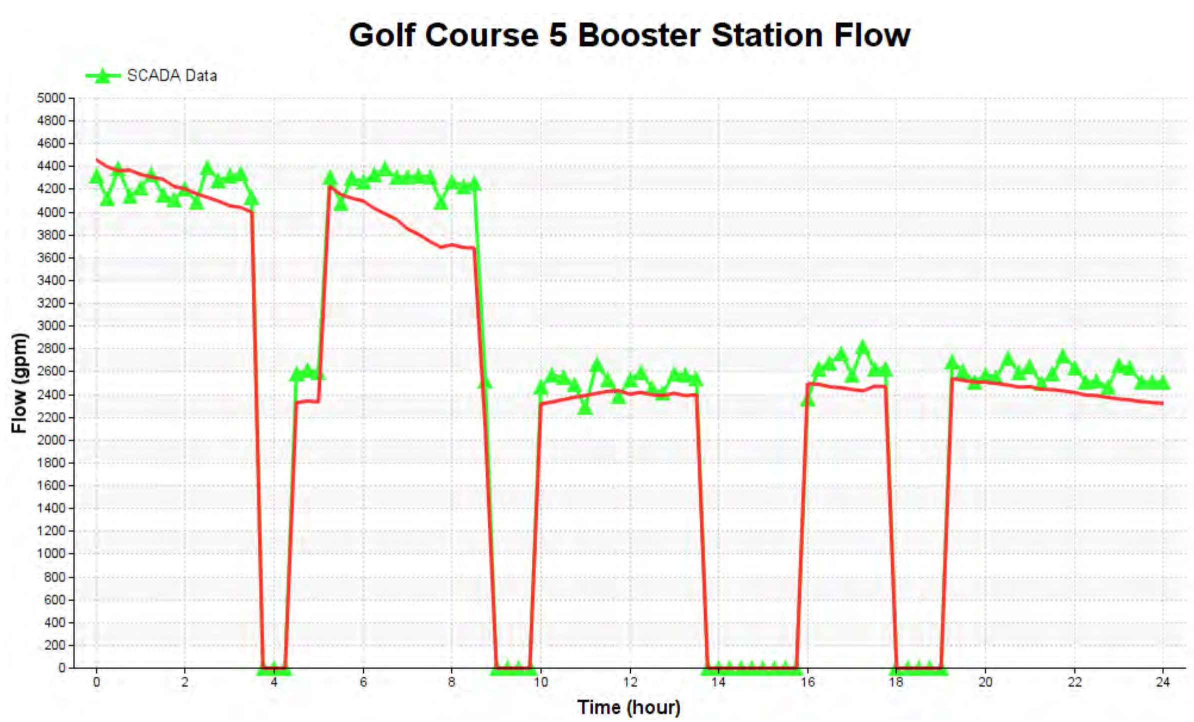
DeWitt Springs Flow

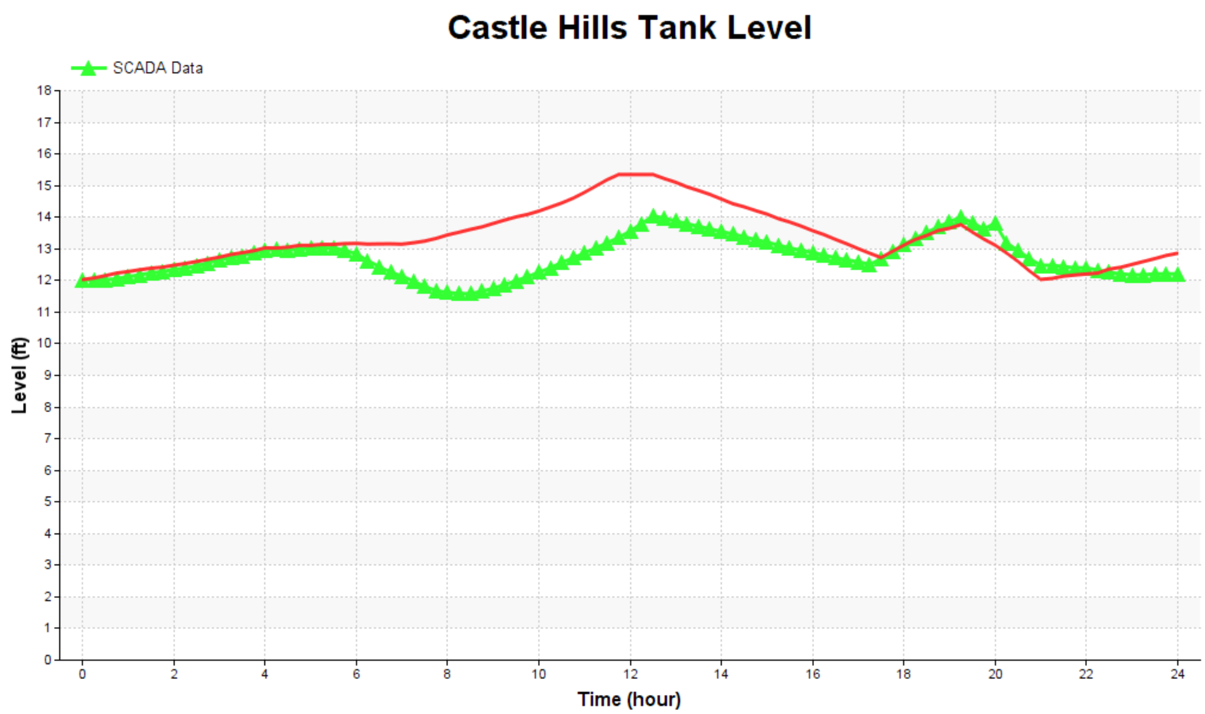



Crockett Well
SCADA Data
Flow (gpm)
Time (hour)
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
22
24

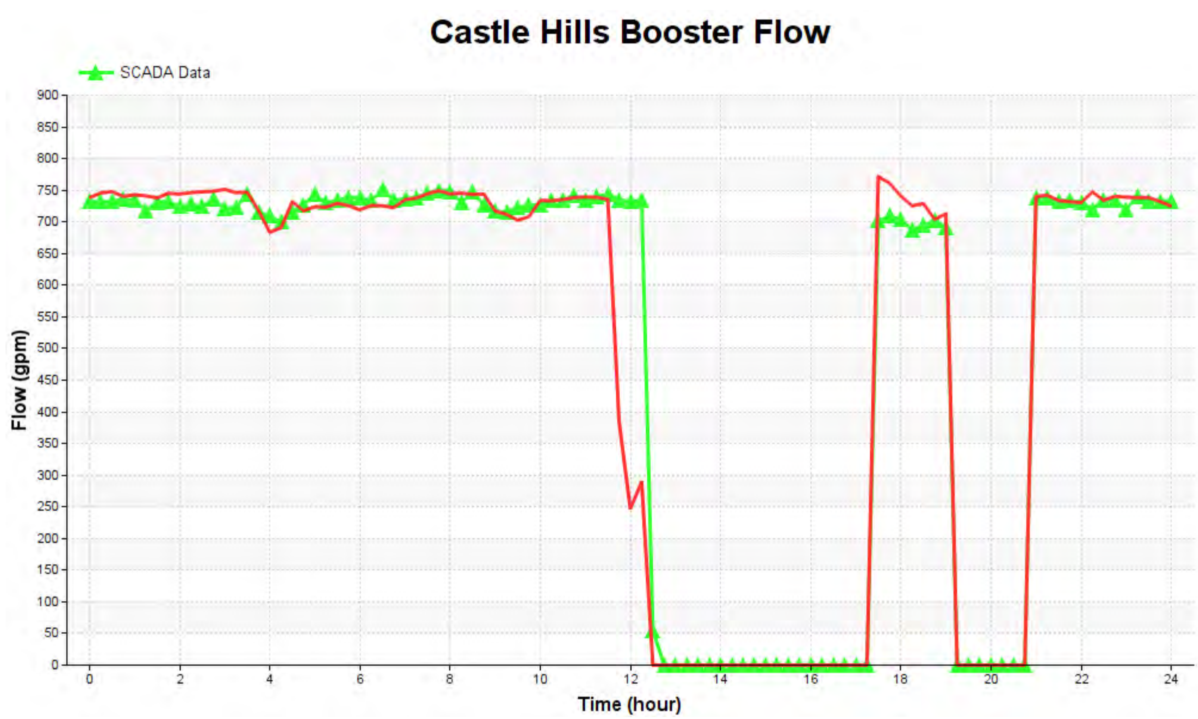

Golf Course 6, 7, 8, & 9 Tank Level
SCADA Data
Level (ft)
Time (hour)
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
20
22
24


Golf Course 5 Tank Level
SCADA Data
Level (ft)
Time (hour)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
0 2 4 6 8 10 12 14 16 18 20 22 24


Golf Course 5 Booster Station Flow
SCADA Data
Flow (gpm)
Time (hour)
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000 4200 4400 4600 4800 5000
0 2 4 6 8 10 12 14 16 18 20 22 24

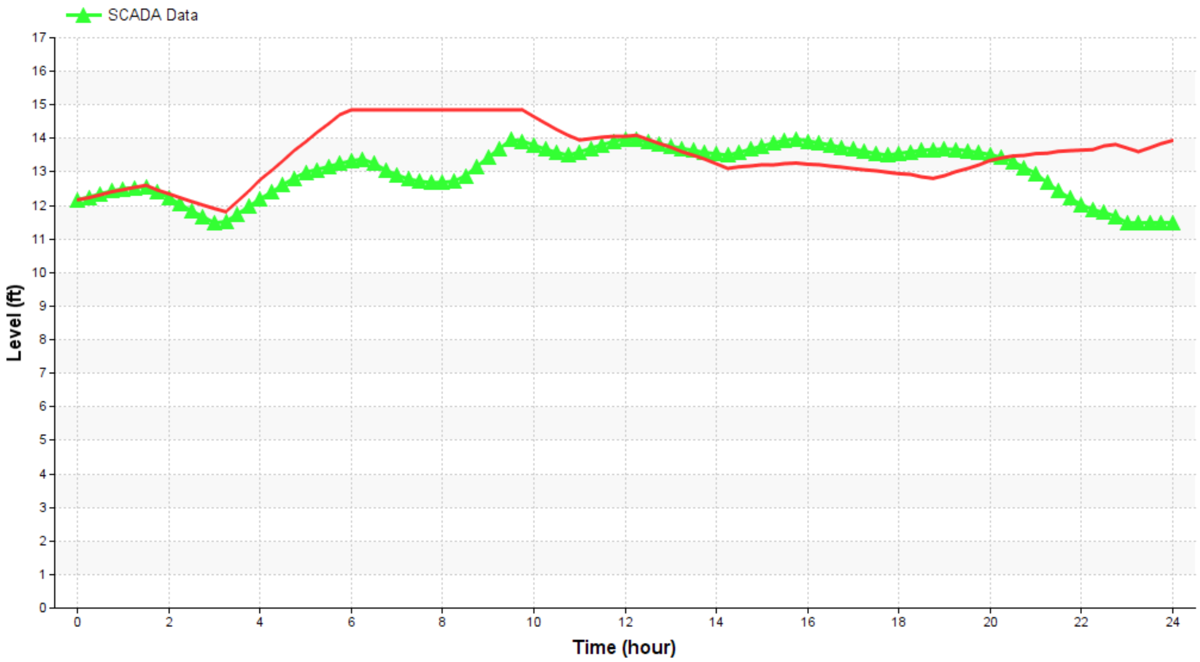


Castle Hills Tank Level
SCADA Data
Level (ft)
Time (hour)

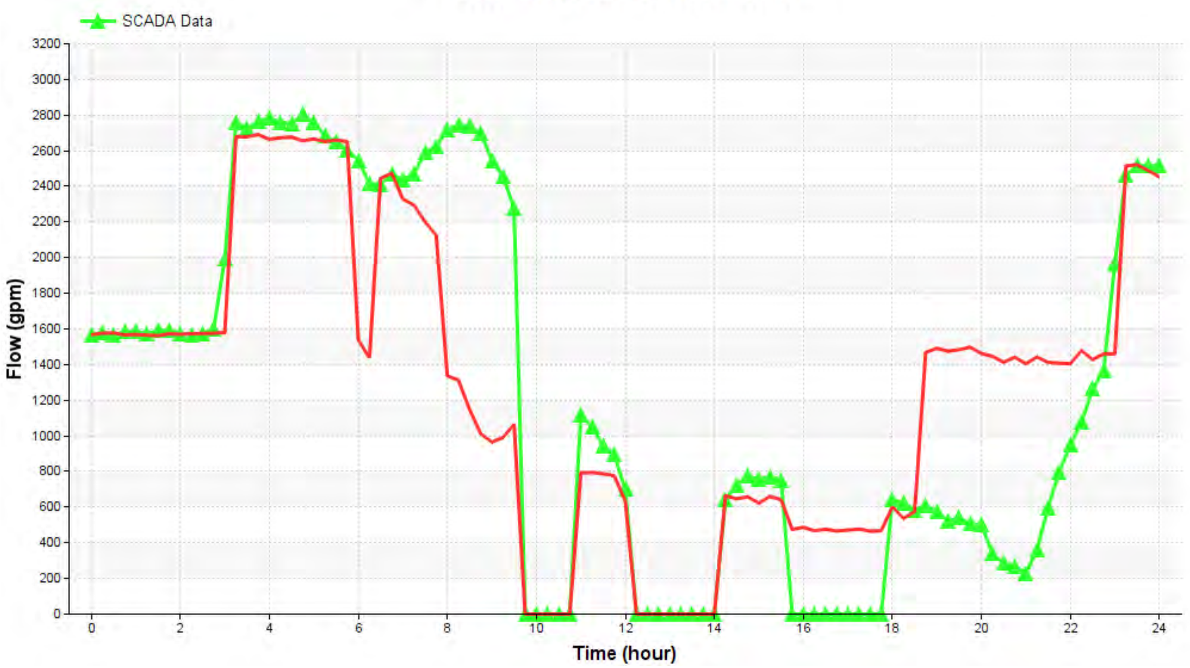


Castle Hills Booster Flow
SCADA Data
Flow (gpm)
Time (hour)

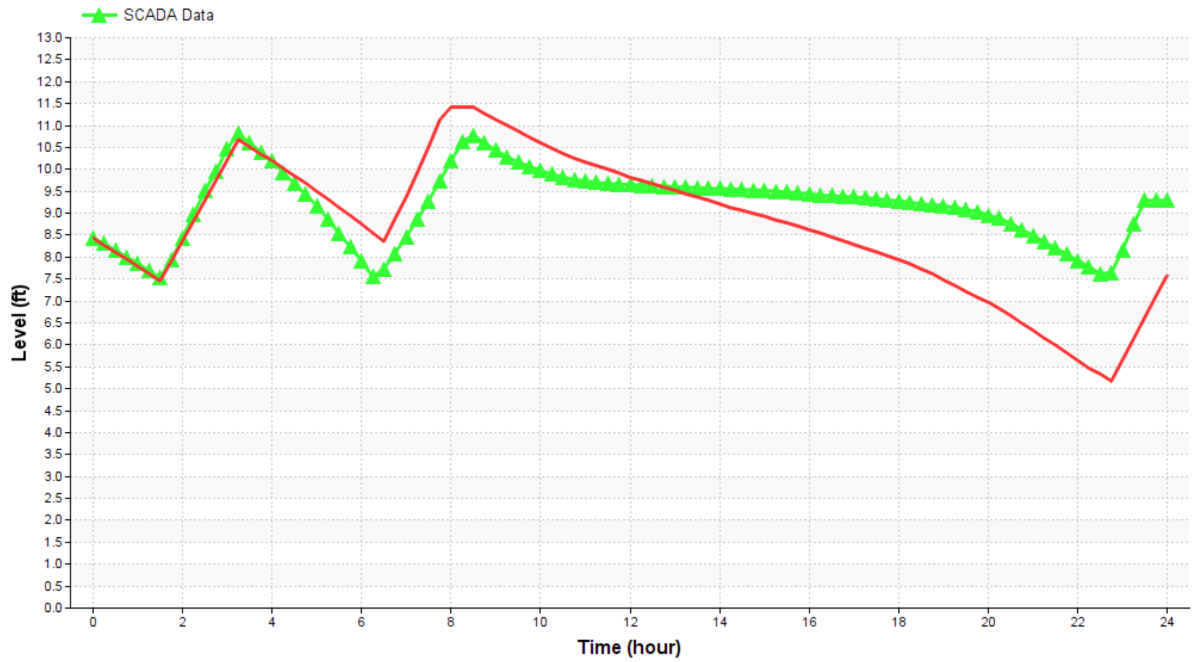
Cliffside Tank Level



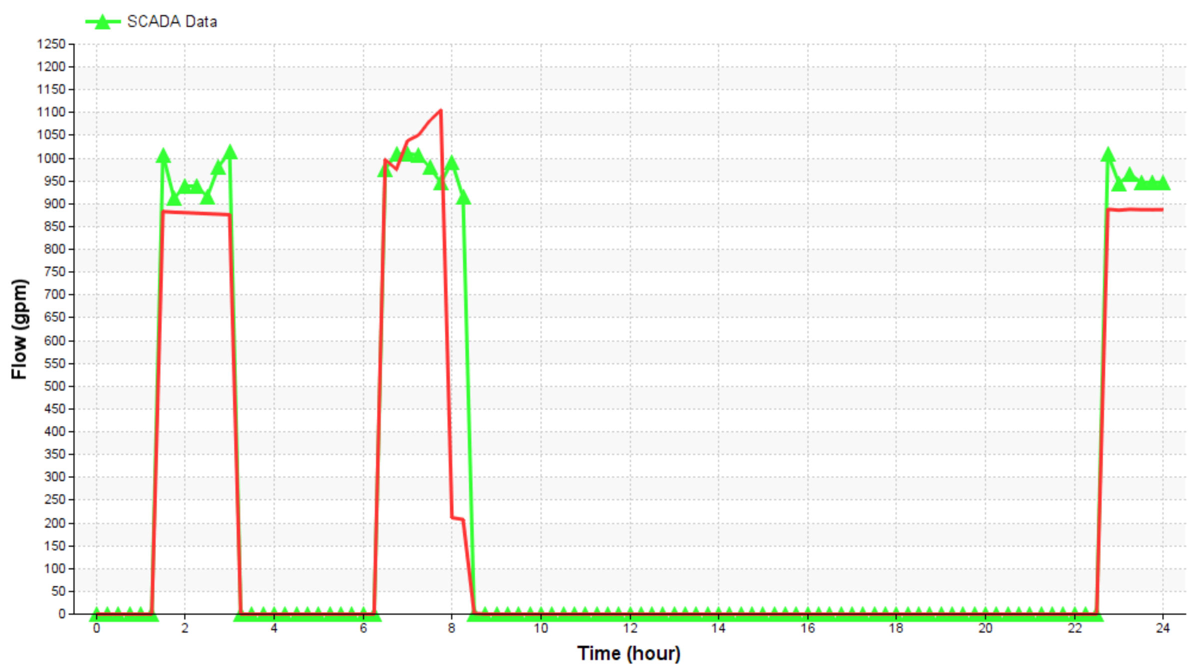
Cliffside Booster Flow



Quail Bluff Tank Level



Quail Bluff Booster Station Flow



APPENDIX D
Computer Model Output

SEE DISK

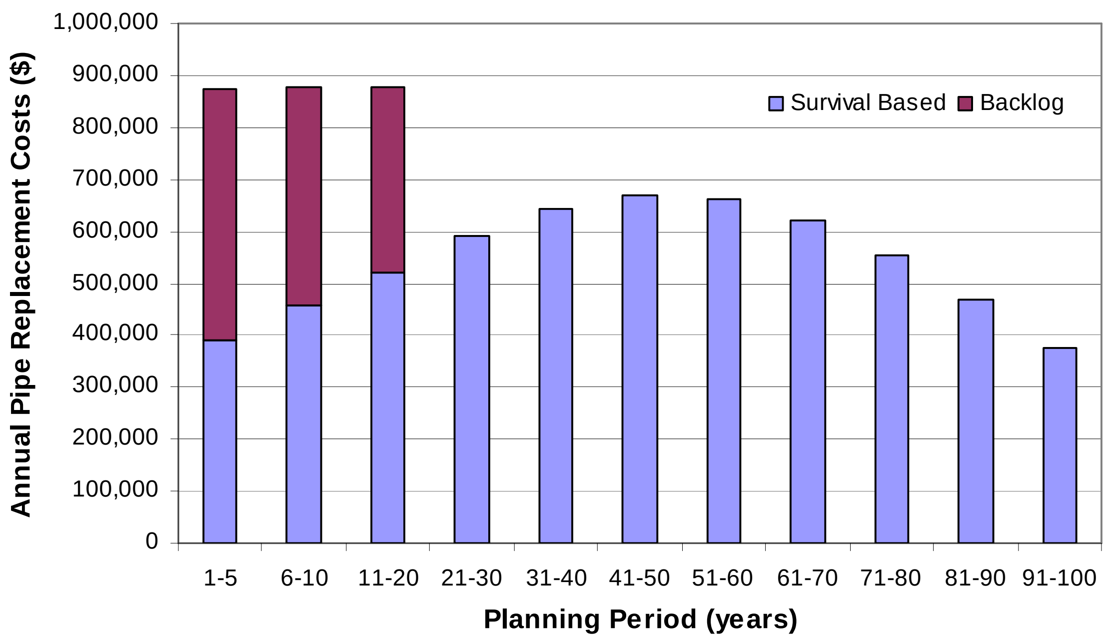
APPENDIX E
Pipeline Replacement Budget

Table 6.2

Logan Pipeline Replacement Plan

Planning Period (years)	Planning Period Cost ($ million)			Annual Cost ($ million/year)		
	Backlog	Survival-based	**Total**	Backlog	Survival-based	**Total**
1-5	2.424	1.946	**4.370**	0.485	0.389	**0.874**
6-10	2.101	2.285	**4.386**	0.420	0.457	**0.877**
11-20	3.555	5.208	**8.763**	0.356	0.521	**0.876**
21-30		5.909	**5.909**		0.591	**0.591**
31-40		6.440	**6.440**		0.644	**0.644**
41-50		6.702	**6.702**		0.670	**0.670**
51-60		6.629	**6.629**		0.663	**0.663**
61-70		6.215	**6.215**		0.622	**0.622**
71-80		5.524	**5.524**		0.552	**0.552**
81-90		4.666	**4.666**		0.467	**0.467**
91-100		3.765	**3.765**		0.377	**0.377**
	8.080	55.287	**63.368**			

Figure 6.18
Logan Annual Pipe Replacement Costs



APPENDIX F
Cost Estimate Calculations

FIRE FLOW PROJECT COST CALCULATIONS

MAP ID	Project Description	UNIT	UNIT TYPE	UNIT COST	COST	Contingency (20%) and Engineering (15%)	TOTAL COST
W-1	Cliffside Pump Station	1	ea.	$500,000	$500,000	$175,000	$675,000
W-2	Golf Course Pump Station	1	ea.	$500,000	$500,000	$175,000	$675,000
W-3	River Park Well equip and build well house	1	ea.	$350,000	$350,000	$122,500	$473,000
W-4	New Jens Johansen Park Well	1	ea.	$1,500,000	$1,500,000	$525,000	$2,025,000
W-5	1000 North Well Upgrades	1	ea.	$350,000	$350,000	$122,500	$473,000
W-6	3 Additional future wells	3	ea.	$1,500,000	$4,500,000	$1,575,000	$6,075,000
S-1	1 MG Cliffside Storage Tank	1	ea.	$1,000,000	$1,000,000	$350,000	$1,350,000
S-2	10 MG Bluff Storage Tank	1	ea.	$10,000,000	$10,000,000	$3,500,000	$13,500,000
F-1	725 feet of 8-inch pipe	725	foot	$99	$71,775	$25,121	$97,000
F-2	2,300 feet of 8-inch pipe	2,300	foot	$99	$227,700	$79,695	$307,000
F-3	255 feet of 8-inch pipe	255	foot	$99	$25,245	$8,836	$34,000
F-4	621 feet of 8-inch pipe	621	foot	$99	$61,479	$21,518	$83,000
F-5	New 4-inch connection	1	ea.	$15,000	$15,000	$5,250	$20,000
F-6	695 feet of 8-inch pipe	695	foot	$99	$68,805	$24,082	$93,000
F-7	New 4-inch connection	1	foot	$15,000	$15,000	$5,250	$20,000
F-8	575 feet of 8-inch pipe	575	foot	$99	$56,925	$19,924	$77,000
F-9	430 feet of 8-inch pipe	430	foot	$99	$42,570	$14,900	$57,000
F-10	430 feet of 8-inch pipe	430	foot	$99	$42,570	$14,900	$57,000
F-11	45 feet of 8-inch pipe	1	ea.	$15,000	$15,000	$5,250	$20,000
F-12	New 8-inch valve	1	ea.	$5,000	$5,000	$1,750	$7,000
	240 feet of 8-inch pipe	240	foot	$99	$23,760	$8,316	$32,000
F-13	275 feet of 8-inch pipe	275	foot	$99	$27,225	$9,529	$37,000
F-14	440 feet of 8-inch pipe	440	foot	$99	$43,560	$15,246	$59,000
F-15	1,080 feet of 8-inch pipe	1,080	foot	$99	$106,920	$37,422	$144,000
F-16	690 feet of 8-inch pipe	690	foot	$99	$68,310	$23,909	$92,000
	New 4-inch connection	1	ea.	$15,000	$15,000	$5,250	$20,000
F-17	700 feet of 8-inch pipe	700	foot	$99	$69,300	$24,255	$94,000
F-18	New 4-inch connection	1	ea.	$15,200	$15,200	$5,320	$21,000
F-19	425 feet of 8-inch pipe	425	foot	$99	$42,075	$14,726	$57,000
F-20	505 feet of 8-inch pipe	505	foot	$99	$49,995	$17,498	$67,000
F-21	2,230 feet of 10-inch pipe	2,230	foot	$113	$251,990	$88,197	$340,000
F-21	480 feet of 8-inch pipe	480	foot	$99	$47,520	$16,632	$64,000
F-22	New firehydrant	1	ea.	$5,000	$5,000	$1,750	$7,000
F-23	1,005 feet of 8-inch pipe	1,005	foot	$99	$99,495	$34,823	$134,000
F-23	6-inch fireflow PRV	1	ea.	$25,000	$25,000	$8,750	$34,000
F-24	720 feet of 8-inch pipe	720	foot	$99	$71,280	$24,948	$96,000
	280 feet of 10-inch pipe	280	foot	$113	$31,640	$11,074	$43,000
	6-inch fireflow PRV	1	ea.	$25,000	$25,000	$8,750	$34,000
F-25	500 feet of 12-inch pipe	500	foot	$120	$60,000	$21,000	$81,000
D-1	3,000 feet of 12-inch pipe	3,000	foot	$81	$243,000	$85,050	$328,000
D-2	New 4-inch connection	1	ea.	$15,000	$15,000	$5,250	$20,000
D-3	300 feet of 10-inch pipe	300	foot	$113	$33,900	$11,865	$46,000
D-4	5,020 feet of 24-inch pipe	5,020	foot	$212	$1,064,240	$372,484	$1,437,000
D-5	6-inch PRV	1	ea.	$25,000	$25,000	$8,750	$34,000
D-6	360 feet of 30-inch pipe	360	foot	$282	$101,520	$35,532	$137,000
BD-1	1,715 feet of 16-inch pipe	1,715	foot	$134	$229,810	$80,434	$310,000
BD-2	1,550 feet of 12-inch pipe	1,550	foot	$120	$186,000	$65,100	$251,000
BD-3	Bluff Tank control valve	1	ea.	$100,000	$100,000	$35,000	$135,000
BD-4	4,615 feet of 48-inch pipe	4,615	foot	$576	$2,658,240	$930,384	$3,589,000
BD-5	10,620 feet of 54-inch pipe	10,620	foot	$648	$6,881,760	$2,408,616	$9,290,000
BD-6	4,690 feet of 54-inch pipe	4,690	foot	$648	$3,039,120	$1,063,692	$4,103,000
	2,660 feet of 48-inch pipe	2,660	foot	$576	$1,532,160	$536,256	$2,068,000
BD-7	5,440 feet of 36-inch pipe	5,440	foot	$377	$2,050,880	$717,808	$2,769,000
BD-8	7,690 feet of 30-inch pipe	7,690	foot	$282	$2,168,580	$759,003	$2,928,000
BD-9	2,610 feet of 12-inch pipe	2,610	foot	$120	$313,200	$109,620	$423,000
BD-10	7,080 feet of 12-inch pipe	7,080	foot	$120	$849,600	$297,360	$1,147,000
BD-11	17,430 feet of 30-inch pipe	17,430	foot	$282	$4,915,260	$1,720,341	$6,636,000

FIRE FLOW PROJECT COST CALCULATIONS

MAP ID	Project Description	UNIT	UNIT TYPE	UNIT COST	COST	Contingency (20%) and Engineering (15%)	TOTAL COST
BD-12	19,120 feet of 24-inch pipe	19,120	foot	$212	$4,053,440	$1,418,704	$5,472,000
BD-13	1,830 feet of 24-inch pipe	1,830	foot	$212	$387,960	$135,786	$524,000
BD-14	2,180 feet of 12-inch pipe	2,180	foot	$120	$261,600	$91,560	$353,000
BD-15	880 feet of 12-inch pipe	880	foot	$120	$105,600	$36,960	$143,000
BD-16	2,100 feet of 12-inch pipe	2,100	foot	$120	$252,000	$88,200	$340,000

TOTAL $70,057,000

APPENDIX G

Checklist for Hydraulic Model Design Elements Report

APPENDIX

CHECKLIST FOR HYDRAULIC MODEL DESIGN ELEMENTS REPORT

This hydraulic model checklist identifies the components included in the Hydraulic Model Design Elements Report for

Logan City Drinking Water System Master Plan
(Project Name or Description)

03010
(Water System Number)

Logan Municipal Water System
(Water System Name)

07/06/2016
(Date)

The checkmarks and/or P.E. initials after each item indicate the conditions supporting P.E. Certification of this Report.

1. At least 80% of the total pipe lengths in the distribution system affected by the proposed project are included in the model. *[R309-511-5(1)]* ☒ RTC

2. 100% of the flow in the distribution system affected by the proposed project is included in the model. If customer usage in the system is metered, water demand allocations in the model account for at least 80% of the flow delivered by the distribution system affected by the proposed project. *[R309-511-5(2)]* ☒ RTC

3. All 8-inch diameter and larger pipes are included in the model. Pipes smaller than 8-inch diameter are also included if they connect pressure zones, storage facilities, major demand areas, pumps, and control valves, or if they are known or expected to be significant conveyers of water such as fire suppression demand. *[R309-511-5(3)]* ☒ RTC

4. All pipes serving areas at higher elevations, dead ends, remote areas of a distribution system, and areas with known under-sized pipelines are included in the model. *[R309-511-5(4)]* ☒ RTC

5. All storage facilities and accompanying controls or settings applied to govern the open/closed status of the facility for standard operations are included in the model. *[R309-511-5(5)]* ☒ RTC

6. Any applicable pump stations, drivers (constant or variable speed), and accompanying controls and settings applied to govern their on/off/speed status for various operating conditions and drivers are included in the model. *[R309-511-5(6)]*

☒ RTC

7. Any control valves or other system features that could significantly affect the flow of water through the distribution system (i.e. interconnections with other systems, pressure reducing valves between pressure zones) for various operating conditions are included in the model. *[R309-511-5(7)]* ☒ RTC

8. Imposed peak day and peak instantaneous demands to the water system's facilities are included in the model. The Hydraulic Model Design Elements Report explains which of the Rule-recognized standards for peak day and peak instantaneous demands are implemented in the model (i.e., (i) peak day and peak instantaneous demand values per *R309-510, Minimum Sizing Requirements*, (ii) reduced peak day and peak instantaneous demand values approved by the Director per *R309-510-5, Reduction of Sizing Requirements*, or (iii) peak day and peak instantaneous demand values expected by the water system in excess of the values in *R309-510, Minimum Sizing Requirements*). The Hydraulic Model Design Elements Report explains the multiple model simulations to account for the varying water demand conditions, or it clearly explains why such simulations are not included in the model. The Hydraulic Model Design Elements Report explains the extended period simulations in the model needed to evaluate changes in operating conditions over time, or it clearly explains (e.g., in the context of the water system, the extent of anticipated fire event, or the nature of the new expansion) why such simulations are not included in the model. *[R309-511-5(8) & R309-511-6(1)(b)]* ☒ RTC

9. The hydraulic model incorporates the appropriate demand requirements as specified in *R309-510, Minimum Sizing Requirements*, and *R309-511, Hydraulic Modeling Requirements*, in the evaluation of various operating conditions of the public drinking water system. The Report includes:
   - the methodology used for calculating demand and allocating it to the model;
   - a summary of pipe length by diameter;
   - a hydraulic schematic of the distribution piping showing pressure zones, general pipe connectivity between facilities and pressure zones, storage, elevation, and sources; and
   - a list or ranges of values of friction coefficient used in the hydraulic model according to pipe material and condition in the system. In accordance with Rule stipulation, all coefficients of friction used in the hydraulic analysis are consistent with standard practices.

   [R309-511-7(4)] ☒ RTC

10. The Hydraulic Model Design Elements Report documents the calibration methodology used for the hydraulic model and quantitative summary of the calibration results (i.e., comparison tables or graphs). The hydraulic model is sufficiently accurate to represent conditions likely to be experienced in the water delivery system. The model is calibrated to adequately represent the actual field conditions using field measurements and observations. *[R309-511-4(2)(b), R309-511-5(9), R309-511-6(1)(e) & R309-511-7(7)]* ☒ ETC

11. The Hydraulic Model Design Elements Report includes a statement regarding whether fire hydrants exist within the system. Where fire hydrants are connected to the distribution system, the model incorporates required fire suppression flow standards. The statement that appears in the Report also identifies the local fire authority's name, address, and contact information, as well as the standards for fire flow and duration explicitly adopted from *R309-510-9(4), Fireflow*, or alternatively established by the local fire suppression agency, pursuant to *R309-510-9(4), Fireflow.* The Hydraulic Model Design Elements Report explains if a steady-state model was deemed sufficient for residential fire suppression demand, or acknowledges that significant fire suppression demand warrants extended model simulations and explains the run time used in the simulations for the period of the anticipated fire event. *[R309-511-5(10) & R309-511-7(5)]* ☒ ETC

12. If the public drinking water system provides water for outdoor use, the Report describes the criteria used to estimate this demand. If the irrigation demand map in *R309-510-7(3), Irrigation Use,* is not used, the report provides justification for the alternative demands used in the model. If the irrigation demands are based on the map in *R309-510-7(3), Irrigation Use,* the Report identifies the irrigation zone number, a statement and/or map of how the irrigated acreage is spatially distributed, and the total estimated irrigated acreage. The indicated irrigation demands are used in the model simulations in accordance with Rule stipulation. The model accounts for outdoor water use, such as irrigation, if the drinking water system supplies water for outdoor use. *[R309-511-5(11) & R309-511-7(1)]* ☒ ETC

13. The Report states the total number of connections served by the water system including existing connections and anticipated new connections served by the water system after completion of the construction of the project. *[R309-511-7(2)]* ☒ ETC

14. The Report states the total number of equivalent residential connections (ERC) including both existing connections as well as anticipated new connections associated with the project. In accordance with Rule stipulation, the number of ERC's includes high as well as low volume water users. In accordance with Rule stipulation, the determination of the equivalent residential connections is based on flow requirements using the anticipated demand as outlined in *R309-510, Minimum Sizing Requirements*, or is based on alternative sources of information that are deemed acceptable by the Director. *[R309-511-7(3)]* ☒ ETC

15. The Report identifies the locations of the lowest pressures within the distribution system, and areas identified by the hydraulic model as not meeting each scenario of the minimum pressure requirements in *R309-105-9, Minimum Water Pressure*. *[R309-511-7(6)]* ☒ RTC

16. The Hydraulic Model Design Elements Report identifies the hydraulic modeling method, and if computer software was used, the Report identifies the software name and version used. *[R309-511-6(1)(f)]* ☒ RTC

17. For community water system models, the community water system management has been provided with a copy of input and output data for the hydraulic model with the simulation that shows the worst case results in terms of water system pressure and flow. *[R309-511-6(2)(c)]* ☒ RTC

18. The hydraulic model predicts that new construction will not result in any service connection within the new expansion area not meeting the minimum distribution system pressures as specified in *R309-105-9, Minimum Water Pressure. [R309-511-6(1)(c)]* ☒ RTC

19. The hydraulic model predicts that new construction will not decrease the pressures within the existing water system to such that the minimum pressures as specified in *R309-105-9, Minimum Water Pressure* are not met. *[R309-511-6(1)(d)]* ☒ RTC

20. The velocities in the model are not excessive and are within industry standards. ☒ RTC